Kerala Agricultural University

RESEARCH REPORT 2019

Edited by
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Kerala Agricultural University
Vellanikkara, Thrissur, Kerala

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FOREWORD

The scientific fraternity of Kerala Agricultural University follow a technology led path for development of Agriculture, and for the prosperity of the farming community of Kerala. Through their constant efforts and science based policy interventions, agriculture in the state has been showing a positive growth as evident from the increase in crop production without substantial increase in the cropped area. Technologies developed through research in the University have played a significant role in solving farmers' myriad problems related to crop production in addition to improving productivity. Reaffirming our commitment towards the agricultural development of the state, Kerala Agricultural University is proud to present the major research findings during the year 2018-19. I hope this report will provide useful information to the diverse stakeholders in the state and also open new avenues to rebuild the agricultural sector of Kerala after the devastating flood in 2018. I take this opportunity to congratulate all those who have contributed t0 this endeavor.

(R. Chandra Babu)

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Healthy soils for a Healthy Life

PREFACE

The Kerala Agriculture is in a fast pace of recovery after the floods of 2018. The growth tragectory in this sector would have been notable, if the period have been a normal one. The rebuilding process in agriculture gained momentum with the technological support from KAU and combined efforts of all concerned. The field presence of KAU, post flood, to support the farmers and understand the changes in agro ecology lead to policy formulation and action plan to revive the sector. KAU, also have focused on research projects that address the problems that were identified to develop scientific prescription to mitigate and adopt the climate change impacts. The constant and systematic interfaces with the stakeholders of agri sector form the basis of our research policy.

The research funding in the University is mostly from public sector i.e., Indian Council of Agricultural Research, Indian Council of Forestry Research and Education, Department of Biotechnology, Department of Science and Technology and Kerala State Council for Science Technology and Environment, to cite a few. The projects are implemented by the scientists working in the seven colleges and 26 research stations of the University. These scientists are also discharging extension and teaching duties. Post graduate and doctoral research projects also contribute to the research outcome.

Director of Research supported by Associate Directors of Research in five agricultural zones and in the headquarters execute the management of the projects. There are three faculties, Agriculture, Forestry and Agriculture Engineering. Project implementation is monitored by the Project Co-ordinators of 24 subject specific co-ordination groups, 19 in Agriculture, 2 in Forestry and 3 in Agricultural Engineering. All the projects including PG and Ph.D projects, are co-ordinated by the Professor (Research Co-ordination).

Every year more than 200 articles are published by the faculty in reputed journals. Many deliverable technologies which support agri enterprenuership are also evolved through the research projects. Continuing our efforts, new varieties in different crops suitable for the different agro climatic zones of Kerala are in the pipe line of release.

This research report includes the research outcome through the projects handled by the faculty and PG and Ph D students during the period 2018-19. The publications by the students and the faculty during 2018-19 are also included.

The support and help rendered by the supportive ministerial staff, technical officers and farm workers in this venture needs special mention. The role of Research Associates and other temporary employees is also equally acknowledged. The funding agencies and other organizations who supported the research in Kerala Agricultural University are acknowledged with gratitude. We place this before the society with pride and hope that the knowledge generated facilitate improvement in the welfare of farming community.

Dr.P. Indira Devi
Director of Research

FACULTY OF AGRICULTURE

Dr. Jayalekshmy. V.G

Professor (RC)

Name of Project Coordination Group: (01)
Rice

Compiled by:
Dr. Reena Mathew, Project Coordinator

Plan & External Aided Projects

Ongoing Projects: 92 Nos.

Post Graduate Projects

Concluded Projects: 1 Nos.
Ongoing Projects:14 Nos.

Ongoing Projects

1. Genetic conservation of rice germplasm- Collection, maintenance, cataloguing and evaluation (Pattambi)

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The programmes envisaged in this project includes Pure seed multiplication of rice germplasm available in the station, adding new varieties from other states, wild types and local types from farmers fields and cataloguing and characeterization.

Pure seed multiplication and characterization of 567 accessions were completed under this project and were stored under Medium Term Storage facility developed at RARS, Pattambi. Selection from Kalluruli was tested under upland condition and early flowering genotypes were selected. Ponkuruka, chenkazhama, kazhama, pallippuram pokkali, cheriya orpandi, Karutha kuruka, chettivirippu, gandhakasala, pandichampan, eluthavattan, mundakan, vellari, velutharikayama, thekkan chitteni were tested for salinity and Chuvanna modan and Kalluruli were tested for high temperature stress tolerance under lab conditions. Selections from land races Veluthitaryan and Kalluruli were tested for yield performance under wetland condition along with check varieties during Rabi 2018-19. Pure seed multiplication of Kalluruli selection was taken up during Rabi 18-19. Pest and disease screening revealed that Kalluruli selection showed resistance to leaf folder and Veluthitaryan selection showed moderate resistance to blast.

2. Collection, maintenance and evaluation of rice germplasm.(Moncompu)

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The objective is to collect, maintain and evaluate the available germplasm of rice, both traditional and exotic for utilization in the breeding programme of RRS, Moncompu. During 2018-19, about six hundred and seventy four rice germplasam are maintained by the station.

3. Collection, maintenance and utilization of saline resistant rice varieties(Vyttila)

Dr.Veena Vighneswaran
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Along with existing fifty nine accessions, selected entries from INGER nursery were raised for seed multiplication during Kharif 2018. Kerala flood resulted in complete loss of the germplasm. Hence morphological data couldn't be recorded. With the available seeds in the refrigerator seed multiplication and maintenance will be continued next year.

4. Conservation and Utilisation of Rice Biodiversity in Kuttanad

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The objectives of the project are to collect and conserve the traditional/ local land races of Kerala with special attributes and identify novel genes for combating stresses induced by climate change. Maintenance breeding and seed multiplication of the varieties are being taken up. During 2018-2019,

Two hundred and eighteen traditional/ local land races collected from different parts of Kerala were conserved in the field. These land races are sources of novel genes for developing new varieties. Morphological characterization and screening of the accessions using IRRI-IPGRI descriptor need to be continued.

5. Establishment of Seed Bank for Biodiversity and Local Germplasm Conservation and Collection

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The project aims to conserve and multiply the traditional varieties and landraces of rice for serving as basic stock for utilization for farmers and research community. The traditional varieties that were under large scale seed production during Kharif (Virippu) include Parambuvattan, Thavalakannan, Thekkancheera, Thonnooran, Chenkayama, Kattamodan, Karutha Modan, Chuvanna modan, Aruvakkari, Raktha Sali, Chennellu, Chomala and Kalladiyaryan. Large scale seed production of photosensitive varieties were started in July 2018 which include Eravapandy, Vellari, Velutharikayama, ThekkanChitteni, Kavunginpoothala, Eravapandy, Thekkan, and Arikkirai. Action has started to augment the germplasm collection from various parts of Kerala. These include collections like Valichoori, Chempakam, Varipidiyan, Karutha navara, Ayiramkana, Kunkuma Sali, Anantharasali, Peetsala, Rajamudi, Krishna Kamod etc. Pure seed multiplication of Aryan, Ponnaryan, Kayama, Maskathi, Jedduhalliga, Athikiraya, Wadakkan Chitteni, Velutha Vattan, Chuvanna Vattan, Cheriya Aryan, Elapapoochampan, Valiya champan and Kodiyan were taken up during Rabi 2018-19.

A seed exchange mela was organized for on farm conservation and promotion of traditional varieties in farmer's field. Exhibition of germplasm of paddy varieties were also organized during the mela.

6.Breeding high yielding, tall, photo sensitive varieties with good straw yield specifically suited for the mundakan season of Kerala.

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This breeding programme is mainly concentrated on evolving second crop varieties for Kerala.PTB 61(KAU Supriya) and PTB 62 (KAU Akshaya), released in 2017 for mundakan season, was popularized in farmers field in various districts. Front line demonstrations and field days were organized in Palakkad, Thrissur, Malappuram and Kannur districts. The seeds of new varieties PTB 61 and PTB 62 were sent to NBPGR for long term storage. National identity numbers were received for PTB 61 and PTB 62 as IC 625889 and IC 625890 respectively.

Promising cultures were evaluated in field for yield along with checks during Rabi 2018-19 and selections were undertaken from segregating lines. Cul 1, 2, 3, 4 of cross Swetha x Kuruka, Cul 7, 8 of cross Pranava x Vellari and Cul 9, 12, 16, 18, 19 of cross Pranava x Chettadi and selections from cultures (Cul 5-1, 8-1, 18-1) were tested. Cul 6 (KAU Supriya), Cul 7 (0614-10-14-17-1) and Cul 9 (0615-15-16-8) were tested under Initial Varietal trials and Cul 14 (KAU Akshaya) was tested under Advance Variety Trial -1 of AICRIP.

7. Evolution of semi tall or dwarf types of tall Indica rice varieties.

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The programme is aimed at developing dwarf/ semi tall varieties from tall indica varieties by mutation. Important tall varieties of Kerala will be subjected to irradiation using gamma rays. The evolving dwarf or semi tall mutants with all other characteristics of traditional varieties will be selected in the M2 and M3 generation. Single plant selection will be continued until uniformity is achieved. Such mutants will either be released as varieties or will be utilized as donors in future breeding programmes.

During 2018-19, Comparative Yield trial-1 of Cul M2-3, Cul M3, Cul M4, Cul M6-2, Cul M8 and Cul M9 and Comparative Yield Trial -2 of Cul M1, Cul M5 and Cul M6 were conducted in Rabi season with parents and check varieties Uma, Matta triveni, Karuna and Ponmani. Uniform mutant lines Cul M2-7, Cul M2-9-5, Cul M2-9-7 and Cul M2-11-3 were tested in Preliminary yield trials along with parents in 2018-19. Eleven segregating mutant lines of PTB 18 and 21 were subjected to selection during 2018-19 and superior progenies were selected. Promising entries will be forwarded to advanced trials. Cultures M1 and M6 were tested under Initial Variety Trials of AICRIP during Kharif 2018.Flood tolerant traditional variety PTB 15 Kavungin Poothala was irradiated with Gamma ray (RTL, KAU, Vellanikkara) at range of 18 Gy to 250 Gy. M1 generation was raised during Rabi 2018-19 and progeny were selected for advancing to next generation.

8. Evolving high yielding multiple resistant rice varieties through gene pyramiding

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Scoring for major pest and diseases are regularly undertaken in promising genotypes identified from different study and in germplasm lines. Promising entries from the crosses Swetha x Kuruka, Pranava x Chettadi, Pranava x Vellari, NPT cultures derived from Interspecific crosses of IIRR, Selection from Jaya variety, mutant lines of PTB 18 and 21 and selections from germplasm were screened for pests like stem borer and leaf folder during Kharif and Rabi 2018-19. The cultures which were found to have high resistance to stem borer (Cul 06-1, Cul 06-2, Cul 06-3, Cul 06-10,Cul 06-14, Cul 06-16, Cul 06-18, JS-3, JS-4 and JS-7) and cultures with resistaance to leaf folder (Cul 06-1, Cul 06- 2, Cul 06-3, Cul 06-6, Cul 06- 7, Cul 06-8, Cul 06-12, Cul 06-16, Cul 06-18, JS-1, JS-2, JS-3, JS-5, Cul M5 and NPT Cul 1) were evaluated under yield trials along with check varieties during 2018-19.

Most promising multiple resistant cultures were evaluated under Donor Screening Nursery of AICRIP during Kharif 2018

9. Breeding for drought tolerant rice varieties suitable for upland ecosystem

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The cultures from interspecific and three way crosses, selection from NPT cul1 and Kalluruli were evaluated along with check varieties under rainfed upland condition during Kharif 2018. Early flowering genotypes from Kalluruli was selected for further evaluation and pure seeds were multiplied during Rabi 2018-19. Under student programmes a marker assisted back crossing programme was started to improve Jyothi variety using drought tolerant Chuvannamodan variety and BC1F1 seeds were produced. Cultures 06-7, Cul M6, Cul JS-6, JS-7, NPT Cul 1, PTB 61, PTB 62 were screened for drought and high temperature stress tolerance under student programmes along with physiology department.

10. Evolving multiple disease and pest resistant rice var. for second crop of Kuttanad

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The main objective of the project was to develop high yielding rice varieties with multiple resistance to major pests and diseases of Kuttanad. During 2018-19, the cultures KAUM 240-1-3-2-2-1and KAUM 238-1-1-1-1-1 were the best performers with respect to grain yield. The grain yield recorded for these cultures were comparable with the check variety Uma (10980 kg ha^{-1}). The culture KAUM 236-1-2-1-1-1 was highly resistant to sheath blight whereas, the other

cultures showed moderate resistance. Among the check varieties, the variety Jyothi showed susceptibility to sheath blight.

11. Breeding for high yielding rice varieties with resistance/ tolerance to adverse soil conditions

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The objective of the project was to evolve high yielding varieties of rice with resistance / tolerance to adverse soil conditions. During 2018-19, the cultures *viz.*, KAUM 168-1 and KAUM 174-6 were found to be promising with respect to grain yield and the culture KAUM 168-1 out yielded all the check varieties including Shreyas (10035 kg ha^{-1}). The culture KAUM 174-6 was found to be highly resistant to sheath blight, whereas, the other cultures showed moderate resistance. After repeated trials for yield stabilisation these promising cultures will be evaluated in farmers' field under adverse soil conditions of acidity, salinity etc.

12.Breeding for high yielding rice varieties having short duration, seed dormancy and resistance to biotic and abiotic stresses suitable for Kuttanad

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The project was started to evolve high yielding rice varieties with a duration of about 100 days and below, varieties with seed dormancy, varieties with tolerance / resistance to flood , salinity and other biotic and abiotic stresses.During Puncha crop 2018-19, cultures KAUM 194-3-1-1-1 and KAUM 192-1-1-1-2-1 were the best performers with respect to grain yield. The culture KAUM 194-3-1-1-1 out yielded all the check varieties. The cultures *viz.*, KAUM 192-1-1-1-2-1, KAUM 184-1-2-1-1-1, KAUM 188-1-2-1-3-1, KAUM 200-2-2-3-2-1 and KAUM 184-1-4-2-2-1 out yielded the check varieties Uma, Jyothi and Prathyasa in grain yield. The evaluation trials have to be continued.

13. Breeding of short duration rice varieties for virippu season and photosensitive, semi tall high yielding varieties for mundakan season in Onattukara

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The objective of the experiment is to develop a short duration rice variety suited to virippu season in Onattukara tract incorporating adaptive genes of Kochuvithu as a substitute of Jyothy and to develop a superior high yielding variety suited to mundakan season incorporating the adaptive genes of Ptb-20 to substitute Lakshmi.

As first part of the programme, a series of crossing was undertaken in Virippu to combine the desirable characters of the varieties. In the second part also a series of crossing were undertaken

in Mundakan season.. Desirable recombinants were selected from segregating generations. The stabilized cultures for virippu viz. Cul.23, Cul.28 and Cul.35 and for mundakan viz., Cul 4, 41 and 52 were forwarded to yield and adaptability trials after conducting grain quality analysis. The Mundakan cultures were multiplied and will be submitted to AICRP to perform trails. The Virippu cultures are sown in the field and will be processed and sent for AICRP trials.

14. Breeding for high yielding rice with resistance to major pests of rice in Kuttanad

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The objective is to develop high yielding rice varieties with resistance to pest like thrips, caseworm, leaf folder, stem borer etc. witch are attaining the states of major pests. During Puncha crop 2018-2019, culture KAUM 231-5-2-1 was the best performer with respect to grain yield and disease resistance followed by KAUM 230-1-1-1. The culture KAUM 231-5-2-1 (9215.68 Kg ha^{-1}) yielded more than the three check varieties *viz.*, Uma, Jyothi and Prathyasa. During Puncha 2017-18 also the culture KAUM 231-5-2-1 showed high yield compared with others. Among the cultures evaluated, the cultures KAUM 230-1-2-1 and KAUM 231-5-2-1 were found to be resistant to sheath blight, blast and sheath rot diseases. The cultures *viz.,* KAUM 230-1-1-1 (IET number: 26427) and KAUM 230-1-2-1 (IET number: 26437) were tested in AICRIP trials (IVT- BORO-2016). The culture KAUM 230-1-1-1 was promoted to AVT-BORO trials in Eastern region (zone III).

15. Breeding for high yielding rice varieties with submergence tolerance

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The objective of the project was to evolve high yielding varieties of rice with submergence tolerance. During Puncha 2018-19 the culture KAUM 180-2 stood first in grain yield (10338.6 kg ha^{-1}) compared with the check variety Uma (9144.39 kg ha^{-1}) and Shreyas (10035.6 kg ha^{-1}). The yield of the culture KAUM 179-1 (9073.08 kg ha^{-1}) was on par with the check variety Uma. KAU M 179-1 showed low score value for Sheath blight compared to the check varieties except Uma.

The cultures *viz.,* KAUM 179-1 and KAUM 180-2 were tested in AICRIP trials during 2016 Kharif. The culture KAUM 179-1 (IET number: 26113) performed well in Eastern zone and Kerala. It came first in Kerala and Bhubaneswar with 20% and 10% yield advantage over best performing check respectively. The culture KAUM 180-2 (IET number: 25996) performed well in states of Bihar and West Bengal coming under Eastern zone. It came first in West Bengal with 12% yield advantage over best performing check.

16. Breeding for high yielding rice varieties having short duration, seed dormancy and resistance to biotic and abiotic stress suitable for Kuttanad

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During Puncha crop 2018-19, cultures KAUM 194-3-1-1-1 and KAUM 192-1-1-1-2-1 were the best performers with respect to grain yield. The culture KAUM 194-3-1-1-1 out yielded all the check varieties. The cultures *viz.*, KAUM 192-1-1-1-2-1, KAUM 184-1-2-1-1-1, KAUM 188-1-2-1-3-1, KAUM 200-2-2-3-2-1 and KAUM 184-1-4-2-2-1 out yielded the check varieties Uma, Jyothi and Prathyasa in grain yield.

17. Breeding lodging resistant rice varieties for dry sowing conditions during virippu season

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The objective is to develop lodging resistant, fertilizer responsive medium tall rice varieties suited for dry sown virippu season in uplands and wetlands of Kerala.F_5 plants were raised in ear to row method and observations were made on characters such as days to flowering, plant height (cm), no. of tillers, no. of panicles and panicle length (cm). The homozygous superior plants were selected to forward further to the F6 generation.

18. Evolution of high yielding abiotic stress tolerant rice varieties by MAS & nutrient dynamics in acid saline pokkali soils.

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The objectives of the experiment were evolution of high yielding abiotic stress tolerant rice varieties for acid saline submerged areas through MAS and monitoring soil and water quality and assessing the dynamics of nutrients in acid saline pokkali soils.

Three CYT experiments were laid out in the field during kharif 208-19 with the dual stress tolerant lines of Jyothi, Uma and Jaya developed by pyramiding the *Salto*l QTL introgressed and *Sub 1* gene introgressed lines of Jyothi, Uma and Jaya. But the experiments were vitiated due to two successive floods in July and August 2018. The available seeds were multiplied in pots for repeating the experiment during kharif 2019-20. The seed production plots were also damaged by flood and the varieties VTL-1 to VTL-11 were multiplied in the third crop season at Perumbavoor. There was spatial and temporal variations in the available nutrient content of soil during low saline and high saline phase due tidal influence. Even though nutrients like Ca, Mg and B fluctuated from deficiency to sufficiency level form low saline phase to high saline phase, Cu and Mg recorded deficiency throughout.

19. Alkaline Tolerant Variety Trial (SATVT) and International Rice Saline Alkaline Tolerance Observational Nursery (National Saline Alkaline Screening Nursery (NSASN) Saline IRSATON

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During Kharif 2018, four trials were conducted, two each under CSTVT and AL& ISTVT. Under CSTVT, 18 entries in AVT and 47 entries in IVT were raised for evaluation. Similarly under AL& ISTVT also 23 entries in AVT and 28 entries in IVT were raised for evaluation with VTL 6 and VTL 10 as local check with each trial. But the flood resulted in complete loss of the crop .

20. Hybridization programme-improvement of pokkali rice

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The programme was started in 1990 to evolve high yielding varieties suitable for pokkali and other coastal saline ecosystem by taking up hybridization between highly adaptive pokkali varieties and other high yielding varieties in such a way to retain the tolerance attributes of pokkali land races along with high yield. The selected homogeneous F6 progeny lines were raised in the field during kharif 2018, but, resulted in complete loss of crop due to flood. Though the conservation of seed through pot culture were attempted, due to bird damage, that too resulted in small quantity of seeds

21. Breeding high yielding rice varieties suitable for pokkali area by hybridization between Pokkali varieties and other high yielding varieties.

Dr. Shylaraj,K.S.
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The objective is to evolve high yielding varieties with multiple tolerance to the various abiotic stresses prevalent in the pokkali ecosystem by a pyramiding approach through multiple crosses. Homogeneous lines of F6 generation were raised in the field for yield evaluation, but resulted in complete loss of crop due to flood. Though the conservation of seed through pot culture were attempted, due to bird damage, that too resulted in small quantity of seeds F 1 seeds of new crosses with VTL 1, VTL 2 and VTL 4 with Pusa 44 were raised and F2 seeds were collected.

22. Induced mutagenesis of pokkali rice land races

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Field demonstrations of the culture51.5 evolved by mutation from Pokkali land race and released as Lavanya during 2017-18 are continued during 2018-19.

23. Evolution of high yielding rice varieties suitable for Pokkali tract of Northern Kerala through farmer's participatory breeding approach (KAU plan project) (Pilicode)

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i) Evaluation of F_7 filial generation of newly developed saline tolerant organic breeding lines in saline flooded Kaipad tract

When 27 newly developed saline tolerant organic breeding lines at F_7 filial generation were evaluated along with traditional varieties of Kaipad- 'Kuthiru' and 'Orkayama' during 2018 Kharif, there was 40 days submergence in the tract due to heavy rainfall. Out of 27 breeding lines, 14 breeding lines and the traditional variety 'Kuthiru' were damaged fully due to flood and submergence. The traditional variety 'Orkayama' showed 100% survival. Thirteen breeding lines showed survival percentage ranging from 1.56% to 65.6% . Among derived breeding lines, JO-15-2 showed the highest survival % of 65.6 under 40days submergence. Considering per plant yield, even though less survival % under severe submergence, the breeding lines 'Ezh-1' × 'FL-478-3', 'Ezh-1' × 'FL-478(S)-1', 'Kuth × Ork-1-2', 'Pok × Ork', 'Pok × Ork-1', 'JO-560', 'JO 15-2' and 'Ork '× 'IRE-28-1 'recorded high yield per plant with highest per plant yield of 36 g/plant for Ezh-1 x FL 478-3. The breeding lines Pok × Ork, Pok × Ork-1, JO-560, and Ork × IRE-28-1 are non lodging inspite of their tall nature of > 120cm height. Hence these eight lines selected based on survival percentage,per plant yield and non lodging nature were decided to carry forward.These selected lines were advanced to F_8 generation during 2018 rabi season at wetland of RARS, Pilicode under organic management.

ii) Evaluation of F_7 filial generation of newly developed organic breeding lines in non saline wetland of RARS, Pilicode, under organic management during Kharif 2018

From 30 organic breeding lines of F_7 filial generation grown under organic management in wetland conditions, based on yield performance (yield = >13g/plant) the breeding lines JO-32-2, JO-15-2, JO-74-2, JK-78, JK-1, IRE-139 (W), IRO-94, JK-78, IRE-50, JO-180-1-2, MK-139-1-1, Kuth × Ork-2, Pok × Ork , Kuth × Ork-1-1 were selected to carry forward. These selected lines were advanced to F_8 generation during 2018 rabi season at wetland of RARS, Pilicode under organic management.

iii) Evaluation of organic rice cultures under CYT during 2018 Kharif and Rabi

Four organic rice cultures namely, JK 71, MK115, JK 59 and JK 14 derived from the hybridization done in 2001 were evaluated as CYT -1 under organic management during 2018 Kharif in the wetland of RARS, Pilicode taking 'Jaiva' organic variety as check. The culture JK 14 which is a partially lodging genotype with average height 159.1cm recorded the highest yield of 16304.kg/ha. All other remaining cultures namely MK115,JK 71, and JK59 showed on par performance with the check variety, Jaiva with yield range of 4435.8kg/ha - 6947.8kg/ha.

These varieties were also evaluated as CYT -2under organic management during 2018 Rabi. There was severe water stress problem during flowering stage. With respect to grain yield and straw yield under organic management all cultures showed on par performance with the check variety 'Jaiva'. Considering over all performance under water stress environment, the cultures JK 14 and JK 71 exhibited good grain yield of 4366.7kg/ha and 3950kg/ha.

iv) Germplasm conservation:

Planted 113 traditional rice genotypes in wetland of RARS, under organic management, for conservation purpose. Seeds of 10 number of traditional varieties namely, 'Kozhivalan', 'Chokkiriyan', 'Chanthondi', 'Karimchama', 'Kunjikayama', 'Chempavu', 'Marathondi', 'Swarnamalli', 'Punchakayama', and 'Ottanori ' were deposited in NBPGR, New Delhi for long term storage.

24. Testing the adaptability and stability of high yielding varieties of rice in Onattukara

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The objective of the trial was to test the adaptability and stability of different newly released rice varieties for the first and Second crop seasons of Onattukara.Out of the 23 rice varieties screened both for virippu and mundakan season using Jyothi as check, the Virippu season varieties MDU-5, Ahitra and Aiswarya and the Mundakan season varieties ADT-16 and Aruna were identified to be superior than the check variety Jyothy in terms of adaptability and stability in Onattukara. Farm trials were conducted and the results presented in the 34th ZREAC and recommended for presenting in the mini package of practices recommendations. The Proposal will be submitted after getting approval of the upcoming Mini POP.

25. Climate resilient rice production technology for Kuttanadu- Sub project – Screening of rice germplasm for biotic and biotic stress (Centre of Excellence in Below Sea Level Farming (Plan))

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The objective of the experiment is developing new rice varieties combining high yield and resistance to biotic and abiotic stresses in the changed climate scenario. Five promising cultures selected from the lines developed under the Kuttanad package project are further evaluated during the period along with 4 check varieties.

The cultures KAUM 242-4-2-1-1-1-1(Pokkali/ Thavalakkannan) and KAUM 250-1-1-1-1-1 (Jyothi/JO345) were found superior to the mid early check varieties Jyothi and Shreyas with an average yield of 9-10 t^{-ha}. These two are medium duration (120 days), semi dwarf varieties (100cm) with moderate tolerance to blast, sheath blight and sheath rot. These two cultures were nominated for AICRIP trials during the season Kharif 2018 and the results are awaited.

The cultures KAUM 255-1-2-1-1-1-1 (Pokkali/ Vytilla 6) and KAUM 261-1-3-1-1-1-1 (Jyothi/ IR 47544) were identified to be medium duration (130 days), semi tall with an average yield of 7-7.5 t^{-ha}. These cultures also showed tolerance to blast and sheath rot.

26. Centre of Excellence in rice at RRS, Vyttila – State Plan

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The objectives of the study were field evaluation of *Saltol* QTLand *Sub1*gene introgressed Jyothi, Uma and Jaya lines, to validate suitable biochemical markers for salinity tolerance screening and to find out critical nutrient range of primary, secondary and micronutrients in organically cultivated rice in the coastal saline ecosystem. The selected superior lines were laid out in separate five comparative yield trials during kharif 2019, but due to two successive field flodding for more than two weeks during July and August, the trials were damaged and viciated. Hence need to be repeated during kharif 2019.

Saline tolerant varieties preserved the pigments (chlorophyll a, chlorophyll b, total chlorophyll, carotenoid content and Xanthophyll content) under salinity stress and there is not much reduction in the pigment concentration upon salinity stress. Increased proline content and decreased electrolyte leakage were observed under salinity in tolerant varieties under salt stress. Non enzymatic antioxidant alpha tocopherol content increased in saline tolerant varieties under salt stress. Due to 2018 floods, crops were damaged and plant samples could not be collected.

There was wide variation in the chemical properties of soil samples collected from different locations. Pokkali fields in the Paravoor block were slightly acidic to neutral and non saline. All the nutrients recorded sufficiency except Mg. In Vyttila block, soils were neutral to slightly alkaline sand non saline. Deficiency of Cu, B, Zn, Ca and Mg were observed.

27. Breeding for hybrids in rice (*Oryza sativa* L.).(COE) and Evolution of high yielding rice hybrids suitable or Kerala.

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The hybrid development programme was continued in three line system using CGMS lines. The F1 progenies derived from test crosses with CMS A lines were evaluated during 2018-19. 156 A x Jyothi, 156Ax Mattatriveni, 156A x PTB 28, 156A x PTB 13, 156 A x PTB 8, 25A X Matta Triveni, 25A x Swarnaprabha, 25A x PTB 8, 25 A x PTB 12, 97 A x PTB 28, 97A x PTB 12, 97A x PTB 8, 97A x PTB 13, 97A x Harsha, 97 A x Annapoorna and 97 A x Matta triveni were evaluated.

Results revealed that PTB 28, Kattamodan is a good restorer of fertility. F1 hybrid of 156 A x PTB 28 is promising with short duration (109 days), long well exerted panicle and with long bold red grains. Being the progeny of kattamodan, F1 hybrid is expected to be drought tolerant. The test cross is to be revalidated for confirmation and performance of hybrids are to be tested under field condition.

PTB 8 Chuvannari Thavalakannan was found to be a complete maintainer of sterility as the F1 was completely sterile. Back crossing was initiated to transfer the sterile cytoplasm to PTB 8, in order to generate CMS PTB 8A lines. All other varieties used in programme were found to be partial restorer/ maintainer and hence is not useful for production of hybrid rice.

Crossing programme was continued during Kharif and Rabi 2018-19 and CMS A lines, IR 58025A, IR 68897 A and IR 79156 A were crossed with Mangala Mahsuri, Aathira, Aiswarya, Kanchana, Sreyas, Prathyasa, Manuratna, Varsha and Uma. Crossing of CMS lines with PTB 28 and PTB 8 was repeated to confirm the restorer and maintainer status of these varieties respectively.

The evaluation of KRH4 was continued in Rabi 2017-18 and 2018-19 with popular high yielding check varieties. Hybrids with high yield and acceptable cooking quality identified from the study will be recommended for the state.

28. Initial Variety Trials (Moncompu) - AICRIP trial

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This experiment is being conducted at RRS, Moncompu as part of the All India Co- Ordinated Rice Improvement Project where in the comparative performance of superior rice cultures of different duration developed at different rice research centres throughout the country are evaluated for their yield and suitability for our situation. Initial Variety Trial is the first stage of evaluation of the cultures. Three sets of cultures belonging to Very Early, Early and Mid Early groups are evaluated for their performance every year. The seed material for the trial is received

from DRR, Hyderabad. The results of experiments conducted during 2018-19 from the three trials are furnished below.

29.1. Initial Variety Trial-Biofortification (IVT-Biofort) - AICRIP trial

Initial Variety Trial of twenty six new entries of AICRP was carried out in two replications along with one check using randomized block design for observing yield and nutritional qualities. Observations were recorded on various characters like days to 50% flowering, plant height, plot yield, disease/pest attack *etc*. The highest grain yield was recorded by Entry No.3902 (11522.88 kg ha^{-1}) followed by Entry No. 3904 (11241.83 kg ha^{-1}) and local check Uma showed an yield of (9382.43 kg ha^{-1}).

29.2 Initial Variety Trial –Early- AICRIP trial

Initial Variety Trial of sixty three new entries of AICRP was carried out in two replications along with one check using simple lattice design. Observations were recorded on various characters like plant height, days to 50% flowering, No. of Panicles/m^2, Grain yield, Disease/pest scoring. The highest grain yield was recorded by Entry No.905 (7869Kg ha^{-1}) followed by Entry No.907 (7026kg ha^{-1}) and out yielded the local check variety Jyothi.

29.3. Initial Variety Trial – IME- AICRIP trial

Initial Variety Trial of sixty three new entries of AICRP along with one check was carried out in two replications using simple lattice design. Among the entries, Entry No.1234 recorded the highest grain yield of 10141kg ha^{-1} followed by Entry No. 1230 with a per hectare yield of 9437kg. The check variety Uma showed an yield of 7450kg ha^{-1}.

30. Advanced Variety Trials- AICRIP trial

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The entries in Initial Variety Trials which give more than 5% yield increase than the check varieties will be tested in Advanced Variety Trials 1 and 2. At Rice Research Station, Moncompu, different duration groups viz., Early and Mid-Early are tested for their regional suitability.

31.1. Advance Variety Trial 1 – Early Transplanted- IME (AVT 1- E-TP) - AICRIP trial

The objective of the project was to study the comparative performance of early duration elite cultures evolved at national level in transplanted irrigated areas. During 2018-2019, the check variety Jyothi outperformed all the entries with an average yield of 8900 Kg ha^{-1}.Among the entries, Entry No.808 recorded the highest grain yield followed by Entry No. 809.

31.2. Advanced Variety Trial- 2- Irrigated Mid Early- AICRIP trial

The objective of the project was to study the comparative performance of mid- early duration elite cultures and hybrids evolved at national level in irrigated areas. During 2018- 2019, the highest grain yield was recorded by Entry No. 1003 with an yield of 13771.24 kg ha^{-1} followed by Entry No. 1015 with a per hectare yield of 1288.10 kg. The local check Uma recorded 9368.19 kg ha^{-1} yield.

31.3. Advanced Variety Trial-1 Biofortification (AVT -1 Biofort) - AICRIP trial

Nine promising entries were tested in three replicationsThe highest grain yield was recorded by Entry No: 3802 (9836Kg ha^{-1}). The performance of entries was on par with the local check Uma with a per hectare yield of 9382kg.

32. Initial Variety Trials (Pattambi) - AICRIP trial

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Promising rice cultures produced at national level and at various co-operating centers of AICRIP will be tested in the IVT- ETP

33.1.Initial Variety Trial-1- Early Transplanted (T- ETP) - AICRIP trial

IVT-ETP was the 1st year testing trial for early group (100-110 days duration) entries under transplanted condition. In Kharif 2018, the trial was constituted with 63 entries. These were tested with checks as CO-51 - National Check, MTU 1153 - regional check and Matta Triveni - local check. Entry No.956 with an average yield of 6813 Kg/ha out yielded the local check variety Mattatriveni.

33.2. Initial Variety Trial - Irrigated Medium (IVT-IM) - AICRIP trial

IVT-IM included the 1st year testing trial for medium duration group (120-130 days duration) entries under irrigated condition. In Kharif 2018, this trial was constituted with 63 test entries, with three checks NDR 359 - National Check, Jaya - regional check and swetha - local check. Entry No. 1530 with an average yield of 7879 Kg/ha out yielded the local check.

33.3. Initial Variety Trial – Rice Biofortification (IVT-1 - Biofort) PTB- AICRIP trial

IVT-Biofort trial was the 1st year testing trial for yield and nutritional quality. In Kharif 2018, this trial constituted 27 entries. The entries were tested with BPT 5204 & IR64 as yield

Checks and DRR Dhan 45 & Chittimutyalu as micronutrient checks. Entry No.3904 with an average yield of 6052 Kg/ha out yielded other entries.

33.4. Initial Variety Trial-Irrigated Mid early (IVT-IME) - AICRIP trial

IVT-IME was the 1st year testing trial for mid early group (110-120 days duration) entries under irrigated condition. In Kharif 2018, this trial was constituted with 64 entries. These were tested with three checks as Gontra Bidhan-3 - National Check, MTU 1010 - regional check and Jyothi - local check. Entry No. 1201 with an average yield of 6880 Kg/ha out yielded the local check.

33.5. Initial Variety Trial Aromatic Short Grain(IVT-1-ASG) - AICRIP trial

IVT-ASG included the 1st year testing trial for superior yield and quality of aromatic short grain cultivars and lines. In Kharif 2018, this trial constituted 17 entries. The entries were tested with checks as Shobini - National Check, Sugandh Samba - regional check, Dubraj & Ketekijoha – quality check and Jeerakasala - local check. Entry No. 1909 with an average yield of 4585 Kg/ha out yielded the local check variety Jeerakasala.

34 Advanced Variety Trials (Pattambi) - AICRIP trial

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34.1. Advanced Variety Trial-1 Rice Biofortification (AVT -1 Biofort) PTB- AICRIP trial

AVT 1- Biofort was the 2nd year testing trial for yield and nutritional quality. In Kharif 2018, the trial was constituted with nine entries, promoted from the last year IVT- Biofort. Entries were tested along with BPT 5204 and IR64 as yield check and Kalanamak and Chittimutyalu as Micro Nutrient check. Entry No. 3806 with medium slender grain type out yielded other entries with an average yield of 5689 kg/ha.

34.2. Advanced Varietal Trial-2 Irrigated Mid Early (AVT-2-IME) - AICRIP trial

AVT-2-IME was the 3rd year testing in AICRIP for mid early group (110-120 days duration) entries under irrigated condition. In Kharif 2018, this trial was constituted with 7 entries, promoted from the last year AVT 1 IME. The check entries of this trial are IR 64 as National Check, US 312 as hybrid check, MTU 1010 as regional check and Jyothi as local check. Entry No. 1011, with long slender rice out yielded the local check with an average yield of 7261 kg/ha.

34.3. Advanced Variety Trial-1-Irrigated Medium(AVT-1-IM) - AICRIP trial

AVT 1-IM included the 2nd year testing trial for medium duration group (120-130 days duration) entries under irrigated condition. In Kharif 2018, this trial was constituted with 14 test entries, promoted from the last year IVT- IM. These entries were tested along with NDR 359 as National Check, HRI 174 & US 312 as hybrid check, Jaya as regional check and Swetha as local check. Entry No. 1408 out yielded the local check with an average yield of 8131 kg/ha.

34.4. Advanced Varietal Trial-2 Irrigated Medium (AVT 2-IM) - AICRIP trial

AVT 2-IM trial was the 3rd year testing trial for medium duration group (120-130 days duration) entries under irrigated condition. In Kharif 2018, this trial was constituted with 7 test entries, which were promoted from the last year AVT 1 IM. These entries were tested along with NDR 359 as National Check, HRI 174 & US 312 as hybrid check, Jaya as regional check and Swetha as local check. Entry No. 1301 out yielded the local check with an average yield of 5133 kg/ha.

34.5. Advanced Variety Trial-1- Early - Transplanted (AVT-1-ETP) - AICRIP trials

AVT 1- ETP was the 2nd year testing trial for early group (100-110 days duration) entries under transplanted condition. In Kharif 2018, the trial was constituted with entries, promoted from the last year IVT ETP. Fifteen entries were tested along with CO-51 as National Check, US 314 as hybrid check, MTU 1153 as regional check and Matta triveni as local check. Entry No.815 with medium slender grain type out yielded the local check Mattatriveni with an average yield of 3193 kg/ha.

34.6. Advanced Varietal Trial-1 Near Isogenic Lines – Yield Control

AVT 1-NIL-YC trial was the 2nd year testing trial for introgressed lines with multiple gene in the background of Pusa 44. In Kharif 2018, this trial was constituted with entries, promoted from the last year IVT 1 -NIL-YC. Three entries were tested along with Pusa 44 (Recurrent Parent) as Check variety. Entry No. 4443 with medium bold grain type out yielded other entries with an average yield of 4066 kg/ha.

35. Development of rice varieties for Kerala with pyramided genes for Resistance to BLB by marker assisted selection

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The main objectives of the project were Pyramid the genes of resistance to bacterial leaf blight (xa 13, Xa 21, Xa 33 and Xa38) into popular rice varieties Prathyasa and Aiswarya, to evolve essentially derived varieties with durable resistance to BLB and foreground selection for the genes using respective molecular markers.

BC1F1 plants of Aiswarya and Prathyasa the popular rice varieties, pyramided with 2/3 genes for resistance to Bacterial leaf blight and having maximum genome recovery of the recurrent parent were back crossed to raise BC_2F_1 plants . 149 BC2F1 plants of Aiswarya was screened for genes for resistance to BLB(xa13,Xa21 and Xa33).79plants with xa13gene,38plants with Xa21 and 28 BC2F1 plants pyramided with xa13 and Xa21 were located and five out of these had more than 80% genome recovery of the recurrent parent Aiswarya. In the 277 BC_2F_1 plants of Prathyasa screened, 78 plants with Xa13, 32plants with Xa21,8plants with Xa33,24plants with xa13 and Xa21,7plants with xa13 and Xa33 and 5 plants with xa13 ,Xa21 and Xa33 were located. Here seven plants with more than ninety percent and eighteen plants with more than 80% genome recovery of the recurrent parent Prathyasa were obtained. BC_2F_2 plants of these lines are carried forward for further evaluation.

36.Physiological and biochemical basis of heat tolerance in rice.

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Ninety two rice genotypes were selected based on high temperature stress tolerance from the existing rice germplasm, AICRP entries and NICRA entries at RARS, Pattambi. The identified tolerant genotypes are being evaluated biochemically for further evaluation under field condition in summer 2018-19. The promising varieties will be selected as donors for breeding programmes**.**

37. Evaluation of rice genotypes for terminal heat tolerance

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The objective was to investigate the differences in the terminal heat stress tolerance in elite rice genotypes. During 2018-2019, the high temperature had significantly influenced the yield and yield contributing characters. The differences among the genotypes were also found to be significant. The interaction between treatment and genotype was statistically significant. High temperature had resulted in maximum increase in the number of unfilled grains in seventeen HT entries. Thirteen HT entries under high temperature in poly house condition in reproductive stage gave high yield on par with control which can be used in further breeding programmes.

38. Physiological characterization of rice genotypes for multiple abiotic stress resistance

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The objective was toidentify the selected genotypes for multiple abiotic stress tolerance. Among the twenty one entries tested 7 entries showed tolerance to water deficit and salinity

stress. None of the entries showed tolerance for low temperature treatment. Seventeen entries showed tolerance to salinity stress alone.

39. Evaluation of Radiation and Nitrogen use efficient promising rice genotype

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The objective of the study is to identify the rice genotypes with maximum nitrogen use efficiency. During 2018-2019, among the twelve entries tested 8 entries performed well under 50% RDN.

40. State Seed Testing Laboratory

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Quality of 447 seed samples were analysed in the State Seed Testing Laboratory Pattambi during 2018-19, in various crops like Rice (419), Vegetables (21) and pulses (1). Study on seed quality of revalidated seed lots on storage was conducted under seed technology research programme during 2017-18 and 2018-19. Seed quality mitigation of paddy under terminal heat stress was also studied during late Rabi of 2017-18 and 2018-19. Observation on seed yield and quality parameters revealed that sterility is increasing from 20%(first set) to 31%(last set) in the field condition due to delay in date of sowing. Among the treatments for mitigating elevated temperature, plants treated with Salicylic acid (400ppm) showed highest fertility percentage and was significantly superior to other chemical treatment.

41. Monitoring soil quality and crop productivity under emerging rice production systems (Kharif and Rabi) (RIC/08-00-01-2004/MON(3)/AICRIP(2))

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The trial was started in 2015 and targeted to continue for five years. In Kharif 2016, there was no significant difference in yield. The trial was repeated during Kharif and Rabi 2018-19. The Kharif crop was lost in flood. During Rabi, significantly superior yield was recorded in transplanted rice. In case of nutrient management practices, maximum yields were obtained with 100% RDF based on STCR and100 % RDF+ 50 % through organics.Conjunctive use of organics and inorganics was found to increase yield without deteriorating soil quality. The results of the study indicated that the use of organic matter addition was necessary to sustain soil quality in soil test based nutrient management also.

42.Screening of rice genotypes for tolerance to soil acidity and related nutritional constraints(AICRIP)

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The trial was initiated during Kharif 2018 with a new set of varieties including Uma and Pournami in Karuvatta, but completely lost in the flood.

43.Response of pre-release Moncompu cultures to varying nutrient ratios

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The experiment conducted to study the effect of varying levels of nitrogen on the growth and yield of the variety Pournami (MO-23) revealed that the variety responded to the higher levels of nitrogen on application of NPK @ 80:45:45, 90:45:45, 100:45:45 kg/ha. It was observed that there was significantly high yield on application @ 90:45:45 and 100:45:45 NPK kg/ha compared to the application @ 80:45:45 NPK kg/ha. However, grain yield at applied @ 90:45:45 NPK kg/ha kg/ha and 100:45:45 NPK kg/ha was statistically on par.

The variety was found to exhibit lodging tendency on application of higher dose of nitrogenous fertilisers after 45 DAS. Among the split dose application treatments included in the study, it was revealed that application at ½, ¼, ¼ requirement of NPK at seedling, active tillering and panicle initiation stage of the crop performed better than the application at $_{1/3,\ 1/3,\ 1/3}$ requirement of NPK at seedling, active tillering and panicle initiation stage of the crop.

It was also observed that foliar nutrition at 65-70 DAS showed significant response at low level of nutrient application 80:45:45 NPK kg/ha at compared to that at 90:45:45 and 100:45:45 NPK kg/ha. The fertilizer recommendation of the variety Pournami (MO-23) can be recommended @ 90:45:45 NPK kg/ha applied as ½, ¼, ¼ requirement of NPK at seedling, active tillering and panicle initiation
stage of the crop. The yield of the variety was statistically on par at 90:45:45 and 100:45:45 NPK kg/ha. The variety exhibits lodging tendency at higher levels of nitrogen applied after 45 DAS.

44. Experiment on development of organic package for rice in kole lands

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The experiment was conducted with the objective of to test the *adhoc* organic package developed by KAU in Kole lands and refine the *adhoc* package based on yield and soil nutrient status and also envisaged to develop a refined organic package for sustained high productivity in kole lands. The experimental design used was RBD with seven treatments and three replications. The observations on plant height and number of tillers were recorded at different growth stages of

crop. The soil and plant samples were collected at different stages to analyse the nutrient contents. The data on growth and yield attributes due to different levels of organic manure revealed that the maximum plant height and number of tillers was recorded in the plot which received 5 t/ha FYM + 2.5 t/ha Vermicompost + 500 kg GN cake followed by T_6 (1.25 t/ha FYM + 0.625 t/ha VC + 125 kg GN cake + foliar spray of panchagavya at 2 weeks interval up to flowering + Azospirllum + PSB + PGPR Mix) at all growth stages of crop. In the case of yield attributes like tiller count, number of panicle/m^2 and thousand grain weight also showed similar trend. The data on grain and straw yield showed that the application of 5 t/ha FYM + 2.5 t/ha Vermicompost + 500 kg GN cake recorded the highest value compared to all other treatments.

45.Nutrient and weed management for higher productivity of different rice cultivation system (AICRP)

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The study aims to identify the optimum and cost effective nutrient management practices in different crop establishment methods and to assess the agronomic efficiency, plant and soil nutrient status under different nutrient management practices in different crop establishment methods.

The experiment trial was conducted to identify the optimum and cost effective nutrient management practices in different crop establishment methods. The crop establishment methods included Mechanical transplanting (25x25 cm), conventional planting (20x10 cm), drum seeding sprouted seeds (20x10 cm) and broadcasting sprouted seeds. The trial was conducted in split plot design. The five subplot treatments included 100 per cent of recommended inorganic fertilizer (90:45:45kg/ha), 75 percent of RDF+ 25 per cent as organic equivalent of N dose, 150 per cent of RDF, LCC based N application in RDF and location specific fertilizer management (90:11.5:42 kg/ha). The Kharif crop was lost by flood. During rabi season, the highest yield under crop establishment methods was obtained for mechanical transplanting followed by conventional transplanting which was significantly superior to drum seeding and broadcasting. The nutrient management practices were on par with respect to grain yield.

46. Targeted yield realisation of rice in major rice tracts of Ernakulam District (ATMA)

Dr. Deepa Thomas
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The existing practice of application of general doses of NPK fertilizers to a crop withoutconsideration of soil type and crop response needs to be given new dimension, as it forms the major reason for low productivity. So a project was implemented to formulate scientific nutritional package for higher yield realization in major rice tracts of Ernakulam District both under GAP(GoodAgricultural

Practices) and Organic practices. In this, the present recommended dose of fertilisers(T_1) was compared with fertilizer dose based on soil test value for major, secondary and micronutrients and soil acidity so as to produce an yield of 8-10 t/ha(T_2) and Farmers' practice(T_3 no lime or FYM, only NPK). In organic practices, organic rice production with soil application of dolomite, vermicompost, Rajphos, and PGPR and foliar spray of SOP (sulphate of potash) at flowering (T_4) was compared with organic rice production using FYM and 4 splits of Jeevamritham application(T_5). Piravom, Poothrikka and Mulamthuruthy blocks were identified and on soil analysis, it was found that all the three locations were found low in K, Ca and Mg. It was found that the nutrient management strategy should take into account all the nutrients including major, secondary and micronutrient available in soil and that the crop needs. Application of magnesium sulphate, correction of K deficiency and spraying of Sampoorna had significant effect on increasing the number of grains per panicle and grain filling. This could also help in overcoming the negative effects of drought to some extent , the crop faced in Thirumarady .Effective water management (draining out water after liming, maintaining a low water level at the start of tillering(20 DAS) resulted in more number of tillers. The experiment is on-going.

47. Crop management approaches for sustainable rice farming in Kari soils (CoE Rice)- State Plan

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Twenty five soil samples were collected from different locations of Kari lands in Kuttanad and analysed for 13 soil fertility parameters Extensive soil acidification, excess levels of phosphorus and wide spread deficiencies of calcium, magnesium and boron were the major limitations to crop production in these soils. Amelioration of soil acidity and external inputs of secondary and micronutrients along with the major nutrients are essential for enhancing crop productivity in these soils**.** Soil samples were collected from farmers' field in Purakkad, Thakazhi and Karuvatta at different growth stages in order to understand the deviations in availability of nutrients.

48. Management practices for enhancing grain yield with green manure and nutrient managementin lowland rice.

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The objectives of the project were to study the influence of agronomic practices for increasing the grain yield of rainfed upland rice and to work out the cost benefit ratio and enhancing the profitability.

In general phosphorous accumulations in acidic soils are very common in Fe and Al rich soils. In addition to that the farmer's are normally applying phosphorous in complex fertilizers as top dress to
the rice after transplanting not as basal manure. Using green manures and P mobilizing bacteria may found useful to solubilise P in P rich acidic double crop wetlands. In this context this trial is started on long term basis in collaboration with Soil science IIRR, Hyderabad. This trial may continue at the least for two more years to get confirmative results. Last two crops the results revealed that the application of green manures and P mobilizing bacteria is comparable with yields obtained from 50
per cent P and control plots. Continuation of this trial may bring good results to use the occluded P in the acid soil.

49.Nitrogen Response trials on selected AVT – 2 cultures

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The objectives of the project were to study the grain yield potential, nutrient response and nutrient use efficiency of promising AVT-2 cultures under high and low input management in rice and to identify promising, efficient and stable genotypes based on the Grain Yield Efficiency Index (GYEI) and percent yield reduction in reduced N application.

In this trial seven AVT-2IME cultures (IET 25746, IET 25764, IET 26079, IET 25749, IET 26125, IET 24931, IET 25330, ZC-PR 113, Lalat (E & NE), Karjat 7 (W) MTU 1010 (C&S), HC-us 312) were evaluated along with check variety Jyothi and Uma. Incremental doses of nitrogen influenced the grain yield. Application of 100% of RDN recorded significantly higher grain yield of IET 25764 (6.9 t/ha) and Chinsurah (4.15 t/ha). Over the locations, the performance of PA 6201 (5.24 t/ha) was promising followed by IET 22212 (4.83 t/ha); IET 22084 (4.80 t /ha) and IET 22569which were tested at all locations. Check variety Uma showed higher yields than Jyothy. Variety Jyothy showed little lodging and yield increments at 150 kg N.

50.Development of technology for enhancing the productivity of organic rice

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The objectives of the project were to standardize the practices for enhancing the productivity of the organic rice cultivation and to evaluate the direct and indirect effect of organic fertilizers and its influence on nutrient use efficiency and soil health.
Organic rice trial was showed that the cost of organic inputs particularly FYM and its availability limited the organic rice production. Moreover the yield reduction of 9.5 per cent with respect to 100 per cent inorganic N on organic inputs applied plots

51. Diagnosis of salinity and development of paddy cultivation in the saline prone areas of Puthenvelikkara Panchayath

Dr.Mini Abraham,
Professor (Agronomy)

The objectives were to identify the problems encountered in the padasekharams of Puthenvelikkara panchayath , to diagnose the salinity problems of paddy soil and to develop scientific package for paddy cultivation in saline prone areas.

In Thazhanchira padasekharam different varieties of Vytilla ie Vytilla 6,8,9 and 10 were tried. Among these Vytilla 9 was found to be the best. In Kuttikkad padasekharam Ezhome2 and Ezhome 3 were tried, but 80% of the crop failure was occurred due to high salinity in the month of February. Electrical conductivity of 9 to 12 ds/m was observed. Sanction was also given for continuing the project for the year 2019-20.

52.Influence of silicon solubilizers on induced stress tolerance in rice genotypes

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The objective of the project was tostudy the effect of applied silicon on rice yield and its on influence on water deficit stress. Application of 0.6% silicon at tillering, Panicle initiation, 50% flowering and milky grain stages in rice imparted tolerance to water deficit stress under reproductive stage across the tested hybrids and varieties

53.Development and evaluation of non conventional nutrient management technologies in rice(COE in rice)- State Plan

Dr Thulasi V
Assistant Professor

The objective of the experiment is to identify the best options for different non conventional nutrient management technologies in paddy such as seed priming, foliar spray in nursery, seedling enrichment through seed bed application and seedling root dip.

During 2018-2019, Field experiments for validation of suitable enrichment methods of nutrient content of rice seedlings before transplanting to an attainable limit is taken for past four years. Paddy seed priming in 2% solution of Sampoorna KAU multi-mix (Paddy) for 4 hours and foliar applicationof 1 % Sampoorna KAU multi mix at 10 and 20 days after sowing in nursery improved seedling vigor and increased average pooled grain yield by 13.1 and 14 % over control. Farm trial conducted this year proved the effectiveness of the two technologies.

54. Planting geometry modification in rice to exploit border effect (COE in rice)-State Plan

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Four different types of planting geometry viz-paired row planting with 35-15X10 cm, paired row planting with 30-15X10 cm, Circular planting geometry and 20X15 cm spacing were compared to assess the border effect under different spacing and its contribution towards yield.20X15 cm spacing have 60 per cent border effect compared to 20 per cent border effect in paired row planting with 35-15X10 cm. Farm trials were conducted with paired row planting with 35-15X10 cm and 20X15 cm spacing in five locations and on an average 17 per cent yield increase were obtained in farmers field. It is recommended for multi location trial.

55. Long term evaluation of weed management

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The objectives of the project were to evaluate the suitable and promising Cost effective weed management practices in different crop establishment methods, to assess the various agronomic parameters as influenced by the weed management practices as influenced by different crop establishment methods and economic evaluation of the different weed management practices.The results showed that the Pre and post emergence herbicides application showed the better yield equal to that of mechanical methods of weed control.

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56. Evaluation of the efficacy of the herbicide molecule Penoxsulam 1.02 % (w/w)+ Cyhalofop butyl 5.1% (w/w) OD for weed control in direct seeded rice

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The objectives of the project were to evaluate the bio efficacy of Penoxsulam 1.02 % (w/w) + Cyhalofop butyl 5.1% (w/w) OD for weed control in Direct Seeded Rice and to assess the impactof Penoxsulam 1.02 % (w/w)+ Cyhalofop butyl 5.1% (w/w) on growth and weed compilations

The herbicide molecule Penoxsulam 1.02 % (w/w)+ Cyhalofop butyl 5.1% (w/w) OD was tested for broad spectrum management of weeds in DSR with special emphasis to the rice fields of Kuttanad. The results conveyed that application of Penoxsulam 1.02 % (w/w)+ Cyhalofop butyl 5.1% (w/w) applied @135 g ai/ha at 15-20 DAS is effective for broadspectrum weed management in DSR compared to the existing herbicide Bispyribac sodium 10% @ 300 ml/ha applied at 20 DAS.

57. Weed management and soil enrichment by concurrent growing of daincha in rice-vegetable cropping system

Dr. K.P. Prameela
Dr. Meera V. Menon

The objectives were to study the effect of concurrent leguminous crop in rice on weed density, weed species, weed growth and rice growth and yield, to study the effect of concurrent leguminous crop on weed diversity in rice based cropping system and to study the residual effect of concurrent leguminous crop in rice on the succeeding rice and vegetable crops in the cropping system

The result showed that Concurrent growing of daincha with rice in rice-rice-vegetable cropping system resulted in lowest weed dry matter production in the treatments hand weeding, rice-daincha concurrent system with daincha incorporated manually followed by bispyribac sodium application, and rice-daincha concurrent system with daincha brown manured by 2, 4-D, followed by application of cyhalofop butyl.

58. Integrated management of *Sacciolepis interrupta*

Dr. K.P. Prameela (upto 30-11-2018)
Dr. Meera V. Menon (from 1-12-2018)

Application of integrated weed control methods in *kharif* rice showed that combinations of pre and post emergence herbicides followed by hand weeding were effective in significantly reducing density of *Sacciolepis interrupta*. Significantly higher grain yield (4442 kg/ha) was recorded on application of pretilachlor + bensulfuron methyl *fb* cyhalofop butyl + penoxsulam *fb* hand weeding. Highest BC ratio of 1.53 was obtained with the treatment pretilachlor + bensulfuron methyl *fb* cyhalopfop butyl + penoxsulam *fb* hand weeding.

59. Management of complex weed flora in wet seeded rice with new herbicide molecules

Dr. K.P. Prameela (upto 30-11-2018)
Dr. Meera V. Menon (from 1-12-2018)

The objective was to study the bio efficacy of new herbicide molecules against weed complex and their effects on growth and yield of wet seeded rice. The trial showed that at 60 DAS, the treatment triafamone + ethoxysulfuron was significantly better in reducing weed growth, and cyhalofop butyl + penoxsulam was on par with this treatment. Rice grain yields followed the same trend.

60.Protocol for testing Thiobencarb 80 ECagainst weeds of puddle DSR rice

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The project on the "Protocol for testing Thiobencarb 80 ECagainst weeds of puddle DSR ricestarted in the year 2018-19. The experiment was conducted during the puncha season at RRS, Moncompu. The treatments included different doses of the test herbicide Thiobencarb 80 EC applied as post-emergence at 20 DASin comparison with Pyrazosulfuron ethyl 10% @ 200g/ha. Pre-emergence application, Bispyribacsodium 10% @ 300 ml/ha post- emergence application, Control (weedy) and Hand weeding twice.

It was observed that the post emergence application of the test herbicide Thiobencarb @ 5.00 l/ha at 20 DASwas found to give significantly higher yield than its lower concentrations of @ 4.00 l/ha and 4.50 l/ha. The application of Thiobencarb at the two lower doses recordedgrain yield on par with the weedy check, revealing the ineffective weed management. The grain yield recorded by Thiobencarb @ 5.00 l/ha at 20 DAS was found be on par with the standard check herbicide Bispyribacsodium 10%@300 ml/ha applied at 20 DAS but significantly lower than Pyrazosulfuron ethyl 10%@200g/ha applied as pre emergence. The weed control efficiency was also highest for pyrazosulfuran ethyl 10%@200g/ha followed by Thiobencarb @ 5.00 l/ha.

61. Gall Midge Biotype monitoring trial (GMBT)

Dr. Shanas S
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The objective of this trial is to monitor prevalence, distribution and occurrence of gall midge biotypes within the country At 30 DAT, only one entries had gall midge damage and at 50DAT, none of the

entries had any gall midge damage, probably due to the low pest pressure after the major floods in Kuttanad.

62.Botanical insecticide evaluation trial (BIET) (AICRIP trial)

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The objective was to screen botanical insecticides for efficacy against major insect pests. In Rabi 2018, Eucalyptus oil 1000ml/ha followed by lemon grass oil 1000 ml/ha was the best treatment against stem borer at 30DAT. In 50 DAT, Cedar wood oil 1000 ml/ha followed by Lemon grass oil 1000ml/ha was found to be the best treatment in controlling leaf folder infestation. Eucalyptus oil 1000ml/ ha was effective against leaf folder at 70 DAT. Lemon grass oil 1000ml/ha followed by Eucalyptus oil 1000ml/ha treated plots have comparatively high grain yield and during late Kharif 2019, the population of stem borer and leaf folder was recorded to be very low. Although the treatments were insignificant, Eucalyptus oil 1000ml/ha was observed

to be the best treatment against stem borer at 50 DAT. No silver shoot infestation was observed at 50 DAT. The plots treated with Cedar wood oil 1000ml/ha followed by Neemazal 1000ml/ was effective in reducing leaf folder damage at 50DAT.

63. Gall midge screening (GMS)

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The objective of this trial was to assess the reaction of advanced cultures/donors against gall midge. Gall midge trial was constituted with 61 entries. At 30 DAT and 50 DAT, none of the entries had any gall midge damage, probably due to the low pest pressure after the major floods in Kuttanad.

64. Insecticides Evaluation Trial

Dr. Karthikeyan K
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The objective of this trial was to study the effectiveness of promising insecticides at low dosages and new insecticides at higher doses against major pests of rice. Overall results of both crop season showed that plant oils viz., eucalyptus oil, lemon grass oil, camphor oil and neemazal @1000ml/ha was showing consistent results against stem borer, gallmidge, whorlmaggot and leaffolder and were
par with check insecticides. So, these oils will be highly useful to manage this rice pests in an eco-friendly manner.

65. National Screening Nursery (Pattambi)

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The objective of the project was to note the reaction of advanced / initial yield trial enteries against insect pests. During the period 104 hybrids were screened. Among them seven entries viz., NHSN 04,07, 10, 39, 61,66, 67 and 96 were completely resistant to gallmidge showing ‘0’ incidence of silvershoots. Hybrids 39,58, 61, 62, 66 and 97 were moderately resistant to stem borer damage. All entries suffered heavy leaf damage due to leaf folder with leaf damage ranging from 25-99% except three entries 9,98 and 104 suffered less leaf damage less than 25 %. For whorl maggot hybrids 9,10, 21, 23,54,70, 84, 92 and 77 suffered low leaf damage

66. National Screening Nursery(Moncompu)(NSN-1)

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The reaction of advanced/initial yield trial entries against insect pests and diseases is observed in this experiment. It was observed that, 209 entries had no Leaf folder damage at 30 DAT and also, no sivershoot and dead heart infestation. Similarly, at 50 DAT, 204 entries were found without leaf folder damage and also, none of the entries had any gall midge and stem borer damage, probably due to the low pest pressure after the major floods in Kuttanad.

67. Gall Midge Special Screening Trial

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The objective of the project was to assess the reaction of advanced cultures/donors against gall midge. It was observed that at 30 DAT and 50 DAT, none of the entries had any gall midge damage, probably due to the low pest pressure after the major floods in Kuttanad.

68. Gall midge biotype screening trial

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The objective of the project was to monitor prevalence, distribution and occurrence of gallmidge biotypes within the state. During the period 17 entries were screened under five sets of differentials showed an average silver shoot incidence of 6.16, 9.80, 12.86, 10.04 and 12.65 per cent respectively showing the pattern of R-R-S-S-S pattern confirming the presence of gallmidge biotype 5.

69. Pesticides compatibility trial

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The objective was to evaluate the compatibility of selected insecticides and fungicides as tank mix as reflected by their effectiveness against target pests under field condtions. Overall results during the periods of study showed that combination insecticide Spinoterum + methoxyfenozide (0.75ml/lit) alone as well as in combination with fungicides, hexacaonazole and tricylclazole caused complete reduction of stem borer (White ear) as well as leaf folder while new systemic insecticide, DPX-RAB 55 (0.48ml/lit) hexaconazole and DPX-RAB 55 (0.48ml/lit.) alone as well as in combination with fungicides, hexaconazole and tricylclazole caused complete reduction of gall midge and whorlmaggot. Sheath blight incidence was low in fungicides treated plots as well as in combination with Spinoterum + methofenoxyfenozide and DPX-RAB 55 treated plots.

70 National Hybrid Screening Nursery (NHSN)

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The objective was to note the reaction of advanced/initial yield trial entries against insect pests and diseases.At 30 DAT, 102 entries were found without silvershoot damage due to very low pest pressure. At 50DAT, none of the entries had any gall midge and stem borer damage, probably due to the low pest pressure after the major floods in Kuttanad

71.National Screening Nursery 2(NSN-2)

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The objective was to note the reaction of advanced/initial yield trial entries against insect pests and diseases. Most of the entries were found without leaf folder and stem borer damage due to the low pest pressure after the major floods in Kuttanad.

72.Bio-intensive pest management trial (BIPM)

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The objective was to assess the difference in management practices between Bio-intensive pest management and the normal Farmers Practice. It was observed that, the stem borer egg parasitisation in the BIPM plots were higher [*Telenomus*sp (40%) followed by *Tetrastichus*sp (36%) followed by *Trichogrammajaponicum*(12%)] compared to the Farmers practice plots *Tetrastichus*sp (28%) followed by *Telenomus*sp (20%) followed by *Trichogrammajaponicum* (8%).

73. Population dynamics of insect pests assessed through Light Trap

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The objective was to monitor on long term basis fluctuations in the populations of insect pests and their natural enemies. Assessment of insect populations throughout the year using light trap revealed that plant hopers, mainly BPH and GLH continued to be the most widespread pest in terms of numbers. From the light trap data, it was inferred that, the green leaf hoppers *N. virescens*(80No.s) and *N. nigropictus* (72 No's) had its peak occurrence during the first standard week of January 2018. Similarly the brown plant hopper *Nilaparvathalugens*occurred in large numbers (206 no's per catch) during the 13th standard week of March 2018.

74. Monitoring of Pests and their Natural Enemies (MPNE)

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The objectives were to study the dynamics of pest species composition and to observe the key natural enemies of major pests. During Kharif 2018,four species of stem borers viz, the Yellow Stem borer (*Scirpophaga incertulas*); White Stem borer (*Scirpophaga nivella*), Striped Stem borer (*Chilo suppressalis*) and Pink Stem borer (*Sesamia inferens*) were reported. It was observed that, Yellow stem borer dominated in early phase (62.5%) followed by WSB (37.5%). In the case of gall midge, *Platygaster oryzae* was observed, causing up to 74.4% parasitisation of galls.

75. Testing of insecticide "Avana" – (EID Parry Ltd.)

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The objective was to study the bioefficacy of insecticide "Avana" in controlling the pests of paddy by multi location trials for one season. During Rabi 2018 in the evaluation of insecticide application of Avana were found to be effective against controlling Stem borer and Leaf folder. Avana @ 15 kg/ha wasfound most effective against Stem borer followed by Avana @ 25 kg/ha .The lowest incidence of Leaf folder was observed in Cartap hydrochloride 4% G @ 750 g a.i./ha treated plots followed by Avana @ 25 kg/ha. Also, grain yield was found to be highest in Cartap hydrochloride 4% G @ 750 g a.i./ha treated plots. In the case of natural enemies, it was observed that, the plots sprayed with Avana @ 10 kg/ha had the highest numbers of parasitoids and predators after spray followed by the plots sprayed with and Azadirachtin 5% EC @ 200 ml/ha confirming that these insecticides can be safely used against insect pests, protecting the natural enemies.

76.Organic pest management of upland rice of Onattukara

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This project was started with an objective to identify the major pests and diseases of upland rice and to draw out an IPM strategy including use of biocontrol agents and botanicals. The results revealed that Spraying with 1% azadirachtin(0.004%) at tillering and milky stage and Dasagavya 3% at tillering and milky stage gave cent percent reduction in dead heart and white ear head symptoms Spraying with Dasagavya 3% at tillering and at milky stage and Dasagavya 3% at tillering stage + fish jaggery extract at milky stage recorded significant reduction in rice bug population and recorded the highest grain yieldProduced and distributed talc based formulation of 684.5 kg *Beauveria bassiana*, 576.5 kg *Lecanicilliun lecanii* and started culturing of *Metarrhizium anisoplea*

Produced and distributed 617 bottles of neem garlic chillie soap (100g each), 261 bottles of fish jaggery extract(100 ml each), 71 bottles of Dasagavya(100 ml each), 131 Bordeaux mixture kits(for 5 litre each) and 132 Tobacco decoction kits.

77. Evaluation of fungicides against brown spot

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Eight fungicides were evaluated against brown spot of rice. The combination of fungicides, Azoxystrobin 18.2% + tebuconazole 11% w/w SC (1.0 ml/l) and Azoxystrobin 11% + tebuconazole 18.3% w/w SC (1.5 ml/l) are effective for the management of brown spot.

78. Screening for sheath blight resistance

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In 2018-19, In National Screening Nursery 1 (NSN1), 398 entries were screened for sheath blight resistance. 17 entries were moderately resistant to sheath blight with score 3. National Screening Nursery 2 (NSN-II) consisted of 682 entries of which 26 entries showed moderate resistance reaction. Out of the 108 entries tested in National Hybrid Screening Nursery (NHSN), 4 entries were moderately resistant to sheath blight. In Donor screening nursery (DSN) out of the 129 entries tested, five entries were moderately resistant to sheath blight.

79. Screening for leaf blast resistance

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In the year 2018-19,In screening for leaf blast resistance, 398 entries in National Screening Nursery 1 (NSN1), 682 entries in National Screening Nursery 2 (NSN-2), 108 entries in National Hybrid Screening Nursery (NHSN) and 129 entries in Donor Screening Nursery (DSN) were evaluated. Out of these, 2 entries in NSN 1 and one entry in NHSN were resistant to leaf blast with score 1

80. Disease Observation Nursery

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The fortnight planting trial was conducted with the cultivars Shreyas (MO 22, Prathyasa (MO 21) and Uma (MO 16) at three different dates at twenty days interval to identify the time and intensity of the disease occurrence. During Kharif 2018, Sheath blight incidence was low in the early, normal and late sown crop of Uma (6.67, 10.55 and 13.89%) and Shreyas (10.22, 14.44 and 13.89%). In Normal sown crop, the incidence was moderately high in Prathyasa(25.55%)

followed by Shreyas(14.44%). Bacterial leaf blight incidence was very low in early and late sown crop of Uma(6.44 and 2.22%) followed by Shreyas(9.11 and 3.89%). It was moderately high in early and normal sown crop of Prathyasa (21.33 and 25 %).

81. Special trial on effect of selected essential oils on location specific rice diseases

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The objective of the project is to manage the location specific disease using botanical oils. The neem essential oil @ 2.0 ml/l was found to be promising fungicide against sheath blight disease followed by Emulsifier(2.0 ml/l), Eucalyptus oil (2.0 ml/l), Cedar wood oil (2.0 ml/l) and Nirgundi oil (2.0 ml/l).

82. Screening for bacterial leaf blight resistance.

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During the year 2018-19, In screening for leaf blast resistance, 398 entries in National Screening Nursery 1 (NSN1), 682 entries in National Screening Nursery 2 (NSN-2), 108 entries in National Hybrid Screening Nursery (NHSN) and 129 entries in Donor Screening Nursery (DSN) were evaluated. Out of these, 2 entries in NSN 1 and one entry in NHSN were resistant to leaf blast with score 1.

83. Development of weather based forewarning system for Blast disease and Leaf folder pest of rice and Formulation of Crop-Weather advisories to the rice farmers of Kuttanad region-(NRM-03-00-04-2013-MC(25) KTNDP(2.6))

The experiment on "Development of weather based forewarning system for Blast disease and Leaf folder pest of rice and Formulation of Crop-Weather advisories to the rice farmers of Kuttanad region" was transplanted in the main field at different seed rates of 75 kg/ha,100 kg/ha and 150 kg/ha.During Kharif 2018, Leaf folder incidence was moderate (15.70%) in high nitrogen and high seed rate plot of alternatively irrigated condition. This occurred at the minimum temperature of 25.4^{0}C, maximum temperature of 32.2^{0}C and RH from 67-97% at panicle initiation. The blast disease was moderately high (21.3%) in high nitrogen (120 kg/ha) and high seed rate plot (150 kg/ha) of alternatively irrigated condition and it was observed at minimum temperature of 24.1^{0}C and maximum temperature 30.4^{0}C and RH from 77-91% during maturity stage.

84. Field monitoring of virulences in *Xanthamonas oryzae*pv. *Oryzae*(PATTAMBI)

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During the year 2018-19, Virulence analysis of bacterial blight pathogen of rice *Xanthomonas oryzae* pv.*oryzae* was done using 31 near isogenic lines with different bacterial blight resistance genes and their combinations. The NIL, IRBB-60 showed moderate resistance to bacterial blight.

85. Field monitoring of virulence in *Pyricularia grisea*(PATTAMBI)

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In the year 2018-19, Virulence analysis of blast pathogen of rice *Pyricularia grisea* on 25 differentials/ NILs revealed that C101LAC, C101A51, RIL- 29 and Raminad-STR-3 were resistant to local isolate of blast pathogen.

86.Evaluation of fungicides to location specific diseases(RIC/03-02-07-04/MON(5)/AICRIP)

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The objective of the experiment is to evaluate the efficacy of new and commercially available fungicides for the control of location specific fungal disease in Kuttanad region. Eight newer and commercially available fungicides were tested against sheath blight disease during Kharif 2018. The combination fungicide Azoxystrobin 18.2 % w/w + Difenoconazole 11.4% w/w SC (Amistar Top 32.5 SC) @1.0 ml/l was found superior in controlling sheath blight disease followed by Trifloxystrobin 25% + Tebuconazole 50% WG (Nativo 75 WG) @ 0.4g/l and Azoxystrobin 11 % + Tebuconazole 18.3 % w/w SC (Custodia)@ 1.5 ml/l.

87. Field Monitoring virulence in *Xanthomonas oryzae.pv.oryzae*(MON)

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Virulence analysis of bacterial blight pathogen of rice *Xanthomonasoryzaepv.oryzae* was carried out during 2018-19. During Kharif 2018, the test on virulence analysis of bacterial blight pathogen of rice *Xanthomonas oryzae pv.oryzae* was carried out with 28 IRBB entries and 3 resistant/ susceptible check varieties. Out of 31 entries were tested 28 isogenic lines (IRBB background) possessing different bacterial blight resistance genes either singly or on various combinations of four genes viz., Xa4, Xa5, Xa13 and Xa21 in the background of rice cultivar IR 24. Three differentials, DV 85, Improved Samba Mahsuri and TN 1 were also included as standard resistant and susceptible check. All the genes and gene combinations tested offered

satisfactory resistance reaction to the native isolates of bacterial blight pathogen except susceptible check TN 1.

88.Integrated management of emerging disease in rice- (R/04-00-05-2017/MON – KAU- PLAN) (CoE)

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Thirteen different treatments were applied for estimate the intensity of grain discoloration disease occurrence at the Research Station experimental plot during late Kharif 2018. Out of 13 treatments applied (T_{12}) treatment with soil test based NPK +foliar spray of NK (1%) +Solubore (0.2%) showed lower incidence of grain discolouration and gave better yield when compared to other treatments.20 different samples of plants and soil was collected from highly infested areas of Kuttanadu region to study the pathogenicity of grain discolouration.Different types of fungus were isolated from the discoloured panicles for further studies.

89.Integrated disease management - sheath blight

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Various disease management strategies including nutrient management were evaluated for the management of sheath blight of rice. The treatment comprising of seed treatment with carbendazim (2g/kg), incorporation of FYM (1 kg/m^2) in the nursery, application of DAP (108 g/10 m^2) and MOP (85 g/10m^2) in the nursery, application of FYM (1 kg/m^2)+ Trichoderma formulation (2 g /kg FYM) just before transplanting in the main field, application of 75 % recommended dose of fertilizer, one blanket application of cartap hydrochloride at 15 DAT and application of propiconazole at booting stage was the best one to reduce the disease significantly and also to improve the grain yield.

90.Screening for Sheath blight and Sheath rot resistance to diseases-(RIC/03-02-03/84/MON (5)/ICAR)

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1316 AICRIP cultures (397 NSN-1, 682 NSN-2, 108 NHSN and 129 DSN cultures) were screened against sheath blight and bacterial leaf blight diseases during Kharif 2018. 566 cultures showed their Multiple Resistant nature for the above diseases

91.Effect of selected essential oils for the management of bacterial blight of rice

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Seven essential oils were evaluated against bacterial blight of rice. Among the oils tested Nirgundi oil (*Vitex negundo*) and Eucalyptus oil showed reduction in disease severity.

92. Production Oriented Survey (RIC/05-00-06-2004/MON(6)/AICRIP)

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Production oriented survey was conducted at Alappuzha (18191 ha) and Kottayam(1708 ha) districts during early Puncha 2018-19 from booting stage to maturity stage of the rice crop. The survey covered five taluks in Alappuzha District, viz., Ambalapuzha, Kuttanad, Chengannur, Haripad and Mavelikkara, while in Kottayam district two taluks namely Kottayam and Vaikom could be surveyed. Most of the padasekharams in the Kuttanad region were totally lost due to bund breaching due to floods which occurred during 3rdweek of July and August 2018. About 10497 ha rice area was vitiated due to flood during additional crop. The silt deposition in the upper Kuttanad region varied from 4 cm to 22 cm. The soils were low in organic carbon in the upper Kuttanad region while it was high in the lower Kuttanad region. There was loss of magnesium, potassium and boron from the soil in most of the locations. Calcium, Copper and Zinc in the soil were reached above sufficient level. The scientists of the research station attended MDDT visits and took classes for the flood affected farmers.

The predominant cropping sequences were rice-fallow, rice-rice and fallow-rice. The predominant varieties in those districts were Uma and Jyothi. The weed population was moderate. Weeds like *Cyperus difformis, Cyperus iria, Echinochloa crusgalli, Sacolepis interrupta* were the major weeds observed during the visit. *Echinochloa spp.* was the major weed found in both Alappuzha and Kottayam districts along with wild rice infestation. Moderate incidence of the biotic constraints like leaf folder, army worm, thrips, BPH, sheath blight and false smut were observed. Lack of sufficient labourers and high labour cost were the main problems faced by the farmers. Fungicides like Contaf (250 ml/acre), Nativo (80 g/acre) and Tilt (100 ml/acre) were commonly sprayed against sheath blight and other foliar diseases like brown leaf spot and sheath rot. Tilt and copper hydroxide were used as foliar spray at the time of flowering stage against false smut disease. The systemic insecticides Feterra (4 kg/acre), Cartap (5kg/acre), imidacloprid (50 ml/acre), Takumi (50 g/acre), Fame (20 ml/acre) and Origin (400 g/acre) were sprayed against leaf folder and stem borer. Tatamida (60ml/acre)and Applaud (120ml/acre) were sprayed against Brown plant hopper.

PG Projects

Concluded PG Projects

1.Evaluation of CMS based rice hybrids developed from rice varieties of Kerala identified as restorers

Name of the student : Nayana Jyothibas
Major Advisor: Dr. Jayalekshmi V.G. Professor
College of Agriculture,Vellayani

The study was carried out in the department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 2016-2018, with an objective to evaluate CMS based rice hybrids developed from rice varieties of Kerala as restorers, for heterosis for yield and grain quality. The study was conducted in two experiments *i.e*., 1) Hybrid seed production 2) Evaluation of hybrids. The first experiment, on hybrid seed production was undertaken in College of Agriculture, Vellayani during May to August, 2017 (*Virippu, 2017).*

Two CMS lines *viz*., CRMS31A and CRMS32A were crossed with nine restorers. Restorers were sown in three staggers, 10 days before the sowing date of CMS lines, at the sowing date of CMS lines and 10 days after the sowing date of CMS lines. Synchronized flowering dates of the CMS and restorer lines were recorded. CRMS31A was crossed with Remya, Jayathy, Swarnaprabha, Kanakom and Neeraja. CRMS32A was crossed with Annapoorna, Aiswarya, Mattatriveni and Kanakom. Six crosses *i.e.*, CRMS31A x Jayathi (H1), CRMS31A x Kanakom (H2), CRMS31A x Remya (H3), CRMS32A x Annapoorna (H4), CRMS32A x Kanakom (H5), CRMS32A x Mattatriveni (H6) that had given more than 1500 viable seeds were carried forward for hybrid evaluation. Date of sowing of the restorers and maintainers for getting synchronization in flowering to undertake hybridization was standardized in this experiment.

In the second experiment, hybrids along with the better parent and checks were evaluated in a Randomized Block Design (RBD) with three replications during October 2017 to February 2018 *(Mundakan)* in IFSRS (Integrated Farming System Research Station), Karamana. This evaluation of hybrids could identify two promising hybrids for Kerala H5 (CRMS32A x Kanakom) and H3 (CRMS31A x Remya) which could give a yield advantage of 17.91% and 16.37% over the popular rice variety Uma. These two hybrids had long slender grain shape with red kernel colour. The amylose content of these two hybrids was also intermediate. These hybrids had a lower cooking time and good head rice recovery. Hence the hybrids can be recommended for Kerala after trials over locations and seasons. A better seed production technique has to be standardized before commercial release.

Ongoing PG Projects

1. Development of cytoplasmic male sterile line in a selected rice variety of Kerala by marker assisted back crossing

Name of the student : Thejasree lachyan
Major Advisor: Dr. Jayalekshmi V.G. Professor,
College of Agriculture,Vellayani

The main objective of this work is to develop cytoplasmic male sterile line in an identified Kerala rice through marker assisted backcrossing. Four potential maintainer lines(from previously reported study) and a CMS line.Jyothi (Ptb 39), Kanchana(Ptb 50) and bharathy (Ptb 41) obtained
from Regional Agricultural Research station, Kerala Agricultural University, Pattambi, Palakkad, Kerala and Aruna (MO8) obtained from Regional Research station KAU, Moncompu, Alleppy were used as maintainers of CMS. CRMS 31A line obtained from CRRI Cuttack, Orissa was used as the malesterile line.

Entire work was conducted in five different experiments. Foreground selection, pollen sterility test and spikelet sterility test showed that among all the four $F_{1's,}$ F_1obtainedfrom a cross between CRMS31A and Jyothi showed >99%pollen sterility and 100% spikelet sterility. Parallely,165genome wide SSR primers were used for screening of the maintainer and CMS line to locate 24 SSR markers specific to the maintainer. It was observed that the germination percentage of $F_1$and BC_1F_1seeds was very low. The percentage of recovery of recurrent parent genome was found to be 65% in BC_1F_1generation. Along with this an advanced generation of a cross between UPA and Kanchana was also screened with 24 SSR primers. It was observed that BC_1F_1plants (CRMS31A x Jyothi) did not flowered even 240 day after sowing. Due to absence of flowering, these plants were screened with marker specific to flowering geneHd3a (Heading date gene- 179bp on chromosome no. 6). On gel documentation the band was obtained revealing the presence of Hd3a gene. As there is delay in flowering even in the presence of Hd3a gene, the expression of Hd3a will be studied at RNA level to know the possible reason for delayed flowering.

2.Marker assisted selection for bacterial leaf blight resistance genes in the back cross projenies of Prathyasa variety of rice(*Oryza sativa*)

Name of the student: Govind Rai Sharma
Major Advisor: Dr. Jayalekshmi V.G, Professor,
College of Agriculture,Vellayani

This study is being conducted with the objective to identify lines in the BC_2F_2 progeny of Prathyasa pyramided with 2/3 genes (xa13, Xa21 and xa5) through marker assisted selection for resistance to bacterial leaf blight and to evaluate these lines morphologically to assess Prathyasa phenome recovery. BC_2F_2 plants with xa13 and Xa 21 genes in homozygous combination and with maximum similarity with the recurrent parent was identified. BC_2F_2 plants with xa5 and xa13 genes in homozygous combination were also identified with similarity to 'Prathyasa'.

These plants can be utilized for either back crossing or for generating BC_2F_3 population for fixation of resistance genes.

3.Marker assisted selection in back cross projenies of Prathyasa and Aiswarya pyramided with two R genes against BLB in rice(*Oryza sativa* L.)

Name of the student: Arya Gopinath M.P.

Major Advisor: Dr. Jayalekshmi V.G, Professor,
College of Agriculture,Vellayani

This study is being conducted with the objective to evaluate BC_3F_1 and BC_3F_2 progenies of Prathyasa and Aiswarya pyramided with two genes *xa13* and *Xa21* for resistance to bacterial leaf blight.

4.Phosphorus nutrition and partial N rice substitution in upland (*Oryza sativa L.)*

Name of the student : Golmei Langangmeilu (2017-11-132)

Name of the advisor : Sri V. Jayakrishnakumar, Associate Prof. (Agronomy)
CoA, Vellayani

The objective was to study the influence of different levels of P on growth and yield of upland rice, to assess the feasibility of partial substitution of inorganic N with FYM, vermin compost and green manure cowpea on growth and yield of upland rice and to work out the economics of cultivation.

The experiment was laid out and sown during the last week of May 2018. Treatments were applied and biometric observations at all growth stages were recorded. The crop was harvested on 15 September 2018. The plant and soil samples were analysed.

5.Productivity of upland rice(*Oryza sativa* L.) at different NK ratios and spacings.

Name of the student : Greeshma S (2017-11-059)

Name of the major advisor :Sri.V.Jayakrishnakumar, Associate Prof.(Agronomy),
CoA,Vellayani

The project aims at studying the influence of different levels of N and K, their ratios and spacing on growth and yield of upland rice and to work out the economics of cultivation. The experiment was laid out and sown during the last week of May 2018. Treatments were applied and biometric observations at all growth stages were recorded. The crop was harvested on 14 September 2018. The plant and soil samples were analysed.

6.Irrigation scheduling and water stress mitigation strategies in upland rice (*Oryza sativa* L.)

Name of the student :Gritta Elizebeth Jolly
Name of the advisor :Dr. T. Sajitha Rani, Professor and Head,
Instructional Farm, CoA, Vellayani

The objectives of the project are to identify a suitable variety and irrigation method for upland rice, to standardize irrigation scheduling and to assess the effect of moisture stress mitigation strategies on the growth, yield and economics of upland rice. The first experiment entitled "Identification of suitable variety and standardization of irrigation method" is in progress.

7.Customized nutrient management for rice (*Oryza sativa* L.) in the Southern Laterites (AEU 8)

Name of the student : Sheeba. S.S. (2016-21-017)
Name of the major advisor :Dr. Shalini Pillai, P.
Professor (Agronomy)

The study aims at assessing and rating the available nutrient status of rice soil in the Southern Laterites (AEU 8), developing a Zn – B mix for rice and evaluating the effect of the mix on rice, at different N/K ratios.Soil samples were collected from the blocks of AEU 8 were rice cultivation is in vogue. The samples were analysed for its nutrient contents. Consequently based on the deficiency of Zn and B, the Chenkal panchayat of Parassala block was selected for conducting the field experiment.Zn and B requirement of rice (variety Uma) was worked out based on the available nutrient status of the soil and crop requirement. Based on this the Zn – B mix was prepared mixing $ZnSO_4$ $7H_2O$ and H_3BO_3 in the ratio 4:1. Field experiment was conducted as per the technical programme in the farmer's field. The data tabulation and analysis on biometric and yield characters is in progress.

8.Regulation of plant Na/K ratio for productivity enhancement in *Pokkali* rice.

Name of student: Emily Alias
Name of Major Adviser: Dr. Deepa Thomas
Assistant Professor (Agronomy)
Rice Research Station, Vyttila

The main objective of the project is to study the effect of narrowing the Na/K ratio by liming and foliar application of potassium in *Pokkali* rice. Field experiment was conducted at RRS, Vyttila during Kharif 2018. Biometric observations on growth and yield parameters of *Pokkali* rice were recorded at various stages of growth. Soil and plant samples were collected from each plot. Chemical properties of soil have been analysed. Analysis of plant samples and statistical analysis are in progress.

9. Management of high temperature stress in aerobic rice (*Oryza sativa* L.)

Name of student:M. Saravana Kumar
Name of Major Adviser: Dr. P. Prameela
Professor (Agronomy), CoH, Vellanikkara

The objective of the study is to assess the response of rice to high temperature stress at different growth phases in respect to growth, yield attributes, yield and physiological parameters of aerobic and wetland rice varieties. The effect of nitrogen and potassium nutrition on mitigation of high temperature stress also will be studied.

The location for field experiment was Agronomy Farm, Department of Agronomy, College of Horticulture, Vellanikkara. Two pot culture experiments (wetland rice varieties) I and (aerobic rice varieties) II were conducted during *puncha* season, 2017. All management practices (weeding, earthing up and fertilization) were according to the Packages of Practices and Recommendations, KAU. Biometric and physiological observations were taken at 15 days interval and at end of stress up to harvest. Yield and yield parameters of rice were taken after harvest. The most susceptible stage to temperature stress was found to be flowering to maturity. The performance of aerobic rice variety Vaishak was found to be superior to other aerobic varieties used in the study. Among wetland varities, Aiswarya was found to perform better. Hence varieties Vaishak and Aishwarya were selected for the field trial in puncha season 2018.. The field trial is under progress now and the crop is in heading stage.

10. Agronomic biofortification of zinc in rice (*Oryza sativa* L.)

Name of student: Amal Jose
Name of Major Adviser: Dr. Jacob D.,
Assistant Professor (Agronomy) and Head,
On Farm Research (OFR) Centre, CoA, Vellayani

The programme aims to study the effect of time and method of zinc application on growth, yield, and zinc biofortification and zinc bioavailability in transplanted rice.

The field experiment study was completed, biometric observation has been recorded successfully at all growth stages. Yield and yield attributes are calculated. Stat analysis of yield data also completed. Chemical analysis of grain and other byproducts are to be completed.

11.Biology and management of *Sacciolepis interrupta* (Willd.) Stapf in rice

Name of student:Pujari Shobha Rani
Name of Major Adviser**:** Dr. P. Prameela, Professor (Agronomy),
CoH, Vellanikkara

The objective of the programme is to study the biology of *Sacciolepis interrupta,* and its distribution in the major rice tracts of Kerala. Investigations will also be made on the bioefficacy of currently used and novel pre and post emergence herbicides on the weed, so as to develop an effective

management strategy to control *Sacciolepis interrupta.* The location for field experiment was selected at farmers field at chitali, Palakkad. Two field experiments (Management by pre emergence herbicides) Exp-I and (Management by post emergence herbicides) II were conducted during *virrupu* season, 2017. After doing the Biometric observations and yield attributes of two experiments from first year, the best three treatments from each of the above two experiments conducted in 2017 was selected, integrated and a third experiment is planned. Soil and plant analysis were done after harvest to obtain the nutrient status. Statistical analysis was also done. A survey was conducted to document the distribution of *Sacciolepis interrupta* in areas of severe weed infestation in major rice growing tracts of Kerala i.e., Kuttanad, Kole and Palakkad. Morphotypes of *Sacciolepis interrupta* was collected and observations was recorded on morphological features. Pot culture experiments are being conducted continuously, to study different methods of propagation and germination. Research work is going on and the field experiments I, II and III has to be laid out during May, 2019.

12.Management of rock bulrush (*Schoenoplectusjuncoides*(Roxb.) Palla) in wet seeded rice

Name of student: Fathima Umkhulzum S
Name of advisor:Dr. Ameena M, Assistant Professor
Dept. of Agronomy

The experiment was conducted to study the biology of the weed rock bulrush and to develop an effective and economic method for itsmanagement in wet seeded rice. The study revealed that the annual or perennial sedge weed, rock bulrush (*Schoenoplectus juncoides* (Roxb.) Palla) with an average duration of 106 days in the cultivated wetlands could be controlled effectively by ethoxysulfuron @15g ha^{-1} and penoxsulam @ 22.5 g ha^{-1} both at 15 DAS fb HW at 35-40 DAS. Considering the economics, ethoxysulfuron @15g ha^{-1} at 15 DAS followed by hand weeding at 35-40 DAS could be adjudged as the most effective strategy for the management of *Schoenoplectus juncoides* (Roxb.) Palla in wet seeded rice.

13.Germination ecology and management of Chinese sprangletop [*Leptochloa chinensis* (L.) Nees.]in wet seeded rice

Name of the student:Lekshmi Sekhar (2017-21-023)
Principal Investigator: Dr. Ameena M, Assistant Professor (Agronomy)

The programme aims to study the habitat features, germination ecology and distribution of *Leptochloa chinensis* in major rice tracts of Kerala. The bio-efficacy of tank mix combinations of novel herbicides for the management of weed, sensitivity of weed to herbicide combinations and mode of action will also be studied.Field experiment was laid out as per the technical programme in IFSRS, Karamana for management studies. Data tabulation is in progress. Phytosociological survey was conducted in the major rice growing tracts of Kerala including Kuttanad, Kole, and Palakkad to document the habitat features, composition and distribution of *L. chinensis* after selecting three severely infested *padasekharam* in each tract. Soil samples and weed samples were collected from each tract.

14.Morphology, ecology and management of *Monochoria vaginalis* (Burm. f.) Kunth

Name of student: Athira G. R.
Name of Major Adviser: Dr. Meera V. Menon
Professor (Agronomy)

The objective of the programme is to study the morphological characters of the wet land weed *Monochoria vaginalis* occurring in major rice tracts of Kerala. It is also aimed at understanding the effect of various ecological factors on germination of the weed, and to test the efficacy of select herbicides against it.Morphological observations were recorded from *Kole*, Kuttanadu, Palakkad and *Pokkali* rice tracts of Kerala. Seeds, soil and plant samples were collected from each location. Pot culture and germination studies are on-going. The experiment on efficacy of post emergence herbicide is planned during the virippu season of 2019.

Name of Project Coordination Group: (02)
Spices & Plantation Crops

Compiled by:

Dr.Sujatha V.S., Project Coordinator

Plan & External Aided Projects

Ongoing Projects:41 Nos.

Post Graduate and Ph.D Projects

Concluded Projects: 4 Nos.
Ongoing Projects:2 Nos.

Ongoing Projects

I. Black pepper

1. Germplasm collection, characterization, evaluation and conservation-(SPC – 01-00-01/72-PNR (9)ICAR)

At present 318 cultivated types, 54 wild types and 3 exotic types of black pepper are being maintained at PRS, Panniyur. The survey work was carried out and 15 new genotypes were collected during the year. During the year 2018, the genotypes PRS 64, PRS 136 and PRS 154 were the top yielders. PRS 64 ranked first with 4.98 kg green berry yield and 1260 spikes/vine. Spike length was maximum for PRS 155 (15.1 cm). The number of developed berries/spike was more for PRS 137 (75.0). The 100 berry weight was high for PRS 154 (12.4 g). The dry recovery % was more for PRS 136 (38 %).

2. Inter varietal hybridization to evolve high yielding varieties- (SPC-01-00-04/72-PNR (9) ICAR)

The hybrids PRS 160, PRS 161 and PRS 165 were found to be promising with mean green berry yield of 6.12 kg/vine, 6.63 kg/vine and 4.84 kg/vine respectively. Number of spikes/vine was higher for PRS 161 (902). Spike length was maximum for PRS 161 (17.0 cm). 100 berry weight was higher for PRS 161 (19.1).

3. Hybridization to evolve varieties tolerant to biotic and abiotic stresses

Seedlings of all the crosses are being maintained. Crossing Panniyur 1 with PRS 4 was carried out this year also and the seeds obtained were sown in nursery.

4. Coordinated Varietal trial in black pepper (CVT 2006 Series VI)

(SPC/03-00-02-2010/PNR(9)/AICRP)

The trial was started during 2007. During 2018, HB 20052 recorded the highest green berry yield of 5.20 kg/vine followed by Acc.no.53 (4.97 kg/ vine). Both the varieties are statistically on par. The highest plant height was recorded for Panniyur 1 (5.17 m).

5. CVT 2015 on Farmer varieties of Black pepper Series VII

The trial was started during 2015. During 2018, *Kumpukkal* recorded the highest green berry yield of 2.20kg and is on par with Panniyur 1. Average spike length was the highest for Panniyur 1 (17.03 cm) which was on par with Panniyur5 (16.6 cm). Number of berries/spike was more for Panniyur 1 (84.66). Higher dry recovery % was recorded for *Zion Mundi*,

Panniyur 5 and Panniyur 1 (35%). There was no significant difference with respect to plant height and number of branches per vine.

6. CVT 2015 on Black pepper Series VIII

The trial was started during 2015. During 2018, PRS 161 recorded the highest green berry yield (1.93 kg.) and dry berry yield (0.73 kg.) and on par with Panniyur 1. Average spike length was the highest for PRS 161 (21.93 cm). Number of berries/ spike was also the highest for PRS 161 (118) which was on par with PRS 160 (112.3).The highest dry recovery % was recorded for PRS 161 (38%). There was no significant difference with respect to plant height and number of branches per vine.

7. CVT 2018 on Black pepper Series IX

New trial – planted in 2018

8. Black pepper based mixed cropping system for sustainable productivity and food security

During 2018-19 good yield was obtained from the intercrops in black pepper garden except arrow root and tapioca. Among the intercrops T_3- elephant foot yam recorded maximum yield of 7.55 kg followed by T_5 -greater yam (6.46 kg) from an inter space of 4m x 2m spacing between black pepper. Colocasia (T_1) yielded 2.28 kg and arrowroot (T_2) – 1.82 kg. It is difficult to maintain the intercrops tapioca and arrow root due to wild boar attack.

9. Biological Management of slow decline in black pepper

The experiment was started during 2014. During 2018-19 three treatments, soil application of *Trichoderma viride* + Neem cake @ 2kg/vine (T1), soil application of *Trichoderma viride* followed by soil drenching with *P. fluorescens* @ 2% (T2), soil application of *Pochonia chlamydosporia* (multiplied in partially decomposed FYM @ 2 kg/vine) followed by soil drenching with *P. fluorescens* @ 2% (T3) were significantly superior in reducing yellowing due to slow decline disease in black pepper. Soil application of *Trichoderma viride* followed by soil drenching with *P. fluorescens* @ 2% (T2) recorded minimum disease incidence (2.77%) and maximum yield of 2.19 kg/vine.

10. Studies on management of *Phytophthora* causing foot rot in black pepper

The Percentage Disease Incidence was minimum in application of Fosetyl Aluminium amended fertilizer brickets at the onset of rain and post monsoon (T3) and RIL070/F1 -72% WP 100ppm soil drenching (T5). The biometric characters *viz.,* plant height and no. of leaves were recorded and there was no significant variation among different treatments.

11. Comparative account of some defense related bio chemicals in resistant and susceptible black pepper varieties/cultivars in response to infection by *Colletotrichum gloeosporioides*

Surveys were conducted during the report period in major pepper growing areas of Idukki to identify the black pepper cultivar / varieties having field tolerance to *Colletotrichum.* Based on the survey of the farmers fields Anakkara (Kattappana block), Cumbummettu (Nedumkandam), Upputhara (Kattappana block)areas were identified as hot spots for the disease.

Twenty different cultivars of black pepper showing field tolerance to pollu disease were collected randomly from these fields. The collected plants were grouped on the basis of disease symptoms noticed in the field as highly tolerant, moderately tolerant, susceptible and highly susceptible varieties and they were planted and maintained at CRS farm. The details of the type are given below.

Sl.No	Highly Tolerant	Moderately tolerant	Susceptible	Highly Susceptible
1	Jeerakamundi	Varikkamunda-1	Myladimundi	Panniyur-3
2	Narayakkodi	Vellakarimunda-2	Pattanimundi	Arayamundi
3	Jeerakamundi-2	Narayakkodi-2	Marampadathy	Thevamundi
4	Karimunda-3	Karimunda-2	-	Karimunda
5	Vellamundi	-	-	Panniyur-6
6	Appappi	-	-	Panniyur-1

Biochemical defense mechanisms in pathogen inoculated plants were analysed daily. Peroxidase, polyphenol oxidase, chlorophyll content, carotenoid content and carbohydrate contents were assayed. The effect of these biochemicals in disease tolerance of plants was variable for different varieties collected during the survey.

12. Effect of various entomo-pathogens and synthetic insecticides on the management of sucking pests in black pepper.

Periodical field surveys were carried out at weekly intervals in farmer's field of three blocks of Idukki district *viz.,* Nedumkandam, Kattappana and Azhutha. During the survey, 108 plants were selected randomly from the field and upper (8 leaves), middle (8 leaves) and lower (8 leaves) leaves of each plant were observed. No infestation of aerial, root mealy bugs and scale insects were recorded from October 2018 to February 2019. So we were not able to conduct the experiment during that period. During the field visit made on 06.03.2019 to Anakkara field in Kattappana block, soft scale infestation was noticed in the field, but there was no occurrence of mussel scale and root mealy bug infestation at that time. So, a field trial was fixed for soft scale and pre- count was recorded. First treatment application was carried out on 06.03.2019.

Among treatments the least infestation was noticed for application of Thiamethoxam 25 WG @ 0.005% (6.96 %), Acephate 75 SP @ 0.15% (9.38 %), Dimethoate 30 EC @ 0.14% (9.38 %) and Imidacloprid 17.8 SL @ 0.006% (10.42) and they were statistically on par, with each other followed by *Lecanicilliumlecanii* 10^8 spores/g @ 10% (14.58 %). The effect of *L. lecanii*was on par with Buprofezin 25 SC.

13. Strengthening Black pepper research unit (SPC – 01 – 00 – 01 – 2016 – VKA – KAU – Plan)

127accessions of *Piper nigrum* collected, field planted and labeled. Eleven species of *Piper* are maintained in the collection. Germplasm collection will be utilized for future breeding programmes. Seventeen released varieties of black pepper (from KAU and IISR Calicut)were field planted and labeled. This will serve as a demonstration plot for farmers and students.

14. Coordinated Varietal Trial 2006 – Series VI (AICRP spicesPEP/CI/3.3)

Highest fresh weight (0.975 kg/vine) of berries per vine was registered for HB 20052which is on par with *Karimunda* (0.932 kg/vine) followed by ACC-53 (0.756 kg/vine). For dry weight of berries *Karimunda* recorded the highest (0.528 kg/vine) chased by HB 20052 (0.525 kg/vine).

II. Cardamom

15. Molecular markers for identifying Cardamom accessions.

Fifteen accessions including local collections (GG), released varieties (PV 1, PV 2, PV 3& PV 5), pre released variety (PV 4) and high yielding accessions selected for the study. DNA isolation protocol was standardized for cardamom. Ten ISSR primers were screened to study the polymorphism in the above accessions. The PCR amplification using ISSR primers showed polymorphism in all the DNA samples of the select 15 cardamom varieties/ accessions. Molecular finger printing of 15 cardamom genotypes was carried out using ISSR analysis and an average of 66.04 % polymorphism was detected. The highest polymorphism 100 %was detected in ISSR primers S851 and UBC 812 which produced 6 and 7 polymorphic bands respectively. A total of 52 reproducible bands ranging from 100 bp to 1110bp was scored with the ISSR technique. Genetic similarities of cardamom varieties were obtained with UPGMA algorithm using Jaccard's coefficient. The genetic similarities ranged from 0.44 to 1.00 (Figure1). The 15 cardamom genotypes were grouped into two major clusters: Cluster I, with PV 1, PV 3, HY 12, PV 34, PV 4, PV 5 and HY 13; Cluster II with PV 2, HY 15, Green gold, PS1 x GG Type 1, HY 9, Pink base, HY 14 and PV 8 (Figure 1).

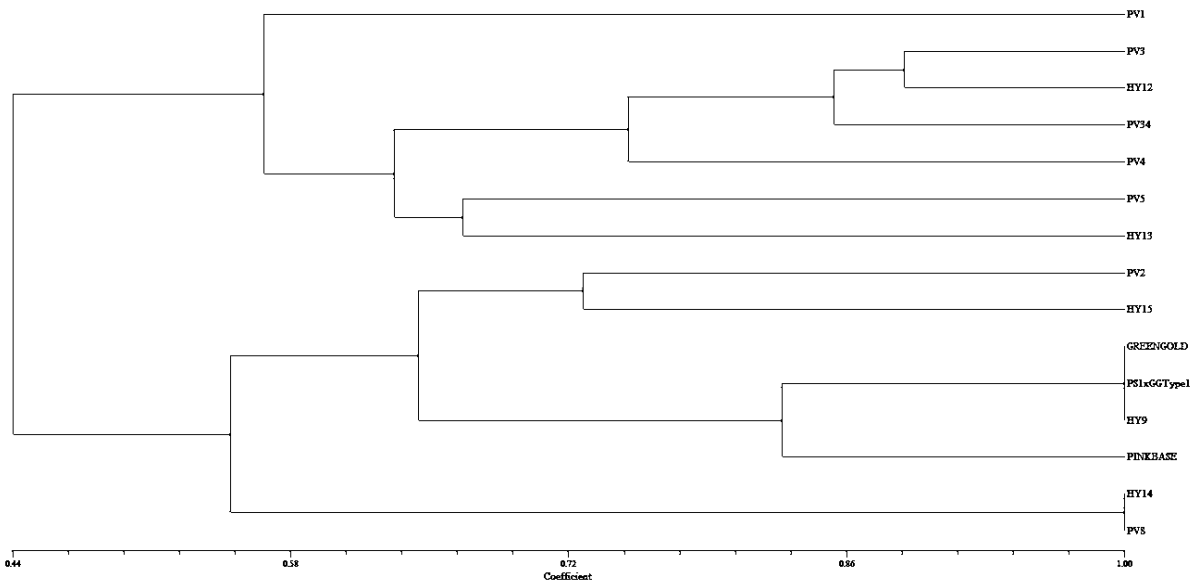

Figure 1: UPGMA dendrogram based on Jaccard's coefficient illustrating the genetic similarities and distance among cardamom cultivars/accessions by the UPGMA cluster analysis (NTSYS)

Some close relationships among genotypes were constant in all ISSR markers performed. For example PV 3, HY 12, HY 15, PV 34 and PV 4 (similarity ranges from 0.72 to 0.88); PV 1, PV 5 and HY 13 HY 14, and PV 8, (similarity sealed from 0.52 to 0.68); Pink base, Green gold, PS 1 x GG Type 1 and HY 9 (similarity spanned from 0.84 to 1.00). However, the dendrogram indicated that PV 1 (Cluster I), PV 8 and HY14 (Cluster II) showed higher genotypic difference.

Among theISSR markers used in this study nine markers have wide genetic relationship between cardamom genotypes. Morphological or phenotypic characters were investigated in all 15 cardamom accessions. Results showed that the number of panicles was ranged 1.00 (PV 8) to 3.33 (PV 4). The number of cinicinni/panicle was higher in HY 15 and lower in PV 8. Panicle length was ranging from 16.67cm in PV 8 to 63.33 cm in HY13. Branching nature was absent in all the genotypes. Capsule length was maximum for PV 3 (1.90cm) and the lowest in PV 2 (1.27 cm). Among the 15 genotypes studied the number of seeds per capsule and 100 dry capsule weight was greater in HY 12.

16. Germplasm collection, characterization, evaluation and conservation (AICRP on spices-CAR/CI/1.1)

A total of 188 cardamom accessions are presently conserved in the gene bank. Among them 73 cardamom accessions (CRSP 1-73) received IC numbers (547920 to 547992) from the National Bureau of Plant Genetic Resources, New Delhi. All of the characters, except Borer and *Azhukal*, other incidence had shown significant difference among the accessions at 5% confidence level. HY 13 recorded the highest fresh yield (1.82 kg/plant) succeeded by HY 16 (1.81 kg/plant) and they were significantly different from each other. The same trend was also observed for dry yield per plant. The percentage thrips incidence was least in HY 12, HY 2, PV 2, HY 16 and HY 15 compared to other accessions.

17. Evaluation of Promising small Cardamom (*Elettaria cardamomum*) (L.) Maton) cultivars/varieties for organic cultivation in the High Ranges of Idukki district (AICRP on spices-CAR/CI/2.2)

In this experiment, PV2 showed the highest plant height (307.6 cm) and closely followed by PL NO 14 (293.0 cm). GG registered maximum no of productive tillers (41.0) followed by PS 27 (32.6) and PV2 (30.3).

18. CVT of drought tolerance in Cardamom– (Series VII AICRP on spices-CAR/CI/3.7)

A total of 8 accessions (IC 349537, IC 584058, GGxNKE-12, IC 584078, CL 668, HS 1, Appangala 1 and IC 5840490) from different AICRP centres were evaluated. The experiment was started during the last year and plants are in their early vegetative stage.

19. CVT 2015 on Farmers varieties of cardamom- (Series VIII AICRP on spices-CAR/CI/3.8)

Farmer's varieties of cardamom such as *Pappalu, Arjun, Elarajan, Thiruthali,* Wondercardamom, *Njallani, Panikulangara green bold no.1*and*Patchaikai*were evaluated in this experiment. Superiority in plant height was observed in *Njallani* and *Thiruthali* (166.30 and 160.63 respectively) followed by Wounder Cardamom and *Patchaikai* (153.83 and 151.50 respectively). Maximum number of tillers were produced by *Thiruthali*(16.53) pursued by *Patchaikai*(14.97).

20. CVT on hybrids of small cardamom-2018 Series VII

Due to *katte* disease incidence we have removed the infected plants. Hence this experiment also requiring a drastic strengthening and maintenance of plant density.

21. Initial Evaluation Trial– 2012 AICRP on spices-CAR/CI/4.3

Maximum number of tillers were produced by PPK 2 (55.6) which on par with Pl. No. 14 and HY 6 (49.3 and 48.3 respectively). Maximum leaf width (12.1cm) was observed in PV 2 which is on par with PPK 2 and HY 6 (11.5 and 11.5 respectively). Length of panicle was maximum in PPK 2 (73.7cm) ensued GG (69.0 cm).

22. CVT Multi Location Evaluation of thrips tolerant cardamom lines-(AICRP on spices-CAR/CI/4.4)

This experiment include six cardamom accessions *viz.*, IC 349362, IC 349364, IC 349370, IC 349606, *Njallani green gold* and PV 2.The experiment was started last year and plants were in early vegetative stage but very poor plant stand after extensive drought condition this season, the experiment need gap filling and maintenance of population.

23. Nematode Pest Management in Cardamom using biocontrol agents and organic supplements (AICRP on spices-CAR/CP/6)

Results of the pooled analysis showed that damage caused by nematode population was significantly reduced with application of neem cake @ 1 kg/plant (twice a year) before and after the monsoon period along with *Paecilomyces lilacinus* @ 10g/lit (5 lit/plant) (17.56 %) followed

by *Pochonia chlamydosporia@* 50g/clump (19.81 %), *Paecilomyces lilacinus* @ 10g/lit (5 lit/plant) (13.25 %) and *Trichoderma viride* @ 10g/lit (5 lit/plant) (22. 78 %)

24. Evaluation of new insecticides for thrips control- (AICRP on spices-CAR/CP/6.9)

The pooled data on thrips infestation after seven sprays revealed that Fipronil 5 SC treated plots registered the least damage (0.72 %) and control (50.42 %). The highest per cent reduction over control was noticed in Fipronil 5 SC (98.57 %) closely followed by Spinosad 45 SC (96.90 %) and Imidacloprid 17.8 SL (96.69 %).

III. Nutmeg

25. Strengthening research on Nutmeg (SPC-01-00-01-2015-VKA-KAU plan)

37 elite nutmeg accessions have been identified from the nutmeg growing tracts of Kerala and characterization of the mother trees has been carried out. Budded plants of these clones have been made and planted in the nutmeg germplasm. At present, the nutmeg germplasm holds 40 elite/unique clones of the crop. The germplasm is being maintained under good management.

During 2017-18, five high yielding varieties of nutmeg were released for cultivation in the state of Kerala, based on the performance of the genotypes in the original farmers plot. In order to assess the spatial and temporal variations in growth, flowering yield and quality of these varieties across different locations of Kerala, a study has been initiated during 2018-19.

Budded trees of each variety in the age group of 6-8 years were located in farmers' holdings at various locations. Climatic and edaphic variables have been recorded from each location. Morphological (qualitative and quantitative parameters), yield and quality parameters are being recorded from the select trees and agro meteorological observations are being recorded on monthly basis.

In the post-harvest technology aspect,protocol for making **v**alue added products *viz*. nutmeg rind wine,pickle,candysticks,nutmeg rind choonda,nutmeg rind shreds,nutmeg rind cake etc. werestandardised.It was inferred that a small scale processing unit can be made operational with the developed protocols which is at present ready for transfer. The results were presented in the Central zone Zonal Research and Advisory Committee meeting held at Pattambi and approved. The questionnaire for estimating the cost of production of technology developed has been prepared and it has been forwarded to the Directorate of Research for further action.

In the aflatoxin management study, the best treatments obtained for stored and field samples of nutmeg were further evaluated with bulk quantity to confirm its effects on the total fungal population and aflatoxinogenic fungi in relation to temperature, moisture, dosage and packing material. The mace and nutswere treated with decoction made of (T_1)citrus leaves (5 and 10 %), (T_2) Curry leaves (5 % & 10 %), (T_3)Anona seed extract (5% & 10 %), (T_4) Anona leaves (5% & 10 %) and T_5kept untreated. The treated samples were properly sealed and stored in plastic drums and enumeration of total fungi and aflatoxigenic fungi were done at two months interval. Ingeneral, the treatment with 5 % dosage (0– 7.66x 10^3 cfu/g) was effective for the management of total fungal population and aflatoxinogenic fungi when compared to 10 % dosage (0 –21x 10^3 cfu/g). The lowest fungal population was recorded in the case of mace samples when compared

to nut and kernel. Among all the treatments, citrus leaves (5%) (T_1) was the best treatment followed by anona seed extract (5%)(T_3). However, noaflatoxigenic fungi were recorded in any of the nutmeg field samples up to6
MAS. All the treatments were effective in reducing the fungal contamination and aflatoxigenic fungi when compared to control.

26. Evaluation of nutmeg genotypes - AICRP Project mode centre on nutmeg- (PCS/ IISR/ 77(01)15: 2017)

The trial which started during 2017 has 10 genotypes + 1 check (IISR Viswasree). The genotypes are Acc.1, Acc.5, Acc.12, Acc.13, Acc.14, Acc.17, Acc.20, Acc.21, Acc.23 and Acc.28. Plants have established well. Morphological observations are being recorded.

27. CVT on farmer varieties of nutmeg - AICRP Project mode centre on nutmeg- (PCS/IISR/77(01)15: 2017)

The trial initiated during 2016 has 4 farmer varieties (Punnathanam Jathi, Kochukudy Jathi, Kadukkamakkan Jathi,Improved nutmeg variety from Mr. Tom C.Antony) + 1 local check (KAU- Pullan)+ 1 national check(IISR-Viswashree). The trial is progressing well and the morphological observations are being recorded.

IV. Cashew

28. Germplasm Collection, Conservation, Evaluation, Characterization and Cataloguing – (AICRP on Cashew Gen 1)

87 diverse types identified and described using the 'Descriptors' for cashew. 64 types have been allotted with the IC numbers (Indigenous collection numbers) by NBPGR. From these 43 types were planted (1998, 2000 & 2002).The dwarf type PLD-57 was used for hybridization with ANK-1 and MDK-1 with the objective of obtaining hybrid progenies having dwarf stature, higher percentage of bisexual flowers, nut setting and high nut yield.
The trial has been concluded. The trees are conserved in the regional field gene bank at Regional Agricultural Research Station, Pilicode. New trial with newer set of germplasm has been initiated. The promising variety from the earlier trial, PLD 4 was also included in the new trial. The observations recorded on plantlets are furnished hereunder. Among the germplasm no significant difference was noted regarding the height while PLD 86 recorded highest girth (0.048m). Lowest girth was reported with PLD 88 (0.021m). Five new germplasm has been identified and the characters are given below:

a. PLD 92 (BTP 1)

- Nut Size – 12g
- Apple – Reddish Orange, Cylindrical Round big apples
- Blathur, Kannur - District

b. PLD 93 (BTP 3)

- Nut weight – 11.68 g
- Apple – Yellow , Big, Cylindrical
- Blathur, Kannur - District

c. PLD 94 (BTP 2)

- Nut weight – 15.45g
- Apple colour – Yellow, Cylindrical Apple
- Blathur, Kannur

d. PLD 95 (BSM 2)

- Nut weight – 10.79 g
- Apple - Yellow with reddish streaks, Round

e. PLD 96 (BSM 3)

- Nut size – 10g
- Apple - Very big , Juicy, Yellow, Cylindrical
- Apple weight – 136 g
- Blathur, Kannur - District

29. Multilocation Trials-V(Performance of released varieties/Hybrids) (AICRP on Cashew Gen 3).

Twenty five varieties have been allotted for the experiment and 20 released varieties with 10 plants each were planted during June 2008. The differences in plant height were statistically insignificant. Highest collar girth was reported in Kanaka (1.06m) which was statistically on par with Madakkathara 2(0.85m). Canopy spread in both EW and NS directions showed statistically insignificant differences. Highest canopy area was observed with Madakkathara 2 (54.74 m) which was statistically on par with Ullal 4 (47.52 m).Varieties like Ullal 4, Ullal 1, V 7 and Madakkathara 2 fared better than the other varieties included in the trial. The varieties BPP 6, Vengurla 4 and Goa 1 had poor biometric growth parameters compared with other varieties in the trial.

Highest number of flowering panicles was observed in K-22-1 (18.00). Higher number of branches that did not have a panicle was noticed in BPP 8 (7.00) and Ullal 1(6.13), while the least was in Vengurla 7 (1.25). Higher proportion of bisexual flowers to male flowers was noted in Madakkathara 1 (0.20), and Ullal 3(0.19) while least was observed in Bhuvaneswar1 and Ullal 1(0.06). Seed set m^{-1} was highest in K-22-1(21.25). Highest nut weight was recorded in Priyanka (10.92 g) followed by, BPP 6 (9.70 g) and Amrutha (9.60 g). Heaviest apples were found in BPP 6 followed by BPP 8 (92.50 g). Highest shelling percentage was reported with Madakkathara 1

(34.45%),Ullal 1 (34.30%), BPP 8 (33.5%) and NRCC sel 2 (33.54%). Madakkathara 2 (15.81kg/tree) had the highest annual nut yield which was followed by Ullal 4 (13.26 kg/tree).Priyanka (64.45kg/tree**)** and Kanaka (64.35 kg/tree) had the highest cumulative yield. This was followed by Madakkathara 2 (49.02 kg/tree). Least cumulative yield was reported from VRI 3 (5.72kg/tree) and BPP 6 (5.56kg/tree).

30. Hybridization and selection in Cashew (AICRP on Cashew Gen 4.)

The dwarf type PLD-57 was used for hybridization with ANK-1 and MDK-1 with the objective of obtaining hybrid progenies having dwarf stature, higher percentage of bisexual flowers, nut setting and high nut yield.

All the growth characteristics of the hybrids produced during 2001 and 2003 recorded found to vary significantly among the hybrids as well as parents and PLD 57 graft. MDK 1 (5.5 m) was found to be tallest, followed by the hybrids from the cross MDK 1 X PLD 57 (4.80 m). The hybrid combination PLD 57 X ANK 1 (36.76 m^2) and ANK 1 X PLD 57(36.57 m^2) had the canopy spread in both the directions. PLD 57 graft was the shortest (1.94 m) with lowest canopy area (5.78 m^2). Higher number of flowering laterals per unit area was observed in PLD 57 grafts (16.18/m^2). Higher seed set per sq. m also observed in ANK 1 X PLD 57 (6.74). The hybrids from the cross PLD 57 X ANK1 (0.22) had the highest proportion of bisexual to male flowers. New hybrids were produced in 2012 and three hybrids planted in the filed during 2012. Out of this one hybrid only survived. This hybrid had precocious behaviour.

H2/1 (PLD 57 x ANK 1)

Flowering behavior:

- 2012 September planting
- 2013 December - flowering (One inflorescence) fruit set- one
- 2014 – Flowering and fruit set 2 nos (3 Inflorescences) Fruit set -2
- 2015 – Flowering and Fruit set – Yield 100g
- 2016 – flowering and seed set - Yield 400 g
- 2017 – Flowering and seed set - Yield 514 g
- 2018- Flowering and fruit set – 3.1 Kg

✓ Highly Precocious
✓ Good no. of Bisexual flowers
✓ Mid Season flowering – December to March
✓ Nut weight medium : 7.8g
✓ Cluster bearing 5-7 nuts per panicle

31. Characterization of germplasm for cashew apple (AICRP on Cashew Gen 5.)

The experiment was laid out during 2013-14. Highest apple weight was recorded in variety VTH 30/4 (139.60 g). Apple to nut ratio was highest in the variety BPP 6 (18.10). Highest juice recovery in volume and Percentage was obtained from VTH 30/4 (100 ml, 71.63 (arcsine

transformed value- 57.81). Highest TSS was reported from PLD 4 followed by BPP 6. Lowest TSS was reported from VTH 30/4. Highest acidity was reported from Madakkathara 1 (0.59%). Sugar: Acid ratio was highest in KGN 1(60.07) and PLD 4 (57.85). Lowest was in Madakkathara 1 (22.11). Tannin content was highest is BPP 6 (0.25% and 24.9 mg/ml) and lowest in PLD 15 (0.1% and 9.95 mg/ml).

32. Evaluation of promising bold nut, bigger size apple types and high yielding cashew genotypes (AICRP on Cashew Gen 6.)

The trial has been laid out. Planting will be undertaken after receiving the grafts from DCR Puttur.

V. Cocoa

33. Germplasm collection and maintenance of cocoa (CC- 07-00-01/84 – VKA – 16 Cad India Ltd)

During the year 2015-16, 41 accessions were introduced from University of Reading, UK as bud wood. These accessions were selected from International *Cocoa Germplasm Database* (ICGD). They were reported to exhibit various levels of resistance to *Phytophthora* in other parts of the world. They form a strong source for *Phytophthora* resistant breeding programme.

34. Cocoa breeding (CC-07-00-02/84 – VKA –16 Cad India Ltd.)

a. Heterosis breeding

a.1. Breeding for Vascular streak dieback disease resistance

Selfing of superior vascular streak dieback disease resistant hybrids

Twenty five hybrids bred for VSD resistance were found to be coupled with comparatively good yield and complete resistance to VSD in the field for more than 13 years. Self-incompatibility position of these hybrids had to be assessed before taking it to polyclonal garden. Hence, selfing of 100 flowers per hybrid were carried out

Sixteen genotypes found to be self incompatible. Pod set was observed only in four genotypes and classified as self compatible. In other genotypes sufficient quantity of flowers were not obtained and the work will be continued.

Self incompatible genotypes identified can be used as parents in establishing clonal garden after assessing combining ability. They can be also evaluated in comparative yield trials.

Development of new VSD double cross hybrids

An attempt was done in this year to produce new double cross hybrids by crossing between VSD resistant single cross hybrids. Even though two thousand two hundred and thirty seven flowers were pollinated, only seven pods were obtained from seven crosses.

a.2. Breeding for Phytophthora pod rot resistance

Development of new *Phytophthora* resistant hybrids

Eleven *Phytophthora* resistant hybrids were crossed with high yielding CCRP varieties however, no pod set were observed and the work continuing during this year.

a.3. Breeding for drought tolerant cocoa hybrids

Preliminary efforts have been taken in Kerala Agricultural University to identify genotypes tolerant to drought. Four genotypes, identified as tolerant to drought in preliminary studies conducted at Cocoa Research Centre (CRC) are listed below.

Parents used in breeding for drought tolerance in cocoa

Sl. No	Accession No.	Source
1	M 13.12	Progeny of pods from Vittal
2	G I 5.9	T76/1224/1201 (Amazon)
3	G II 19.5	Progeny of pods from Nileshwar
4	G VI 55	Progeny of pods from Cadbury farm, Chundale

The four selected genotypes were crossed in all possible combinations and the pods obtained from these crosses are raised in the nursery.

Screening of hybrids

Hybrids at five month stage are selected based on HD ^{2} value and screened in drought screening structure based on gravimetric method. At present a total of 120 hybrids selected. Morphological and physiological parameters were estimated after giving a stress period of two weeks at 40 % field capacity. A control was kept in each category under fully irrigated condition.

After two weeks of stress period, the main symptom shown by drought stressed plants was the withering of leaves and based on which the plants were divided into 4 categories

Analysis of biochemical parameters and physiological parameters

Biochemical analysis was carried out in all 120 hybrids by collecting sample during stress-imposed. All the biochemical and physiological parameters considered except leaf temperature showed clear cut distinction between tolerant and susceptible hybrids. Leaf temperature did not show any variation between tolerant, susceptible and control hybrids. This is a peculiar phenomena noticed in cocoa indicating the crop capacity to maintain temperature in a desirable level under its canopy and this is the first kind of report in the world. Further investigation has to be carried out in order to unreveal the science behind it. Based on the physiological and biochemical parameters ten top performing hybrids were selected and the details are given below.

Selected hybrids with better physiological and biochemical parameters

Sl. No.	Hybrid number	Cross
1	H107	G II 19.5 x G VI 55 (i) 16
2	H52	G I 5.9 x M 13.12 (i) 2
3	H43	M 13.12 x G VI 55 (i) 12
4	H112	G VI 55 x G I 5.9 (i) 25
5	H74	G I 5.9 x G VI 55 (i) 17
6	H64	G I 5.9 x G II 19.5 (i) 25
7	H118	G VI 55 x G II 19.5 (i) 17
8	H119	G VI 55 x G II 19.5 (ii)23
9	H113	G VI 55 x G I 5.9 (ii) 6
10	H97	G II 19.5 x G I 5.9 (i) 8

a.4. Genetic stock development for tea mosquito resistance

Twenty hybrids of cocoa which are in the steady bearing stage, selected from the comparative yield trial (CYT) 5, planted during 2008 at CRC farm, KAU serve as the material for the study. CCRP 13 and CCRP 15 are included as check variety.

Screening for tea mosquito bug resistance

Five budded plants of each hybrid will be screened thrice in the insect net house. Freshly reared *Helopeltistheivora* at the rate of 100 adults (50 male and 50 female each) per screening test will be released into the insect net house. Intensity of infestation on shoots/ leaves will be scored. Genotypes resistant to tea mosquito is not reported anywhere in the world. Hence this attempt was initiated. Eleven genotypes - PIV 59.8, SIV 10.11, VSDI 10.13, PIV 60.9, PII 12.11, SIV 5.15, VSDI 33.4,PIV 56.9,VSDI 11.11, SIV 1.6, VSDI 29.9 were found to be resistant to tea mosquito out of which six hybrids were VSD resistant ones. This is an achievement of gene pyramiding by imparting multiple resistances to a fungal disease and insect.

b. Inbreeding

Inbred selfing

Selfing of inbreds were done to advance the next generation.

Techniques to overcome self incompatibility

Attempts will be initiated to overcome self incompatibility. Certain techniques tried are: Bud pollination, Surgical technique, Intraovarian technique, Salt spray and High humidity. Six pod set was obtained from surgical technique. Seedlings raised in the nursery and evaluated and field planted.

35.Development of black pod resistant varieties of cocoa

Screening for *Phytophthora* resistance in lab condition

The hybrids bred under the programme breeding for *Phytophthora* resistance were field established and evaluated in the field by screening for the disease during peak season. It resulted in identification of thirty hybrids in the field which showed no symptom. It is very much necessary to confirm the resistance by artificial inoculation to prove that the disease is due to the genetic makeup and not due to environmental influence. For this pod inoculation method was carried out.

Only four hybrids were screened during this year in addition to the twenty six hybrids screened during previous years.

36.Strengthening Cocoa Research Centre, Kerala Agricultural University - Standardization of primary processing to reduce free fatty acids

Bean Recovery was found highest in Sack method of fermentation and the details are given below.

Fermentation methods	Fermentation Period (FP)		
	5th FP	6th FP	7th FP
Basket	44.16	37.08	28.81
Heap	44.24	39.38	34.07
Sack	44.97	40.97	28.84

37. Strengthening of research on value addition of cocoa, KAU (ATMA)

Three novel products developed i.e., cocoa choco pea, cocoa crunch'O and cocoa chubby. Details are listed below.

1. Cocoa Choco Pea

Ingredients	*Quantity*
Peanut Butter	650 g
Cocoa Butter	150 g
Cocoa Powder	40 g
Powdered Sugar	150 g
Salt	10 g

Method of preparation: The raw peanuts are dipped in hot water for one minute (blanching). Blanched peanuts are roasted in an oven and remove the skin. Then grind to a smooth paste in a mixer grinder. To this peanut paste add cocoa powder, cocoa butter, powdered sugar and salt. It grinds for 2- 3 hours until a smooth texture is obtained.

2. Cocoa Crunch' O

Ingredients	*Quantity*
Chocolate (4'U)	As per the need
Chocolate wafers	As per the need

Method of preparation: Pour ¼ th of the chocolate (4' U) to the mould of Crunch'O. Above this place wafer and pour chocolate mixture. Use after cooled in refrigerator.

3. Cocoa Chubby

Ingredients	*Quantity*
Sugar	100 g
Pea nut	100 g
Butter	10 g
Fresh cream	50 g
Chocolate	100 g

Method of preparation: Melt chocolate in an oven. Heat sugar in a pan, after caramelization, add fresh cream and butter in low flame. Mix pea nuts in to it when the mass reaches soft ball stage. Pour ¼ th of the chocolate to the mould of Chubby. Above this pour the prepared mixture, again add melted chocolate mixture. Keep in refrigerator and packed.

38.Maximizing production through conventional breeding and molecular approaches - Screening for drought tolerant cocoa

Screening of newly released cocoa hybrids (CCRP 11, 12, 13, 14 and 15) to estimate its capacity to with stand drought by gravimetric method. Estimation of physiological and biochemical parameters of 25 plants of each hybrids were completed.

39. Standardization of *in vitro* techniques in cocoa – (Station wise funding – State Plan)

Budded plants of CCRP 1, CCRP 2, CCRP 3, CCRP 4, CCRP 5, CCRP 6, CCRP 7, CCRP 8, CCRP 9, CCRP 10, CCRP 11, CCRP 12, CCRP 13, CCRP 14 and CCRP 15 are maintained in polyhouse as mother stock. Shoot induction percentage and multiple shoot induction percentage were together high in cocoa but the number of shoots with minimum growth for inoculation in culture tubes for rooting was low. Thus, the rooting experiment was tried in limited number of cultures. In vitro shoots were kept for rooting in half strength MS medium after pulse treatment with IBA at different concentrations. Some of the cultures showed rooting after 1 month. Root

induction *in vitro* shoots of five different varieties of cocoa viz. CCRP 2, CCRP 6, CCRP 8, CCRP 15 and Scavina was found to be congenial in the media ½ MS + IBA 4000 ppm (pulse treatment for 2-3 sec) and ½ MS + IBA
5000 ppm (pulse treatment for 2-3 sec) were found to be congenial. In ½ MS + IBA 5000 ppm (pulse treatment for 2-3 sec), varieties, CCRP 2, CCRP 6, CCRP 8, CCRP 15 and Scavina showed 20 per
cent, 60 per cent, 60 per cent, 80 per cent and 70 per cent root induction respectively. However, in two varieties, CCRP 15 and Scavina, had successful root induction in ½ MS + IBA 4000 ppm (pulse treatment for 2-3 sec). Hence in general, it can be concluded that ½ MS + IBA 5000 ppm (pulse treatment for 2-3 sec) was superior to all the media tried for root induction.
Hardening of tissue culture cocoa plants were not successful in both Sand: Vermicompost (1:1) and Vermiculite: Perlite: Vermicompost (1:1:1). The Vermiculite: Perlite: Vermicompost (1:1:1) media showed a maximum survival of plantlets for one week and later the plant showed yellowing and finally the shoots were completely dried off. More detailed works to be continued.

40. Voluntary centre for cocoa in KAU at Cocoa Research Centre, Vellanikkara (AICRP on Palms)

Establishing and maintaining a polyclonal garden for the production of quality planting material

41. Estimating combining ability of identified superior genotype

GCA analysis of *Phytophthora* resistant hybrids

Three hybrids found to be resistant to *Phytophthora* were top crossed with the tester GI 5.9 to find out best general combiner in order to release them as parental material in polyclonal garden establishment. Thirty five hybrids short listed after nursery evaluation were field planted for further analysis.

GCA analysis of Vascular Streak Dieback Disease resistant hybrids

Seven hybrids found to be resistant to VSD were top crossed with the tester GI 5.9 to find out best general combiner in order to release them as parental material in polyclonal garden establishment. Sixty one hybrids short listed after nursery evaluation were field planted for further analysis.

PG Projects

Concluded PG Projects

1. Nutrient Scheduling in bush pepper *(Piper nigrum)* (SPC-06-00-01-2017-ACV(16)-KAU-PG)

The study indicated that growing bush pepper in potting medium containing soil + FYM + vermicompost + coirpith compost (3:3:1:1) with the application of inorganic fertilisers@25:25:50 g NPK plant^{-1} year^{-1} scheduled at quarterly intervals produced better growth characters like number of secondary branches, length of primary and secondary branches, number of leaves, total leaf area, root dry weight and yield parameters like number of spikes, number of berries spike^{-1} which ultimately doubled the yield compared to the package of practices recommendation of KAU.

The above mentioned medium recorded highest nitrogen, phosphorus and potassium harvest indices, indicating that nutrient removal in bush pepper was proportional to yield. The discounted benefit-cost ratio was 2.51 with 67 % of Internal Rate of Returns indicated that bush pepper production was highly profitable following the above treatment.

2. Priming seed rhizome to enhance growth and yield of transplanted ginger

Priming seed rhizome with ethephon 200 ppm for 1 hr was found superior for better survival. Fresh rhizome yield was superior in transplants planted in the month of April. Fresh rhizome yield from seed rhizome primed with Ethephon 200 ppm was found superior irrespective of planting season. Seed rhizome primed with *Pseudomonas fluorescens, Trichoderma viridae* and hydropriming can also be recommended.

3. Survey, characterization and evaluation of clove (*Syzigium aromaticum*(L) Merr. & Perry) accessions. (SPC-01-00-01-2017-ACV (16)-KAU-PG)

The survey was carried out in the major clove growing plantations of Tthiruvananthapuram, Kollam and Pathanamthitta districts of Kerala and Kanyakumari district of Tamil Nadu, as these districts harboured the major clove population. Twenty varied accessions were selected from these locations.

Twenty one qualitative and thirty four quantitative characters were recorded. Bivariate analysis of major qualitative characters revealed major association between canopy shape and branching pattern; colour of young leaf and petal colour, sepal colour and colour of stigma; colour of mature leaf and bud size; fruit shape and seed shape. The principal component analysis undertaken reduced the thirty two quantitative characteristics to two principal components accounting for 88.8 % of total variation. Stem girth at 45 cm height and single bud weight, fresh and dry displayed high correlation with the first axis while the number of inflorescence per m^2 highly influenced the second axis indicating that these characters have an important role in clustering of clove accessions.

The results of the study indicated that by observing the qualitative characters and the minimum data set characters in the bearing the season, one can optimally sort out ideotype clove accessions. Identification of ideotype using existing data revealed accessionsBRC-1, BRC-3, MRC-5 and MRC-6 as ideotypes and can be suggested as elite accessions for further study and breeding programme.

4. Evaluation of Garlic (*Allium sativum* L.) genotypes in the high ranges of Idukki district of Kerala

Fresh bulb weight showed highly significant positive correlation with leaf width, plant girth, plant height, leaf length, equatorial diameter, polar diameter of bulb and clove length. The genotypes Yamuna Safed -3 and local cultivar were the high yielders. Considering yield and quality, the local cultivar was found to be promising over Yamuna Safed -3

Ongoing PG Projects

1. **Spatio-temporal variations and DNA fingerprinting in elite genotypes of nutmeg (*Myristica fragrans*Houtt.) - PhD Project (SPC-01-00-04-2018-VKA(16)-KAU-PG)**
2. **Standardization of package of practices for leaf coriander (*Coriandrum sativum* L.) under rain shelter -PG Project**

Name of Project Coordination Group: (03) Vegetables

Compiled by:
Dr. C. Narayanan kutty, Project Coordinator

Plan & External Aided Projects

Concluded Projects: 3 Nos.
Ongoing Projects: 5 Nos.

Post Graduate Projects

Ongoing Projects: 8 Nos.

Concluded Projects

1. Network project on development of hybrid vegetables and hi tech production technologies

Dr. I. Sreelathakumary
Professor and Head
Department of Vegetable Science, CoA, Vellayani

Twenty tomato genotypes collected from different sources were evaluated in the field to identify genotypes with high yield and bacterial wilt resistance. Based on yield and bacterial wilt resistance, six female parents and four male parents were selected for hybridization programme. The female parents selected are LE 3, LE 12, LE 13, LE 16, LE 19 and LE 20. The male parents selected are bacterial wilt resistant KAU varieties such as LE 38 (Manulakshmi), LE 39(Akshaya) LE 45 (Vellayani Vijai) and LE 53(Anagha). Hybridization was carried out in line x tester manner and 24 hybrids were produced.Out of the 24 hybrids tested, 8 hybrids *viz*., LE 13 x LE 38, LE 16 x LE 38, LE 20 x LE 38, LE 19 x LE 38, LE 16 x LE 53, LE 19 x LE 53, LE 16 x LE 45 and LE 13 x LE 45 were found superior with bacterial wilt resistance.

2. Evaluation of cherry tomato genotype(s) suitable for rain shelter and open field cultivation

Dr. I. Sreelathakumary
Professor and Head
Department of Vegetable Science, CoA, Vellayani

An experiment was conducted in Department of Vegetable Science, College of Horticulture, Vellanikkara to identify cherry tomato genotype (s) suitable for rain shelter and open field cultivation, and also to study the feasibility of cherry tomato cultivation inside rain shelter and open field. Ten genotypes of cherry tomato were evaluated in both growing conditions.

The fruit yield varied with respect to genotypes inside rain shelter. Significantly superior yield was observed in SLc-9 (425. 96 g) which was on par with SLc-2 (414. 34 g), significantly lowest fruit yield was observed in SLc-4 (214.66 g) inside rain shelter. A comparative study in open field and rain shelter showed that yield per plant was highest inside rain shelter. However higher yield was observed in SLc-2 (573.40 g) followed by SLc-9 (471.00 g) in open field. Bacterial wilt was one of the major problem observed during the cropping period. None of the genotypes were free from bacterial wilt incidence. The intensity of occurrence varied between rain shelter and open field. Incidence was more in open field. Among the ten genotypes SLc-9 showed lowest incidence of bacterial wilt inside rain shelter (29.10%) and Slc-2 in open field (57.10%).

3. Strengthening research on under exploited vegetables for adaptability and quality(State Plan)

Dr. P. Anitha, Assoc. Professor
AICVIP,CoH,Vellanikkara

As a part of the project 49 accessions of moringa and eight accessions of coccinia were collected. Two new crops viz, cluster bean (*Cyamopsis tetragonoloba*) and roselle (*Hibiscus subdariffa*) were also evaluated for their yield and adaptability as a part of this project. Thirty

five accessions of moringa which were already established and in the fifth year of planting were analyzed for their nutritive quality and yield. Nutritional components like vitamin C(mg/100g), Protein (g/100g), beta carotene(mg/100g), phenol (mg/100g), calcium (mg/100g) iron(mg/100g) were analyzed for the above accessions. Vitamin C was estimated in fresh leaf samples and the remaining all nutrients were estimated in dry samples. The content of vitamin C ranged from 160.00(mg/100g) in VKMo 11, VKMo 15, VKMo 21, and VKMo 35 to 239.90(mg/100g) in VKMo17 and VKMo 30. The content of protein ranged from 4.92 (g/100g) in VKMo6 to 15.22(g/100g) in VKMo 37.Amount of beta carotene (mg/100g) ranged from 9.38(mg/100) in VKMo 9 to 49.06 (mg/100g) in VKMo16. Amount of total calcium content showed significant variation in various accessions. Calcium content was lowest (927.25 mg/100g) in the leaves of VKMo16. Total phenol ranged from (2.70mg/100g) in VKMo 32 to 25.96(mg/100g) in VKMo 33. Iron content also showed significant variation in among accessions and the lowest content of iron was found in 12.4 (mg/100g) in VKMo8 and the highest Iron content was found in 66.4(mg/100) in VKMo 21.

The newly collected eight coccinina accessions were planted in the perennial plot along with the already existing collections. The yield ranged from 3.0(kg/plot) to 10.3(kg/plot) among the eight accessions. Yield kg/plot was recorded highest in accessions no.CG1, (10.3kg/plot), followed by CG.4 (8.8kg/plot). All the accessions were susceptible to mosaic.

In Cluster bean, a total of eighteen accessions along with two checks were evaluated for yield and reaction pests and diseases. Among the cluster bean accessions the highest yield recorded was 2075.0(g/plant) in CT 10, followed by CT15 (1975.0 g/plant). Accession CT 10 recorded more yield than the two checks viz, Pusa Navbahar and one improved selection from done at COA, Vellayani. All the accessions were susceptible to powdery mildew, thrips and mite.

Ten roselle collections were planted in the month of August, after active growth, they flowered in the month of October. Fruits with fleshy calyx were ready during December. The calyx was medium thick and fleshy and highly acidic. The highest yield as obtained in No. 10 (625.0g/plant). No serious pests and disease was observed in roselle.

A one day training program was conducted on 24/11/2018 (Saturday) m to 50 students from KAU school 'AGRI CLUB' on the topic "Role of Vegetables in Human Nutrition". The students were familiarized with with various vegetables and their role in human nutrition; various under exploited vegetables and their role in human nutrition and food security. In the practical session, they were taken to the model kitchen garden to make

familiarize them with the various vegetables and the parts used and there was a hands on session on filling of portrays for plug plant production of vegetables.

Ongoing Projects:

1. Advanced Centre for Tropical Vegetable Research - State Plan

Dr. P. Indira, Professor & Head
Dept.of Vegetable Science, CoH,Vellanikkara

Four varieties of cauliflower were transplanted inside the rain shelter during the first week of June 2018. Though all the genotypes performed well. Initially, due to the heavy rains during August 2018 curd formation was affected. But the hybrid Nanda produced good quality curd even under the flooded situation outside the rain shelter. Hence the trial has to be repeated by including more number of hybrids.

Pusa cherry tomato was planted inside the rain shelter during the second week of October 2018. Two hundred and forty plants were transplanted in a $200m^2$ rain shelter. Only 165 plants survived because of bacterial wilt incidence and viral leaf curl. The plants came to flowering within 33-35 days and harvesting started within 40-45 days after transplanting. Average fruit weight was 8gm and yield per plant was 368 gm. During next season grafting on wilt resistant root stock can be tried and the performance of the grafted plants is to be studied.

Eleven genotypes of dolichos bean were evaluated during July 2018- Jan 2019. Attukomban amara from Attapadi was also evaluated along with Hima and Grace. Maximum yield /plot was for Hima (3.92kg) followed by DL-50(2.87kg) and DL-204(2.83kg). Pod length was maximum for DL-222(13.5cm), followed by Hima (13.0cm). All the accessions were photosensitive. Among thirteen types of winged bean evaluated during July2018-Jan 2019, maximum yield/plot was recorded by Vellayani type (2.49kg) followed by Revathy (2.35kg). Fruit number was maximum for Revathy (235) followed by Vellayani type (220). PT- 62, a purple poded type was day neutral and very early also; hence it can be recommended for homestead cultivation. PT-67, a collection from Pattambi, recorded maximum fruit length (37cm).

Fifteen genotypes of Amaranth were screened against leaf spot disease during rainy season (June- August 2018). All the genotypes were susceptible to leaf spot disease and the minimum incidence was for AT 83(32%), which recorded maximum yield also (665g/plot). AT 77 recorded a yield of 640g/plot.

Eighteen genotypes of Amaranth were evaluated during October 2018 to January 2019. There were 5 plants per plot in each genotype. Yield / plot was maximum for AT 83 (860g), followed by AT 209 (850g) and AT 205 (780g). There was no leaf spot incidence for the Accession AT 82 during this season. AT 82, AT 83 and AT 209 were late flowering accessions.

Twenty genotypes of chilli and 14 genotypes of brinjal were evaluated during May- October 2018. Due to heavy rains the performance of the crops was not good. Hence their seeds were collected for next season evaluation

Twenty accessions of snake gourd are also being evaluated. They are in the harvesting stage.

2. Maximising production through conventional breeding and molecular approaches – strengthening research on vegetable breeding- Utilisation of genetic potential and management techniques to enhance vegetable production - State Plan

Dr. M.L. Jyothi, Prof. (Hort.)
RARS, Pattambi

To develop ash gourd and chilli varieties with disease tolerance, hybridiastion was done between high yielding types and accessions with commercially acceptable shape and mosaic tolerance. 45 crosses were made in the previous seasons. Segregant population from selected crosses of ash gourd were raised and selection made from F2 for disease tolerance, size and shape for further evaluation. During the year from F3 population around 50 types showing variation were selected. 15 types were further selected from this which will be evaluated. Ten chilli accessions which were showing field tolerance to viral diseases were evaluated during the year. Crosses were made between these accessions and released varieties, which will be evaluated for further selection.

Precision, management practices with organic manures for vegetables. Precision production techniques with organic manures was compared with fertigation with inorganic fertilisers. Studies were conducted in bhindi, bitter gourd, cucumber and water melon. In bhindi, cucumber and water melon yield was on par between the organic and inorganic fertigation.. Studies in bitter gourd and cucumber are to be repeated.

3.Intensification of Research on Horticultural crops

Dr. M.L. Jyothi, Prof. (Hort.)
RARS, Pattambi

F_1 hybrids of ash gourd were evaluated (12 nos) with parents of which, 7 were selected based on disease tolerance and fruit characters. Crosses were repeated and the hybrids will be evaluated for one more season. Selfing of parent materials was done and seeds collected. Selfing and seed multiplication of virus tolerant chilli accessions was done during the season.

4. Study on Structural Design and Management of Hi-tech Horticulture in Kerala

Dr. P. Suseela, Professor
IF, Vellanikkara

A design of mini polyhouse suitable for Kerala has been standardized.Multitier grow bags with composting facility suitable for growing vegetables inside the mini polyhouse have been designed.

5.Centre for High Tech Horticulture and Protected cultivation - State Plan

Dr. C .Narayanankutty,
Professor Hort, ARS , Mannuthy

Expt 1. Standardisation of agro-techniques for precision farming in commercial F1 Hybrids of Cabbage.

Experiments undertaken for 2 seasons on standardisation of precision farming in Cabbage as per approved technical programme which include combinations of fertiliser and mulching.Observations were recorded on 13 important quantitative characters viz, leaf length,

leaf width, stalk length, head length, head width, core length, plant spread, gross head weight, net head weight, no.of wrapping leaves, no. of non-wrapping leaves, total no. of leaves, and days to harvest. Data for 2 seasons were compiled and ready for statistical analysis.

Expt 2. Standardisation of agro-techniques for farming in commercial F1 Hybrids of Cauliflower

Field experiment was undertaken to standardise precision farming in Cauliflower as per approved technical programme.Observations were recorded on 10 important quantitative characters viz, leaf length, leaf width, stalk length, curd length, curd width, plant spread, gross curd weight, net curd weight, total no. of leaves, and days to harvest. Data are being tabulated.

Expt 3. Standardisation of agro-techniques for farming in commercial F1 Hybrids of Tomato

Field experiment was laid out to standardise precision farming in Tomato as per approved technical programme.Observations were recorded on 7 important quantitative characters viz, days to flowering, plant height, fruit length, fruit girth, fruit number, fruit yield and days to harvest. Data are being tabulated.

Expt 4. Standardisation of agro-techniques for precision farming in commercial F1 Hybrids of Chilli

Field experiment was undertaken to standardise precision farming in Chilli as per approved technical programme.

Expt 5. Development of F1 Hybrids in Ash gourd

10 parents were chosen out of a collection of 45 Ash gourd germplasm collected from different parts of the country. The selected 10 parents were crossed in a diallel mating design to develop 45 F1 hybrids. The 45 F1 hybrids were evaluated with their parents and 10 promising F1 hybrids were selected for further trials . The 10 F1 hybrids were evaluated with their parents during 2017 and 2018.

The F_1 hybrids P_2 x P_7, P_3 x P_4 and P_2 x P_5 which exhibited highest heterosis over top parent for fruit yield, fruits per plant, flesh thickness and fruit length with average fruit weight ranging from (1.655 to 2.04 kg) can be utilized as small fruited F_1 hybrids of Ash gourd.

Promising F1 hybrids of Ash gourd

Expt 6. Production Technology of Tomato In Poly house

Polyhouse cultivation of tomato has failed in Kerala due to high temperature coupled with high humidity. Hence efforts were made to identify indeterminate varieties with high yield and capability to produce fruits under high temperature and humidity.

Performance of tomato variety GS 600 in polyhouse (November –March, 2018-2019)

Sl No	Character	Grafted Plants		
		R1	R2	R3
1	Plant Height(cm)	780.2	748.15	765.6
2	No. of trusses	16.3	14.8	15.12
3	Fruit number	157.4	161.3	148.6
4	Fruit yield/plant (kg)	7.90	7.80	7.80

Production technology of tomato in polyhouse

Expt. 7 Root stock evaluation and field performance of grafted solanaceous vegetables

Field screening of rootstocks

Sixteen genotypes which included eight *Solanum* species, three reportedly resistant local collections of *Solanum melongena* and two wilt resistant varieties, one each in brinjal and chilli were spot planted with Pusa Ruby, a universally susceptible check variety of tomato in a wilt sick plot for two consecutive seasons. Significant differences were observed for bacterial wilt incidence among the solanaceous species, local collections and varieties. Per cent disease incidence (PDI) was worked out.

Field screening of *solanum* and capsicum root stocks for bacterial wilt

Sl. no.	Root stocks	2015-16		2016-17	
		PDI	Reaction	PDI	Reaction
1	*S. macrocarpon*	100	HS	100	HS
2	*S. viarum* Acc No: 190	100	HS	100	HS
3	*S. viarum* Acc No: 143	100	HS	100	HS
4	Brinjal Purple Round	0.33	R	0	R
5	Brinjal Green Round	3.33	R	0	R
6	Brinjal Purple Long	14	MR	16.67	MR
7	S. insanum	100	HS	100	HS
8	*S. indicum* Acc. No. 196	100	HS	100	HS
9	*S. indicum* Acc. No. 206	100	HS	100	HS
10	S. indicum Acc. No. 210	100	HS	100	HS
11	S. incanum	100	HS	100	HS
12	S. acculatissimum	80	HS	81.25	HS
13	S. sysimbrifolium	75.33	HS	83.33	HS
14	S. torvum	0	R	66.67	MS
15	Pusa Ruby	100	HS	100	HS
16	Haritha	0	R	0	R
17	Ujjwala	0	R	0	R
	CD	**5.64**		**14.64**	
	SE(m)	**1.95**		**5.06**	

HS – Highly Susceptible >70% **R – Resistant 10%**

MR –Moderately Resistant > 10 - 20% **MS – Moderately Susceptible >30-70%**

High wilt incidence (PDI) ranging from 75 to 100 per cent was observed in seven *Solanum* species viz. *S. viarum, S. indicum, S. incanum, S. insanum, S. macrocarpon, S. acculatissimum* and *S. sysimbrifolium*. Days to wilt ranged between 20 to 30 days after planting. Resistance to bacterial wilt was observed in two *Solanum melongena* collections *viz.* Brinjal Purple Round and Brinjal Green Round, brinjal variety "Haritha", and chilli cultivar 'Ujjwala'.

Artificial screening - Confirmatory screening against bacterial wilt through artificial inoculation by root dipping, media drenching and stem injection was carried out in the resistant genotypes. Genotypes showed significant differences with respect to PDI ranging from 0 - 35.56 per cent. No significant differences were observed among the three methods of inoculation.

All the four root stocks found resistant in field evaluation studies were also resistant to bacterial wilt under artificial inoculation.

Field evaluation of grafted and non-grafted plants

Efficacy of grafting susceptible hybrids on resistant root stocks was also studied. Grafted and non- grafted plants of selected hybrids of capsicum and tomato were tested in the same wilt sick plot used for field evaluation studies. All the grafted plants of capsicum hybrids showed hundred per cent resistance to bacterial wilt where as non-grafted capsicum hybrid recorded a PDI of 47.2 per cent. Yield per plant was also significantly high in grafted capsicum genotypes. Grafted tomato plants also showed the same trend with respect to wilt incidence and yield. Among the different rootstocks used, PDI was more in plants grafted on to *Solanum torvum* when compared to those grafted on the brinjal variety "Haritha".

Field performance of grafted capsicum and tomato hybrids

Crop & Genotypes	PDI(%)	Yield/plant(Kg)
Capsicum		
Indra grafted on Ujjwala	0	1.51
Bomby grafted on Ujjwala	0	1.35
Indra non-grafted	47.2	0.82
CD	**4.74**	**0.11**
SE(m)	**1.43**	**0.03**

Crop & Genotypes	PDI (%)	Yield/plant (Kg)
Tomato		
Arka Rakshak grafted on S. torvum	19.57	2.73
Arka Rakshak grafted on Haritha	7.67	1.73
Arka Samrat grafted on S. torvum	22.35	4.42
Arka Samrat grafted on Haritha	6.37	4.84
Lakshmi grafted on S. torvum	17.62	4.97
Lakshmi grafted on Haritha	9.44	3.97
Lakshmi non-grafted	65.97	3.61
CD	**3.97**	**0.41**
SE(m)	**1.27**	**0.13**

PG Projects

Ongoing PG Projects

1. **Rootstock evaluation and grafting studies in brinjal (*Solanum melongena L*)**
   Sadanand Kumbar.K(2017-12-027)

2. **Breeding for gynocey in bitter gourd(*Momordica charantia* L)**
   Minnu Ann Jose (2017-12-001)

3. **Characterization and Evaluation of drum stick (*Moringa oleifera* Lam) accessions for yield and quality**
   Anitta Judy Kurain (2017-12-002)

4. **Evaluation of herbicidal properties of horticultural crop products and by-products in organic farming ofokra [*Abelmoschus esculentus* (L.)Moench]**
   Saranya Sasikumar (2017-12-019)

5. **Standardisation of micropropagation technique in ivygourd (*Coccinia grandis* (L.) Voigt.) variety Sulabha**
   Thasni A. (2017-12-021)

6. **Performance of netted musk melon (*Cucumis melo* var. c*antalupensis* Naudin.) for growth, yield and quality**
   Shivakumara Y.B. (2017-12-026)

7. **Evaluation of bitter gourd (*Momordica charantia* L.) grafts for growth, yield and quality**
   Aiswarya V, Dev K P (2017-12-033)

8. **Generation mean analysis in yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcourt) for yield and mosaic resistance.**
   Airina C. K. (2017-22-005)

Name of Project Coordination Group: (04)
Fruits

Compiled by:
Dr. M.L. Jyothi, Project Coordinator

Plan & External Aided Projects

Concluded Project: 4 Nos
Ongoing Project: 30 Nos.

Post Graduate Projects

Concluded Projects: 5 Nos.
Ongoing Project: 19 Nos

Concluded Projects

1. **Safe agricultural practices for the management of mango hopper** (Dept. of Agriculture)

Dr. Sumiya., K.V.
Assistant Professor (Plant Pathology),
RARS, Pattambi
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The experiment was conducted in farmers' fields in Muthalamada. Emergence of mango hopper was noticed only after flowering. No hopper was observed in plots which did not flower even if the climatic conditions were the same in the plots. This indicates that emergence of inflorescence acts as a cue for insect emergence. Later increase in insect population was observed during cloudy weather.

Biocontrol agents and botanicals were evaluated for the management of mango hopper. Two sprayings were given, during flowering and 15 days after flowering. It was found that pre-flowering application of *Metarhizium anisopliae* is effective in reducing the initial population of hoppers. Results of the experiment carried out during 2017-18 and 2018-19 indicate that spraying acephate @2g/l at the time of flowering followed by azadiractin 3000ppm @ 3ml/l 15 days after first spray is equally effective as application of acephate @2g/l at flowering followed by thiomethoxam @0.2g/l 15 days after first spray for the management of mango hoppers. *Metarhizium* 20g/l and azadirachtin 3000ppm @ 3ml/l are the next best alternatives. Effectiveness of biocontrol agent, *Metarhizium* and botanical azadirachtin can be increased by reducing the interval between applications and increasing the number of sprays.

Incidence of mango hoppers



Damage caused by mango hoppers

2. Integrated management of banana pseudostem weevil (*Odoiporus longicollis*)- (AICRP on Fruits)

Dr. Gavas Ragesh, Asst. Prof.(Ag.Ent.),
BRS, Kannara
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The percent infestation, infestation index, intensity of Pseudostem weevil (%) incidences were least in swabbing chlorpyriphos 0.05% (2.5ml/litre) at 5th, 6th and 7th months after planting (12.50 percent, 0.43 and 10.94percent respectively) over untreated check. It was closely followed by stem injection with triazaphos 0.05% , 2 injections per plant @ 4 ml/plant (150 ml triazaphos in 350 ml water) at 5th , 6th and 7th months after planting) and Pseudostem trapping with EPF, *Beauveria bassiana* (1x 10^{7} spores/ml) 15 g/trap at 5th ,6th and 7th months after planting.

Biointensive management option of pseudostem trapping with EPF, *Beauveria bassiana* also recorded the lowest number. Maximum infestation (3.47) was in Control.

Swabbing chlorpyriphos 0.05% (2.5ml/litre) at 5th, 6th and 7th months after planting), stem injection with triazaphos 0.05% , 2 injections per plant @ 4 ml/plant (150 ml triazaphos in 350 ml water) at 5th , 6th and 7th months after planting) and pseudostem trapping with EPF, *Beauveria bassiana* (1x 10^{7} spores/ml) 15 g/trap at 5th , 6th and 7th months after planting), recorded the highest bunch weight of 12.44 kg, 12.03 kg and 11.45 kg respectively, which were significantly higher than the untreated control plants.

The above results proved that Swabbing chlorpyriphos 0.05% (2.5ml/litre) at 5th, 6th and 7th months after planting and pseudostem trapping with EPF, *Beauveria bassiana* are suitable chemical and biointesive management options for the control of pseudostem weevil infestations.

3.Biorationals for the management of nematodes of banana - (AICRP on Fruits)

Dr. Gavas Ragesh, Asst. Prof.(Ag.Ent.),
BRS, Kannara
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Among the biorational nematode management options, the least root necrosis was recorded in the application of *Paecilomyces lilacinus*@ 25g/ plant (63.16 % and 69.23 % at vegetative and shooting stages respectively). This was on par with the treated check *i.e.*, cartap hydrochloride @ 10g/ plant (64.91 % and 74.51 % at vegetative and shooting stages respectively). Application of *Bacillus subtilis* @ 25g/ plant) and *Pseudomonas fluorescens* @ 25g/ plant, recorded the lowest root necrosis at vegetative stage (62.58%) and shooting stage (62.97%) respectively.

Among the biointensive management options, application of *Paecilomyces lilacinus* @25g/plant effectively reduced the nematode population in both soil and root when observed in vegetative and shooting stages of the banana cv. Nendran. There were 46.84 % and 50.95 % reduction of soil population in vegetative and shooting stages respectively, and 61.12% and 50.70 % reduction of root population in vegetative and shooting stages respectively.

The above results were on par with the treated check *i.e* cartap hydrochloride @ 10g/plant. The treatment recorded significantly least number of nematode populations both in 250 cc soil and 10 g roots. It could bring 51.20 % and 59.95% reduction of soil population in vegetative and shooting stages. Similarly 70.00 % and 62.44% reduction of root population in vegetative and shooting stages was also observed.

Plant height was significantly higher in treated check, cartap hydrochloride @ 10g/ plant, closely followed by others except in *Bacillus subtilis* @ 25g/ plant. Lowest plant height was recorded in untreated check. Plant girth were on par among the treatments but significantly higher than control.

Bunch weight showed significant differences with highest values recorded in biointensive management option of application of *Paecilomyces lilacinus* @ 25g/ plant (12.00 kg) which was on par with treated check (cartap hydrochloride @ 10g/ plant (12.84 kg) and closely followed by EPN, *Heterorhabiditis bacteriophora* @ 1 x 10^7 1Js/ml). The least bunch weight was recorded in untreated control (9.72 kg).

It could be concluded that application of *Paecilomyces lilacinus*@ 25g/ plant was the effective biorational method in reducing the nematode population, increase in the plant growth parameters

and bunch weight and these were on par with standard treated check, *viz.* application of cartap hydrochloride @ 10g/ plant.

4.Management of banana skipper butterfly-Erionota torus -(AICRP on Fruits)

PI: Dr. Gavas Ragesh, Asst. Prof.(Ag.Ent.), BRS, Kannara
email id: gavas.ragesh@kau.in

Foliar application of chlorantraniliprole (18.5 SC) @3ml/ 10 l with first spray before the onset of rainy season and thereafter three foliar applications at monthly intervals effectively reduced the banana skipper butterfly population. Among the biological control methods, foliar application of Bt @ 3ml/l ($1x10^{t8}$cfu) was better.

Ongoing Projects

1. Collection, characterisation, conservation, evaluation and utilization of germplasm in Banana - (AICRP on Fruits)

Dr. P. B. Pushpalatha,
Professor (Hort.),
BRS, Kannara

During the period one primary collection was made from Thrissur district, Kerala and its characterization is going on. Total of 236 collections are maintained in the germplasm. This include: AA-32, AAA- 29, AAAA-1, ABBB – 11, BRS Hybrids- 6, Exotic hybrids-15, AAB - 73, AB – 14, BB-7, ABB - 45.

Accessions characterised during the year are Borkal baista (BB), Makkale Potty (AAB) Progeny No. 5 (Karpooravalli x PisangJajee) ABBB, Tjau Lagada (AA), Simili Radjah, Mannan, Progeny No. 6 (Karpooravalli x Pisang Jajee) ABBB, Progeny No.95 (Udhayam x Chengdawt) ABBB.

Total numbers evaluated till end of reporting period are AA- 28; AAA- 27; AAAA- 1; BRS Hybrids- 6; Exotic hybrids- 15; AAB - 71; AB – 14; BB-6; ABB- 45

Quality evaluation

TSS of the varieties ranged between 18 to 32^{o} brix, the maximum was recorded for Pachakappa, Karivazha, Chinia, Ankur, Fougamu and PA 03 22. Maximum total sugar was recorded for Fougamu (25.45%), followed by Ankur (24.56%). Lowest sugar content was for Bangrier (8.53%), followed by TMB 3 x 15086 (8.75%). Fruit acidity ranged between 0.14 % (Lacatan) to 0.68% (Pisang Radjah).

Among the varieties evaluated, Nendran recorded the highest carbohydrate content of 32.0%, followed by Kunnan (30.67%). Popoulu and Kunnan had the highest protein content of 2.6%. Total sugar varied from 1.20% in Popoulu to a maximum of 4.40% in Blue Torres Straight Island. Acidity among the varieties ranged between 0.22% (Popoulu) to 0.54% (Palayankodan).

Maximum fibre yield was recorded for FHIA 3 (2.19% fibre recovery), followed by TMB x 5295-1 (1.45%). Fibre yield was comparatively less for Kunnan, Karpooravalli and Monthan (0.26 to 0.36%). Popoulu recorded a fibre yield of 1.05%, while the fibre recovery of most of the commercially cultivated banana varieties like Nendran, Big Ebanga, Chenkadali, Dwarf cavendish and Grand Naine ranged from 0.6 to 0.8%.

Grand Naine recorded the highest juice recovery of 70% where as Pisang Lilin had the lowest (20%). Sensory attributes of juice from Pisang Lilin was very good compared to other accessions studied.

Number of collection so far utilized along with names and specific purpose for which utilized

a. Accessions suitable for pseudostem sweetened juice : Palayankodan (AAB), Nendran (AAB), Popoulu (AAB), Grand Naine (AAA), Kadali (AA), SH-3640.
b. Accessions suitable for pseudostem and rhizome pickle: Palayankodan (AAB), Popoulu (AAB), Kluai Namwa Khom (ABB), Poovan (Rasthali, AAB).
c. Accessions suitable for pickling and as vegetable : Male flower of Yangambi km5 (AAA) and SH-3640.
d. Accessions suitable for fibre extraction –Palayankodan (AAB), Nendran (AAB), Grand Naine (AAA), Kunnan (AB).
e. Accessions suitable for preparing banana flour –Popoulu (AAB), Nendran (AAB), Kunnan (AB),KudapanillaKunnan (AAB), Rasthali (AAB). The end use of flour is under evaluation.
f. Accessions suitable for for making cakes and cookies: Popoulu (AAB), Nendran (AAB) and Kunnan (AB) flour ideal
g. Accessions suitable for making flavored chips : Popoulu (AAB), Grand Naine and SH 3640 raw fruits.
h. Accessions suitable for fruit juice – Grand Naine, Karpooravalli and Palayakodan (Poovan)
i. Accessions suitable for wine : Palayankodan, Karpooravalli, Red banana
j. Accessions suitable for halwa and payasam – All plantain varieties in the germplasm
k. *For Breeding/hybridization work* - Matti, Cultivar Rose, Pisang lilin, Pisang Jajee, *Musa acuminata* ssp. *malaccensis*, Borkal baista, Calcutta4

2. Clonal Selection in banana -(AICRP on Fruits)

Dr. P. B. Pushpalatha, Professor (Hort.),
BRS, Kannara

Nine Nendran (AAB) clones and six clones of Rasthali (Poovan, AAB) collected from various parts of Kerala during the reporting period has been established in the field and evaluation is being carried out.

Eight clones of Rasthali collected and conserved in the germplasm were evaluated for different quantitative and qualitative characters. Clones were characterized for vegetative, floral, bunch and fruit characters based on IPGRI descriptor. They differed significantly for all characters except in number of suckers per plant.

Among the clones, 2017 1KA PC 2017 (Venneer poovan) recorded the maximum bunch weight of 9.90 kg per plant, which was on par with 2017 8KA PC 2017 (Poovan, Kottarakkara) , 2017 2KA PC 2017 (Valiya poovan) and 2017 5KA PC 2017 (Martaman). Hands per bunch (8.44) as well as fingers per bunch (133.61) was also maximum for the clone 2017 1KA PC 2017 (Venneer poovan). 2017 2KA PC 2017 (Valiya poovan) recorded the maximum finger weight (92.60 g), finger length (13.93 cm) and finger girth (12.47 cm).

2017 8KA PC 2017 (Poovan, Kottarakkara) recorded the minimum plant height of 230.00 cm which is 54 to 63cm shorter than the existing clones, 2017 2KA PC 2017 and 2017 3KA PC 2017. 2017 8KA PC 2017 (Poovan, Kottarakkara) was the earliest in bunching (242.83 days), which was on par with 2017 7KA PC 2017 (Poovan, Pullani), 2017 2KA PC 2017 (Valiya poovan) and 2017 3KA PC 2017 (Cheriya poovan). Days to harvest was least in 2017 8KA PC 2017 (97.42 days) and 2017 7KA PC 2017 (100.50 days), and hence they were the earliest in harvest (340.25 and 347.75 days respectively), compared to the rest of the clones. Maximum TSS (27.50 °B), total sugar (23.65%) and minimum fruit acidity (0.13%) was observed in 2017 8KA PC 2017 (Poovan, Kottarakkara).

Organoleptic analysis revealed that mean score for taste, texture, sweetness, flavour, colour and overall acceptability of fruits were highest in 2017 5KA PC 2017 (Martaman), followed by 2017 8KA PC 2017 (Kottarakkara collection). Lowest mean score for sweetness, flavour, overall acceptability and taste were observed in Cheriya Poovan. Colour and texture were minimum in Venneer Poovan.

Considering yield, quality and organoleptic characters, Martaman (2017 5KA PC 2017) as well as Kottarakkara collection (2017 8KA PC 2017) were the best. However Kottarakkara collection (2017 8KA PC 2017) had a shorter stature (118 cm shorter) than the other which makes it suitable for cultivation in wind prone areas.

3. Evaluation of new introductions of banana (MLT – 2) -(AICRP on Fruits)

Dr. P. B. Pushpalatha, Professor (Hort.),
BRS, Kannara

BRS selection Popoulu vs. Manjeri Nendran and Nendran

Bunch weight was significantly higher in Popoulu (15.91 kg/ plant), followed by Manjeri Nendran (13.35 kg/ plant) and Nendran (10.69 kg/ plant). An additional yield of 19.2% was obtained from Popoulu compared to Manjeri Nendran. This can be attributed to higher hands per bunch (6.78) and finger weight (217.72 g) in Popoulu than Manjeri Nendran (6.06 and 184.19g

respectively) and Nendran (5.65 and 174.35 g respectively). Finger girth (17.70 cm) and pulp weight (156.61 g) was also significantly higher in Popoulu than the local checks. TSS and shelf life after ripening was on par among the three varieties. Popoulu also had the maximum B:C ratio of 2.65.

Days to bunching in Popoulu (241.25 days) was on par with Nendran (235.14 days) but early than Manjeri Nendran (280.98 days) by almost 40 days. Earliness in bunching has resulted in early harvest as well. Popoulu came to harvest 58 days early than Manjeri Nendran. Days to harvest (bunching to harvest) was significantly shorter in Popoulu. While Manjeri Nendran and Nendran recorded 89.55 and 85.84 days respectively from bunching to harvest, popoulu took only 64.40 days for the same.

Pseudostem girth in Popoulu was significantly higher than Manjeri Nendran and Nendran. It is much more rigid than the local Nendran checks and hence propping, which is a high investment cultural practice followed in Nendran could be avoided for growing Popoulu.

Reaction to *Eumusae* leaf spot shows that Popoulu is tolerant to the disease with an infection index of 13.24 which is on par with Manjeri Nendran (12.98), but significantly different from Nendran, a susceptible variety with 23.48 infection index. Popoulu has high in carbohydrate and mineral content than other varieties.

NRCB Selection 10 Vs. Karpooravalli

NRCB Selection 10 registered a significantly higher bunch weight (17.82 kg/ plant) than local check Karpooravalli (14.10 kg/plant) giving an additional yield of 26%. Finger weight (119.06g), finger girth (13.28 cm) as well as pulp weight (81.75g) was also higher in NRCB Selection 10 than local check (84.22g, 11.38 cm and 55.50g respectively). Days to bunching was early in NRCB Selection 10 by 32 days than local check. Similarly, earliness in harvest by 27 days was observed in NRCB Selection 10 compared to Karpooravalli.

NRCB Selection 10 had a plant height of 2.49m which is shorter by 1.15m than local check Karpooravalli (3.64m). Hence this variety could be recommended for wind prone areas. Leaves per plant (13.78) and leaf area in NRCB Sel 10 (17.31 m^2) is significantly higher than Karpooravalli (12.01 and 14.09 m^2 respectively). TSS and shelf life after ripening is on par among the two varieties. NRCB Sel. 10 recorded significantly less incidence of Eumusae leaf spot with an infection index of 14.55 compared to Karpooravalli (19.85). Both introduced banana varieties *viz*., BRS Selection Popoulu and NRCB Selection 10 outperformed their local checks. The experiment has been continued for the second season (PC2).

4. Evaluation of the field performance of the macro-propagated plants of banana- (AICRP on Fruits)

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Macropropagated plantlets Vs Sucker – Grand Naine and Nendran

Macropropagated plants performed better compared to suckers in banana varieties Grand Naine and Nendran. Macropropagated plants of Grand Naine recorded a significantly higher bunch weight of 28.29 kg/ plant (70.73 t/ha) than sucker plants (18.13 kg/plant and 45.33 t/ha). In Nendran, macropropagated plants recorded a significantly higher bunch weight of 12.25 kg/ plant (30.62 t/ha) than sucker plants (9.78 kg/plant and 24.46 t/ha).

Increased bunch weight and yield in macropropagated plants is attributed to significantly higher hands per bunch and fingers per bunch in both Grand Naine and Nendran compared to sucker derived plants. They also recorded better pulp weight and TSS. There was no significant difference for shelf life and fruit acidity among the treatments.

Growth parameters, finger characters as well as reaction to Eumusae leaf spot was found on par among macropropagated plants and suckers.

Macropropagated plants (secondary seedlings) can be effectively used for the propagation of banana varieties Grand Naine and Nendran and was also found to perform better with respect to yield compared to suckers.

5. Evaluation of BSV free (Episomal BSMYV) tissue culture banana cv. Poovan

PI: Dr. P. B. Pushpalatha, Professor (Hort.),
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Tissue culture bananas (Poovan) were evaluated for the occurrence of streak disease at all growth stages, compared to Local poovan (suckers). One out of 72 TC plants and two out of 72 suckers was infected. The samples of the same were sent to NRCB, Trichy for confirmation. Observations were recorded with respect to growth as well as yield parameters. Tissue Culture plants of Poovan recorded significantly higher bunch weight (13.40 kg/plant), hands per bunch (8.75) and fingers per bunch (126.88) compared to suckers (11.66 kg/plant, 8.25 and 104.00 respectively). They were also early in bunching (285.80 days) and harvest (351 days) compared to suckers (294.40 and 442.00 days respectively). No significant difference was observed among the treatments with respect to growth parameters like plant height and stem girth.

6. Assessment of phenology, productivity and incidence of insect pests and diseases in banana grown under varying climatic conditions - (AICRP on fruits)

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During the reporting period a total rainfall of 3452.3 mm was received, around 1066 mm more than the corresponding previous year (2385.8 mm). The month of August alone received a quantum of 928mm rainfall, out of which 543mm was received during August 15th to 17th, resulting in flooding. Plants which were in bunch development stage toppled due to rotting of rhizome as a result of anaerobic conditions manifested by flood. Those which survived after flood was also affected due to rhizome rot caused by *Erwinia*. The post harvest quality of the bunches were affected badly. Blackening of fruits was noticed as a result of rupture of cells in fruits while expelling excess moisture. Subsequent ripening was also affected. In general, diseases like Eumusae leaf spot, Fusarium wilt, pseudostem rot and rhizome rot was high compared to the previous year. Among the insect pests, the population of Banana skipper butterfly (*Erionota torus),* slug caterpillar *(Miresa decedens),* pseudostem weevil (*Odoiporus longicollis*), banana mites (*Tetranychus sp.,* and *Oligonychus sp.*) and aphids (*Pentalonia nigronervosa*) increased over the previous year. Changes in phenology, pest and disease incidence in banana due to flood is being investigated.

Comparison of weather data with 30 years long term average indicated a rise in temperature (max) by 1.0 to 1.9 °C after the southwest monsoon months from October to December, a decline in minimum temperature up to 2.2 °C during May, and an increase in rainfall amounting to 663 mm compared to the previous 30 years average.

***7.* Enhancing input use efficiency in banana (AICRP on Fruits)**

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The treatment *viz:* drip irrigation + fertigation + micronutrient foliar spray (Banana Shakti 2%) + SOP bunch spray (2%) recorded the maximum bunch weight (27.45 kg/plant) and yield (84.70 t/ha), with a B:C ratio of 3.15. The same treatment also had the maximum hands per bunch (9.48), fingers/ bunch (160.06), finger weight (165.97 g), finger length (23.15 cm) and finger girth (13.78 cm).This gives an additional yield of 37.7 % compared to control (19.94 kg bunch weight/plant and yield 61.54 t/ha). Drip irrigation + Fertigation + Micronutrient foliar spray (2%) + SOP bunch spray (2%) + Polyethylene mulching was the earliest in bunching (184.95 days) and harvest (269.93 days), which was on par with treatment drip irrigation + fertigation + micronutrient foliar spray (Banana Shakti 2%) + SOP bunch spray (2%). The earliness in the best treatment was by 24 days compared to control which had a crop duration of 299.62 days. With respect to fruit quality characters, drip irrigation + fertigation + micronutrient foliar spray (Banana Shakti 2%) + SOP bunch spray (2%) had significantly higher TSS (22.34 °B) and shelf

life (6.38 days) compared to control. The treatment drip irrigation + fertigation + micronutrient foliar spray (Banana Shakti 2%) + SOP bunch spray (2%) was found to be the best treatment with respect to bunch weight, yield, quality and B:C ratio.

8. Assessment of post-harvest loss in banana (AICRP on Fruits)

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Post harvest loss at farm level, during transportation, wholesale market, retail market, storage/ripening was assessed drawing a fixed quantity of produce at random. The observation was pooled and average worked out. The stage of the crop at harvest was 90% maturity of the crop. The produce was traced as per the information provided by the farmer, wholesaler and retailer, till it reaches to the consumer.

Post harvest loss in Nendran – at a glance (Thrissur & Palakkad)

S.No	Content	Thrissur District (%)	Palakkad District (%)
1	Loss in field level (%)	1.10	2.28
2	Loss during transport (%)	2.38	3.50
3	Loss during assembly market/wholesale market (%)	6.05	7.25
4	Loss during storage and ripening (%)	-	-
5	Loss during retail market (%)	8.29	8.63
	Total loss (%)	**17.82**	**21.33**

Post harvest loss assessment was done only from April to June 2018. During July - August, 2018, abnormal rainfall and resultant flood caused crop loss of more than 90%. Hence, the realistic estimate of post harvest loss could not be done during the major harvesting season of Nendran. The average values given in the table is based on the data from April to June 2018.

9. Performance evaluation of local banana cultivars of southern Kerala under coconut- (State plan)

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The experiment was conducted to find the cultivar suitability of banana under coconut and to study the performance of various indigenous cultivars of Southern Kerala. Banana varieties *viz*., Red banana, Pachavettan, Rasakadali, Nendran, Kadali, Palayankodan, Padathy, Annan, Psiangilin, Monthan, Karpooravally, Peyan, Sannachenkadali, Ambalakadali, Matti, Poovan, Koombillkannan, Malayannan and Karimkadali were evaluated. Among the table cultivars, highest bunch yield was obtained from Red banana followed by Karpporavally. Number of hands and number of fingers

were found to be more in Palayankodan and Karpooravally. Among the culinary cultivars, Monthan recorded the highest bunch weight.

Among the local banana cultivars evaluated for quality parameters Karimkadali recorded the highest total sugar and reducing sugar percentage and the lowest in Matti. Non reducing sugar content percentage was found to be the lowest in Pachavettan and the highest in Nendran cultivar. TSS content was found to be the highest in Nendran and the lowest in Matti. Ascorbic acid content was found to be the highest in the cultivar Karpooravally and the lowest in Njalipoovan. Among the two culinary cultivars, Peyan recorded the highest total sugar percentage, reducing and non-reducing sugar percentage. Ascorbic acid content was found to be the highest in Monthan.

10. Bioversity international project on 'Improvement of banana for small holder farmers in the great lake region of Africa (Indian component – Breeding for improved banana with Fusarium wilt resistance'

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BRS, Kannara, KAU has been involved in screening germplasm for resistance / tolerance to *Fusarium* wilt. Seventeen diploid banana accessions were screened by artificial inoculation of *Fusarium oxysporum* f. sp. *cubensi* (FOC). The accessions were raised in sterile soil in pots.

The result of artificial screening based on the symptom appeared in rhizome showed that the disease incidence ranged between 0 to 100 per cent and the disease severity (Disease Index) ranged between 16.7 to 83.3 per cent. The accession, Cultivar Rose (AA) recorded zero per cent incidence and the lowest disease index (16.7). Seven accessions *viz.*, Pisang Jaribuaya (AA), Njalipoovan (AB), Pisang Jajee (AA), Sanna Chenkadali (AA), Kunnan (AB), Elavazha (BB) and Beejikela (BB) recorded 100 per cent incidence and disease index in the range of 33.3 to 83.3 per cent. Based on the disease index, the accessions were classified in to three groups; those with disease index <30, 30- 60 and > 60. The accessions with disease index < 30 are Cultivar Rose (16.7), Tongat (23.33), Calcutta 4 (23.33), Erachivazha (25), Pisang Madhu (23.33) and Pisang Lilin (28.6). The accessions with disease index 30 – 60 are Anaikomban (30), Matti (30.6), Type 2X (33.3), Sanna Chenkadali (33.3),
Pisang Jaribuaya (33.3) and Pisang Jajee (35.7). The accessions with disease index > 60 are Poomgalli (63.3), Kunnan (66.7), Beejikela (75), Njalipoovan (80.6) and Elavazha (83.3).

11. Station wise funding on on-going research projects and minor infrastructure support (State plan)

a. Sub Project 1. 'Strengthening infrastructure facility for fibre extraction, processing and value addition

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Maximum fibre yield was recorded for FHIA 3 (2.19% fibre recovery), followed by TMB x 5295-1 (1.45%). Fibre yield was comparatively less for Kunnan, Karpooravalli and Monthan (0.26 to 0.36%).

b. Sub Project 2. 'Entomopathogenic nematodes (EPNs) for the management of pseudostem weevil of banana'

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Developed a separate area for mass multiplication of EPN. Platform and cages were installed for rearing EPN. The most effective concentration of the pure culture/ populations of EPN in various formulations will be compared for the management of Pseudostem Borer (PSB).

c. Sub Project 3. 'Development of health proactive powder mixes and nutritive delicacies based on raw and ripe banana'

Dr. P. B. Pushpalatha,
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Among the varieties evaluated, Nendran recorded the highest carbohydrate content of 32.0%, followed by Kunnan (30.67%). Popoulu and Kunnan had the highest protein content of 2.6%. Total sugar varied from 1.20% in Popoulu to a maximum of 4.40% in Blue Torres Straight Island. Acidity among the varieties ranged between 0.22% (Popoulu) to 0.54% (Palayankodan).

Evaluation of Kunnan based proactive infant food

Evaluation of Kunnan powder for nutritional composition proved that Kunnan contains a fairly good amount of total carbohydrates (30.67%), minerals like potassium, iron, magnesium and phosphorus. Potassium and calcium are the minerals which are highly required for the growth and development of infants and hence an infant food was tried with Kunnan powder supplementing the protein with different pulses like bengal gram, ground nut, green gram and soya chunks in different combinations.

Evaluation of the powder mixes as infant food

On organoleptic evaluation the best combination for infant food was a combination of Kunnan powder 50 g supplemented with soya chunks (5 g), Bengal gram (10 g), ground nut (5 g), green gram (10 g), sugar (10 g) and corn flour (10g).

12. Survey on emerging insect pests of banana- (AICRP on Fruits)

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Twenty one different insect and non-insect pests were observed infesting banana in Kerala during the survey period (April, 2018- March, 2019). Pseudostem and rhizome weevils, the major banana pests, were observed in all the surveyed areas with high incidences in cv. Nendran. Slug caterpillar *(Miresa decendens)* turned out to be a pest of concern and serious defoliator during monsoon and post monsoon. Severe defoliation by slug caterpillars were seen in Nendran plots in Ernakulam, Thrissur and Kottayam and pockets of Palakkad district, causing 5-40% damage to leaves. Similar heavy incidences of leaf caterpillar (*Spodoptera litura*), was also seen in banana grown in rice fallows in surveyed areas of Thrissur, Ernakulam and Kozhikode districts. Banana skipper butterfly (*Erionota torus*) was observed at Thrissur, Wayanad, Idukki, Alappuzha and Kottayam districts on cv. Nendran in the monsoon and later it was recorded from parts of Palakkad Wayanad and Kottayam districts of Kerala during February and March, 2019.

Infestations of sucking pests *viz.*, mealy bug (*Ferrisia virgata*), white flies *(Dialeurodicus disperses),* banana spittle bugs (*Phymatostetha deschampis)* were recorded. Invasive pest, Rugose spiraling whitefly, *Aleurodicus rugioperculatus* Martin is now emerging as pest of concern in coconut-arecanut-banana intercropping system and high incidences were recorded from Thrissur, Palakkad, Wayanadu and Ernakulam districts.

There were heavy infestation of Banana Leaf Thrips (*Helionothrips kadaliphilus*) and Lace wing bugs (*Stephanitis typicus*), with clear feeding damage symptoms by these pests in the surveyed areas of Malappuram, Thrissur, Palakkad, Alappuzha, Kozhikode districts. During summer months (second half of February and March) heavy incidences of leaf thrips, lacewing bugs, white flies and mites were reported from across Kerala. Red spider mite infestation was observed from Thrissur, Palakkad, Malappuram, Idukki and Kozhikiode districts.

High incidences of Yellow spotted locust; *Aularches miliaris* (20-45% plant infestation) from Kollam district was recorded. Both nymphs and adults were observed damaging the whole leaves.

Coconut rhinoceros beetle infestation was high in banana cv. Nendran on pseudostem from central Kerala, causing large bore holes.

Slug caterpillar *(Miresa decendens*) on cv. Nendran and Njalipoovan in monsoon period and banana leaf thrips (*Helionothrips kadaliphilus*) and lace wing bugs (*Stephanitistypicus*), along with Rugose Spiralling Whitefly in summer months are emerging as pests of concern in Kerala. Coconut Rhinoceros beetle infestation was on rise in banana cv. Nendran from central Kerala.

13. Survey of plant parasitic nematodes associated with banana (AICRP on Fruits)

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Survey of nematode pests of banana was conducted across the state of Kerala for *Radopholus similis, Pratylenchus* sp., *Helicotylenchus multicinctus, Meloidogyne* sp. and *Heterodera oryzicola*. Major banana nematodes *viz., Meloidogyne incognita, Radopholus similis, Helicotylenchus multicinctus and Pratylenchus penetrans* were recorded from surveyed areas. Severe infections of burrowing nematodes were recorded from Ernakulam district leading to decay and death of roots, yellowing of leaves, stunted growth and in some cases toppling of banana plants. Similarly high incidences of *Meloidogyne spp.* was observed in banana monoculture or in banana plants intercropped with vegetables. In Thiruvananthapuram district, *M. incognita* was predominant whereas *M. javanica* was predominant in Idukki. Banana spiral nematode, *Helicotylenchus multicinctus* was more in districts of central Kerala. The incidence of *Pratylenchus coffea* was more at Thrissur, Ernakulam, Malappuram and Kozhikode (Central and North Kerala), Idukki, Kottayam, Wayanad and Alappuzha districts. *Radopholus similis* was observed to heavily infest banana roots along with *Pratylenchus sp.* in Ernakulam and Thrissur Districts.

Incidences of Root Lesion Nematode (*Pratylenchus coffea*), burrowing nematode (*Radopholus similis*) and Root Knot nematode (*Meloidogyne spp.*) were on rise in banana cultivated areas. In central Kerala, nematode-disease complex was observed in sandy loam soils.

14. Diagnosis of banana viruses in germplasm and planting materials used in experiments. (AICRP on Fruits)

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Out of 260 germplasm accessions, four accessions were infected with BBTV, eight accessions were infected with BBrMV, one accession was infected with CMV and two accessions Mottapoovan and Alpan were infected with BSV. In TC planting materials of major cultivated varieties, infection of BBTV, BBrMV and CMV was 5. 65%, 7.55% and 6.08 % respectively.

15. Management of sigatoka or Prevalent leaf spot disease with oil based formulations- (AICRP on Fruits)

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The per cent disease index (PDI) and youngest leaf spotted (YLS) were on par for all treatments at 6 MAP where as it was significantly different at flowering. At flowering, the PDI was reduced by 28.49 to 53.52 per cent over control by the treatment application. The alternation of

chemicals with mineral oil is the most effective treatment for management of Eumusae leaf spot There was no significant difference between treatments in vegetative and yield characters.

16. Survey for fungal, bacterial and virus disease of banana. (AICRP on Fruits)

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No new diseases were recorded during the period under the report. The incidence of Emmusae leaf spot, Fusarium wilt, rhizome rot and viral diseases was more in the current year compared to last year. This may be due to favourable weather condition (well distributed rainfall, high temperature), varietal susceptibility and ratoon cropping and intensive cultivation. Major diseases of banana observed in the survey were Emmusae leaf spot, Fusarium wilt, rhizome rot, banana bract mosaic and bunchy top and infectious chlorosis.

17. Collection, conservation and evaluation of pickling mangoes (State plan)

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Tender mango and cut mango pickles were prepared from 13 and 18 pickling mango accessions respectively. Based on organoleptic evaluation, 7 accessions were rated as good for tender mango pickling and 10 for cut mango pickling. 4 accessions were good for both tender mango and cut mango pickle preparation. 45 accessions flowered in Jan. – Feb., 2019 and observations are being recorded on fruit characters. Tender mango pickles and cut mango pickles were prepared from 15 and 41 accessions respectively, which are to be evaluated.

18. Evaluation of native/indigenous mango varieties of Kerala (State plan)

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Collection, evaluation and maintenance of indigenous mango varieties in the existing germplasm of COH,Vellanikkara is continued

Objective of the experiment was to analyse variability of indigenous mango varieties available in Kerala and to develop a database for indigenous varieties of mango available in Kerala. A preliminary survey was conducted in Elanad, Chelakkara, Pazhayannur areas in Thrissur district, Vaniyankulam, Ottapalam, Muthalamada, Kollencode areas in Palakkad district and also in Mundamveli, Cheranalur areas in Ernakulam district for locating native mango varieties. Five native types were collected from RARS Kumarakom (Kumarakam selection, Kainadi, Polachira, Pallikuduma, Karuthakappa) and Kurukkan from Chelakkara and planted as a separate block.

The native/indigenous types already present in the mango and college orchard are maintained for further studies and for producing planting materials.

19. Survey, collection, establishment and maintenance of superior lines of traditional mango variety Karpooram in southern Kerala (SHM)

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Traditional mango variety *Karpooram* is found mainly in the homesteads of southern Kerala viz. Kollam, Pathanamthitta, Thiruvananthapuram, districts. The fruit of this variety has a characteristic flavor of *Karpooram*. This is a table variety with medium to large fruit size, high pulp content, less fibrous flesh compared to other traditional mango varieties. Fruits of Karpooram mango is having high consumer acceptability and fetches high price in market. Fruit weight varies from 250g to 675g. The tree is moderately vigorous with spreading habit . It is a regular bearer. It normally flowers during January-February (mid season flowering) and off season flowering (secondary flowering) was seen in some of the plants . The skin colour is green with brown spots .Oil glands are present on the rind. The fruit is highly susceptible to fruit fly infestation.

Survey in 69 panchayaths spread across 11 blocks in Kollam district, 53 panchayaths spread across 8 blocks in Pathanamthitta district, 11 blocks in Thiruvananthapuram district were completed in the year. Farmers having Karpooram variety of mango has been inventoried. During survey, a good number of Karpooram mango trees were located in Kollam district but reverse situation exists in Pathanamthitta and Thiruvananthapuram districts where population of this variety is seen less and trees are becoming extinct from homesteads

20. Collection, characterisation, conservation, evaluation and utilization of jackfruit germplasm -(AICRP on Fruits)

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The survey was conducted at Thrissur, Wayanad, Palakkad and Idukki districts to identify jackfruit types with early bearing characters, extended cropping period, high yield with more number of attractive flakes. The flake characters considered were their weight and colour. The suitability for product preparation was also studied. During 2018-19 30 accessions were collected and 32 characterized. 22 accessions were conserved in the field gene bank. A few accessions were lost during the flood, 2018. Attempts are being made to conserve them through fresh planting.

Among the 22 accessions identified from different parts of Kerala, four (KJ – 10/18, KJ – 11/18, KJ – 12/18, KJ – 14/18) were early bearing types, collected from Wayanad district. Three accessions, KJ – 27/18, KJ -28/18 and KJ-4/15 were identified as all purpose type. Two accessions KJ-29/18 and KJ-4/15 possess coppery red and orange red flakes respectively. Chips recovery as high as 68% was recorded for the accession KJ-25/18. Accessions KJ-11/18, 14/18,

15/18, 16/16, 17/18, 19/18, 20/18, 21/18, 22/18, 23/18, 24/18, 27/18 has chips recovery more than 50%.

A jack fruit type KJ – 10/18 from Wayanad (Poothady panchayath) recorded maximum fruit weight (32.4 kg) among the collections made during 2018. This was due to more flakes per fruit (983) and seeds per fruit (958). The lowest fruit weight was for KJ -25/18 (2.35 kg). Weight of flake with seed was maximum for accession KJ 26/18 (10.90 g).
During 2018, 14 jack types (KJ – 1/18 to KJ – 14/18) were characterized using IPGRI descriptor for jack fruit. The fruit characters of KJ – 1/18 to KJ – 9/18 is to be characterized in the current fruiting season.

21. Varietal trial on jackfruit - (AICRP on Fruits)

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Significant difference in vegetative characters of different varieties was noticed. Maximum trunk height (8.82 m) was recorded for Velipala, followed by Pechiparai 1 (8.42 m). Maximum canopy height was for Pechiparai 1 (2.72 m) and Palur 1 recorded the minimum (1.84 m). Spreading (both East- West and North- South) was maximum for Pechiparai 1 and the canopy volume was also high for this variety. Gumless jack recorded lowest spreading and canopy volume.
Konkan prolific and Muttom Varikka started bearing during 2019. One fruit in Muttom Varikka and two fruits in Konkan Prolific was recorded. Maximum height recorded was for G-11a (399.61cm). Girth of stem was maximum for Sindoor (19.97 cm) which was on par with G-11a. The variety Sindoor also had maximum plant spread (160.15 EW and 159.12 NS respectively).

22. Survey for new and emerging insect pests of jackfruit- (AICRP on Fruits)

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Macrochenus isabellinus Aurivillius, 1920 (Coleoptera: Cerambycidae) was recorded as a new pest and pest of concern of jackfruit *Artocarpus heterophyllus*. Insect cage studies revealed that these hardy beetles have 2-5 generations per year. The adult beetles feeds extensively on the leaves of medium maturity, leaving large shot holes, leading to shoot death. The females lays eggs beneath the bark on Primary and secondary braches. The life cycle of the beetle was 7-10 days of egg period, 1-3 months of larval period and 22-24 days of pupal period in jackfruit. The adult beetles lived for 1.5 to 3 months. Hence the present study revealed that *M. isabellinus* has added jackfruit (*Artocarpus heterophyllus)* as its most preferred host, which is a new host record, and causes severe defoliation in adult stage by reducing the leaves to veins and grubs by feeding heavily on woods causing their death.

High incidence of leaf eating cerambycid beetles (*Olenecamptus bilobus)* was observed across the surveyed areas during the monsoon period. They feed alone or in groups of 3-4 beetles. *Glenea multiguttata*, a cerambycid beetle was reported from Ernakulam, Idukki, Wayanadu, Palakkad, Kottayam and Alappuzha districts damaging 2^{o} and 3^{o}branches. Young plantations were infested by *Oberea artocarpi,* leading to shoot death, from Thrissur and Palakkad districts.

Bud weevil (*Ochyromera artocarpi)* that heavily fed on young and tender jack fruits was less due to heavy rain. Jack fruit aphid (*Greenidia artocarpii),* tingid bug and spittle bug (*Clovia lineaticollis*), were observed as mild but regular pests on growing young shoots and causes crinkling of leaves. Defoliation by Long horned Grasshoppers/Katydids and leaf caterpillars were of sporadic occurrence.

Fixed plot surveys

Coleopteran defoliators like *Oberea artocarpi, Epepeotes uncinatus, Macrochenus isabellinus* and *Glenea mulitiguttata* were high during wet monsoon period. Fruit borer/ shoot borer infestation was insignificant in the fixed plots. Sporadic incidences of Breadfruit mealy bug (*Icerya aegyptica*), and leaf caterpillar (*Margaronia bivitralis*) closely followed the attack of cerambycid defoliatiors. Jack fruit mealy bugs were keenly attended by red ants for the honey dew they secrete and protected them from predators and parasitoids. Sometime they were observed to smother the whole growing shoots. The Large stem borer, *Batocera rufomaculata* was noticed on older primary branches during July-September with adults feeding on tender leaves and larvae as borers. Attacks of long horned grasshoppers (katydids) were high in the wet season. Gregarious chrysomelid beetles infested the leaves during the monsoon months of June and July.

Macrochenu sisabellinus Aurivillius, 1920 (Coleoptera: Cerambycidae) was recorded as a new pest and pest of concern of jackfruit *Artocarpus heterophyllus*.

23. Survey and incidence of diseases in Jack Fruit -(AICRP on Fruits)

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Leaf spot caused by *Colletotrichum gloeosporioide* was the pre dominant disease of Jack in Kerala. Fruit rot cused by *Rhizopus sp* and *Botridiplodia sp* are responsible for yield loss in Jack.

24. Organic versus inorganic nutrient management of pineapple varieties for safe and sustainable production-(State plan)

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The treatment which received 500 g FYM + reduced N equivalent (6g) of PoP as FYM (600 g) + Azospirillum + PSB+ KSB 1 g each, had the maximum plant height (80.93 cm), total sugar content (6.56%) and non reducing sugars (3.41%). TSS was maximum (13.07^0B) in treatment with 300 g vermicompost + reduced N equivalent of PoP as vermi compost (335 g) + Azospirillum + PSB + KSB 1 g each. However, the treatments did not show any significant influence on number of leaves and D-leaf width.

25. Demonstration of high yielding potential of pineapple variety Amritha (State plan)

Dr.K.Ajith Kumar &
Dr.A.Sobhana , Prof. (Hort)
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The treatments did not influence the number of leaves and plant height at 4 and 8 months after planting. However significant difference was observed at 12 months and maximum number (45.16) was observed in treatments which received 25% higher N + 25% higher K + PoP recommendation for P, which was on par with 25% higher N + 50% higher K + PoP recommendation for P. Maximum D leaf width (2.73 cm) was also noticed in 25% higher N + 25% higher K + PoP recommendation for P which was significantly superior to all other treatments. The plants which received 50% more N & K than KAU PoP recommendation had maximum fruit weight (0.94 kg) which was significantly superior to all others. No difference with respect to qualitative parameters like TSS, acidity, total sugar, reducing sugar and non reducing sugar was recorded.

26. Assessment of influence of different types of planting materials on the performance of pineapple variety Mauritius- (State plan)

Dr.K.Ajith Kumar &
Dr.A.Sobhana, Prof. (Hort)
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Different types of planting materials did not show any significant effect on fruit weight, acidity, reducing and non reducing sugar as well as total sugars. However, the fruit quality in respect of TSS was found to be significantly improved by planting sucker (10.76^0Brix) which also recorded maximum yield of 0.80 kg/plant.

27. Evaluation of pineapple hybrids for yield and quality- (State plan)

Dr.K.Ajith Kumar &
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There was difference between the hybrids with respect to fruit characters. Among the Mauritius x Kew hybrids evaluated for fruit characters, H-57 of Mauritius x Kew cross was found to have good pulp percentage, high TSS (18.1%), total sugar (10.25%), reducing sugar (5.04%), non reducing sugar (5.21%) and better sugar acid ratio (10.05) with medium content of ascorbic acid (107.6 mg/100g). Among the Kew x Mauritius hybrids, H-101 had high content of total sugar (12.39%), reducing sugars (4.3%), non reducing sugar (8.07%) and highest ascorbic acid content (256.41 mg/100g). Thus these hybrids are found to be promising with respect fruit quality parameters.

28. Station wise funding on ongoing research projects and minor infrastructure support (State plan)

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Identification of causal organism for marbled fruit disease, a severe widespread disease that occurred during heavy rainfall during July- August 2018 was done. The disease caused deformation in mature fruit and water blisters during continuous rainfall. It was evident from the study that this disease was diagnosed at immature stages of pineapple fruits and the symptoms were complete in half mature fruit. The pathogen was identified as a novel bacterial strain *Acinetobacter calcoaceticus*. This phytopathogen has got resistance to Penicilllin, Ampicillin and *Pseudomonas fluorescens*. But it is susceptible to biocontrol agent *Tricoderma viride* followed by antibiotics Gentamycin and Choramphenicol.

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Fig.1. Marbled fruit

Fig.2. Marbled fruit

Fig.3. Positive antagonism of *Trichoderma viridae*

29. Network projects on Strengthening production of quality planting materials and bio inputs in KAU- State plan

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Strengthening tissue culture rooting of MD-2 pineapple was carried out. Several rooting hormone combinations were tried and Naphthalene acetic acid + Indole Butyric acid combination gave the best result.

Passion fruit

A new bacterial wilt disease was observed in passion fruit plants which is serious in high ranges of Kerala. The causal organism was identified through 16S RNA sequencing as *Brevundimonas Mediterranean.*

Symptoms of bacterial wilt in Passion fruit

30. Collection, evaluation and characterization of rambutan and mangosteen from central Travancore region- (State plan)

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Objective of the experiment is to to identify superior genotypes of rambutan and mangosteen from Central Travancore region, to study the fruit qualities of the superior genotypes and to identify techniques for reducing gestation period in mangosteen. A survey was conducted in Kottayam and Pathanamthitta Districts to identify promising genotypes of mangosteen and rambutan. Identified thirteen rambutan and two mangosteen genotypes which are promising. Morphological observations and fruit quality studies were carried out for these selected genotypes. In rambutan genotypes free seed aril was observed for 5 collections while the attachment was medium in three collections. Very strong (very good) attachment of aril to seed was observed in 4 collections. Among the collections the number of fruits per bunch varied between 13 to 33 and weight ranged between 22.5 and 61.5. The Acc. 12 showed maximum fruit weight (61.5) and lowest fruit weight was recorded for Acc.10 (22.5). The largest edible portion (aril to fruit ratio) was recorded in Acc.10 and it varied from 0.43 to 0.27. All the accessions recorded a shelf life of 4 days under ambient conditions.

Total soluble solids ranged between 5.5 and 27.5 and the highest value was recorded for Acc. 7. The titratable acidity was highest for Acc.2 (1.4%) and lowest for Acc. 1 (0.25%). The values for total sugar ranged between 12.09% and 18.41%. Accession 5 recorded highest value for ascorbic acid 35.23mg/100 and the total ascorbic acid was highest in Acc.2 (0.036mg/100). As part of molecular characterisation works the protocol for DNA isolation of rambutan was standardised. Bud wood was collected from the promising genotypes of rambutan and budding was performed during December 2018 to February 2019 and the buds are now in the establishment stage. Not much variability was observed in mangosteen, being an apomictic crop. Studies for increasing seedling vigour and growth rate of mangosteen at nursery stage were carried out incorporating 10 treatments and the work is in progress.

PG projects

Concluded PG Projects

1. Standardization of macropropagation technique in banana *Musa* (AAB) 'Nendran'

Objective of the project was standardizing the mass multiplication of quality suckers using macropropagation technique in banana *Musa*(AAB) 'Nendran'. The study included four experiments *viz.*, standardization of the number of cuts and depth of incision for activation of new banana sucker, standardization of the grow bag media constitution for macropropagation, standardization of macropropagation technique using micronutrients in Banana *Musa* (AAB) 'Nendran' and effect of AMF (*Glomus fasciculatum)* and *Azospirillum* on macropropagation by using banana sucker (Nendran AAB).

From this study it was concluded that with 5.0 ml of one per cent sulphuric acid application on the apical meristem portion of sucker in 20kg soil media along with a combined application 20g of *Glomus fasciculatum* plus 10g of *Azospirillum*, and Zn (0.1%) to the sucker in the first ratoon and Zn at 0.5% in second ratoon formed a standard protocol of rapid multiplication using macropropagation technique for quality planting material production in banana *Musa* (AAB) 'Nendran'.

2. Standardization of *in vitro* male bud culture in banana *Musa* (AA) 'Kadali'

Objective of the study was to standardize a protocol for mass multiplication of banana *Musa* (AA) 'Kadali' through *in vitro* male bud culture. Results of the study indicated that full MS medium containing a combination of NAA 1.0 mgL^{-1} and BA 4.0 mgL^{-1} was suitable for better and faster explant establishment. In multiple shoot induction media, multiple shoots were found to develop in all the cultures with full MS medium containing BA 4.0 mgL^{-1} and BA 6.0 mgL^{-1}, and the highest number of shoots were recorded in full MS medium supplemented with NAA 1.0 mgL^{-1} + BA 4.0 mgL^{-1}. In *in vitro* rooting studies, early rooting and significantly higher

number of roots were recorded in full MS medium with three per cent sucrose and IBA 1.0 mgL^{-1}. From the above study it was also concluded that one male bud can provide an average of 10 explants and each explant can provide an average of 16 shoots. There by within a span of 90 days, on an average, a total number of 160 shoots develops from a single male bud. Hence male bud culture can be efficiently used in addition to shoot tip culture to produce large number of planting material of this elite genotype to meet the present day demand of farming community.

3. Evaluation of clonal variation in banana *Musa spp* (AAB group) 'Rasthali'

Objective was to assess the natural variability in Rasthali (Poovan) clones of banana in central parts of Kerala. A survey was conducted in the central zone of Kerala covering Thrissur, Palakkad and Ernakulum districts. Seven clones were selected for field evaluation and their morphological, vegetative, flowering, bunch and fruit characters, quality parameters and pest and disease incidence were studied. All the clones showed significant variation for all morphological and fruit characters except for number of suckers/plant, male bud length, length and width of peduncle and fruit pedicel. Among the different clones evaluated, plant height, plant girth and total leaf area per plant at bunch emergence were highest in Venneer Poovan while lowest was in Madakkathara collection. Length of petiole was lowest in Pullani collection which was, highest in Cheriya Poovan. Andhra Poovan took maximum time for shooting followed by Venneer Poovan. Shortest vegetative phase was observed in Madakkathara collection. Shooting to harvest duration was higher in Venneer Poovan followed by Valiya Poovan. Collection from Pullani recorded the shortest duration. Crop duration was longest in Venneer Poovan and shortest in Madakkathara collection. Venneer Poovan, Valiya Poovan and Marthaman are good yielders having highest bunch weight among different clones. TSS, total sugars and sugar- acid ratio were highest in Marthaman and it was lowest in Cheriya Poovan. High heritability along with high genetic gain was observed for characters like fruit weight, fruit length and fruit girth. Bunch weight was significantly and positively associated with bunch length, number of hands per bunch, plant girth, total crop duration, number of fingers per hand, fruit length, fruit girth and plant height indicating the possibility of direct selection for these characters. Path analysis revealed that plant girth, total crop duration, number of fingers/ hand, fruit length, fruit girth and fruit weight have shown positive direct effect on bunch weight per plant while plant height, number of hands per bunch and bunch length showed negative direct effect on bunch weight.

4. Organic nutrient management of papaya (*Carica papaya* L.)

Maximum girth, leaves, fruit set percentage, TSS, ascorbic acid content, carotenoids, total sugar, reducing sugar etc were found highest in plants applied with 100% of recommended dose of N as organic along with PGPR mix 1 and AMF. Yield characters like maximum fruit weight, fruit length, fruit girth, fruit volume, pulp percentage, total yield per plant were obtained by application of 100% of recommended dose of organic along with PGPR mix 1 and

AMF at bimonthly interval. Regarding B:C ratio and net income obtained, application of 100% of recommended dose of N as organic along with PGPR mix 1 was found to be maximum. Overall assessment indicated that application of 100% of recommended dose of N as organic + PGPR Mix 1+ AMF was found to increase the growth and yield.

5.Field evaluation of promising jack fruit(*Artocarpus heterophyllus* Lam.) types

Name of student : Ajeesh B.R.,
Major advisor: Dr. Rajagopalan

A study was carried out during 2016-2018, to identify the promising jackfruit type from the variability present in selected firm fleshed jackfruit types available in Kasargod district. The fruit characters were recorded as per the Jackruit Descriptor (IPGRI). The variability of selected 8 types were analysed statistically. The result revealed that, there is considerable variation in mean leaf blade length (10.7 to 17.1 cm), mean leaf blade width (5.1 to 9.03 cm), average flake length (5.43 to 8.33 cm), average flake width (3.37 to 4.63 cm), moisture percentage of ripe flake (60.8 to 65.94 %), TSS (25 to 31.87 ^{0}Brix), total sugars (20.91 to 26.04), reducing sugar (8.69 to 13.31 %) and non-*reducing sugar (10.8 to 13.83 %). Highest TSS were observed in KJ 182 (31.87 ^{o}Brix) and lowest in* KJ 121 (25 ^{o}Brix).

Ongoing PG Projects

1. Evaluation of propagation techniques and rootstock studies of mango (*Mangifera indica* L.).
2. Precision farming studies in Papaya (*Carica papaya* L.)
3. Nutrient standardization in banana *Musa* AAB.Popoulu
4. Effect of preharvest treatments on fruit drop and fruit quality of Rambutan(*Naphelium lappaceum*.)
5. Evaluation of promising accessions of papaya for cultivation in the Northern Zone of Kerala.
6. Standardization of patch budding in jackfruit (*Artocarpus heterophyllus* Lam.)
7. In vitro nitrogen sources and acclimatization studies in TC banana cv. Nendran.
8. Production dynamics of strawberry (*Fragaria x ananassa* Duch.) in Kerala
9. Response of banana *Musa* (AAB) 'Nendran' to nutrient sources
10. Evaluation of hybrids and clonal variants in pineapple (*Ananas comosus* L.)
11. Production technology and crop improvement of passion fruit (*Pssiflora edulis* Sims.)
12. Salinity stress tolerance in rootstock mango (*Mangifera indica* L.)
13. Characterization of avocado (*Persea americana* Mill.)
14. Effect of crop regulation on yield and quality of mango (*Mangifera indica* L.) under high density planting system in Kerala
15. Nutrient management for pineapple (*Ananas comosus* L.) cv. Amritha
16. Standardization of growth promoters for mangosteen (*Garcinia mangostana* L.)
17. Standardization of propagation techniques in avocado (*Persea Americana* Mill.*)*
18. Ecophysiology of mango (*Mangifera indica* L.) grown in Muthalamada area
19. Response of mango (*Mangifera indica* L.) to chemical regulator under high density planting system

Name of Project Coordination Group: (05)

Field crops - cereals (Other than rice), Millets, Pulses, Oilseeds, Fodder crops and Green manure crops

Compiled by:
Dr. Anitha S, Project Coordinator

Plan & External Aided Projects

Ongoing Projects:12Nos.

Post Graduate Projects

Concluded Projects: 2Nos.
Ongoing Project:5Nos.

Ongoing Projects

1. Evaluation of Bajra Napier Hybrids for Yield and Forage Quality- (AICRP on Forage Crops & Utilization)

Dr. Usha C Thomas &Dr.Beena Thomas
CoA, Vellayani

Fiftyonebajara-napier hybrids received from IGFRI, Jhansi during Kharif 2010, were evaluated during Kharif 2011. Out of the 51 hybrids sown, 20 hybrids have germinated and they were multiplied. Evaluation of 20 hybrids was done during Kharif 2012. **Five hybrids** with superior fodder attributes were selected for yield trials.The five cultures were compared with the local check (Suguna) and the green fodder yield was significantly different in all harvests. The data was presented in the ZREAC workshop 2016 and one culture (Culture 1) was accepted for farm trial. Farm trial was conducted in five different zones of Kerala and the data of farm trials were presented in the ZREAC workshop 2017 . Proposal will be submitted to state variety release committee.

2. Evaluation of Guinea grass cultures for Yield and Forage quality-- (AICRP on Forage Crops & Utilization)

From the germplasm collection maintained at Vellayani centre, four superior cultures were identified and compared for their performance .From the three year data of the trial, The data was presented in the ZREAC workshop 2016, two cultures (Culture 1 & 2) were accepted for farm trial and farm trial was conducted in five different zones of Kerala. The data of farm trials were presented in the ZREAC workshop 2017 and proposals for variety release will be submitted to state variety release committee.

3. Genetic analysis of yield and quality in fodder cowpea (*Vigna unguiculata*)Walp.) - (AICRP on Forage Crops & Utilization)

Objective of the study is genetic analysis of fodder yield and quality in fodder cowpea and evaluation of F_2 progenies to identify superior recombinants.

Thirty cowpea accessions were evaluated and eight parents were selected based on yield, protein and fibre content (CO – 8, MFC - 09 – 1,IC – 1061,IC – 25105,IC – 39916, IT – 38956-1,IT – 37154999-38 and Pant Lobia – 2). Eight parents were crossed in half allele and 28 cross combinations were obtained. F_1 (420) are planted in field.

4. Evaluation of BN Hybrid cultures for yield and quality-(AICRP on Forage Crops & Utilization)

The cultures BN Culture-1, BN Culture-2 and Suguna will be evaluated for three years.(2018-2021)

5. Evaluation of Guinea grass cultures for yield, quality and flowering nature - (AICRP on Forage Crops & Utilization)

The cultures GG Culture-1, GG Culture-2, and Harithasree will be evaluated for three years. The two mutant cultures were obtained from P.h D thesis work entitled 'Induced mutagenesis for delayed flowering and high tillering in guinea grass (*Panicum* maximum Jacq.)'. The preliminary evaluation trials along with the released check showed that the cultures have delayed flowering and in some instances no flowering after the first and second cut.

6. Genetic analysis of yield and quality in fodder cowpea (*Vigna unguiculata*)Walp.)- (AICRP on Forage Crops & Utilization)

Objective of the study is genetic analysis of fodder yield and quality in fodder cowpea and evaluation of F_2 progenies to identify superior recombinants. Thirty cowpea accessions were evaluated and eight parents were selected based on yield, protein and fibre content (CO – 8, MFC - 09 – 1,IC – 1061,IC – 25105,IC – 39916, IT – 38956-1,IT – 37154999-38 and Pant Lobia – 2). Eight parents were crossed in half allele and 28 cross combinations were obtained. F_1 (420) are planted in field.

7. Studies on carbon sequestration in perennial grass based cropping systems.

The trial was laid out in Kharif 2015(establishment year), with the objectives to study the effect of cropping system on carbon sequestration, fodder yield, quality, soil fertility, and economics. Highest total GFY and DFY was recorded in T3 (BN hybrid in paired row + fodder cowpea-cowpea). Highest GFY and DFY among the grasses was recorded in T3((BN hybrid in paired row + fodder cowpea-cowpea). Highest GFY and DFY among legumes was recorded in T5(BN hybrid paired row+ *Sesbaniagrandiflora*) (3989q/ha) followed by T2 (3539q/ha).

8. Intensive forage production through Agase based (*Sesbaniagrandiflora*) cropping system under protective irrigation

The trial was laid out in Kharif 2015, First year was considered as establishment period and the observations were taken from Kharif 2016 onwards. Significantly superior values for GFY and DFY of grasses was recorded in T5. Significantly superior GFY and DFY of agase was recorded inT2.When the total fodder yield was analysed, highest GFY and DFY was recorded in T5 (Agase+setaria(2:2)) (805q/ha) followed by T4 (767q/ha).

9. Studies on performance of Top feeds under varied planting geometry with and without inter crop

Cumbunapier planted b/n Erythrina recorded highest GFY(27.6 t/ha/cut) followed by that in Moringa (24.6 t/ha/cut).

10. Farm Trial on Impact of Mg nutrition in Bajra Napier hybrid

The objective is to assess the influence of Mg nutrition on the performance of Bajra Napier Hybrid in the southern districts of Kerala. Three-year trial was conducted at AICRP on Forage Crops & Utilization, Vellayani to assess the impact of Mg and B nutrition on the performance of Bajra Napier hybrid from Kharif 2015-2017. In Kerala state , application of 80 kg $MgSO_4$ along with RDF(200:50:50 kg NPK and 25 t/ha of FYM) to bajra x napier hybrid is recommended for higher fodder yield and better quality fodder'.

11. Evaluation of native *Rhizobium* cultures on cowpea- AINP on Arid legumes

Dr. S. M. Purushothaman
RARS, Pattambi

Kanakamony seed treated with the native *Rhizobium* culture (RH3) from College of Agriculture, Vellayani recorded with the maximum yield of 1476 kg/ha.

12. Cowpea IVT

Cowpea IVT conducted during rabi 2018-2019 showed that the entry CP-12 recorded the highest yield of 1530 kg/ha

PG Projects

Concluded Projects

1**. Nutrient optimization for grain cowpea (*Vigna unguiculata*(L.) Walp.) in high phosphorus soils** - (FC-02-03-01-2017-ACV(10)-KAU-PG)

Anjaly V & Dr. Sheeba Rebecca Isaac

The project aims to optimise the levels of phosphorus, potassium and zinc for grain cowpea in high phosphorus soils, to study the interaction effect of the nutrients and to assess the residual effect on the succeeding Amaranthus crop. The treatments consisted of two levels of P (p_0 -0 kg ha^{-1} and p_1 -7.5 kg ha^{-1}), three levels of Zn (z_0 - 0 kg ha^{-1}, z_1 - 2.5 kg ha^{-1} as $ZnSO_4$ and z_2 - 0.025% $ZnSO_4$ as foliar at branching and flowering) and two levels of K (k_0-10 kg ha^{-1} and k_1 - 20 kg ha^{-1}). The 2 x 3 x 2 factorial experiment was laid out in randomized block design with three replications. Lime, FYM and N were applied as per package of practices recommendations (KAU, 2016). Grain cowpea (*Vigna unguiculata*(L.) Walp.) variety Shubra, was raised during January to March 2018 After the harvest of cowpea, the residues were incorporated and ten days later, amaranthus seeds were sown (April to May 2018) in the respective plots. Amaranthus variety Arun was raised without addition of any external inputs and harvested by uprooting at 35 DAS.

The results of the study indicated that **f**oliar application of $ZnSO_4$ @ 0.025 % (at branching and flowering) and K_2O @ 10 kg ha^{-1} recorded significantly higher yield, net income and BCR for grain cowpea in high phosphorus soils**. T**here existed an antagonistic interaction between P and Zn**,** negative interaction between Zn and K at higher level sand non-significant interaction between P and K, on the basis of grain yield. The residual effect of cowpea did not vary with the treatments.

2. Performance of greengram (*Vigna radiata* (L.) Wilczek) cultivars under different tillage methods- FC-02-03-02-2017-VKA(1)-KAU-PG

Abid V &Dr.Bindhu J.S.

The programme aims to study the response of selected green gram cultivars under different tillage methods and to identify the most economical combination of cultivar and tillage.

The experiment was conducted during the period from December 2017 to March 2018 at Agronomy Farm, College of Horticulture, Vellanikkara. Split plot design was adopted with three replications. The main plot treatments were four tillage methods *viz*., M_1 - minimum tillage (primary tillage only), M_2 - minimum tillage followed by pre-emergence application of pendimethalin @1 kg ha^{-1}, M_3 - Minimum tillage followed by post-emergence application of imazethapyr + imazamox@ 80 g ha^{-1} at 20 DAS and M_4 - conventional tillage (Primary and secondary tillage) followed by two hand weedings at 15 and 30 DAS. Sub plot treatments were four cultivars; V_1 –CO 6, V_2 –CO 7, V_3 –CO 8 and V_4 -VBN (Gg) 2.

Results indicated that green gram cultivar CO 8 (V_3) grown under minimum tillage method followed by post emergence herbicide spray of imazethapyr + imazamox@ 80 g ha^{-1} at 20 DAS (M_3) can be recommended for summer rice fallows considering the yield and profitability.

Ongoing PG Projects

1. Input optimization for short duration redgram[*Cajanus cajan* (L.) Millsp.]

FC-02-03-03-2018-ACV(01)-KAU-PG- Ph.D

Dr.Sheeba Rebecca Isaac
CoA, Vellayani

The study aims to assess the suitability of two short duration varieties of red gram, standardize the spacing and nutrient management practices and examine the legume effect on succeeding fodder maize crop.

The first experiment on the assessment of the suitability of two short duration red gram varieties and standardization of spacing and nutrient levels has been completed. The residues have been incorporated to study the carry over effect on subsequent maize crop.

2. Seed invigouration for yield enhancement in grain cowpea (*Vigna unguiculata*L. Walp)

FC-02-03-01-2018-ACV(01)-KAU-PG

Anju B Raj &Dr. Sheeja K Raj

The study aims to assess the effect of seed invigouration with zinc sulphate and borax on grain cowpea and to evaluate its effect along with *Trichoderma viride*on growth and yield of the crop**.**

The Pot culture experiment to study the influence of seed invigouration methods on germination and seedling vigour of grain cowpea was completed. The data was statistically analyzed. Based on the results it was found that, among the priming treatments, priming with $ZnSO_4$ 0.025% and 0.05% for 4h recorded higher germination percentage, germination index, germination rate index and required less time to reach 50 percent germination. These treatments also recorded higher vigour index I and II. Similarly, among the pelleting treatments, pelleting with Borax 50 and 100 mg kg^{-1} seed recorded higher values for the germination parameters. Hence, priming with $ZnSO_4$ 0.025% and 0.05% for 4h and pelleting with 50 and 100 mg Borax kg^{-1} seed were selected for the field experiment. Based on the results of pot culture experiment, field experiment was laid out with 9 treatments. The experiment has completed. Chemical and statistical analysis is in progress.

3.Performance of high yielding varieties of finger millet *(Eleusinecoracana* (L.) Gaertn)

Kishore Neeruganti&Dr. P Prameela

The objective of the experiment is to evaluate the performance of some prominent high yielding varieties of ragi suitable for *Rabi* and *Kharif* seasons in central Kerala. Nine different varieties from three SAU,s were collected and field experiment are over. Biometric observations were taken at 30 DAS, flowering and harvest. Yield parameters were taken recorded at harvest. Meteorological data has been collected and lab analysis work is ongoing.

4.Variability in horsegram [Macrotylomauniflorum (Lam.) Verdc.] under open and partially shaded conditions.

Swathy Sivan & Arya K

The experiment was conducted to assess the variability and performance of horse gram genotypes at College of Agriculture, Vellayani. About thirty accessions of horse gram were collected from different regions and were raised both under open and partially shaded conditions simultaneously. The experimental design used was RBD with three replications and all the requirements fulfilled were in accordance with KAU Package of Practices. The duration of the crop was about three and a half months. Fourteen biometric observations, including yield were recorded and their mean values were calculated. Protein analysis is also being carried out and statistical analysis is progressing. From the data obtained so far, it is evident that clear variability exists among these genotypes.

5. Seed treatment and foliar nutrition for enhanced productivity of blackgram (*Vignamungo*L.) -FC-02-03-01-2018-ACV(01)-KAU-PG

VaddulaYamini&Dr. A.S. Anilkumar

The study aims to evaluate the influence of seed treatment and foliar nutrition on the growth and yield of blackgram and also to work out the economics of production. The experiment was laid out during the last week of September 2018. Treatments were applied and biometric observations at 20 days interval were recorded. The crop was harvested on 18 December 2018. The plant and soil analysis are being analysed.

Name of Project Coordination Group: (06) Floriculture

Compiled by:

Dr. Sreelatha U, Project Coordinator

Plan & External Aided Projects

Ongoing Projects:7 Nos.

Post Graduate and Ph.D Projects

Concluded Projects: 3 Nos
Ongoing Projects: 15 Nos

Ongoing Projects

1. Standardization of production package for selected seasonal flowers in Kerala- (FL-02-00-04-2017 – VKA(10) –KAU-Plan)

Dr. Sreelatha U
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Seasonal flowers are in great demand in Kerala for multiple uses like loose flowers, landscaping, industrial purposes like extraction of natural colors, phytochemicals of medicinal value and essential oils. Many seasonal flowers like marigold can be grown in Kerala throughout the year. The growers prefer F1 hybrids of marigold which are prone to bacterial wilt disease in the state. Hence, marigold genotypes were evaluated for bacterial wilt incidence as well as for yield, vegetative and floral parameters. Among the genotypes evaluated, there were 8 F1 hybrids, 9 varieties, 6 local collections of *Tagetes erecta*, 4 varieties, 4 local collections of *Tagetes patula*, one genotype of *Tagetes tenuifolia* and *Tagetes minuta*. Field evaluation revealed 4 genotypes *viz*. Bhagawati, Maria 91, M-1 & M-2 as resistant to bacterial wilt; Arka Agni, Arka Bangara, P 4& KDA 2 as moderately resistant and these genotypes can be recommended for cultivation in Kerala. P4, Maria 91 and Bhagawati are F1 hybrids with good yield. But, during artificial screening these three hybrids were found to be susceptible to bacterial wilt. However, among these hybrids, Bhagawati showed the minimum incidence of bacterial wilt. Though M-1 & M-2 are completely wilt resistant, these cannot be recommended for commercial cultivation due to poor flower shape. However, these two genotypes can be used as rootstock for grafting the susceptible F1 hybrids. Both M-1 & M-2 can be included in selective breeding programmes against bacterial wilt and also for enhancement of flavonoid content and M-2 can be included for breeding for carotenoid content.

Ten genotypes of China aster were grown during Oct 2018-Feb 2019 to evaluate the performance with respect to vegetative and floral characters. Among the genotypes, Phule Ganesh Pink, Local Pink (Karnataka) and Phule Ganesh White performed well and can be recommended for cultivation in tropical plains from October to February.

2. Developing a conservation strategy for Indigenous herbs in the hillocks of Kerala by domestication and exploiting their potential ornamental & medicinal value- (FL-03-00-01- 2017 – VKA(10) –KAU-Plan)

Dr. Sreelatha U
Professor,
sreelatha.u@kau.in

When the floral wealth is concerned, hillocks are the rich abodes of wide variety of flowering plants including grasses, herbaceous perennials, shrubs and trees. Many of these plants which were utilized by traditional medical practitioners are either endangered or critically vulnerable due to human interventions. Since most of the hillocks are in private possession, these are subjected to exploitation for soil excavation, laterite mining and establishment of plantations of different crops. For many flora, the habitat destruction is extremely fast that 50% habitat loss was observed during last decades. *Ex situ*

conservation of endangered flora is the only strategy to protect these plants. Survey was conducted in Thrissur district. Plants like *Pogostemon quadrifolius, Sesamum laciniatum, Impatiens* species, *Naregamia alata, Memecylon* species were found to be potential ornamental.

Crop improvement was tried in *Exacum bicolor* which was already identified as an ornamental. Genotypes were collected from 11 different localities in Kerala, seedlings were raised and selfed and seeds collected for performance studies. Stigma receptivity and pollen viability was found to be maximum on third day after anthesis. Maximum viable pollens were observed between 9 to 10 am and hence for crop improvement programmes, pollination can be done between 9am and 10 am. Inbred development was initiated for hybridization programmes.

3. Development and evaluation of anthurium hybrids

Dr.Beena Thomas, Asst.Professor
Dept.of Plant Breeding and Genetics
CoA, Vellayani

Anthurium is a cut flower crop having demand in the domestic as well as expert markets. New hybrids with good spathe quality are in great demand. The objective of the project was to develop and evaluate commercially important anthurium hybrids for yield and quality. Commercially important valuable anthurium hybrids (20 no.) were developed and characterized and observations on vegetative and floral characters were done. Spathe size and spadix life was found to be highest in the hybrid HoR x KR. Selection of best performing hybrids with commercially important floral characters are continued for further crop improvement programmes.

4. Germplasm conservation and evaluation - AICRP projects

a.Collection, characterisation, evaluation and maintenance of tropical orchids germplasm- Twelve native orchids collected from different parts of Kerala were added to the existing germplasm. In addition to this, ten trigeneric hybrids were evaluated and among these, based on commercial traits like number of flowers/spike and vase life, Aranda types *viz*. 'Noorath Alsagalf blue' and 'Salaya Red' and Mokara 'Calypso' were found to be promising and can be recommended for cut flowers.

b.Collection, characterisation, evaluation and maintenance of anthurium - Six new varieties *viz.* Arion, Cavalli, Missouri, Royal Pink, Joli and Orange added to germplasm last year were evaluated for their commercial characters. The variety 'Joli' produced more number of flowers compared to others.

c.Collection and evaluation of underexploited ornamentals (Heliconias, Ginger lily, lotus) Lotus accessions (five indigenous) collected from different parts of Kerala and four exotic types (Philipine Gold, Red Heart Lotus, Indian Red Lotus, Blue Bowl Lotus) are planted for evaluation. Fifteen Heliconia varieties were maintained in the germplasm, along with ginger lily (*Alpinia* sp) and torch ginger (*Etlingera* sp).

d.Collection and evaluation of fillers (Asparagus, Dracaena, gypsophila and ferns) - Two *Dracaena* types *viz. D. reflexa* variegata and *D. fragrans* victoria were added to the existing germplasm of fillers

e.Survey, collection and evaluation of native ornamentals for commercial cultivation -

Native ornamental plants of different genus collected from different parts of Kerala are *Torenia bicolor, Eranthemum capens, Ocimum* species, *Barleria repens, Seasamum laciniatum, Melastoma malabthricum, Ixora* species, *Leucas aspera,Memecylon malabaricum, Memecylon edule, Pogostemon quadrifolius, Impatiens flaccida* and *Cosmos caudatus. Ocimum* accessions (10 no.) were procured from NBPGR, New Delhi. The seeds were germinated and are under evaluation.

5. Crop Improvement studies- AICRP projects

a. Testing of new genotypes of crossandra for loose flower – Five IIHR varieties *viz*. Arka Ambara, Arka Kanaka, Arka Shreeya, Arka Shravya and Arka Chenna were procured, multiplied for evaluation along with a local crossandra collection. The crop planted in last week of April.

b. Testing of new genotypes of jasmine – the new entry from TNAU, Acc. JN-1, an accession of *Jasminum nitidum* will be compared with *Jasminum grandiflorum* types as well as other jasmine species. Land preparation was completed; crop will be planted during third week of May.

6. Crop Management studies- AICRP projects

a. Induction of off-season flowering in jasmine (*Jasminum sambac*) – Trial will be conducted by combining pruning with various growth retardants like cycocel, paclobutrazol and mepiquat chloride. Land preparation completed; crop will be planted during second week of May.

b. Standardization of alternate media for nursery industry – Planting material of Aglaonema being raised. Potting media ingredients being procured.

7. Post Harvest Technology studies- AICRP projects

a. **Standardization of dry storage of *Nephrolepis exaltata*** - mature fronds will be precooled and then storage in non vented PE & PP films will be tried. The trial is initiated.
b. **Solid state fermentation technique for Marigold for extraction of carotenoids -** In this work, the use of a solid-state fermentation (ensilage) process for increasing the yield of xanthophylls extracted from fermented marigold flowers will be examined. The trial will be conducted in August – September

PG projects

Concluded PG Projects

1. Evaluation of rose varieties for commercial cultivation under the warm humid tropics of Kerala

Name of student-Priya Philip

Ten cut flower varieties *viz*. Arka Ivory, Arka Pride, Arka Swadesh, Gold Strike, Noblesse, Revival, Taj Mahal, Corvette, Emma, Peach Avalanche and ten loose flower varieties *viz*. Arka Parimala, Sherba Gold, Mirabel, Vernish, Charisma, Jadiov, Star Light, Spray Orange, Spray Yellow and Red Varnish were evaluated for vegetative as well as floral and genetic parameters. Variety Star Light was found to be superior in terms of overall performance. The marketable flower yield over the months of observation indicated that November – December is the best season for rose production after the October pruning.

2. Standardization of grafting techniques in African marigold (*Tagetes erecta* L) for combating bacterial wilt

Name of student -Athira Baburaj

The rootstock used in the study was the bacterial wilt resistant local collection M-1 and the wilt susceptible F1hybrid Maria 91 was used as scion. Grafting was done in the month of January. Three methods of grafting viz., cleft, splice and hole insertion were tried at different ages of rootstock (4, 5, 6 and 7 weeks after sowing) and different ages of scion (3, 4 and 5 weeks after sowing).Cleft grafting four week old scion on to six week old rootstock was found to be the best with a graft survival of 61 percent.There was no survival when grafting was done on four week old rootstock irrespective of age of scion and grafting method followed.

3. Nutrient management in gerbera (*Gerbera jamesonii Bolus*.) grown under naturally ventilated polyhouse.

Name of student -Anaswara S. J

Five varieties were selected for the study Beaudine, Double date, Mammut, Esmara and Aquamelon. Different nutrient treatments (N1- 10:10:10 N, P_2O_5, K_2O g m-2, N2- 15:15:15 N, P_2O_5, K_2O g m-2, N3- 20:20:20 N, P_2O_5, K_2O g m-2) were applied to the varieties at monthly and fortnightly interval.The best performing variety was Beaudine followed by Esmara and Aquamelon. BC ratio was highest for Beaudine.All the five varieties while treated with 10:10:10 N, P_2O_5, K_2O g $m^{-}2$ at monthly intervals resulted high values for vegetative, flower and flowering characters

Ongoing PG Projects

1. Vegetative propagation in African Marigold(*Tagetes erecta*) hybrid.
2. Standardization of production technology for African marigold (*Tagetes erecta*)
3. Regulation of flowering in *Ascocenda* orchids through growth regulator and micronutrients
4. Standardization of growing media and growth regulators for rose (*Rosa* sp.)
5. Evaluation of China aster [*Callistephus chinensis* (L.) Nees] for cultivation in tropical plains
6. Genotypic evaluation and *in vitro* multiplication of anthurium (*Anthurium andreanum* Linden) hybrids
7. Utilization of male sterility and polyploidy for genetic improvement in *Tagetes* spp.
8. Standardization of alternate potting media for potted ornamental foliage plants for export
9. Assessment of diversity in native orchids
10. Standardisation of spacing and nutrients for *Gomphrena globosa* L.
11. Genetic improvement through hybridization and molecular characterization in *Dendrobium* orchids.
12. Varietal evaluation and genetic improvement in *Phalaenopsis* orchids through hybridization
13. Palynological and cross compatibility studies in anthurium (*Anthurium andreanum* Linden)
14. Varietal evaluation of tuberose (*Polyanthes tuberosa* L) for growth, yield and quality
15. Morpho molecular characterization of intergeneric hybrids of *Ascocentrum*

Name of Project Coordination Group: (07) Aromatic and Medicinal Plants

Compiled by:

Dr. N. Mini Raj, Project Coordinator

Plan & External Aided Projects

Concluded: 12 Nos.
Ongoing: 10 Nos.

Post Graduate Projects

Concluded projects: 2 Nos.
Ongoing projects: 8 Nos.

Concluded Projects

1. **Evaluation of promising lines of kalmegh for high yield and quality (MLT) - AICRP on Medicinal and Aromatic Plants**

Dr. M.T. Kanakamany
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MLT evaluation of promising lines of Kalmegh (*Andrographis paniculata)* for high yield and quality was done with 39 entries obtained from DMAPR. Observations on the yield parameters *viz;*plant height, plant spread, days to reproductive phase, days to 50% flowering, number of primary branches/plant, leaf length, leaf width, leaf stem ratio, leaf yield, length of the spike and dry biomass yield of the accessions were taken. Entries AK 9 (5489 Kg/ha) and AK 11 (4449 kg/ha) performed well with respect to biomass yield under Kerala conditions.

2. **Evaluation of promising accessions of bach (*Acorus calamus*) (IVT) -AICRP on Medicinal and Aromatic Plants**

Dr. M.T. Kanakamany
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Evaluation of promising accessions of bach(*Acorus calamus*) was done with five entries obtained from DMAPRin 4 replications in a randomized block design. The data on yield attributes were taken. Performance of the crop was very poor at our conditions.

3. **Development of DUS descriptors for *lalchithrak* (*Plumbago rosea*)- AICRP on Medicinal and Aromatic Plants**

Dr. M.T. Kanakamany
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Twenty five accessions of *Plumbagorosea* were evaluated for morphological, plant, yield and quality characters. Variations were noticed in plant height, number of branches, internodal length, leaf length, leaf breadth, root number, root weight fresh and root weight dry, root length and root girth. Accessions were grouped based on 32 characters and a Germplasm Catalogue was prepared. Biometric characters were statistically analysed to find outskewness, kurtosis, sample variance, mean, standard error and standard deviation.

4. **Development of DUS descriptors for *kaipanpadavalam* (*Trichosanthes cucumerina*) - AICRP on Medicinal and Aromatic Plants**

Dr. M.T. Kanakamany
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Trichosanthescucumerina is an important medicinal herb of high demand in Kerala and with good genetic variability. The experiment to develop DUS descriptor for the 19 available accessions was started during 2013-14. Observations were recorded on general growth

characters, leaf characters, inflorescence, flower, fruit, yield and quality characters. Variations noticed in vine length, number of branches, days to flowering and fruit set, fruit characters like fruit shape, fruit curvature, length, width, weight and number of fruits and yield characters including herbage yield and fruit yield. Based on these characters the accessions were grouped and a germplasm catalogue was prepared. Statistical analysis of biometric characters was carried out to find out frequency distribution, skewness, kurtosis, sample variance, mean, standard error and standard deviation.

5. Development of minimum seed certification standards for *Indigofera tinctoria, Trichosanthescucumerina* and *Desmodium gangeticum* -AICRP on Medicinal and Aromatic Plants

Dr. M.T. Kanakamany
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Minimum seed certification standards were developed for *Indigofera tinctoria*,*Trichosanthes cucumerina* and *Desmodium gangeticum* including the field standards like isolation distance for foundation and certified seed, contaminants and off types. Seed standards like minimum pure seed, maximum inert matter, other crop seeds, weed seeds, other distinguishable varieties, and minimum germination percentage were developed for foundation and certified class of seeds.

6. Seed viability studies in *Indigofera tinctoria* and *Desmodium gangeticum*- AICRP on Medicinal and Aromatic Plants

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Seeds of *Indigofera tinctoria* and *Desmodium gangeticum* loose their viability immediately after harvest. Experiment was conducted, storing the seeds having different moisture content (8% and 10 %) using different packing materials (polythene cover, aluminium foil and cloth bag) under ambient and refrigerated conditions.

Results indicated that storing the seeds at 8% moisture in polybags at refrigerated condition gave better seed quality parameters seed germination, seedling root growth and seedling shoot growth in the case of *Desmodium gangeticum* where as in the case of *Indigofera tinctoria* storing the seeds in cloth bags at 8% moisture under refrigeration is ideal for getting better seed quality parameters.

7.Effect of method of crop establishment and shade level on yield and quality of *Desmodium gangeticum* (*Orila*) -AICRP on Medicinal and Aromatic Plants

Dr. Sindhu,P.V
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Among the methods of crop establishment, transplanting resulted in the highest root yield of 6023 kg/ha. The root yield increased significantly with increase in intensity of shade. The highest root yield of 6722 kg /ha was noticed under 75 per cent shade. Open condition resulted in lowest root yield (3441 kg/ha) which was 49 per cent less than best yielded treatment. Treatment combination of transplanting under 75 per cent shade recorded the highest root yield (7424

kg/ha). No significant difference was observed between direct seeded and transplanted crop with respect to total alkaloid content. Among different shade levels, 75 per cent shaded condition and 50 per cent shaded condition gave better alkaloid content, which were at par (160.01 mg/g and 159.48 mg/g respectively). Open condition recorded the lowest alkaloid content of 117. 56 mg/g. Treatment combinations direct seeding either at 75 per cent or 50 per cent shade and transplanting at 75 per cent or 50 per cent shade recorded higher alkaloid content in roots which were at par.

8. Standardization of organic production technology for *kalmegh (Andrographis paniculata)* -AICRP on Medicinal and Aromatic Plants

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The direct effect of main plot treatments was not significant with respect to biomass yield. However, there was significant difference with respect to andrographolide content and andrographolide yields with higher values in the plants with FYM @15 t/ha. Compared to plants which received organic manuring alone plants with inorganic fertilizers recorded higher biomass, andrographolide content and yield.

Among subplot treatments, combination of biofertilisers with *jivamrut* and individual application of *jivamrut* gave higher biomass yield and quality. Among organic treatments, combination of farm yard manure with biofertilisers and *Jivamrut* recorded higher biomass yield of 4283 kg/ha, which was on par with combination of castor cake with *Jivamrut* (4141 kg/ha). All the treatment combinations with basal FYM recorded higher androgarpholide per cent and lower values were observed in combinations with vermicompost. Regarding andrographolide yield on per hectare basis, combination of farm yard manure with biofertilisers and *jivamrut* was the best treatment (64.12 kg/ha).

Plants which received integrated nutrient management recorded higher biomass yield and andrographolide contents. Treatment combination with NPK (80:40:20 kg/ha) + Azo + PSB + *Jivamrut* recorded a biomass yield of 4877 kg/ha. The quality parameter *ie* andrographolide content was also higher in this treatment (1.72 per cent). Higher B:C ratio of 1.78 was obtained when farm yard manure alone was applied as basal followed by basal application of biofertilisers alone.

9. Standardization of organic farming practices for sweet flag (*Acorus calamus)* - AICRP on Medicinal and Aromatic Plants

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Among organic treatments, the plants which received FYM @ 15 t/ha gave the highest rhizome yield of 1428 kg/ha, 1573 kg/ha and 1495 kg/ha respectively during 1st, 2nd and 3rd years of study. The pooled mean was also highest in this treatment (1499 kg/ha). The next best alternative was basal application of vermin compost @ 7.5 t/ha. Compared to treatments with basal application of organic manures alone, application of recommended dose of fertilizers (N, P and

K@45:12.5:12.5 kg/ha) recorded significantly higher rhizome yield (pooled mean of 1864 kg/ha).

10. Quality evaluation of Orila *(Desmodium gangeticum)*market samples from Kerala

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Market samples of orila *(Desmodium gangeticum)* root from different raw drug markets of Kerala were collected.. As a reference sample original orila roots from the plants cultivated in the herbal garden was also taken. Samples were dried and powdered. Hot methanol extracts (10%) were prepared from all these samples and analysed by developing TLC reference fingerprints (Silica gel 60 $F_{254,}$ hexane: chloroform 6:4, ANS reagent) with genuine samples. TLC fingerprints of market samples were developed following the same procedure and matched with that of reference sample to find out the spuriousness of the material coming to the market as raw drug. The results revealed that out of 34 samples tested only one was original orila root. Instead of original roots, shoot is used in markets of Kerala. Substitution with shoot was 94 %.

11. Comparative quality evaluation of Brahmi *(Bacopa monnieri)* from different nutrient management practices (organic, inorganic and INM)

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Field experiment was conducted with six treatments and brahmi samples were collected for analysis from 150-day-old plants. Yield was also recorded on harvest. Bacoside A was estimated in total herbage .Sample extracts in methanol were prepared and subjected to HPTLC (Silica gel 60 $F_{254,}$ Toluene: Ethyl acetate: Methanol: Acetic acid (3:4:3:1) using Bacoside A as standard . The mineral and heavy metal analysis was also done.

The results of the study revealed that application of chemical fertilizers along with organic manure (INM) was more effective to increase percent Bacoside A content in *brahmi*. In general, integrated nutrient management (INM) treatments (FYM 10t/ha+NPK 100:60:60 kg/ha) was the best to maximize the active ingredients in brahmi as well as herbage yield, compared to purely organic or purely inorganic cultivation practices. Calcium, Magnesium and Iron content were also found higher in plants receiving INM. No presence of heavy metals such as cadmium, arsenic, lead and chromium was noted.

Bacoside A content in brahmi under different cultivation practices

Nutrient Management	Treatment code	Treatment details	Bacoside A (%)	Herbage yield (kg/ha)
Absolute	T1	No manures and fertilizers	0.655^{e}	3335^{f}
Inorganic	T2	NPK (100:60:60 kg/ha)	0.845^{c}	5189^{c}
Organic	T3	FYM (10 t/ha)	0.870^{b}	4169^{d}
	T4	FYM (5 t/ha)	0.733^{d}	3629^{e}

Integrated	T5	FYM (10 t/ha) + NPK (100:60:60	0.940[a]	6672[a]
	T6	FYM (5 t/ha) + NPK (100:60:60	0.928[a]	6216[b]
	CD(0.05)		0.021	47.323

12. Development of SOP / Extraction technologies of mandated crops

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Developed standard operating procedure for authentication and adulteration detection in the raw drug of tree turmeric (*Coscinium fenestratum*) A bulletin was prepared on "Standard operating procedure for authentication and adulteration detection in the raw drug of tree turmeric (*Coscinium fenestratum*)

Ongoing Projects

1. Characterization and evaluation of *Desmodium gangeticum*

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*Desmodium gangeticum*is a crop of high genetic variability. Twenty five accessions were collected from different parts of the State and evaluated for two seasons. Important morphological characters studied were plant type, stem shape, stem pubescence, leaf shape, leaf margin, leaf pubescence, leaf colour, inflorescence characters, flower colour, fruit colour before and after maturity, seed shape and colour. Based on the morphological characters accessions were grouped.

Majority of the accessions were medium tall plants with circular stem, ovate leaves with entire leaf margin, purple flowers, hairy calyx, with coloured corolla which is papilionaceous, fruit cylindrical brownish lomentum with 6-10 reniform compressed seeds. Two accessions TCR DG 9 and TCRDG 12 were identified with superior root characters like length, thickness, number and weight of roots.

2. Evaluation of promising lines of long pepper- (IET)

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Evaluation of promising lines of long pepper was done with three accessions (ALP 01, ALP 02and ALP 03) obtained from DMAPR. The observations on morphological characters were taken. The crop is in the field for taking further observations.

3. Studies the performance analysis of medicinal plants under banana plantation

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The medicinal plants Neelamari and Sida performed well under intercropping system without reduction in yield. However, reduction in yield of brahmi could be observed under intercropping. LER was more than unity for all intercrops, indicating biological advantage of intercropping banana with medicinal plants. "Banana yield equivalent"was highest for neelamari.

4. Evaluation of Vetiver (*Vetiveriazizanioides*) accessions for superior genotypes

(AMP-01-00-01-2015- ODL- KAU Plan)

Dr. Gracy Mathew
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a. Evaluation of vetiver accessions for high root and oil yield

The selected accessions viz. ODV 7, 24, 27 and 33 were compared with ODV -3.

Performance of vetiver accessions at 12 and 18 months after planting

Accession No.	Plant height (cm)		Tillers per hill		Root yield per plant (g)		Oil content in root - on dry weight basis(%)	
	12MAP	18MAP	12MAP	18MAP	12MAP	18MAP	12MAP	18MAP
ODV 3	124.0	180.0	90.6	143.0	197	136.33	0.69	0.48
ODV 7	145.0	147.0	148.6	181.8	125	171.78	1.10	0.48
ODV 24	120.0	172.0	133.2	211.0	133	293.25	0.30	0.71
ODV 27	128.0	168.6	75.2	224.2	259	287.78	1.15	1.07
ODV 33	154.0	187.8	59.2	162.0	288	327.15	1.04	0.59

Observations at 12th month showed that ODV-27 and ODV -33 produces higher root yield as compared to ODV-3. Percentage of oil was higher in ODV-7, ODV-27 and ODV-33.

Observation at 18th month showed that ODV-33 produces higher root yield per plant and it was 1.5 times higher than the yield obtained at 12 MAP. Percentage of oil was higher in ODV-27. However, oil yield obtained at 18 MAP was always less than the oil yield at 12 MAP. Experiment is continued.

ODV-7 and ODV-33 exhibited more drought tolerance than others.

5. Collection, maintenance and evaluation of germplasm of medicinal and aromatic plants

(AMP/0l-00-22-95/ODL (9) KAU - Plan)

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Enrichment of herbal collection by new planting:

5 new species have been collected and planted in the herbal garden. Rare medicinal plants like *Pachoti* (*Symplocos racemosa*), *Vellakunthirikkam* (*Vateria indica*), *Ellooti* (*Pterospermum rubiginosum*), *Makkottadeva*(*Phaleria macrocorps*), *Njarambodal* (*Hiptage benghalensis*) etc. are planted and maintained under this programme.

Plant propagation studies on medicinal plants:

Continuing the propagation studies of different medicinal plants like *Chavandi* (*Ehretia laevis*), *Keezharnelli* (*Phyllanthus amarus*), *Marotti* (*Hydnocarpus laurifolia*), *Karimthumba* (*Stachytarpheta indica*), *Noni* (*Morinda citrifolia*), *Karuva* (*Cinnamomum verum*), *Thumba* (*Leucas aspera), Ithi* (*Ficus microcarpa*), *Aduthinnapala* (*Aristolochia bracteolate*), *Vishnukranthi* (*Evolvulus alsinoides*), *Thozhukanni* (*Desmodium gyrans*), *Paadavalli (Stephania japonica*) etc.

A book "Propagation manual of medicinal plants' is published.

Essential oil extraction from aromatic plants:

Essential oil yield from various aromatic plants grown in the farm were recorded.

Item	Time (hours)	Essential oil content on fresh weight basis (%)	Properties	Colour	Whether separate easily or procedure to separate oil
Cinnamon leaf (Fresh leaf)	3	0.5%	heavier	pale yellow	settles at bottom on cooling
African malli leaf (Fresh leaf)	4	0.05%	lighter	yellow	separates on top
African malli Aerial part –leaves + inflorescence (fresh)	4	0.07%	lighter	yellow	separate clearly at top
Citronella –aerial portion (fresh)	3	0.25%	lighter	pale yellow	separate clearly at top
All spice leaf (fresh)	3 5	0.5% 0.2%	both lighter (major) & heavier fractions	first colourless, turn yellow	foggy

Camphor leaf (fresh)	6	0.34%	lighter	crystalline white	solidifies fast at room temp, milky white
*C*urry leaf (fresh)	6	0.06%	lighter	yellow	separates clearly at top
Vayambu(rhizome, fresh – 1 year old)	12	0.4%	both heavier (major) &lighter (trace)fractions	yellow	foggy distillate, does not separate even after cooling in fridge
Vayambu (dry leaves collected from 1 year old plant)	6	0.063* (content on dry weight basis)	lighter	yellow	foggy distillate, does not separate even after cooling in fridge

6.**Extraction and purification of antioxidant principles from selected medicinal plants-**
(AMP-06-00-01-2016-ODL- KAU- Plan)

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In addition to ten compounds Acteoside, Isoacteoside, Artanemoside, Leucoseptoside A, Martynoside, Plantainoside, Oraposide/ Crenatoside/ Orobanchoside, 3"'-O-Acetylmartynoside, 2"'-O-Acetylmartynoside and Clerodenoside A isolated and identified earlier, and Luteolin-7-O-rutinoside isolated from leaf alone, additional three compounds were newly isolated.

Phyto-constituents are extracted from the roots of *Artanemasesamoides*by sequential solvent extraction with hexane, chloroform and methanol and sequential methanolic extractives were subjected to column chromatography using Silica gel 100-200 mesh using appropriate solvent system. Similar column fractions were pooled and subjected to preparative HPLC.The isolated peaks were subjected to NMR and MS analysis for its structure elucidation and based on the I D , 2 D ^{1}H NMR (400 MHz) and ^{13} C NMR (100 MHz) spectral data and HRMS, LC MS/ MS and in comparison with literature, the compounds were identified as Darendoside B, Campneoside II R & S epimers, and Campneoside I.

7. Screening of underexploited medicinal plants for economic biomolecules
(AMP-06-00-04-2017- ODL- KAU- Plan)

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HPLC screening of plant extracts for biomolecules:
90% methanolic extractives of selected plants were screened for the presence of phenyl propanoids. Phenyl propanoid compounds obtained by purification in our lab from *Artanemasesamoides* were used as standard. Presence/ absence of phenyl propanoids was determined in comparison with standards based on RT and UV spectra. Among 26 extracts screened, Phenylpropanoids were detected in a few extractives; but only two of them contained

acteoside which is an anti-inflammatory Phenyl propanoidconstituent. The acteoside content in these two plants was quantified.

Methanolic extracts containing of phenyl propanoids using analytical HPLC along with standards

Sl No	**Plant name**	**Plant part**	**Phenyl propanoids Present/ absent**	**Acteoside Present/ absent**
1	*Clerodendronserratum*	root	present	present
2	*Mimosa pudica*	aerial part	Present	present

- HPLC system Analytical HPLC : Dionex Ultimate 3000 with ultimate 3000 PDA detector
- Column: Merck LiCrospher 100 RP 18e (250 mm x 4.6 mm I.D, 5 :m
- Mobile phase : Two solvents (A & B) ; A H2O with 0.1 % orthophosphoric acid v/v and B (90 % ACN and 10% A v/v)
- Gradient system : 20 % B (0-20 min), 20-30 % B (20-40 min), 30-50 % B (40-55 min, 50-60 % (55-65 min , 60-70 % (65-75 min) at 1ml/min; Injection volume: 20 :l

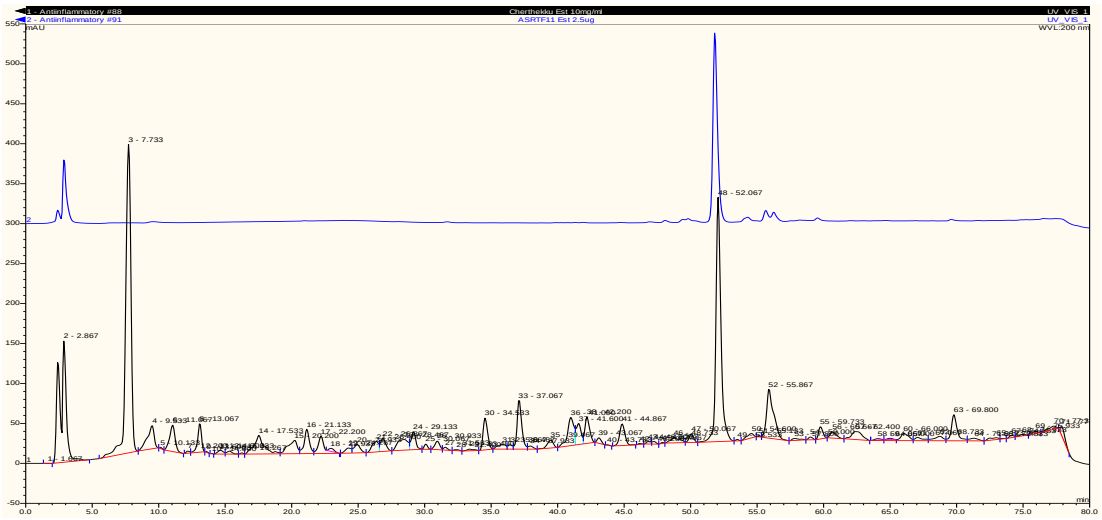
Determination of acteoside content in the identified sources:

The acteoside content of plants in which presence of acteoside was detected in preliminary HPLC screening was then quantified. The dry powders of identified new sources were further sequentially extracted with Hexane, Chloroform and methanoldue to the impurities in some peaksand in order to keep a uniform preparation method for all sample squantitative analysis of acteoside content in each plant was done with sequential methanol extractof the aforesaid acteoside containing plants

Acteoside content of selected medicinal plants

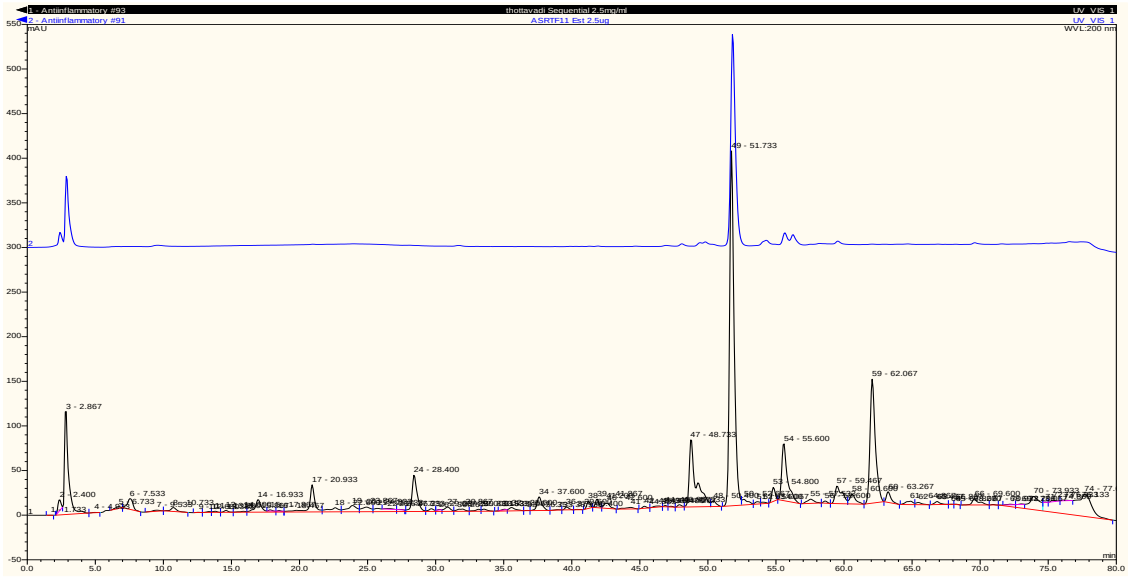
No	**Sample**	**% content of Acteoside on dwb**
1	*Clerodendronserratum* root	0.23%
2	*Mimosa pudica* aerial part	0.75%

HPLC profile of sequential methanolic extract of *Clerodendronserratum* root along with acteoside standard



❖ ***Percentage content acteoside 0.23% on dry weight basis of extracts***

HPLC profile of sequential methanolic extract of *Mimosa pudica* whole plant along with acteoside standard



❖ ***Percentage content acteoside 0.75% on dry weight basis***

❖ ***No other Polypropanoid glycoside matching with standards was observed in the extracts***

8. **Evaluation of antioxidant activity, cytotoxicity and phenol composition of selected anti-inflammatory plants (**AMP-06-00-02-2016-ODL- KAU- Plan)

Dr. Ancy Joseph
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a. Development of mosquito repellent creams for skin application

Using a few selected direct and sequential solvent extracts which showed promising mosquitocidal activity during 2016-18 studies, skin application creams were developed during 2018-19. These creams were tested for mosquito repellency and anti biting effects, both indoor and outdoor through employees in the station. Out of these, two were found to be very promising in terms of efficacy, pleasant aroma and colour. Studies on stability, dermatological aspects etc. are to be carried out for technology is ready for transfer/ commercialization of the product.

b. In vitro screening against mosquito larvae in water

From 2016 onwards, *in vitro* screening of different crude powders and solvent extracts of medicinal plants against mosquito larvae of *Aedesalbopictus*&*Culexquinquefasciatus*is being carried out.

From the first two years of screening, five plants namely, *manjakoova, karimanjal, kacholam, kattinchi&vayambu* were found to possess significant larvicidal activity of which *Acoruscalamus* (rhizome) was identified as the best. Different adsorbents were tested and single and composite formulations were developed for sachet application. Dosage of the sachet for application in contained water bodies for mosquito larvae control was determined. Though the extract was effective at 0.005%, to reduce the dosage requirement for application in water bodies, search for better sources was continued during 2018-19 also. Out of 35 plants newly screened, three plants namely black pepper, banglathippali and cinnamon were found to be promising. It is proposed to continue the search for better plant sources for mosquito larvicidal activity and develop single and composite formulations from the newly identified sources.

c. In vitro screening against human pathogens

In vitro screening of methanolic extracts of plants were continued against two human pathogens viz. *Pseudomonas aeruginosa* and *Staphylococcus aureus* by poison food method and extracts with significant activity against the tested micro-organisms were identified.
Out of the 22 plants screened against human pathogens, few plants showed broad spectrum activity against both bacterial pathogens tested.

This information will be utilized for development of human health care products in collaboration with appropriate agencies.

9. Development of Pest and Disease Control Products from Medicinal Plants

(AMP-05-00-01-2018- ODL- KAU Plan)

Dr. Ancy Joseph
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During 2013-15, under 100 crore ICAR institutional grant project, general toxicity screening of more than 100 selected medicinal and aromatic plants, was done in two test organisms namely *Artemiasalina* and *Eudrillus eugenia* by rapid assay methods and crude drugs and extracts with very low LD 50 were identified for screening against various crop pests, non insect pests and plant and human pathogens. During 2016-18, these selected raw drugs were further tested for efficacy against caterpillar pests by in vitro screening techniques (Leaf disc dip assay, Direct spray & Anti-feedant assay).

Screening on *Pythium, Colletotrichum* & ***Alternaria*** are being done in collaboration with Dept of Plant Pathology, College of Horticulture, Vellanikkara.

a. *In-vitro* experiments carried out at AMPRS, Odakkali during 2018-19

No	Pest	Material tested	Findings
1	Hairy caterpillar (*Spilosoma obliqua)* - 2nd instar larvae in banana	Solvent extracts of *Acorus calamus, Curcuma zedoaria* and *Kaempferia galanga*	70-95% antifeedency for Hexane, chloroform, ethyl acetate & methanol extracts of *Acorus calamus*, 85 to 98% antifeedency for hexane and sequential methanolic extract of *Curcuma zedoaria.*
		0.5% spray of liquid soap formulation *Acorus calamus, Curcuma zedoaria* and*Kaempferia galanga*	Found promising. Trial continued.
2	Epilachna beetle (*Henosepilachna viginctiotopunctata*)	2% Crude powder soap solutions of 5 selected plants by feed dip method & spray method (one time application)	
	1st instar		72 – 99% mortality at 3 DAT
	2nd instar grubs		39- 99% mortality at 3 DAT
	3rd instar grubs		15 - 90% mortality at 3 DAT
	Ovicidal activity		97-100 % mortality at 3 DAT
3	Rice weevil (*Sitophilus oryzae*)	0.2% dry powder of 5 selected plants mixed with the stored grains	23 – 43% mortality at 10 DAT
4	Pulse beetle (*Callosobruchus maculates*)	Crude drug powders of *Acorus calamus, Melaleucaalternifolia and Curcumazedoaria*	60-100% mortality at 5% concentration.

		Solvent extract of *Acoru scalamus,Melaleucaalter nifolia and Curcuma zedoaria*	2% hexane extract of *Acorus calamus* gave 100% mortality, *Melaleuca alternifolia* (77%), *Curcuma zedoaria*(73%) Sequential Chloroform and methanol extracts also gave significant control. The grains treated with crude powders and extracts showed normal germination.

Salient findings of in-vitro screening

- When tested against hairy caterpillar (*Spilosoma obliqua)* larvae, 70-95% antifeed encyobserved for hexane, chloroform, ethyl acetate & methanol extracts of *Acorus calamus*, 85 to 98% antifeedency for hexane and sequential methanolic extract of *Curcuma zedoaria.*
- 0.5% spray of liquid soaps of *Acorus calamus, Curcuma zedoaria* and *Kaempferia galangal* gave significant control of 2ndinstar banana hairy caterpillar (*Spilosoma obliqua)* larvae.
- 2% crude powder soap solutions of selected plants were effective to control larvae of Epilachna beetle *(Henosepilachna viginctiotopunctata*). Some of them showed ovicidalactivity also.
- 0.2% dry powder of 5 selected plants mixed with the stored grains showed 23 – 43% mortality of Rice weevil (*Sitophilus oryzae*).
- Crude drug powders of*Acorus calamus,Melaleuca alternifolia and Curcuma zedoaria* gave 60-100% mortality at 5% concentration . against Pulse beetle (*Callosobruchus maculates*). 2% hexane extract of *Acorus calamus***,** *Melaleuca alternifolia and Curcuma zedoaria were* found to be effective against pulse beetle. Sequential Chloroform and methanol extracts also gave significant control. The grains treated with crude powders and extracts showed normal germination.

b. Field testing against rhinoceros beetle and red palm weevil of coconut

Based on findings of *in vitro* trials on grubs and adultsofbeetle and weevil pests, single and composite formulations were made and tested in the AMPRS field during June 2018 and October 2018 against rhinoceros beetle and red palm weevil of coconut and observations were recorded for 60 days. One of the formulation tested checked infestation till 45 days whereas chemical control as per POP was effective upto 60 days.
Based on the observations, formulations were modified and evaluation is progressing.

c. Evaluation of selected solvent extracts against phytopathogenic fungi *(Pythiumsp. Colletotrichum sp and Alternaria sp.)*

Selected plant extracts which were found to possess activity against *Rhizectonia solani, Fusarium oxysporum, Phytophthora capscici*in the *invitro* screening studies at AMPRS, Odakkali during 2013-2017 were supplied to Department of Pathology, College of Horticulture, Vellanikkara for further screening against *Pythium aphanidermatum, Colletotrichum gloeosporioides* and *Alternaria solani*. Out of the 23 extracts screened against *P.aphanidermatum*, Karimanjal, Kacholam and Vayamb showed significantly higher inhibition at 0.05% copared to others. The *in vitro* evaluation of *Colletotrichum*sp. and *Alternaria*sp. is going on.

10. Isolation and characterization of phyto-constituents with pesticidal activity and development of botanical formulations from under- exploited tropical zingiberales

(AMP-06-00-05-2017- ODL- KAU Plan)

Dr. Ancy Joseph
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a. Multi locational trials of Zedoary formulation against sucking insects

Zedoary formulation was tested against the following pests at farmers plot at Paniyeli, Department of Olericulture, CoH, Vellanikkara and AMPRS, Odakkali farm.

- Mango mealy bug (*Drosicha mangiferae*)
- Papya mealy bug *(Paracoccus marginatus*)
- Spherical mealy bug *Nipaecoc cusviridis*in jack
- Aphids (*Aphis craccivora*) in brinjal and cow pea
- Whitefly (*Bemisia tabaci*) in Brinjal& cauliflower
- Cotton leaf hopper (*Amrasca devastans*) in Brinjal&bhindi

Results are given in the table below

Pest	Location	Findings
Papaya mealy bug	farmer's field at Paniyeli	Formulation @ 0.4 %, gave 88% control
Mango mealy bug	AMPRS field	Formulation @ 0.4% gave 80% control
Spherical mealy bug of jack	AMPRS field	Formulation @ 0.4 %, 98% control at 2 DAT
Hoppers of brinjal	Dept of Olericulture, CoH	Formulation @ 2 % gave 40% control
Hoppers of bhindi	AMPRS	Formulation @ 2 % gave 48% control
Aphids in Brinjal	Dept of Olericulture, CoH	Formulation @ 2 % gave 86% control
Aphids in cow pea	AMPRS	Formulation @ 2 % gave 76% control
Whitefly of brinjal	Dept of Olericulture, CoH	Formulation @ 2 % gave 73% control
Whitefly of cauliflower	Dept of Olericulture, CoH	Formulation @ 2 % gave 70% control

Formulation is effective against mealy bugs at 0.4% concentration, whiteflies, hoppers and aphids @ 2%. The formulation showed mortality, repellency and IGR activity. A repeated

spray after one week is recommended and the results are proposed to be included in POP under organic farming.

b. Field testing of raw drugs against Fusarium wilt in cowpea (*Fusarium oxysporum*)

A few crude plant powders with broad spectrum activity observed *in-vitro* screening against *Fusarium oxysporum, Phytophthora capsici and Rhizoctonia solani* were tested against Fusarium wilt in precision farming plot of cowpea during January 2019. The crude drug powders were applied in the planting hole at 5 g per pit 3 times (at sowing, 10th day, 20th day). The results are shown in Table 1.

Treatment	% of plants survived	Pod yield (dry) / per plot of 10 m2	Seed yield (dry) per plot of 10 m2
Bavistin 2g/lit- 300 ml /plant pit	17	180	122
Lime solution 10% @ 300ml/hole	65	375	195
Manjakoova dry powder 5g/hole	100	1500	835
Kalyanasougandhikam 5g/hole	41	182	122

Observations showed that *manjakoova* dry powder was effective in checking the infection and this treatment recorded significantly higher yield compared to chemical control. The results are in conformity with indications of *in vitro* trials.

PG Projects

Concluded PG Projects

1. Standardisation of nursery management practices in *pachotti* (*Symplocos cochinchinensis* (Lour.) S. Moore).

Ajil M.S. (M.Sc. Student)
Dr. Deepa S. Nair (Chairperson),
Assistant Professor

The seeds were subjected to *in vivo* and *in vitro* germination studies. In *in vivo* study, among the pretreatments tried, *viz*., physical treatments, chemical priming and bio priming, only physical treatment of scarification (with sand paper) responded with a very low germination of 2 per cent. The germination commenced after two months of the treatment. Other *in vivo* pretreatments as well as *in vitro* treatments did not give any germination.

Among the different types of cuttings *viz.*, hardwood, semihardwood, softwood and root cuttings, hardwood cuttings were identified as the preferred planting material for the nursery establishment of pachotti. The cuttings could be treated with salicylic acid @20 mg L^{-1} for initial establishment of nursery plants. When pretreated with SA @ 20 mg L^{-1}, at three months after planting, the hardwood cuttings responded with 30 per cent survival. Root cuttings pretreated with IAA @ 250 mg L^{-1}, after three months of planting responded with 33.33 per cent survival. Though root cuttings had slightly higher survival percent, hardwood cuttings were selected as the preferred planting material due to better availability and ease in procurement.

The preferred potting media for transplanting the established cuttings for raising the nursery plants of pachotti is Soil : Coirpith compost: Vermicompost (1:1:1) + AMF (5g/plant). Among the various potting media tried, Soil :Coirpith compost: Vermicompost (1:1:1) + AMF recorded significantly higher plant growth potential (0.522) followed by Soil : Coirpith compost: Vermicompost (1:1:1) + PGPR Mix I (0.428).

2. Developmental morphology of tuberisation and phytochemical profiling in milk yam (*Ipomoea digitata* L.)

Sonia N.S. (Ph.D Student)
Dr. P.C. Jessykutty, Professor

Morphological, anatomical and phytochemical investigations of milk yam tubers during its growth stages at regular intervals revealed that milk yam tubers were optimally mature at 21 MAP. Milk yam tubers of 21 MAP were having more than two (2.33) number of tubers; length, 29.50 cm; breadth, 21.90 cm; fresh tuber yield $plant^{-1}$, 983.33 g and dry tuber yield $plant^{-1}$, 414.97 g.

Compared to immature (6 MAP) and optimally mature (21 MAP) milk yam tubers, over mature (36 MAP) tubers recorded highest Umbelliferone concentration through both HPLC (High Performance Liquid Chromatography) and HPTLC (High Performance Thin Layer Chromatography) analysis (0.44 µg g^{-1} and 0.42 µg g^{-1} respectively). Phytochemical profiling of crude methanolic extract of milk yam tubers (21 MAP) through GC-MS (Gas Chromatography-Mass Spectrometry) analysis revealed the presence of sixteen different bioactive components of which 2-tert-Butyl-4-isopropyl-5-methylphenol in abundant, 8.03 per cent (peak area).

Optimally mature tubers had potent *in vitro* anti-oxidant activity since, it recorded least IC_{50} value for DPPH radical (1040.00 µg ml^{-1}) and nitric oxide radical (355.00 µg ml^{-1}) scavenging activity as well as higher reducing power (400 µg ml^{-1}), 0.118 nm. It recorded higher alpha amylase enzyme inhibition activity (99.20 per cent) which indicated its superior *in vitro* anti-diabetic activity as well.

Milk yam tuber powder prepared using peeled tuber shreds washed three times, dewatered by keeping in bamboo basket and dried in hot air oven at 60 ^{0}C recorded least moisture content (4.60 per cent), moderate yield (23.27 per cent), drying time (12.33 hours) and carbohydrate (50.82 g 100 g^{-1}), high protein (12.44 g 100 g^{-1}), vitamin A (613.33 µg 100 g^{-1}), vitamin C (7.43 mg 100 g^{-1}) and superior sensory quality too. However, by following the above said protocol a substantial reduction in anti-nutrients viz., tannins (69.84 per cent), phytic acid (81.02 per cent), oxalates (94.69 per cent) and trypsin inhibitor (86.83 per cent) were achieved.

Essential amino acids (150.62 mg g protein^{-1}) in milk yam tuber powder could satisfy 57.18 per cent RDA (Recommended Dietary Allowances) of an adult. Moreover, it contributed 40.23 per cent RDA of sulphur containing amino acids, 35.73 per cent RDA of lysine and 18.33 per cent RDA of tryptophan for an adult.

Composite flour containing milk yam, ragi, ground nut and green gram in the ratio 30: 30: 10: 30 recorded higher Net Dietary Protein Calories per cent, 3.31, and it scored higher sensory quality too, hence, selected as the best combination of dietary supplement. Milk yam dietary supplement when compared with commercial product-Quaker Oats Plus multi-grain meal recorded high protein (15.45±0.13 g), fat (3.27±0.36 g), calcium (186.63±2.22 mg) and iron (12.21±0.61 mg), less carbohydrate (58.78±1.00 g) and sodium content (28.27±0.06 mg). Milk yam dietary supplement packaged in aluminium foil covers and stored under refrigerated condition up to three MAS (Months After Storage) recorded least moisture content (10.93 per cent), peroxide value (7.73 meq. O_2 kg^{-1}), fungi (0.67x10^{5}cfu g^{-1}), bacteria (1.00x10^{7}cfu g^{-1}) and highest sensory scores.

Ongoing PG projects

1. Development of gel stabilisation technique and nutraceutical development in *Aloe Vera* AMP-05-00-01-2016 ACV (16)- KAU- PG-Ph.D(Major advisor : Dr. G.S.Sreekala)
2. Performance analysis of medicinal *Kaempferia* species . AMP- 06-00-01-2017- VKA (16)-KAU- PG-Ph.D (Major advisor : Dr.N.Mini Raj)
3. Propagation and bioactivity studies in *Ellotti* (*Pterospermum rubiginosum* B.Heyne ex Wight&Arn.) -Ph.D (Major advisor :Dr.N.Mini Raj)
4. Chitosan mediated metabolite elicitation and growth responses in kasthuri turmeric (*Curcuma aromatic* Salisb.) AMP-03-00-04-2018-ACV(16)-KAU-PG(Major advisor : Dr.DeepaS.Nair)
5. Salicylic acid mediated metabolite elicitation and growth responses in long pepper (*Piper longum* L.) AMP-03-00-05-2018-ACV(16)-KAU-PG(Major advisor : Dr.DeepaS.Nair)
6. Germination and plant growth responses in *Ashwagandha* (*Withania somnifera*(L.) Dunal) and *Kiriyathu* (*Andrographis paniculata* (Burm.f.) Nees) to seed pretreatments.(Major advisor : Dr.DeepaS.Nair)
7. Germination and plant growth responses in Ocimum spp. to seed pretreatments (Major advisor :Dr.DeepaS.Nair)
8. Phytosphere variations of sida hemp [*Sida alnifolia* L.] under varying agronomic management(Major advisor : Dr.Sindhu,P.V))AMP - 03 - 00 - 01 -2018 - VKA (01) - KAU - PG

Name of Project Coordination Group: (08) Biotechnology, Biochemistry and Plant Physiology

Compiled by:
Dr. M.R Shylaja, Project Coordinator

Plan & External Aided Projects

Concluded Project : 2 Nos.

Ongoing Projects :6 Nos.

Post Graduate Projects

Concluded Projects : 37 Nos.

Ongoing Project :69 Nos.

Concluded Projects

1.Marker Assisted Breeding to develop a bacterial wilt resistant chilli paprika variety (*Capsicum annuum* L.) suited for the tropical regions of India (BT/PR11822/BPA/118/18/2014 (DBT Project))

Dr. Deepu Mathew
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Objectives of the project were to develop progenies of chillies segregating for capsaicin content, bacterial wilt resistance and adaptation to warmer climates by selfing the F1 progenies of paprika cv. Kt-Pl-19 and bacterial wilt resistant chilli variety. Anugraha, to select bacterial wilt resistant paprika F_2 population using SCAR markers and to develop back crosses progenies with bacterial wilt resistance up to BC_4 using Kt-Pl-19 as recurrent parent, to develop a non-segregating and stable variety of bacterial wilt resistant paprika through MAS among selfed progenies of BC_4 up to BC_4F_3.

A paprika cultivar suited for the tropical conditions of Southern India was mandatory for a long time since the companies producing Kashmiri chilli were transporting the pods from northern India. Commercial cultivation of paprika high yielding varieties used to fail since they are susceptible to bacterial wilt.In this project, non-pungent paprika lines with bacterial wilt resistance, long pods, high yield, deep red fruits suited for drying were developed. F2 lines were developed by crossing Anugraha, the bacterial wilt resistant variety with Kt-Pl-19, the paprika line, at IIHR. F2 population was screened under field conditions and BC1F1 was developed using the non-pungent and bacterial wilt resistant female parent. BC1F1 population was screened under open field with artificial inoculation and the selected lines were screened using markers for both the traits. The selected lines were further carried forward to BC2F1 which was screened with artificial inoculation followed by marker assisted forward and background markers. BC2F1 population was further screened in the same way and plants with resistance, non-pungent deep red, long, easy-to-dry fruits were selected. The generation was carried forward to BC3F1 and this needs to be fixed at BC3F3 by selfing.

2.Marker assisted introgression of thermosensitive genic male sterile gene to red rice background for stable sterility for hybrid seed production-(CPB-03-00-02-2015-ACV(21)KSCSTE)

Dr. Roy Stephen
Professor
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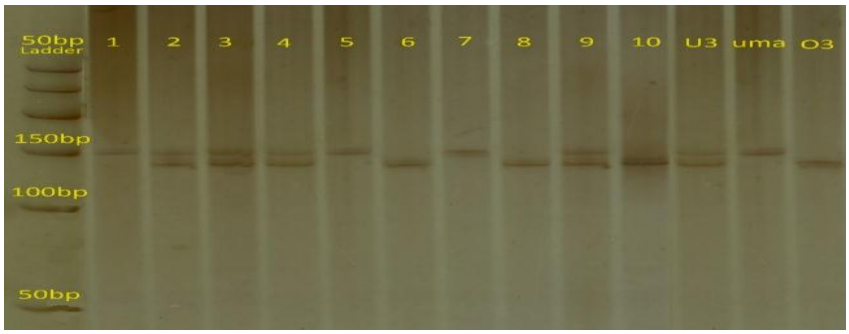
Objectives of the project were to develop a red rice line with multiple *tms* genes through three way cross, to develop a stable marker associated with the TGMS genes, to analyze the molecular mechanism associated with thermosensitivity.

The stable Thermosensitive Genetic Male Sterile lines IR75589-31-27-8-33 (EC 720903) was imported from International Rice Research Institute, Philippines through a Standard Material Transfer Agreement.

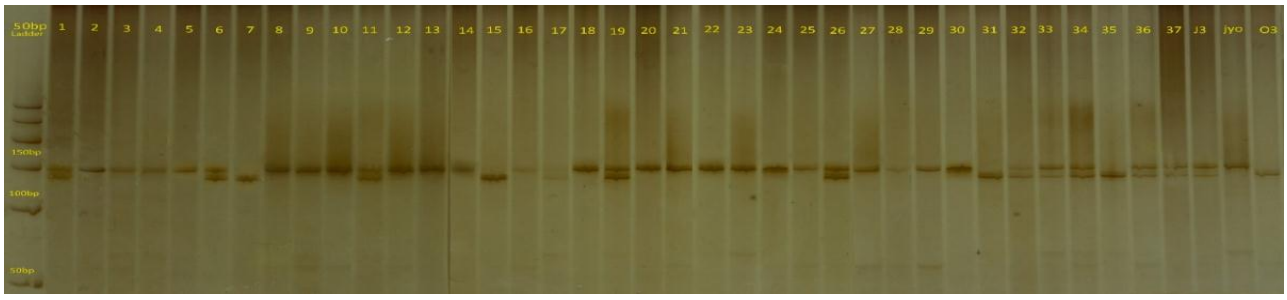
This TGMS line was used as the donor plant for transferring male sterile gene to the two ruling red rice varieties Uma and Jyothi.

The critical sterility temperature and the critical stage of thermo sensitivity of the TGMS line were identified. IR75589-31-27-8-33 showed complete pollen sterility when the daily mean temperaturewas greater than 26.9^{o}C during critical sterility phase of 10 – 25 days before heading. The phenological characteristics of this TGMS line were evaluated through sequential monthly sowing for one year.

The stable TGMS line IR75589-31-27-8-33 was crossed with popular red rice varieties Uma and Jyothi to yield F1 hybrids. Fifty percent of the generated F1 seeds were used for generating mapping population and the remaining 50% was used for back crossing. All the F1 plants were completely fertile with high pollen and spikelet fertility. The sterile F2 plants were back crossed with the corresponding pollen donors, and BC3F2 seeds were collected. For the multiplication of the sterile F2 plants, anther culture was attempted. An SSR marker RM 5897 linked to tms 5 gene was identified for selecting male sterile plants.



Amplified product on urea page (1-10(F_2 progenies of Uma X EC720903), U3 (F_1 progenies of Uma X EC720903), Uma, EC720903) with the marker RM5897.



Amplified product on urea page (1-37(F_2 progenies of Jyothi X EC720903), J3 (F_1 progenies of Jyothi X EC720903), Jyo (Jyothi), EC720903) with the marker RM5897

Ongoing Projects

1. Centre of Excellence in Biotechnology and Secondary Agriculture at CPBMB

(BBP-11-00-04-2017-VKA(19)-KAU Plan)

Dr. M.R. Shylaja
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Research on centre of excellence and secondary agriculture focused on development ofregeneration protocols in recalcitrant species like coconut and nutmeg, gender identification in nutmeg through molecular marker analysis, *In silico* screening and molecular docking of compounds from nutmeg, pepper, pineapple against major diseases.

Bulging, sprouting, adventitious bud like structures and embryoid like structures were observed in coconut embryo culture in Y3 medium supplemented with different levels of auxins and cytokinins. Bulging was observed in 32.27% of cultures, sprouting in 4.99% of cultures, adventitious bud like structures in 2.32% of cultures and embryoid like structures in 7.63% of cultures.

In nutmeg, with the surface sterilization procedure standardized, better culture establishment could be observed. Sprouting was observed in 62.6% of cultures in SH medium supplemented with BA and NAA. Growth of induced shoots and leaf opening were found very slow. Withering of leaves and detaching of sprouts were observed in many of cultures, Further trials for growth of shoots and leaf opening with different media combinations are in progress.

In nutmeg for sex identification, various reported RAPD and ISSR primers were screened for polymorphism. RAPD primer OPBD 20 gave polymorphic band in female plants. Further validation of the primer and development of scar marker are in progress. Amplification of specific sex markers reported in other crops are also in progress.

Malabaricone b, Malabaricone c from nutmeg, undecanone, Methyl octanate, 4 methyl acetophenon cymenol, pellitorine from black pepper, Butyl formate vanillin and theobromine from pineapple showed good interaction with least binding energy when docked with receptor proteins of arthritis (51 KT and 3 E7G) and cardiovascular disease 2VOZ 2 ETK). Quericetin, curcumin, 4 hydroxy benzaldehyde from *Zingiber zerumbet* showed good interaction with least binding energy when docked with receptor protein for diabetes (1IR3, 5.IX70), cancer (8 GNK, 1ZXN, 1PYE) and arthritis (51 KT, 3E7G). The lead compounds (18 Nos.) from nutmeg, black pepper, Pineapple and *Zingiber zerumbet* found to be pharmokinetically superior to commercially available ten drugs each for diabetes, cancer, arthritis and cardiovascular disease with respect to hepatotoxicity when ADME/T analysis was done. Protein –protein docking studies of receptor proteins of cancer (5GNK) diabetes (1IR3), arthritis (51KT) and cardiovascular disease (2VOZ) against bromelain protein from pineapple showed good interaction. Diabetic receptor protein (1IR3) also showed good interaction with bromelain showing least Z rank score.

2. Commercial micropropagation of high demand high value crops as per National Certification System for Tissue Culture Plants (NCSTCP)- (BBP-01-01-05-2016-VKA-KAU-Plan)

Dr. M.R. Shylaja
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The project started in 2012 was aimed at developing a well designed commercial micropropagation unit at CPBMB as per NCSTCP, advanced facility for virus indexing at CoA, Vellayani, well designed micropropagation facilities at four satellite centres (BRS Kannara, RRS Vyttilla, RARS Pattambi and CoA Padanakkad), operational capacity building of the units in a revolving fund mode at later stages, need based development of micropropagation protocols on new high demand crops and refinement of already developed protocols for commercial application, capacity building of entrepreneurs on commercial plant tissue culture, virus indexing and clonal fidelity testing. Establishing demonstration plots of tissue culture derived plants at lead and satellite centres are also aimed in the project.

In the project a well designed commercial micropropagation unit was developed at Centre for Plant Biotechnology and Molecular Biology, College of Horticulture as per NCSTCP. Developed an advanced facility for virus indexing at CoA, Vellayani, developed well designed micropropagation facilities at four satellite centres (BRS Kannara, RRS Vyttilla, RARS Pattambi and CoA Padanakkad), developed operational capacity for productionin different units in a revolving fund mode, developed micropropagation protocols on new high demand crops and refined already developed protocols for commercial application, capacity building of entrepreneurs on commercial plant tissue culture, virus indexing and clonal fidelity testing facility developed at CPBMB, CoA, Vellayani, BRS, Kannara and RRS, Vyttilla, established demonstration plots of tissue culture derived plants at lead and satellite centres.

During the period 2018-19, project was in operation at eight network centres. The production of TC plants was continued at different centres in RF mode also. The fund allotted for the different centres was Rs. 8.0 lakhs and utilization was 7.94198 lakhs. During 2018-19, 134011 TC plants (banana, black pepper, anthurium and orchid) were produced utilizing the funds allotted and income generated was Rs. 11.05250 lakhs. New micropropagation protocols of special type of *Aloe vera* and passion fruit (134P) are in progress.

3. Allele mining for new *SalTol* QTL and barcoding of rice varieties of Kerala

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Objectives of the project were to identify additional saline tolerant QTL from different land races, to develop allele specific markers for use in marker assisted breeding, bar coding the varieties to discriminate them from each other.

The Na- K content, Peroxidase activity, Proline accumulation in the shoot as well as in root portion were estimated for the available saline tolerant germplasm so as to assess any remarkable difference among the popular landraces. Pokkali, Chettivirippu, Cheruvirippu and Ponkurukka were selected for detailed study of their physiological mechanism and for crossing programme to identify additional saline tolerant QTL. Crossing to findout alternate saline tolerant QTL is in progress

4. Crop improvement of high yielding rice variety with biotic stress tolerance for Pokali

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Objective was the development of HYV for Pokkali rice with blast and sheath blight tolerance The programme included Hybridisation of rice variety VTL 6 with blast and sheath blight tolerant variety 'Tetep' and development of RILs, Evaluation of RILs for tolerance, genotyping and selection of heterozygous lines using foreground and recombinant markers, genotyping in each generation for desirable QTL combinations along with RP genome recovery, artificialand field screening of the developed lines. Tetep landrace was collected from RARS, Pattambi and RRS, Moncompu and raised in pots to get sufficient viable seeds, to assess its maturity duration and to study the biometrical characters. Crossing block was raised with VTL 6 as female parent and Tetep as male parent. Crossing done and F1 seeds were collected. Project is in progress

5. Yield enhancement strategies for production of anticancer and other therapeutic compounds by cell and tissue cultures of *Tinospora cordifolia* and *Withania somnifera*

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Objective of the study was to standardize *invitro* culture techniques for enhancing the production of anticancer and other therapeutic compounds in *Tinospora cordifolia* and *Withania somnifera*. Callus cultures were established in *Tinospora cordifolia* and *Withania somnifera*. The project is in progress.

6. Developing organic rice varieties by pyramiding of biotic and abiotic stresses through MAS

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Objectives of the project were, Introgression of major abiotic and biotic stresses into three major high yielding varieties of rice, Collection and purchase of required gene specific SSR markers for BLB tolerance in rice corresponding to Xa5, Xa13 and Xa21genes. Parental polymorphism study to choose polymorphic markers. Raising the F1 generation of the cross Jyothi x Swarna MAS . Hybridisation of *Saltol* and *Sub 1* introgressed Jyothi with Swarna MAS. F1 seeds were collected. F1 seeds will be

raised for developing RIL population as well as for backcrossing for molecular evaluation for BLB QTLs. Project is in progress

PG Projects

Concluded PG Projects

1. Isolation, characterization and evaluation of *PINI* and *BP* genes in relation to inflorescence architecture in black pepper (*Piper nigrum* L.) (BBP-04-00-04-2016 -ACV(19)-KAU-PG)

Smitha Bhasi (2015-21-026)

The objective was to isolate and characterise *PIN1* (*PINFORMED1*) and *BP* (*BREVIPEDICELLUS*) genes in black pepper (*Piper nigrum* L.) and to evaluate the role of these genes in branching of spikes by studying their differential expression in branching and non-branching varieties of black pepper. Isolation and characterisation of coding sequences of *PIN1* (124 bp and 650 bp) and *BP* genes (145 bp) in black pepper reported for the first time. Differential expression analysis showed overexpression of *PIN1* (14 fold) and *BP* (27 folds) in Thekken compared to non-branching varieties. The study revealed that the auxin (IAA) content in Thekken, was significantly lesser (1/4 th) when compared to non-branched varieties, whereas, the total cytokinin content was found increasing during a particular growth stage of inflorescence. The differential expression of the floral genes as well as the differential levels of the hormones indicate their significant role in inducing the spike branching trait in Thekken.

2. Cryoconservation of koovalam *(Aegle marmelos* L. Corr.*)* by encapsulation-dehydration technique (BBP-01-01-01-2016-ACV(19)-KAU-PG)

Deepa E (2015-11-071)

Objective of the project was to standardize cryoconservation protocol by encapsulation –dehydration technique for long-term conservation of *Aegle marmelos*and to assess the genetic fidelity of plantlets recovered and regenerated from cryostorage using molecular markers.Single node segments with axillary buds from *in vitro* maintained cultures gave maximum shoot multiplication (9.33 shoots per explant) in MS medium supplemented with BA 2 mg L^{-1} + IBA 0.5 mg L^{-1}. The best shoot proliferation response was obtained in MS + BA 2 mg L^{-1} + IBA 0.5 mg L^{-1} + chitosan 10 mg L^{-1} (35.67 shoots per explant). Even though higher shoot proliferation was observed in CH and TDZ supplemented media, they exhibited morphological abnormalities. MS + BA 2 mg L^{-1} + IBA 0.5 mg L^{-1} was used as basal medium for cryopreservation studies.

The protocol for encapsulation dehydration technique of cryopreservation was standardised using axillary buds of *A. marmelos* with preconditioning in semi solid MS medium supplemented with sucrose 0.1 M for 7 days, encapsulation using sodium alginate 3.5 per cent in modified liquid MS medium and calcium chloride 100mM followed by pre-culture in liquid MS medium supplemented with DMSO 3 per cent and sucrose 0.5 M for 3 days and dehydration 6 h MC (19.5%), rapid freezing

in liquid nitrogen for at least 2 h and recovery in the medium ½ MS+BA 2 mg L^{-1}+ IBA 0.5 mg L^{-1}.The shoot regenerated were also genetically similar to the control plants.

3. Establishment of *in vitro* regeneration systems from callus and protoplast in *Capsicum frutescens* L. (BBP-01-01-02-2016-ACV(19)-KAU-PG)

Jancy J. Sathyaraj (2015-11-078)

The objective of the study was to establish callus culture from different explants in *C. frutescens*,to establish protocol for protoplast isolation from callus/leaf mesophyll and to culture protoplast. Maximum callusing response was obtained in MS medium with picloram 1.50 mg L^{-1}. Organogenesis was obtained from the calli derived in MS medium with BA 3.00 mg L^{-1} and NAA 1.00 mg L^{-1}. The shoot initiated from the calli in MS medium with BA 3.00 mg L^{-1} and IBA 1.00 mg L^{-1}. The rooting of microshoots could be obtained in MS medium with IAA 1.50 mg L^{-1}. Leaf gave higher protoplast yield and viability in CPW solution with cellulase 2.00 per cent, macerozyme 0.50 per cent and mannitol 0.50 M, incubated in dark for 6 h and callus, in CPW solution with cellulase 2.00 per cent, macerozyme 0.50 per cent and mannitol 0.60 M, incubated in dark for 4 h. The protoplasts purified in 21 per cent sucrose supplemented floatation medium and adjusted to a plating density of 10 x 10^5, initiated microcalli in liquid MS medium supplemented with mannitol 0.50 M, 2,4- D 0.50 mg L^{-1} and sucrose 30g $L^{-1.}$ The visual colony formation of microcalli was obtained on addition of liquid MS medium supplemented with mannitol 0.40 M and sucrose 5g L^{-1}.

4. Evaluation of siRNA mediated banana bract mosaic virus (BBrMV) resistance in banana
(BBP-03-00-01-2016-ACV(19)-KAU-PG)

Harshitha C.K. (2015-11-086)

The objective of the project was to evaluate siRNA mediated resistance against *Banana bract mosaic virus* (BBrMV) in transgenic banana (*Musa* spp. Var. Nendran) plants developed using ihpRNA construct for replicase gene by artificial infection and to confirm the expression of siRNA products in infected plants.

Somatic embryos of banana var. Nendran, transformed with*A. tumefaciens* strain LBA4404 containing the binary vector pART 27 harboring ihpRNA cassette targeting replicase gene of BBrMV were regenerated. The shoots were confirmed for the presence of ihpRNA cassette by doing PCR and were rooted and hardened. Three months old hardened plants were challenged with 50 infectious viruliferous aphids for 24hrs immediately after they were allowed acquisition-access to BBrMV-infected banana plant for 30min. After 2 weeks of infection, the plants were tested for the presence of viral RNA in young leaf by RT-PCR using BBrMV replicase gene specific primers. An amplicon of size 733bp corresponding to replicase gene was detected in the infected untransformed control plants, but none of the ihpRNA transformed plants showed infection. Northern hybridization showed strong signals corresponding to 21nt long siRNAs in all the transformed plants, indicating siRNA mediated silencing of replicase gene of BBrMV as the cause of virus resistance in transformed plants.

5. Somatic embryogenesis in black pepper (*Piper nigrum* L.)(BBP-01-01-03-2016-ACV(19)-KAU-PG)

Afna Mol O.P. (2015-11-123)

Objective was to standardise a protocol for somatic embryogenesis in black pepper (*Piper nigrum* L.*)* var. Panniyur 5. Leaf tissue from *in vitro* raised seedlings was found to be most responsive to the callus induction (68.75% in 40 days) in MS medium supplemented with1.5 mg L^{-1} of picloram. As there was no response on the somatic embryo induction from shoot tip, stem node and leaf, somatic embryogenesis was tried in fully ripened seeds of Panniyur5. In 46% of the seeds, somatic embryos emerged indirectly from the micropylar region of the seed and direct embryo induction was occurred in the rest (SH with 1.5 or 3% sucrose and half strength SH with 3% sucrose). The calli initiated from seeds in MS and SH media supplemented with 1.5 and 2 mg L^{-1} picloram and 3% sucrose produced somatic embryos in the same medium. Somatic embryogenesis was early in SH medium (40 days) compared to MS medium (60 days).The primary embryos formed in SH medium with 1.5% sucrose produced the maximum (50%) secondary embryos in semi solid SH medium with 1.5% sucrose . Secondary embryo formed in SH with 3% sucrose got regenerated in to plantlets in the same medium. Secondary embryos from semi solid SH

medium were regenerated only when transferred to liquid SH medium with different concentration of sucrose (3.0% and 3.5%) with continuous shaking (110 rpm). Somatic embryogenesis was confirmed by visualizing the different developmental stages of the somatic embryos *viz.* globular, heart, torpedo and cotyledonary stages under the stereo microscope. Histological studies of the embryos confirmed their origin from micropylar tissue and not from zygotic tissue.

6. Molecular basis of acaricide resistance in *Tetranychus truncates* Ehara (Prostigmata: Tetranychidae) infesting vegetable crops (BBP-02-00-03-2017-VKA(4)-KAU-PG)

Anushree Bachhar (2016-11-107)

The objective of the project was to investigate the status, biochemical and molecular bases of acaricide resistance in *Tetranychus truncates* (Ehara). The status of acaricide resistance in *Tetranychus truncatus* was identifed via toxicological assay with three commonly used acaricide molecules *viz,* spiromesifen, fenazaquin and diafenthiuron with three frield strain VkOk1(okra) VkAm3(amaranthus) VkPm3(pumpkin) and a strain maintained in the lab as susceptible strain (SS) with 150 generations without exposure to any agro chemicals. Bioassay study revealed that the level of resistance varied among the strains for the acaricides evaluated. The strain VkOk1 recorded highest LC50 value and has developed 8 (1794.293 ppm), 13 (852.394 ppm) and 10 (1968.496 ppm) fold resistance to spiromesifen, fenazaquin and diafenthiuron, while VkAm3 recorded 7.0 (1571.021 ppm), and 5.53 (362.789 ppm) resistance to spiromesifen and fenazaquin, respectively. Biochemical assays conducted for carboxylesterase enzymes revealed, enhancement in enzyme activity which led to detoxification and insenetivity to acaricides in two strains VkOk1 and VkAm3 where as no significant level of resistance development in VkPm3. PCR amplification of the gene, cytochrome P450 showed that there was no amplification in the case of susceptible strain, whereas there were distinct amplifications in the strains, VkOk1 and VkAm3. Cytochrome P450 and Carboxyl esterase enzymes play important roles in acaricide resistance in *T. Truncatus.* Cytochrome P450 an Carboxyl esterase genes were characterised

and developed standard markers for discriminating the resistant and susceptible population in *T. truncatus.* The study reportsacaricide resistance in *T. truncatus* for the first time in India.

7. Elicitation mediated carotenoid production and *Capsanthin capsorubin synthase* gene expression in Byadagi chilli (*Capsicum annuum* L.)(BBP-01-03-02-2017-VKA(19)-KAU-PG)

Pooja S.J. (2016-11-111)

The objective of the study was elicitation mediated carotenoid production and *Capsanthin capsorubin synthase* gene expression in Byadagi chilli (*Capsicum annuum* L.). Studies were conducted in chilli cultivar Byadagi Dabbi and variety Anugraha. Elicitation treatment of two month old chilli calli with salicylic acid 20 mgL^{-1} for 72 hours increased β-carotene content.At 20 mg L^{-1} of salicylic acid elicitation for 72 hours, Byadagi Dabbi was significantly superior to variety Anugraha in β-carotene production.Asthe concentration of elicitor increased in the medium, the total carotenoid production was found decreased in both the chilli genotypes.*Capsanthin capsorubin synthase* gene expression, the major gene responsible for carotenoid production in chilli was studied using Real time PCR. In highest β-carotene yielding elicitation treatment *viz* 20 mgL^{-1} salicylic acid elicited for 72 hours, the *Ccs* gene expression was up regulated 2.35 fold in Byadagi Dabbi as compared to variety Anugraha. Elicitation with salicylic acid could scale up *in vitro* carotenoid production and elicitation enhanced CCs gene expression.

8. Low cost alternatives in commercial micropropagation of banana (*Musa* spp.)
(BBP-01-01-02-2017-VKA(19)-KAU-PG)

Faiza Mohamed (2016-11-112)

Objective of the study was to reduce the cost of production in commercial micropropagation of banana. Studies were conducted in sixcultivars of bananaviz. Attunendran (AAB), Nedunendran (AAB),Chengalikodan(AAB),Poovan(Rasthali-AAB), jalipoovan(AB)andGrandNaine(AAA)whichare beingcommercially produced at CPBMBin themicropropagation unit. Established cultures in the 5^{th}subculture stage was used for study.

Sucrose can be substituted with common sugar in MS multiplication and rooting media and it did not influence shoot proliferation and rooting in different banana cultivars. Fifty per cent of agar can be substituted with 50 per cent of either sago or isabgol in MS multiplication and rooting media and the combinations did not influence shoot proliferation and rooting in different banana cultivars. There was 87 per cent reduction in media cost when low cost carbon source and gelling materials (common sugar+ marine agar+ sago) were used instead of standard laboratory grade additives.

Polymorphic amplicons were observed as subculture progressed from S9 – S11 in cultivars like Nedunendran, Attunendran and Grand Naine. In Chengalikodan, up to 10^{th} subculture passage no polymorphic bands were observed. In cultivars like Poovan and Njalipoovan which exhibited low multiplication rate, no polymorphic bands were observed in regenerants up to S11 stage. So for highly multiplying cultivars like Attunendran, Nedunendran and GrandNainesubculturing for multiplication up to 8^{th}subculture stage is recommended. In Chengalikodan, subculturing for multiplication can be

advanced up to 9thsubculture passage and in Poovan and Njalipoovan multiplication can be advanced up to 10thsubculture passage in the micropropagation protocol standardized at CPBMB.

9. Developing dwarf specific SCAR markers from WCT inbreds of coconut (Cocos nucifera L.) (BBP-02-00-05-2017-VKA(19)-KAU-PG)

Anto Varghese (2016-11-127)

Objective of the study was to develop and validate dwarf specific SCAR markers for screening superior inbredswith dwarfing trait in WCT inbreds of coconut

DNA samples were isolated from total 54 genotypes - 22 seedlings belonging to the inbred families IAS3-1and IBS3-1, 10 seedlings from other three families viz, IIS3, IIIS3 and VS3, 14 dwarf seedlings (including COD, CGD and MYD) and 8 tall seedlings (WCT). Dwarf specific band was observed when DNA was amplified with primer OPAW 15 . The amplicon was eluted, cloned and sequenced for designing SCAR marker. The designed SCAR marker was tested in S3 inbred families IAS3-1, 1BS3-1,IIS3-1, IIIS3-1,VS3-1. The SCAR marker was found more stable and reproducible when compared to RAPD marker.

Molecular studies support the earlier morphological classification based upon height SCAR marker was present in most of the S3 inbreds with dwarfing nature grouped as Low. However, some of the seedlings under 'Low' and 'Medium' groups lack the marker which indicate that a classification based on morphological and molecular markers is more effective than classification based on morphology alone.

10.*In vitro* studies on morphogenesis and plant regeneration in elite clones of cocoa (*Theobroma cacao* L.) (BBP-01-01-01-2017-VKA(16)-KAU-PG)

Sreelekshmi.S (2016-12-007)

Studies were conducted in four varieties of cocoa (CCRP 2, CCRP 6, CCRP 8 and CCRP15) and Scavina (high response genotype). Single nodded cuttings of 2-3 cm collected from the budded plants were used as explants. The best treatment for surface sterilization of nodal segments was washing in Teepol followed by shaking in 0.2 per cent Mancozeb for 30 minutes and then, Streptocycline 0.1 per cent for 10 minutes outside the laminar air flow chamber. Inside the laminar air flow chamber, the explants were treated with Ethyl Alcohol 70 per cent for 3 minutes followed by $HgCl_2$ 0.1 per cent for 5 minutes. This treatment showed the highest survival percentage (91.67%) of cultures with minimum microbial contamination (8.33%). Variety Scavina showed highest shoot induction in culture establishment medium followed by CCRP 2.Highest multiple shoot induction was recorded in medium WPM+2-ip 4 ppm + IAA 0.08 ppm + $AgNO_3$ 5 ppm (91.67%). Among the rooting media tried, ½ MS + IBA 5000 ppm (pulse treatment for 2-3 sec) proved superior. Potting medium with Vermiculite: Perlite: Vermicompost (1:1:1) showed a maximum plant survival for one week.The anatomical study of root-shoot transition zone indicated the presence of an intervening callus inhibiting proper vascular connection and thus the plants kept for hardening were difficult to get established.

11. Marker assisted backcross breeding for pyramiding genes conferring resistance to bacterial blight in rice variety Uma (BBP-02-00-01-2017-VKA(9)-KAU-PG)

Megha L.M.(2016-11-016)

The project aimed to identify BC_2F_1 lines pyramided with genes *xa5, xa13* and *Xa21* imparting resistance tobacterial leaf blight (BB) and to produce advanced breeding generations. Advancing the R-gene introgressed BC_2F_1s to BC_3F_1 and BC_2F_2 generation, pathotyping of BC_1F_2s (850 Nos.) and generating BC_1F_3s from the plants exhibiting resistance to BB pathogen were also aimed in the project.

Of the 21 BC_2F_1s subjected to foreground selection, BC_2F_1 Plant No. 8.3.9.10 was the only 3-R-gene introgressed pyramid (*xa5xa5 + Xa13xa13 + Xa21xa21*). Background profiling revealed that the magnitude of recovery of recurrent parent genome in 3-R-gene introgressed BC_2F_1 Plant No. 8.3.9.10was 81.82 per cent and was more similar to the recurrent parent Uma and possessed red kernels.

The identified 3-R-gene pyramid (BC_2F_1 Plant No. 8.3.9.10) was backcrossed to both recurrent parent Uma as well as selfed resulting in production of BC_3F_1s (15 Nos.) and BC_2F_2s (28 Nos.) respectively.

Bioassay of BC_1F_2 population (106 Nos.) through leaf clipping method of pathotyping suggested by IRRI (1991)revealed that more than half the BC_1F_2 individuals screened exhibited resistance to BB pathogen. Selfing of the BC_1F_2 individuals exhibiting resistance and moderate resistance to BB pathogen resulted in production of 725 BC_1F_3 seeds.

12.Standardization of *in vitro* male bud culture in banana *Musa* (AA) 'Kadali'

(BBP-01-01-03-2017-VKA(15)-KAU-PG)

Lakshmi K.S. (2016-12-013)

Objective of the study was to standardize a protocol for mass multiplication of banana *Musa* (AA) 'Kadali' through *in vitro* male bud culture.

In vitro male bud culture is a cost effective method and also has the advantage of absence of latent contamination, a problem which is often faced in the tissue culture protocols for commercial micropropagation of banana. In the present study, it was seen thatone male bud can provide on an average of 10 explants and each explant can provide on an average of 16 shoots.Within a span of 90 days, on an average, 160 shoots develop from a single male bud.Hence male bud culture can be efficiently used in addition to shoot tip culture to producelarge number of planting materials of elite genotypes. However, field studies on the morphological, flowering and fruiting characters of the male bud derived plantlets and clonal fidelity analysis are to be done before commercialization of the protocol developed.

For culture establishment of male bud explants, combination of full MS + NAA 1.0 mgL^{-1}+ BA 4.0 mgL^{-1} was found best.The best media for induction of multiple shoots were full MS + NAA 1.0 mgL^{-1}+ BA 4.0 mgL^{-1} and full MS+ NAA 1.0 mgL^{-1} + BA 6.0 mgL^{-1}.The addition of media supplements (coconut water and thidiazuron) were found effective in inducing more number of multiple

shoots.Early rooting and higher number of roots were recorded in full MS medium + sucrose 3% + IBA 1.0 mgL^{-1}.

13. Enhancement of phenyl propanoid glycosides in *Artanema sesamoides* Benth (vathomvaretti) by hairy root induction- (BBP-01-03-01-2017-ACV(19)-KAU-PG)

Elzabeth Jose (2016 -11-076)

Objective of the study was to scale up the production of phenyl propanoid glycosides in *Artanema sesamoides* by inducing hairy roots using *Agrobacterium rhizogenes. In vitro* multiplication of *A. sesamoides* is reported for the first time and maximum number of shoots was obtained in MS medium supplemented with BA 0.1 mg L^{-1}. 100% callus induction was obtained in MS medium supplemented with BA and NAA/IAA combinations. Hairy root was not induced with any of the *Agrobacterium rhizogenes*wild strains (MTCC 532, MTCC 2364 and ATCC 15834) tried. Phenyl propanoid glycosides (PPGs) content in the field grown (*in vivo*) root, *in vitro* root and callus was quantified and callus showed high content (acteoside - 0.98%, artanemoside A - 2.14%, isoacteoside - 0.11%, leucoseptoside A - 0.08%, martynoside - 0.21%) compared to field grown roots and *in vitro* roots.
In vitro production of PPGs was attempted from callus and *in vitro* root cultures. High Performance Liquid Chromatography (HPLC) analysis showed higher percent of PPGs (acteoside - 0.98%, artanemoside A - 2.14%, isoacteoside - 0.11%, leucoseptoside A - 0.08%, martynoside - 0.21%) in callus compared to that in the roots of field grown plants, *in vitro* root, indicating a possibility of using *in vitro* cultures as source of PPGs.

14. Computational prediction of miRNAs in banana (*Musa* spp.) and evaluation of their role in virus infection(BBP-04-00-01-2017-ACV(19)-KAU-PG)

Kokila Sajeev Anurag Mathew (2016-11-078)

The objectives of the study were prediction of miRNAs in banana, their validation and expression analysis during *Banana Bract Mosaic Virus* infection. Computational miRNA prediction tool NOVOMIR was used for the prediction of miRNAs in banana genome. Analysis was performed with all the gene coding or nucleotide sequences of banana (*Musa acuminata*) genome and 85 pre-miRNAs were predicted from 11 chromosomes. Mature miRNAs were obtained by BLAST analysis of pre-miRNAs against annotated mature miRNAs in miRBase. A total of 52 mature miRNAs were identifiedfrom 85 pre-miRNAs. The targets for the 52 mature miRNAs were predicted using the web tool psRNATarget and were functionally annotated by Blast2Go analysis server. A total of 124 targets were found, with each miRNA having more than one target. For experimental validation, five miRNAs and their target genes having role in metabolic process were selected and stem-loop/gene specific primers were designed. Expression analysis using qPCR showed the presence of all the five miRNAs selected in healthy and *BBrMV* infected leaf samples. Out of them, one miRNA showed differential expression during *BBrMV* infection.

15. Green synthesized silver nanoparticles for suppression of algal rust pathogen, *Cephaleuros* sp.(BBP-06-00-01-2017-ACV(19)-KAU-PG)

B. L. Bijula (2016-11-087)

The objective of the projectwas to green synthesise silver nanoparticles using leaf extracts of plants having antialgal property and to evaluate their potential for the growth inhibiton of model alga *Chlamydomonas* sp. Results of the present study indicated that green synthesised silver nanoparticles using leaf extract of *Tinospora cordifolia* was able to inhibit the growth of *C. reinhardtii*, thus exhibiting potential antialgal property.

16. Efficacy of silver nanoparticles as delivery system in genetic transformation
(BBP-06-00-02-2017-ACV(19)-KAU-PG)

Gorantla Nagamani (2016-11-096)

The objective of the project was to evaluate the efficiency of silver nanoparticles for gene delivery in microbes. The results indicated that silver nanoparticles aid in bacterial transformation. Silver nanoparticles of 100 nm size at a concentration of $1mgL^{-1}$ showed ten fold increase in the transformation efficiency of *E. coli* DHα cells with the vectors pUC18, pBR 322 and pCAMBIA as compared to the conventional method using 0.1M calcium chloride.

17. Prediction of SSR and SNP markers for anthracnose resistance in yam using bioinformatics tools and their validation(BBP-11-00-02-2017-ACV(19)-KAU-PG)

Sahla K. (2013-09-102)

Objective of the project was the prediction of SNP and SSR markers for anthracnose disease resistance in Greater Yam (*Dioscorea alata*), and the verification of predicted SNP and SSR markers for anthracnose disease resistance using susceptible and resistant varieties of yam. Yams (*Discorea alata)* is one among the most important tuber crops grown on a global scale. It is reported that up to 80-90% decline in the yam production occur due to a fungal disease, anthracnose caused by *Colletotrichum gleosporioides*. In this study, SSR and SNP markers related to anthracnose resistance in yam were predicted and validated both in resistant and susceptible varieties. The primary dataset obtained from NCBI-EST section were cleaned using Seqclean and the rest valid 43114 sequences were used for BLASTX against the resistant gene database. The resulting sequences were then assembled using CAP3 assembly programme. SSRs were predicted using MISA and SSRIT, while Quality SNP and AutoSNP were used for the prediction of SNPs. On comparative evaluation of prediction tools, it is found that MISA and QualitySNP have better algorithm to identify SSR and SNPs. Based on percentage identity and E value of the contigs, five primers were designed for SSRs and SNPs. On validation with three resistant and three susceptible varieties, two SSR and three SNP primers were found discriminating.

18. Comparative evaluation of gene regulatory network prediction and network reconstruction using genomic data(BBP-11-00-03-2017-ACV(19)-KAU-PG)

Reshma Bhasker T. (2013-09-103)

The objectives of the study were to compare the different computational methods for the prediction and analysis of gene regulatory networks, to reconstruct gene regulatory networks using genomic data and to develop an online visualization tool using the different methods. Using the approach of integrating genomic information along with gene expression data, it was tried to develop the regulatory network of genes controlling immunity in cassava with special context to bcterial blight resistance. A set of 1919 immunity related genes in cassava were identified, out of which 22 of them were specifically conferring virus resistance, 727 of them were screened for bacterial blight resistance and a network was created using the predicted interactions identified from 324 genes. A comparison of various approaches used for GRN prediction like probabilistic method, mutual information-based method, correlation-based approaches etc. was also conducted and various tools like ARACNE, WGCNA etc were evaluated. Validation was done using a simulated dataset generated from synTRen and the reconstructed networks were visualized using Cytoscape.

19. Molecular characterization of pathogens associated with post – harvest diseases in elephant foot yam(BBP-11-00-04-2017-ACV(19)-KAU-PG)

Adithya V. (2013-09-104)

Objectives of the study were to isolate, characterize and identify the pathogens that cause post-harvest diseases in elephant foot yam by adopting pathogenicity tests, morphological and molecular characterization. Sixty-two samples showing tuber rot symptoms were collected, symptoms were studied and the symptoms were grouped into nine categories. Thirty-three isolates were selected for pathogenicity test and Koch's postulates were proved with fifteen isolates. The morphology as well as symptom expression in host by both original and reisolated isolates were compared and found same. The pathogens were identified as *Atheliarolfsii*,*Lasiodiplodia theobromae*, *Rhizopus oryzae*,*Cunninghamella elegans*, *Rhizoctoniasolani*, *Ceratobasidium*sp., *Fusarium brachygibbosum*, *Fusarium solani*, *Fusarium oxysporum*, *Colletotrichum gloeosporioides*, *Aspergillus tamarii*, *Aspergillus nomius*, *Aspergillus niger* and *Penicillium citrinum.* The study could identify nine new organisms associated with tuber rot in elephant foot yam. The present study helped in precisely identifying the pathogens responsible for postharvest diseases in elephant foot yam.

20. Evaluation of miRNA prediction tools and *in silico* analysis of micro and long non coding RNAs in sweet potato.(BBP-11-00-05-2017-ACV(19)-KAU-PG)

Aswathy M.B. (2013-09-105)

The objectives of the study were to compare different miRNA and target prediction tools and *in silico* analysis of the miRNA and lncRNA in sweet potato. The plant miRNA identification tools: NovoMIR and miRPlant and miRNA target prediction tools: psRNATarget and miRanda were compared for their performance in miRNA research. NovomMIR and psRNATarget were found to be better tools in miRNA research. About 13 potential miRNAs were predicted in sweet potato through homology based

approach. The identified miRNAs were 20 to 22nt in length and had a high MFE and MFEI values. Potential 81 target genes were identified by psRNATarget followed by its functional annotation. About 9215 potential lncRNAs and 8655 mRNAs were predicted by the plant lncRNA identification tool RNAplonc in sweet potato. miRNAs and lncRNAs specific primers were designed and qRT-PCR reaction was performed and their presence were validated.

21. Development of infectious clones of *cassava mosaic virus* and their validation- (BBP-11-00-06-2017-ACV(19)-KAU-PG)

Vishnu Narayanan (2013-09-106)

The objectives of the study were to develop infectious clones of *Cassava mosaic virus*, their confirmation and validation in propagative host (*Nicotiana benthamiana*). The whole genome amplification of SLCMV/ICMV DNA samples were done using rolling circle amplification and cloned in pUC19 vectors to obtain pSLCMV A7 (2746 bp), pSLCMV B2 (2738 bp) and pICMV A5 (2739 bp) full length clones. Partial dimers of pSLCMV A7 and pSLCMV B2 were cloned in pPZP binary vector. Agroinfection of these infectious clones were done in *N. benthamiana.* Plants agroinoculated with DNA-A + DNA-B partial dimers showed severe symptoms like downward leaf curling, stunting. Agroinfection of DNA-A partial dimer alone caused the appearance of symptoms like upward leaf curling which is typical for monopartite geminiviruses.

22. Cloning and expression of coat protein gene of *Sweet potatoleaf curl virus* (SPLCV) (BBP-11-00-07-2017-ACV(19)-KAU-PG)

Sruthy G.S. (2013-09-107)

Objective of the study was to clone the coat protein gene of *Sweet potato leaf curl virus* and its expression in bacterial system. *Sweet potato leaf curl virus*(SPLCV)belonging to the genus Begomovirus (family *Geminiviridae*), is one of the major threats to sweet potato production in world wide, causing yield reduction up to 45%. Serological detection of this virus was not successful because of the lack of antiserum specific to SPLCV due to the low concentration of purified virions. Cloning and expression of coat protein gene in bacterial system is an alternative strategy to produce antiserum. In this study, initial screening of SPLCV was done by Polymerase chain reaction. Then new primers were designed for the whole coat protein gene amplification and cloned successfully in pET28a+ expression vector and transformed into *E. coli*BL21-DE3 expression cells. The expressed protein was confirmed by serological assays.

23. Genetic diversity analysis of sweet potato (*Ipomoea batatas* L. Lam.) germplasm using morphological and ISSR markers. (BBP-11-00-08-2017-ACV(19)-KAU-PG)

Sabarinath V.B. (2013-09-108)

The objective of the study was to analyse the genetic diversity in the sweet potato germplasm collections from the eastern states of India maintained in the National active germplasm site (NAGS) at ICAR-CTCRI, Sreekariyam, Thiruvananthapuram using morphological and molecular markers.

The genetic diversity of 54 accessions of sweet potato including 52 accessions from Eastern India and two wild species, selected from the National Active germplasm site of ICAR- CTCRI was done

through morphological and molecular characterization. The morphological characterization formed two principal clusters and an outlier at a Euclidean distance of 1.2. Accessions S1439 and S1442 showed maximum similarity at a Euclidean distance of 0.2. *I. triloba* was an outlier. Based on Principal Component Analysis, predominantvinecolour and leaflobestype were the highly loaded variables that contributed to clustering of accessions.

Molecular characterization using 11 ISSR markers generated 80 polymorphic bands with an average of 7.3 bands/primer. Analysis with NTSYS PC 2.02 program, generated a dendrogram, which grouped the accessions into three principal clusters. Similarity between the different accessions was 37-89%. The accessions S-1574 and S-1576 were 89% similar, and the least similar were S1408 / S1572 and S1527/ S1572 (37%). Diversity among accessions was 63%. Mantel's test revealed significant correlation between molecular and morphological distance matrices.

24. Development of molecular markers for blight disease resistance in taro using bioinformatics tools.(BBP-11-00-09-2017-ACV(19)-KAU-PG)

Athul V. S. (2013-09-109)

Objectives of the study were to develop and evaluate various Single Nucleotide Polymorphisms (SNPs) and Simple Sequence Repeats (SSRs) marker prediction pipelines in taro (*Colocasia esculenta*), computational prediction of SNPs and SSRs and verification of co-segregated SNP and SSR markers in taro leaf blight disease resistant and susceptible breeding lines.Taro (*Colocasia esculenta*. (L.) Schott) is one of the superior starchy tuber crops cultivated in the world. Leaf blight caused by *Phytophthora colocasiae* is a major constraint in the production of taro. Development of molecular markers using sequence information publicly available in the biological databases has been of utmost credibility over the years. With high-throughput technologies accelerating the marker development, a specific one conferring disease resistance could be of great significance in taro. In the present study leaf blight resistant Simple Sequence Repeats (SSRs) and Single Nucleotide Polymorphisms (SNPs) were developed using transcriptome data available in NCBI. QualitySNP and AutoSNP were used for predicting SNPs and MISA and SSRIT were used for predicting SSRs. 562 SNPs and 3034 SSRs were predicted and primers were developed corresponding to 5 SNPs and SSRs. Selected markers from the predicted ones were validated using susceptible and resistant varieties of taro and were capable of differentiating between them. The predicted markers could serve to be valuable in marker-assisted selection and breeding programmes of taro.

25. Identification and evaluation of endophytes from tropical tuber crops against *colletotrichum gloeosporioides* (Penz.) Sacc. causing anthracnose in greater yam (*Dioscorea alata* L.)
(BBP-11-00-10-2017-ACV(19)-KAU-PG)

Shahana N. (2013-09-110)

The objective of the studywas to identify and evaluate the endophytes from tropical tuber crops against *Colletotrichum gloeosporioides* (Penz.) Sacc. causing anthracnose in greater yam (*Dioscorea alata* L.) An attempt was made to explore endophytes for the management of the anthracnose disease caused by *Colletotrichum gloeosporioides* since there is no efficient ecofriendly method for the control of the disease. Endophytes (37 bacterial and 37 fungal) from different tropical tuber cropswere screened

against *C. gloeosporioides* and found two bacterial endophytes viz., *Bacillus cereus* and *Bacillus subtilis*, with antifungal index of 88.6 and 85.7 respectively. The bacterial endophytes were more potent than fungal. Species specific primers were designed for potent bacteria and confirmed its colonization in tissue cultured greater yam plants. The pot trial studies in glass house and in open field condition proved that *Bacillus cereus* reduced the disease intensity significantly followed by *Bacillus subtilis*. The new endophytes are highly potent in managing the anthracnose disease with growth promotion activity.

26. *In silico* screening and identification of lead molecules with anti-hepatitis B activity in selected spices.(BBP-11-00-11-2017-ACV(19)-KAU-PG)

Alina A. Nazir (2013-09-111)

The objective of the study was to identify lead compounds with antihepatitis B activity in major spices of Kerala *viz Elettaria cardamom* (L.) Maton, *Curcuma longa* L. and *Zingiber officinale* Roscoe. A total of 571 phytochemicals from three plants viz. *Elettaria cardamomum* (L.) Maton, *Curcuma longa* and *Zingiberofficinale* were screened against Hepatitis B Virus proteins such as HBx, HBc and polymerase (Poly) through docking using the tool AutoDock 4.2. The structures of phytochemicals were procured from open access databases or drawn using ChemSketch and the 3D structure of the target protein HBc was retrieved from Protein Data Bank (PDB ID: 1QGT) whereas the structure of HBx and Poly were modelled using the software MODELLER. The results indicated that all the three plants have anti-hepatitis B activity and among the three plants the most potential lead molecule were β-carotene, α-ylangeneand vanilic acid against HBx, HBc and polymerase respectively.

27. Development of functional SSR markers for D- Limonene content and analysis of genetic polymorphism in cardamom (E*lettaria cardamomum* Maton)(BBP-11-00-12-2017-ACV(19)-KAU-PG)

Reshma Retnakaran (2013-09-112)

The study was intended to analyse the genetic diversity inherent in cardamom germplasm using cardamom specific SSR markers and to discover functional SSR markers for D-Limonene content and establishing a correlation between the same. Thirty accessions including cultivars, wild varieties, landraces and large cardamom (as outgroup) were tested. Initial diversity analysis was done with six cardamom specific SSR primers and POPGENE, a software employed in estimating genetic variation. D-Limonene content in four cultivars was analyzed using GC-MS method and five D-Limonene specific SSR markers were developed for its functional validation. Results showed that D-Limonene, an antimicrobial, anti-inflammatory, antioxidant and tumour suppressive constituent in cardamom essential oil is comparatively high in cultivars Njellani and Green Bold. Thirty accessions validated with D-Limonene specific SSR markers, clearly demonstrated distinct variation in the PCR result of sample Pathumuriyan indicating disparity in the genes involved D-Limonene biosynthesis. The molecular and chemical analysis successfully identified genetic variability and functional validation of D-limonene biosynthesis genes.

28. Development of functional EST-SSR and analysis of genetic diversity in *Centella asiatica*
(BBP-11-00-13-2017-ACV(19)-KAU-PG)

Arya Aravind (2013-09113)

The aim of the project was to develop and use transcriptome based SSR molecular marker for analysis of genetic diversity in *C. asiatica* in relation to the content of asiaticoside.Fifteen primers were used for genetic diversity analysis in 30 different *Centella* accessions. The genetic diversity analysis grouped the accessions in to six groups based on the Neigenetic distance. Single accessions were randomly selected from each group and asiaticoside content and two phenotypic characters were also characterised. The result showed less Neiheterozygosity (0.0433) between the studied accessions and positive correlation (0.142) with the asiaticoside content. In phenotypic study, number of leaves per node showed more positive correlation (0.291) with asiaticoside content than genetic diversity.

29. Genome wide marker assay for the recovery of recurrent parent genome in rice (Oryza sativa).(BBP-11-00-14-2017-ACV(9)-KAU-PG)

Bhagyalekshmi R. (2013-09-114)

Objective of the study to estimate the reconstitution of genome of Aiswarya rice variety in the BC_2F_2 plants pyramided with genes for resistance to Bacterial Leaf Blight through molecular markers covering the entire genome of Aiswarya. Bacterial leaf blight (BB) caused by *Xanthomonasoryzaepv. Oryzae* (*Xoo*) is one of the major constraints faced by major rice growing countries of Asia. Three bacterial blight resistance genes xa13, Xa21 and Xa33 were pyramided into variety Aiswarya, a popular variety in kerala with high yield and cooking qualities but highly susceptible to Bacterial leaf blight causing yield loss upto 35 per cent. In the previous study, BC_2F_1 plants pyramided with the two/three genes for resistance were developed.

The present study was undertaken to estimate the recovery of recurrent parent genome in the pyramided lines of BC_2F_1 population through Marker Assisted Backcross method. The foreground selection was carried out using gene specific markers xa13 pro, pTA248 and RMW7.1 for xa13, Xa21 and Xa33 respectively. Out of 149 plants screened, 79 plants were with xa13 gene and 38 plants with Xa21 gene. But Xa33 gene was absent in all the screened plants. Twenty lines pyramided with xa13 and Xa21 were identified in the foreground analysis and these lines were subjected to background selection by using 44 polymorphic SSR primers. The results of background selection revealed that out of 23 plants studied, 5 lines showed more than 80 per cent recovery of Aiswarya genome in the BC_2F_1 population.

30. Assessment of anti-inflammatory and antioxidant properties of *Chlorophytum laxum* R. Br.
(BBP-11-00-15-2017-ACV(19)-KAU-PG)

Arundhathy G.B. (2013-09-115)

Objective of the study was to evaluate anti-inflammatory and antioxidant potential of an ethnomedicinal plant *Chlorophytum laxum* R.Br. (Neeruvatti) *Chlorophytum laxum* R.Br is one of the

important medicinal plants used by Kani tribes for curing inflammation, insect and snake bites. The tubers of *Chlorophytum laxum* showed the presence of metabolites like carbohydrates, alkaloids, proteins, steroids, saponins, glycosides etc. and the total phenolic content was found to be 5.12 mg GAE/g of extract. In *in vivo* antiinflammatory studies in wistar rats, it showed maximum percentage inhibition of paw oedema in 450 mg/kg in both Carrageenan and Formalin induced paw oedema. It also protected haemolysis of HRBC in *in vitro* antiinflammatory analysis. The ethanolic extract of *C. laxum* showed hydroxyl and NO radical scavenging and antilipid peroxidation activity.

31. **Identification of molecular markers for resistance to taro leaf bight in *Colocasia esculenta* L. schott.(**BBP-11-00-16-2017-ACV(19)-KAU-PG)

Anjitha Nair U. M. (2013-09-116)

Objective of the study was to identify molecular markers associated with leaf blight resistance in taro and to isolate the gene. Thirty six genotypes (18 each of susceptible and resistant ones) were analysed using three marker systems *viz*., RAPD, ISSR and SSR. The ISSR primer UBC 811 yielded a unique band in seven of the 18 resistant genotypes, which was completely absent in the susceptible ones. Sequencing and blast analysis of a band obtained from R13 (Accession 370) showed 100% similarity with *Arabidopsis lyrata* subsp. *lyrata* disease resistance protein RML1B (LOC9323997) with mRNA sequence, TTTGAAGAAGATAGCCT (17bp).Mantel's test established no correlation between the three marker systems.

32. **Identification of molecular markers linked to anthracnose resistance in greater yam (*Dioscorea alata* L.)(**BBP-11-00-17-2017-ACV(19)-KAU-PG)

Arya R. S. (2013-09-117)

Objective was to identify resistant genotypes and molecular markers linked to genes conferring resistance to anthracnose in greater yam. The results indicated the association of three ISSR markers (UBC 807, UBC 836 and (GA)9AT) with anthracnose resistance in greater yam.The presence of UBC 836 (1754bp) in the three highly resistant genotypes and absence in three highly susceptible genotypes, used as reference varieties for final validation, suggested it as the best marker linked with anthracnose resistance. The highly resistant genotypes *viz.* Da110, JAS2 and DaH9/196 identified can be further evaluated to develop a variety with high level of resistance to anthracnose disease for cultivation in Kerala.

33. Molecular screening of rice genotypes for submergence tolerance

(BBP-11-00-18-2017-ACV(19)-KAU-PG)

Aryalekshmi A.S. (2013-09-118)

Objective of the study to phenotype the field tolerant rice genotypes under submergence and to screen them for *sub* 1 QTL using SSR markers.

One of the major constraints in rice cultivation worldwide is submergence stress. *Sub1* is a major qualitative trait locus (QTL) representing a cluster of three ethylene responsive factor (ERF) genes: *sub1A, sub1B* and*sub1C* that confers submergence tolerance to rice genotype. Rice varieties with the *Sub1* gene were shown higher survival rate with better yield even after 2 weeks of submergence stress.

34. Physiological and molecular analyses of flowering response in amaranthus (*Amaranthus* spp.) and cowpea (*Vigna* spp.) under elevated CO_2 environment(BBP-09-00-02-2016-ACV(21)-KAU-PG)

Ghade Rameshwar Pandurang (2015-11-089)

The objective was to study the physiological, molecular and biochemical basis of elevated Co_2 mediated modifications in the flowering responses of amaranthus and cowpea. Two pot culture experiments were conducted with two varieties of amaranthus – Arun and CO-1 and two varieties of cowpea-Anaswara and Vellayani Jyothika. The technology used for CO2 enrichment was Open Top Chamber system (OTC). CO2 was released from cylinders to OTC bringing the CO2 level to 600ppm. Amaranthus and cowpea plants were raised and maintained in pots as per PoP (KAU) recommentdations under elevated CO2. The control sets were kept under open field condition. Growth analysis and analyses of physiological and biochemical parameters were done at the time of harvest. The varieties which showed modification in flowering time to a greater extent under exposure to elevated CO2 were chosen for molecular analyses.

Flowering time was modified in CO-1 in terms of days to first flowering and days to 50% flowering (2 days); but Arun did not show any significant response in flowering time and hence CO-1 was selected for molecular analyses. The variety Arun showed a reduction in ascorbic acid and vitamin A content under CO2 enrichment with an increase in oxalate content. In the case of CO-1, though ascorbic acid and vitamin A contents were less under open condition, upon exposure to higher concentrations of CO2, there was tremendous increase in these quality parameters along with oxalate content. Both the varieties of cowpea recorded significant variations in growth, physiological and biochemical parameters when exposed to higher concentrations of CO2.

Flowering time was modified in cow pea variety Anaswara-2 days to first flowering and days to 50% flowering. The DNA of Flowering locus (FT) was amplified from Anaswara and CO-1. Differential expression was observed in both the crops under elevated CO2 condition. In the present study, both cowpea and amaranthus were found to be responding to elevated CO2 in terms of flowering time. This can be correlated with the higher photosynthate accumulation with a net positive effect on growth parameters. The increased gibberellic acid level displayed by both the crops upon CO2 enrichment can also play a role in signaling the crosstalk between reproduction and other developmental processes. Understanding the mechanisms involved in the regulatory network modulating floral initiation in response to elevated CO2 and elevated temperature will facilitate understanding and identifying options to develop plants better adapted to changing climate.

35. Physiological studies on enhancing growth and yield of ginger (*Zingiber officinale* L.) by Nano-NPK fertilizers and organic management.(BBP-08-00-05-2017-VKA(21)-KAU-PG)

Sreelaja Kizhakkekara (2016-11-067)

Nano fertilizers due to its very small particle size have higher surface area which provide more reaction sites to facilitate different metabolic processes in plant system. Nano fertilisers are highly water soluble which can increase the penetration capacity of fertilisers into plant system thereby enhancing the nutrient uptake, nutrient use efficiency (NUE) and ultimately increase in the yield and quality of crop plants.

The study aimed to understand the influence of Nano – NPK fertilizers and organic management for enhancing growth, quality and productivity of ginger (*Zingiber officinale* L.). The results from the experiment indicated that application of nano fertilizers both in the form of granules as well as foliar at frequent intervals improved the NUE thereby increasing growth, physiological processes and finally the yield and quality of ginger.Nano NPK and humic acid were given as foliar at 60, 90, 120 ,150 and 75, 105, 135, 165 days after planting respectively. Significant rhizome yield was recorded in PoP NPK fertilizers as Nano NPK granules + Nano NPK foliar spray @ 0.5%+ Humic acid foliar spray @ 0.5% (72.39 % over control)

36. Physiology and management of submerged weeds in wetland rice ecosystem

(BBP-09-00-01-2017-VKA(21)-KAU-PG)

Athira K.A. (2016-11-069)

The study aimed to characterize the different algae and hydrophytes of the wet land rice ecosystem and to understand the growth and management of *Utricularia*sp. A survey of submerged weeds of rice ecosystem was conducted in the wetland rice fields of central zone of Kerala including Thrissur, Palakkad and Ernakulam districts.The samples were then sent to the Botanical Survey of India, Coimbatore for confirmation Identification was done based on the description provided in the book "A Manual of Aquatic Weeds" (Fasset, 2000). The most common submerged weed in the rice ecosystem was *Utricularia aurea* and hence this weed was selected for further studies.Pots of size 30 cm height × 30 cm diameter were used for the study. The pots were filled with 6 kg soil and filled to the brim with water. Twenty centimeter long *Utricularia aurea* filaments were kept in each pot. pH had the highest influence on the growth of submerged weed species. The maximum weed growth was observed in the pH range of 7.2 to 8.02. The presence of submerged weeds reduce dissolved oxygen content of the water and increases the content of TSS and *E coli.* Nitrates content in the water promote the weed growth. High IAA, GA and chlorophyll content promote weed growth. Potassium content in water inhibit the weed growth. Phosphatase enzyme in soil increase the phosphorus availability. *Utricularia aurea, Hydrilla, Cabomba, Najas, Utricularia exoleta, Elodea canadensis, Egeria densa* were the hydrophytes observed in the rice fields. *Spirogyra,Chara* and *Nitella* were the algae observed. Maximum growth of *Utricularia aurea* observed in zero UV radiation. Light intensity did not affect the growth of the weed. $CuSO_4$, lime and 2,4-D gave good control of *Utricularia aurea.* Lime was more efficient for the control of *Utricularia aurea*

37. Interactive effect of elevated temperature and UV radiation on rice growth and physiology
(BBP-09-00-02-2017-VKA(21)-KAU-PG)

Amjath.T (2016-11-103)

The study aimed to understand the interactive effect of elevated temperature and UV radiation during different phenophases of rice and its effect on growth physiology and productivity .UV-B and high temperature are major weather parameters that influence the productivity of rice during the third crop season. The influence of these parameters on the phenology, biochemistry and physiology of rice plants indicate that early stress during the period up to active tillering is comparatively less harmful. While stress experienced during reproductive stage drastically reduced the yield. Among the weather parameters UV-B influences the biochemical components of plants such as IAA, GA and chlorophyll contents while high temperature affects mostly on yield components.The UV-B radiation was more in open condition as compared to polyhouses. A 1^0 C rise in temperature above ambient had caused a 13% decline in yield while both UV-B and temperature stress had contributed to 20% yield loss in rice. UV-B radiation and elevated temperature altered the phenological characters in rice crop like days to heading, 50% flowering and harvestable maturity. High temperature stress conditions reduced the phenophaes of the crop by 4-6 days. Stress imposed after active tillering (P_2 and P_3) stages affected the yield components and reduced the productivity of the crop. Elevated temperature coinciding with early reproductive stage affected the pollen viability resulted in higher chaff percentage.The amylose content of grains was found to be lower in high temperature growing conditions.

Ongoing PG Projects

1. *In vitro* synthesis of gingerol and analysis of Expressed Sequence Tags for gingerol production in ginger (*Zingiber officinale* Rosc.)(BBP-04-00-05-2016-VKA(19)KAU-PG)

Manjusha Rani (2015-21-027)

The objectives of the study were to analyse the synthesis of gingerol under *in vitro* conditions, to characterize the ESTs related to gingerol synthesis and to validate the identified ESTs for high gingerol production in ginger.

Modified MS media supplemented withthe abiotic elicitors methyl jasmonate and salicylic acid at concentrtions 5, 10,15 mg/Lwere tried to study the effect of elicitors on gingerol synthesis in microrhizomes. Salicylic acid at 5mg/L recorded highest total gingerol both in solid and liquid media. In precursor feeding, ferrulic acid 30 mg/L recorded highest content of total gingerol. Gingerol synthesis in callus cultures and validation of identified ESTs for gingerol production are in progress

2. DNA barcoding in genera *Benincasa* and *Praecitrullus* (BBP-02-00-08-2016-VKA(19)-KAU-PG)

Sonkamble Priya Ashok (2015-11-104)

Morphological characterization of different collections of the two genus were completed and grouped.Species specific DNA barcodes were developed in *Benincasa* and *Praecitrullus* using matk and ITS2 loci. The barcode gap generated by ITS2 loci gave a perfect picture of difference between both the species as compared to matK primer.

3.Inheritance of molecular markers linked to vascular streak dieback disease resistance in hybrid progenies of cocoa (*Theobroma cacao* L.)(BBP-02-00-02-2017-VKA(9)-KAU-PG)

Midhuna M. R. (2016-11-106)

Objective of the project was to study the inheritance of identified ISSR and SSR markers linked to VSD resistance in hybrid progenies of cocoa (*Theobroma cacao* L.). Nineteen hybrids, exhibiting resistnace to VSD after screening for a period of thirteen years and progeny obtained from these hybrids were selected for the study. Two hundred and sixty nine seedlings were raised from the seven hybrid pods and nursery screening for VSD disease resitance was done. Visual screeing recorded one hundred and eighty seedlings as disease resistant and eightly nine seedlings as disease susceptible. Three ISSR markers (UBC 811, UBC 815 and UBC 857) and one SSR marker (mTcCIR 42) linked to VSD resistance gene were used for screening the one hundred and twenty seedlings, out of which one hundred and six were found resistant and fourteen were susceptible. In thirty seedlings all the three markers were found expressed. Detailed analysis of results is in progress.

4. Marker assisted backcross breeding in rice for drought tolerance(BBP-02-00-04-2017-VKA(21)-KAU-PG).

Athulya S. Nair (2016-11-108)

Objective of the project was to improve drought tolerance of rice variety PTB 39 (Jyothi) through marker assisted backcross breeding. Rice variety PTB39(Jyothi)is a high yielding widely accepted variety derived from the cross between PTB10 and IR8. Chuvannamodan (PTB30)is a traditional variety derived through mass selection, The variety is particularly recommended for upland cultivation due to its drought tolerance. The studies conducted by Babu*et al* (2014) and Beena*et al* (2018) confirmed the drought tolerance of Chuvannamodan. PTB30 out performed PTB39 in water mining traits like root length, root volume, root dry weight and root to shoot ratio. .Both the parental varieties were screened using 120 SSR primers whichwere distributed throughout the rice chromosomes. Out of 120 primers, 47primers showed polymorphismbetween the parents. Among the 47 polymorphic primers, 24 primers are reported to be linkedto drought tolerance. The varieties PTB39 and PTB30 were crossed to produce 45 F1 seeds. Of the 45 F_1s seeds sown , six seeds germinated and they were genotyped for hybridityconfirmation. Two plants among six germinated were confirmed as true hybrids. Production of BC_1F_1 and F_2 populations and further genotyping are in progress.

5. Molecular cloning and characterization of virus causing leaf curl disease of *Capsicum* spp.
(BBP-06-00-03-2017-VKA(5)-KAU-PG)

Niranjana Menon. C. (2016-11-109)

Objective of the project was **t**o study the incidence and symptomatology of leaf curl disease of chilli and capsicum, and to clone and characterize the coat protein gene of *Chilli leaf curl virus.* Purposive sampling surveys were conducted at 15 locations in Thrissur district of Kerala. During survey, symptomatology on different parts of the plant (leaves, internodes, stem and fruits) were documented. Total DNA isolation was carried out from the infected leaf samples collected during survey . Two

universal degenerate primers (Deng 540 / 541 and AV 494 and AC 1048) for Begomovirus coat protein gene were used for PCR. The PCR products were sequenced. Sequene analysis is in progress.

6. Development of doubled haploids for iron toxicity tolerance in rice (*Oryza sativa* L.)
(BBP-01-02-01-2017-VKA(9)-KAU-PG)

ChakravarthiMarri(2016-11-015)

Objective of the project was to develop doubled haploids in rice for iron toxicity tolerance. Production of F_1s using Tulasi as the male parent and genotypes Cul-8709,Cul-90-03,PTB53 (MangalaMahsuri),PTB 57 (Swetha) as the female parent and standardization of anther culture technique are in progress.

7. Physiological and molecular studies on cyanogenic potential in cassava (*Manihot esculenta* Crantz) in response to nitrogen nutrition, water stress and shade.(BBP-11-00-19-2017-ACV(19)-KAU-PG)

Achuth P. Jayaraj (2013-09-119)

The objective of the project was to study the effect of plant nitrogen status, light intensity and water stress on cyanogenesis of cassava and to determine the cyanogenic glycoside in plant tissues using novel methods such as Near-infra red (NIR) spectroscopy and High Performance Thin Layer Chromatography (HPTLC).

Plants grown in shade with water stress showed cynagen glycisode (CNglc) amount on par with plants grown in open with water stress. Increased nitrogen supply stimulated plant growth and productivity as well as photosynthetic capacity of leaves through increased amounts of stromatal and thylakoid proteins in leaves. NIR data and HPTLC data obtained from this investigation can be used for developing methods for quantifying the CNglc content directly in plant samples in the future without cumbersome sample preparation techniques.

8. Development of resistance against banana bract mosaic virus in *Musa* spp. var. Grand Naine using small interfering RNA (siRNA)(BBP-03-00-02-2016 ACV(19)-KAU-PG)

Jadhav Pritam Ramesh (2015-21-014)

The objective of the project was to develop resistance against *Banana bract mosaic virus* in banana var. 'Grand Naine' using siRNA mediated technology.IhpRNA construct targeting coat protein of banana bract mosaic virus was prepared and ligated in the cloning site of pStarling vector and transformed into DH5alpha. From pSTARLING , ihpRNA cassette was released using Not1 enzyme and transferred to the binary vector pART27 and confirmed using colony PCR. Embryogenic calli of banana var. grand Naine was transformed with Agrobacterium strain carrying ihpRNA cassette.

9. IhpRNA mediated resistance for *Banana bract mosaic virus* in *Musa* spp. by targeting replicase and movement protein genes (BBP-03-00-01-2017-ACV(19)-KAU-PG)

Ekatpure Sachin Chandrakant (2016-21-022)

Objective of the study was todevelop multiple ihpRNA constructs against replicase and movement protein genes of *Banana bract mosaic virus* and to evaluate their silencing potential in banana variety Grand Naine. ihpRNA cassettes targeting replicase, movement protein genes individually and in combination were made ready in the primary RNAi vector (pSTARLING). The cassettes are transferred to the binary vector (pART27) in GV 3103 *Agrobacterium* strain. The embryogenic calli developed from male flower bud were transformed and selected on MS medium supplemented with 2 mg/l BA+ Kanamycin 150 mg/l + Cefotaxim 25 mg/ l and were kept for regeneration.

10. Characterization of selected *Curcuma* species germplasm using morphological and molecular markers(BBP-11-00-01-2017-ACV(19)-KAU-PG)

Bimal Thomas (2013-09-101)

Objective of the study was to analyze the genetic variation existing in *Curcuma* species germplasm based on morphological and molecular markers (SSR). Fifteen selected accessions under eight species of *Curcuma* collected and maintained in the field gene bank of ICAR-CTCRI, Sreekariyam from different parts of India were characterized using morphological and molecular markers. Morphological characteriztion using 13 qualitative and 15 quantitative traits grouped the genotypes into four clusters. PCA showed that the characters such as leaf midrib colour, rhizome flesh colour, leaf texture and aroma of rhizome had contributed mostly to the variability. Molecular characterization was done using 10 ISSR and 7 SSR markers. ISSR marker analysis formed five clusters while SSRs formed six clusters. Mantel's test showed a positive correlation between the morphological and molecular data.

11. Validation of antituberculosis activity in selected vegetable crops through docking and *in vitro* assay techniques (BT-07-00-18-2013-ACV(19)KAU-PG)

The objective of the study was to validate antituberculosis activity in selected vegetable crops through *in silico* docking of selected phytocompounds against identified targets for tuberculosis and through *in vitro* assay techniques.

Less explored vegetables such as *Allium cepa* L., *Allium sativum* L. and *Moringa oleifera* Lam. with anti-tuberculosis activity were selected based on end to end review of literature, ethno-botanical information and traditional knowledge. Phytochemicals so far reported from the selected plants were used as the ligands and docked with the target protein to find out the lead molecule using the docking software Auto Dock 4.2. Molecules namely, 24-Methylene Cycloartenol; Quercetin; 1-O-feruloyl-beta-D-glucose; 4-Alpha-Methyl-Zymostenol; 5-Octyl-Cyclopenta-1,3-Dione and Campesterol were identified as hit molecules. They were later docked again with another set of docking software for further confirmation of the activity of the hits and finally 24-Methylene Cycloartenol (*Allium cepa* L.

and*Allium sativum* L.) and Quercetin (*Moringa oleifera* Lam.) were identified as potential lead molecules for tuberculosis.

12. Differential expression of pathogenesis related genes by plant growth promoting rhizobacteria in controlling taro leaf blight (BT-07-00-29-2014-ACV(19)KAU-PG)

To study aimed the selection of plant growth promoting rhizobacteria (PGPR) for taro leaf blight (TLB) management, its characterization and study of the differential expression of pathogen related genes in susceptible and tolerant varieties of taro, consequent to application of PGPR. Eighty four bacterial isolates of tuber crops rhizosphere origin were tested against taro leaf blight pathogen *Phytophthora colocasiae* by using dual culture, diffusible and volatile metabolites production method. Fifteen bacterial isolates showing >60% inhibition against the target pathogen were tested for their growth promotion activity by studying IAA production. The growth promotion of isolates in cow pea was also studied. Based on the results, 10 isolates were selected for further study. The most potent isolates were identified by 16SrDNA amplification and the isolates were identified as *Bacillus subtilis*, *B. cereus* (2 isolates), *Pseudomonas aeruginosa*(5 isolates) and *Bacillus amyloliquefaciens* (2 isolates). Disease incidence, growth promotion and differential expression of enzymes consequent to application of the best isolate were studied in susceptible (Sree Kiran) and tolerant (Muktakeshi) varieties released by ICAR- CTCRI.

13. Characterization of antioxidant fractions in curry leaf (*Murraya koenigii* L.) and molecular docking of selected bioactive compounds (BBP-04-00-02-2018-VKA(19)-KAU-PG)

Bhamare Deepak Prashant (2017-11-001)

The objectives of the study were to characterize antioxidant fractions in curry leaf through *in vitro* assays and to identify the most potent bioactive compound through LC-MS /MS and molecular docking analyses. The oleoresin extracted from curry leaf powder showed high antioxidant activity similar to synthetic antioxidant Butylated hydroxyanisole in DPPH assay. Purification of the extract , LC-MS analysis and molecular docking are in progress.

14. Marker assisted backcross breeding in two R-gene pyramided lines of rice variety Jyothi for bacterial blight resistance (BBP-02-00-03-2018-VKA(19)-KAU-PG)

NayanaNayak (2017-11-002)

Objective of the study was to develop lines pyramided with three bacterial blight resistance genes (*xa5 + xa13 + Xa21*) using the two-R gene pyramids (*xa5 + Xa21*) developed from the rice variety Jyothy (PTB 39) and donor Improved Samba Mahsuri, through marker assisted backcross breeding and generate backcross populations (BC_2F_1 andBC_1F_2)introgressed with three resistance genes.

Of the 24 BC_1F_1s subjected to foreground selection, only three BC_1F_{1s} *i.e.,*Plant No.9.7., Plant No.9.15., and Plant No.9.17 were the only R- gene introgressed pyramids (*xa 5+ Xa 21+xa13*).Background profiling of the selected three R-gene pyramided individuals of BC_1F_1s using 50 rice microsatellite (RM) markers, morphological characterization of pyramided lines (BC_1F_1

population), production of BC_2F_1's and BC_1F_2'sand morphological characterisation and pathotyping of BC_2F_5 population and production of BC_2F_6 population are in progress.

15. Molecular and biochemical characterization of aroma in *Biriyanicheera* rice genotype
(BBP-02-00-04-2018-VKA(19)-KAU-PG)

Veerabhadraswamy, M. (2017-11-003)

Biochemical analysis of compounds present in *Biriyanicheera* and *Gandhakasala* rice samples (one each collected from three districts of Kerala) were performed by Gas Chromatography - Mass Spectroscopy.Volatile compounds specific torice genotypes, grown in three locations have been identified.Sequenceof *fgr* gene was retrieved from Rice Genome Annotation Project nucleotide database and primers were designed and DNA of all the genotypes were amplified using PCR. Sequence analysis of amplified PCR products is in progress.

16. Expression of *Chalcone synthase* gene in ginger (*Zingiber officinale* Rosc.) as influenced by various management practices.(BBP-04-00-03-2018-VKA(19)-KAU-PG)

Archita Unnikrishnan (2017-11-004)

The objectives of the project were to analyse the influence of nutrient management and sprayingof elicitors on *Chalcone synthase* gene expression in ginger under poly house and open conditions.

The high gingerol yielding ginger variety Karthika was raised in open and poly house conditions following the nutrient management as per PoP and adhoc organic nutrient management of KAU. Two elicitors viz. Salicylic acid (100 µM) and methyl jasmonate (100 µM) were sprayed at weekly intervals in active growth phase of the crop up to 4 months after planting. Expression studies of *Chalcone synthase* gene and quantification of gingerol in different treatments are in progress.

17. DNA barcoding of spider mites (Prostigmata: Tetranychidae) associated with ornamental plants- (BBP-02-00-05-2018-VKA(19)-KAU-PG)

Jayalakshmi Prakash (2017-11-005)

Objective of the study was to generate DNA barcodes for different species of spider mites infesting commercial ornamental plants of central Kerala and to find out the variability among them. Purposive sampling surveys were conducted in commercial ornamental nurseries and homestead gardens of Thrissur and Ernakulam districts, for collection of spider mites associated with major ornamental plants.Mite specimens collected from rose, jasmine, marigold, chrysanthemum, balsam, cock'scomb, *Gerbera*, *Adenium*, *Bauhinia,Tabernaemontana*, *Ipomea*, orchid, *Zinnia*, *Bougainvilia*and *Arachis pintoi*from different localities were maintained in the Acarology laboratory as separate isoline cultures, by assigning unique accession numbers. A total of 29 accessions of mite culture are being maintained as part of the study. Male and female specimens from different isolines were slide mounted using Hoyer's medium for morphological characterization.Morphological characterization of mite specimens of 16 accessions identified seven species namely, *Tetranychustruncatus*(rose and cock's comb), *T. okinawanus*, (rose, adenium, gerbera, marigold, balsm, orchid, *Ipomea*), *T. udaipurensis* (Zinnia), *T. fijiensis* (cassia), *Oligonychusbiharensis* (bauhinia and *Arachis pintoi*) and *Eutetranychusorientalis*

(*Tabernaemontana*). Isolation of DNA from mite specimens of different ornamentalsand PCR amplification of DNA using COI primer are in progress

18. Cloning and characterization of *myo-inositol phosphate synthase* gene coding for phytates in *Dolichos lablab* L. (BBP-04-00-04-2018-VKA(19)-KAU-PG)

Sreedevi Jagal Kishore (2017 -11- 006)

Objective of the study was to sequence and annotate *myo-inositol phosphate synthase* gene from the cDNA of developing dolichos bean seeds. Total RNA was isolated from the developing seeds of dolichos bean. The cDNA first strand was synthesized from RNA using oligo(Dt)primer and reverse transcriptase. The *MIPS1* gene was amplified from the cDNA using the reported primers from soybean. The PCR product with desired size was eluted and the cloning work is in progress.

19. DNA Fingerprinting of selected cocoa (*Theobroma cacao* L.) varieties of Kerala Agricultural University (BBP-02-00-06-2018-VKA(19)-KAU-PG)

Megha Totaganti (2017-11- 007)

Objectives of the study were to develop DNA fingerprint profile of cocoa varieties using SSR and ISSR markers. DNA was isolated from seven varieties. Tender leaves from the actively growing tips of plant were used for DNA isolation. Modified Dellaporta method (1983) was used for extraction of good quality of DNA.Of the thirty five IISR primers screened in the seven varieties, 24 primers gave good amplification. Of the thirty SSR primers screened in the seven varieties, 16 primers gave good amplification. The project is in progress

20. Somatic embryogenesis from immature inflorescence of coconut (*Cocos nucifera*L.)
(BBP-01-01-01-2018-VKA(19)-KAU-PG)

Radhika R (2017-11-097)

The objective of the study was to assess the *in vitro* response of immature inflorescence of coconut explants for induction and germination of somatic embryos by supplementing the medium with byproduct of neera processing and neera. Immature inflorescence was collected for culture initiation from different palms of above 20 years from Kasaragod district. After surface sterilization, the rachillae was inoculated in standardized medium CM2 (Y3 basal medium containing 0.5 mg/L picloram, 1 mg/L NAA, 0.1 mg/L TDZ and 300 µM 2,4-D) along with 0.3% activated charcoal and 4% sucrose. Initiation and subculturing was also done in CM2 media by varying the amount of activated charcoal, sucrose and different amount of the supplement and neera. Out of the treatment combinations studied, callus formation was observed in control and treatments except the T6. As coconut is very slow in response under *in vitro* conditions, so far only uptocallus stage has been obtained and the work is in progress

21. RNA mediated resistance to yellow vein mosaic virus in okra(BBP-03-00-01-2018-VKA(19)-KAU-PG)

Kelkar Vipul Ganesh (2017-21-013)

Objective of the study was to develop okra lines transformed with RNAi constructs of βCI ORF sequence of begomovirus causing yellow vein mosaic disease and to evaluate their silencing potential. Okra plants (cv. Anakomban andvariety Salkeerthy) were raised in open field during summer for YVM virus infection. Seeds were harvested from healthy plants. Total DNA was isolated from the YVMV infected plants and amplified using Beta-C1 specific primers which were designed using Primer3. The PCR product was sequenced and analysed to confirm that the region is beta-C1 (186 bp). The vector construct designing for RNAi is in progress. Morphogenesis from hypocotyle calli is also in progress

22. Allelic difference in the putative gene *ipk 1* sequence and phytic acid (InsP6) content in black pepper (*Piper nigrum* L.) (BBP-04-00-01-2018-ACP(09)-KAU-PG)

Gladish Mary Joy (2017-11-079)

In black pepper, partial sequence (1072 bp) of the gene ipk1 (Pnipk1), coding for one of the important kinases viz., inositol-pentakisphosphate 2-kinase was reported (Sujatha, R., 2012; Giridhari,2017). The objective of the project was to sequence the 5'sequence of the partially sequenced gene fragment ipk1. RCA method was employed for whole genome amplification of black pepper genome (Panniyur 1) using Phi 29 DNA Polymerase and walker adaptor primers. RCA overnight products gave several bands of nearly 800 bp in nested locus specific amplification with nested locus specific primers (NLSP).Several NLS amplifications were done using different primer combinations. An amplicon of 250 bp was resulted from NLS amplification of RCA overnight products with PNC F2 and PNC R2 whereas NLS amplification performed with primers PNC F2, PNC R2 and R8 B, a single band of 700 bp was observed. Several 100 bp bands were also observed in NLS amplification with primers F8, R8A and R8B.Sequencing of the putative sequences and phytic acid estimation is in progress.

23. Investigation on extraction of starch from cassava stem (*Manihot esculenta* Crantz)
(BBP-11-00-01-2018-ACV(19)-KAU-PG)

Hasmi Sulain K.K (2014-09-102)

Objectives were to identify the cassava (*Manihot escalanta* Crantz) genotypes suitable for extraction of starch from stem and to identify suitable method of extraction of starch from cassava stem and to characterize the starch obtained from stem tissue.Completed raising of selected genotypes, sample collection, extraction of starch from stems, quantification of starch and functional analysis of stem starch. Identification of best starch extraction method is ongoing.

24. Identification and characterization of bioactive leads from mangrove sediment-associated bacteria and assessment of their therapeutic potential (BBP-11-00-02-2018-ACV(19)-KAU-PG)

Lakshmi Rajan**(**2014-09-103)

Objective was to isolate and characterize the mangrove sediment associated bacteria by microbiological, molecular and chemical characterization, to assess the therapeutic potential of isolated bacterial strains and to isolate and characterize potential bioactive pharmacophores. A total of 10 sediment samples from mangrove ecosystem were collected and isolated 40 bacteriae, which were screened for antimicrobial activities against pathogenic bacteriae. The isolates with potential antimicrobial and antioxidant activities were characterized by biochemical and molecular methods (16S rRNA gene sequencing on progress). Extraction of bioactive metabolites from the selected bacteria (*Bacillus amyloliquefaciens*) and chromatographic purification are in progress

25. Meta analysis of QTLs associated with pests and disease resistant genes in cassava. (BBP-11-00-03-2018-ACV(19)-KAU-PG)

Reshma Parveen J. (2014-09-104)

Objectives of the study were to combine the results of QTL detection studies conducted on cassava mosaic disease resistant genes in cassava and to integrate the data with genomic information of cassava. It also aims to validate the results obtained using resistant and susceptible variety. Completed collection of QTL data, Installed Biomercator software and developed tools for meta-analysis and constructed reference map. Project is in progress.

26. Modeling of Cassava- Cassava Mosaic Virus interactions with computational biology and bioinformatics approach(BBP-11-00-04-2018-ACV(19)-KAU-PG)

Rajani K.R. (2014-09-105)

Objectives of the study were Data mining of Plant-Virus Interaction through Protein-Protein Interaction (PPI) networks, construction analysis of PPI networks of genes involved in Cassava-Cassava Mosaic Virus (CMV) interaction, computational prediction of PPIs and validation of the protein-protein interactions in Cassava-CMV. Collected data of protein-protein interaction from different databases (phytozome)and information regarding different methods to create Protein-Protein Interaction Network. Collected the genomic information of Cassava Pathogenesis Related Proteins (PR Proteins) and Cassava Mosaic Virus proteins responsible for infection in Cassava. Constructed a pipeline for the current project work. Installed the software cytoscape for the analysis of network constructed.

27. Investigations on nutritional aspects of cassava (*Manihot esculenta* Crantz) leaf and its enrichment. (BBP-11-00-05-2018-ACV(19)-KAU-PG)

Reshma A (2014-09-106)

Objective of the study was screening of cassava genotypes for suitability of leaf meal and characterization of leaf protein and nutrient content and its enrichment. Completed raising of selected cassava genotypes, harvesting and processing of cassava leaves, determination of protein content, biochemical characterization. *In vitro* digestibility study is ongoing.

28. Targeting drug resistance in cancer cells by the anthelminthic drug, pyrvinium pamoate (BBP-11-00-06-2018-ACV(19)-KAU-PG)

Keerthana Suresh K. (:2014-09-107)

Objective was to find out the IC50 of *Pyrvinium pamoate* in colon, breast and pancreatic cancer cell lines and to check its ability to sensitize the drug-resistant tumor cells. Completed the screening of cancer cell lines and induction of drug resistance is in progress.

29. Differential response of resistant gene analogues (RGAs) against *Phytophthoracolocasiae* causing leaf blight in taro (*Colocasia esculenta*).(BBP-11-00-07-2018-ACV(19)-KAU-PG)

Jyothi Lekshmi O. B. (2014-09-108)

Objectives were to isolate, characterize and sequence the Resistant Gene Analogues in taro against *Phytophthora colocasiae* and gene expression profiling of resistant and susceptible taro cultivars upon leaf blight infection. Completed DNA isolation, amplification of RGAs with available primers(waiting for remaining primers). Disease induction has been done and the RNA isolated from both resistant and susceptible variety was stored as cDNA.

30. Assessment of multiple abiotic stress tolerance mechanisms in rice (*Oryza sativa* L.) (BBP-09-00-03-2018-ACV(19)-KAU-PG)

Alif Ali (2014-09-109)

Objectives were to study multiple abiotic stresses viz, drought, salinity and high temperature stress tolerance mechanisms in rice and to validate the identified QTLs for stress tolerance in rice. Priliminary screening of plants for different stress was done . Pot culture experiment is in progress.

31. Molecular phylogeny of the South Indian *Aphthona* spp. (*Coleoptera:Chrysomelidae*) (BBP-11-00-08-2018-ACV(19)-KAU-PG)

Vishnu GM (2014-09-111)

Objective of the study was to identify the population genetic structure of South Indian *Aphthona* spp. using mitochondrial DNA markers and to identify patterns of intra generic genetic diversity among South Indian *Aphthona* spp.Collected samples, isolated DNA and amplified using mitochondrial DNA markers. Sequencing and sequence analsis is in progress.

32. Morphological, biochemical and molecular characterization of *Trichoderma* isolates from tuber crop ecosystem.(BBP-11-00-09-2018-ACV(19)-KAU-PG)

Linet K. Joseph (2014-09-114)

Objectives of the project were to study the differential antagonistic potential of *Trichoderma* isolates against *Sclerotium rolfsii*, the collar rot pathogen of *Amorphophallus paeonifolius* (Dennst.), to characterize the isolates using morphological, biochemical and molecular approaches and to analyse the molecular diversity.Screened 43 *Trichoderma* isolates against *S. rolfsii* and selected 28 isolates. Studied the effect of volatile organic compounds produced by *Trichoderma* isolates on plant growth.

Crude enzyme for the biochemical assay had isolated. DNA extraction of the selected 28 isolates is completed. The project is in progress

33. Extraction of cellulose from the stem of cassava (*Manihot esculenta* Crantz)
(BBP-11-00-10-2018-ACV(19)-KAU-PG)

Adithya Subash (2014-09-115)

Objectives of the study were to extract and estimate cellulose from stems of different genotypes of cassava (*Manihotescalanta*Crantz) and their characterization.Completed raising of selected cassava genotypes, sample collection, extraction of cellulose, estimation of extracted cellulose and its biochemical characterization. Enzymatic method of extraction of cellulose is in progress

34. Identification and analysis of antimicrobial biosynthetic genes in the marine microbial symbionts.(BBP-11-00-11-2018-ACV(19)-KAU-PG)

Akhitha Mary Benny**(**2014-09-116)

Objectives of the project were isolation and identification of microbial symbionts of some unexplored marine invertebrates having activity against human and aquatic pathogens including some multidrug resistant (MDR) strains and Identification and analysis of antimicrobial biosynthetic genes in these antagonistic bacteria.Samples of *Pernaviridis* (Bivalve) and 4 crab species, *Charybdis feriatus, Portunuspelagicus, Portunussanguinolentus*&*Charybdis lucifera* were collected from Munambam and the density of microbial symbionts was estimated and cultivable symbionts were isolated in pure form and stored. These pure symbionts were then subjected to antagonism against six aquatic and six human pathogens including two Multidrug resistant strains by spot on lawn method and inhibition zone diameter was measured. The positive isolates were identified using polyphasic taxonomic approach and now standardization of PCR conditions for amplification of biosynthetic gene (PKS and NRPS) is in progress.

35. Molecular cloning, characterization and functional analysis of Growth Arrest Specific gene 2 in Pear Spot (*Etroplussuratensis*)(BBP-11-00-12-2018-ACV(19)-KAU-PG)

Amiya Thalakkattu **(**2014-09-117)

Objective of the study was molecular cloning, characterisation and functional analysis of growth arrest specific gene 2 in Pearl Spot (*Etroplus suratensis*).The total RNA of *Etroplus suratensis* was isolated, cDNA was prepared and partial amplification was done and got a 560 bp portion of 1020 bp full gene sequence. The rest of the sequence was also amplified using a set of specific primers. The plasmids were isolated and the full sequence was joined together by PCR. Sequencing and sequence analysis is in progress.

36. Integration of Quantitative Trait Loci (QTL) for tuber color variations with genomic information in sweet potato (*Ipomoea batatas* L.) (BBP-11-00-13-2018-ACV(19)-KAU-PG)

Reshma T.K. (2014-09-118)

Objectives of the study was to identify differentially expressed genes for various tuber colours in sweet potato using RNA sequence data; to integrate QTL information on tuber colour with genomic information in sweet potato and to validate the identified candidate genes using accession of white and

orange fleshed sweet potato. Collected data on QTL information controlling tuber colours in sweet potato, collected the genomic information on tuber colour variation in sweet potato, constructed a pipeline for the current project work, installed the software to identify the differentially expressed genes for various tuber colours. Project is in progress

37. *In vitro* studies on the anti-infective properties of leaf and root extracts of selected medicinal plants against gastro intestinal bacterial pathogens (BBP-11-00-14-2018-ACV(19)-KAU-PG)

Anjana Babu (2014-09-119)

Objectives of the study were screening of mature leaf and root extracts of Moringa sp., Bixa sp., Polygonam sp.,Pimenta sp. and Homonia sp. for anti-infective activity against gastro bacterial pathogens, demonstration of the mode of action of the extracts targeting on FtsZ protein through in-vitro and in-silico analysis, and assessment of lead compound over virulence factor and biofilm formation. Initial screening of selected leaf and root extracts for antiinfective activity against bacterial pathogens has been tested. In-vitro analysis on the mode of action by the bioactive extracts targeting on FtsZ protein had been assessed by observing elongation assay, standardizing polymerization and malachite green assay. Biofilm inhibition by the crude extract had been assessed. Project is in progress

38. Evaluation of immumo-biochemical attributes of Asian green lipped mussel (*Perna virdis*) and characterization of selected immune related genes(BBP-11-00-15-2018-ACV(19)-KAU-PG)

Neethu B. Raj (2014-09-120)

Objectives were to analyze the seasonal impacts on biochemical and immunological parameters in the haemolymph and mantle fluid of *Pernavirdis* and to characterize two immune related genes (ferritin and Rel Homology Domain (RHD) of NFκB family) in *Pernavirdis.* Standardized the protocols for evaluating various immuno-biochemical parameters.*Pernaviridis*samples were collected from Njarackal, Cochin coast. Various immuno biochemical parameters were evaluated in hemolymph and mantle fluid of 36 samples (3 samplings: hemolymph and mantle fluid of 12 animals were pooled in each sampling) in the month of January and February (first season) and data were tabulated. Total RNA was isolated from the mantle tissues, cDNA was prepared and partially characterized the ferritin encoding gene of this mussel. Then 3'RACE of ferritin encoding gene was performed using a designed gene specific primer and obtained PCR product. Sequencing and sequence analysis is in progress.

39. *In vitro* studies on the anti-infective properties of flower and fruit extracts of selected medicinal plants against enteropathogens.(BBP-11-00-16-2018-ACV(19)-KAU-PG)

Muhsina A. S. (2014-09-122)

Objectives of the study were to screen the mature flower and fruit extracts of *Punica spp, Syzygium spp, Aegle spp, Annona spp* and *Vanilla spp* for anti- infective potential against enteropathogens (*Vibrio cholera* and *Escherichia coli*) ; to study the mode of action of fruit and flower extracts targeting FtsZ protein through *in vitro* and *in silico* analysis and then finally to demonstrate the effect of plant compounds on virulence factors and bio film formation of *Vibrio cholerae* and *Escherichia coli* and to identify the lead compounds from the potential plant extracts. Completed

initial screening of selected fruit and flower extracts for anti-infective activity against bacterial pathogens . *In-vitro* analysis on the mode of action of the bioactive extracts targeting on FtsZ protein had been assessed by observing elongation assay, polymerization and malachite green assay. Bio-film inhibition by the crude extract had been assessed. Project is in progress.

40. **Identification of the Population genetic structure of *Carcharhinus longimanus* (ocean white tip shark or Brown Milbert's shark) using mitochondrial DNA Markers**.(BBP-11-00-17-2018-ACV(19)-KAU-PG)

Sreelekshmi S. **(**2014-09-123)

Objectives were to identify the population genetic structure of *Carcharhinus longimanus* (oceanic white tip shark) using mitochondrial DNA markers and to identify patterns of intra-specific genetic diversity, gene flow and connectivity among oceanic white tip sharks of Indian ocean.105 samples of *Carcharhinuslongimanus* (oceanic whitetip shark) were collected from different sites of Indian peninsular waters followed by DNA isolation of those samples. Primers for partial D Loop region of mitochondrial DNA were designed using Primer 3 and standardized PCR conditions. Sequencing and sequence analysis to perform the population genetics studies of the samples are in progress.

41. **Identification and characterization of virus responsive miRNAs in banana *Musa* (AAB) 'Nendran' (**BBP-04-00-05-2018-ACV(19)-KAU-PG)

Athira Subramanian (2017-11-099)

The objective of the study was to identify the miRNAs associated with *Banana Bract Mosaic virus* (BBrMV) infection in banana var. Nendran from the expression profile of selected miRNAs. Vector transmission of BBrMV on healthy tissue culture plants had been completed. cDNA conversion is in progress.

42. **Expression profiling of auxin biosynthesis genes during inflorescence development in black pepper (*Piper nigrum* L.) (**BBP-04-00-06-2018-ACV(19)-KAU-PG)

Arathy L. S. (2017-11-106)

The objective was to study the expression of auxin responsive genes such as Barren stalk fastigate1(BAF1), Barren inflorescence, ramosa (RA) during inflorescence development in black pepper (*Piper nigrum* L.) by RT- qPCR. cDNA conversion of all the stages of different varieties had been completed for expression studies using Real time PCR. The project is in progress.

43. **Elicitation of phenyl propanoid production and expression profiling of acteoside biosynthetic genes in *Artanema sesamoides Benth* (vathomvaretti)**(BBP-01-03-01-2018-ACV(19)-KAU-PG)

Monisha G (2017-11-150)

The objective was to study the effect of elicitors like salicylic acid, meth yl jasmonate and abscisic acid on phenyl propanoid glycosides production in *Artanema sesamoides Benth*and to analyse the expression profile of key genes of acteoside biosynthesis pathway, such as *PAL* (phenylalanine

ammonia-lyase), *HCT* (Shikimate O-hydroxycinnamoyl transferase) and *UGT* (UDP-glucose glucosyl transferase). Callus culture was established. Elicitation is in progress.

44. Selection of stable house keeping genes for gene expression studies during inflorescence development in black pepper (*Piper nigrum* L.) using real time PCR(BBP-04-00-07-2018-ACV(19)-KAU-PG)

Nasreena C. (2017-11-153)

The objective of the study was to compare the expression profile of different house keeping genes such as *Actin*, β-*Tubulin, Elongation factor, Initiation factor, Ubiquitin* and *GAPDH* (Glyceraldehyde phosphate dehydrogenase) during inflorescence development and to identify the most stable gene as reference gene for RT-qPCR studies during inflorescence development in black pepper (*Piper nigrum L.*). Primer designing and cDNA conversion were completed for expression studies using Real time PCR. The project is in progress.

45. Expression profiling of auxin responsive genes during inflorescence development in black pepper (*Piper nigrum* L.)(BBP-04-00-08-2018-ACV(19)-KAU-PG)

Karapareddy Sowndarya (2017-11-154)

The objective of the study was to compare the transcript profile of auxin biosynthesis genes such as flavin monoxygenase and tryptophan aminotransferase during inflorescence development in different cultivars of black pepper (*Piper nigrum* L.) using RT- qPCR. cDNA conversion of all stages of inflorescence development in different varieties were completed. Real time PCR is in progress.

46. Population structure analysis of indigenous rice varieties in Kerala using molecular markers. (BBP-11-00-20-2017-ACV(9)-KAU-PG)

Objective of the study to analyse the structure of populations of traditional rice in four different agro climatic zones of Kerala using SSR and RAPD markers.

Five traditional rice varieties from each of the four agro climatic zones of Kerala such as Kuttanad, Pokkali saline tract. rice growing tract of Palakkad and,hill tracks of Wayanad were collected and analysed using ten RAPD and 10 SSR primers. Population structure analysis is in progress.

47. Molecular marker analysis for cassava mosaic disease resistance(BT-07-00-08-2013-ACV(19)KAU-PG)

The study aimed to identify reliable molecular markers linked with mosaic disease resistance in tapioca.

48. Physiological and molecular analyses of flowering response in amaranthus (*Amaranthus* spp.) and cowpea (*Vigna* spp.) under elevated CO_2 environment (BBP-09-00-02-2016-ACV(21)-KAU-PG)

Ghade Rameshwar Pandurang (2015-11-089)

The objective was to study the physiological, molecular and biochemical basis of elevated Co_2 mediated modifications in the flowering responses of amaranthus and cowpea. Two pot culture experiments were conducted with two varieties of amaranthus – Arun and CO-1 and two varieties of cowpea-Anaswara and Vellayani Jyothika. The technology used for CO2 enrichment was Open Top Chamber system (OTC). CO2 was released from cylinders to OTC bringing the CO2 level to 600ppm. Amaranthus and cowpea plants were raised and maintained in pots as per PoP (KAU) recommentdations under elevated CO2. The control sets were kept under open field condition. Growth analysis and analyses of physiological and biochemical parameters were done at the time of harvest. The varieties which showed modification in flowering time to a greater extent under exposure to elevated CO2 were chosen for molecular analyses.

Flowering time was modified in CO-1 in terms of days to first flowering and days to 50% flowering (2 days); but Arun did not show any significant response in flowering time and hence CO-1 was selected for molecular analyses. The variety Arun showed a reduction in ascorbic acid and vitamin A content under CO2 enrichment with an increase in oxalate content. In the case of CO-1, though ascorbic acid and vitamin A contents were less under open condition, upon exposure to higher concentrations of CO2, there was tremendous increase in these quality parameters along with oxalate content. Both the varieties of cowpea recorded significant variations in growth, physiological and biochemical parameters when exposed to higher concentrations of CO2.

Flowering time was modified in cow pea variety Anaswara - 2 days to first flowering and days to 50% flowering. The DNA of Flowering locus (FT) was amplified from Anaswara and CO-1. Differential expression was observed in both the crops under elevated CO2 condition. In the present study, both cowpea and amaranthus were found to be responding to elevated CO2 in terms of flowering time. This can be correlated with the higher photosynthate accumulation with a net positive effect on growth parameters. The increased gibberellic acid level displayed by both the crops upon CO2 enrichment can also play a role in signaling the crosstalk between reproduction and other developmental processes.

Understanding the mechanisms involved in the regulatory network modulating floral initiation in response to elevated CO2 and elevated temperature will facilitate understanding and identifying options to develop plants better adapted to changing climate.

49. Physiological approaches for manipulating male sterility in thermo- sensitive genic male sterile system for hybrid rice seed production (BBP-09-00-03-2016 -ACV(21)-KAU-PG)

Gayathri Rajasekharan (2015-21-010)

The objectives were to evaluate the environmental conditions required for complete male sterility of TGMS plants and to manipulate the male sterility by using plant growth regulators and to understand the molecular mechanism associated with TGMS system.

The stable Thermosensitive Genetic Male Sterile (TGMS) line IR75589-31-27-8-33 (EC720903) was imported from International Rice Research Station (IRRI), Philippines through Standard Material Transfer Agreement (SMTA) through National Bureau for Plant Genetic Resources (NBPGR), New Delhi. The TGMS line BC_1F_2 red rice developed was raised in the rice plot and Rain Out Shelter (ROS). The seeds were sown in the pots at monthly intervals for twelve months starting from 20th June, 2017 to 20th May, 2018 in order to identify the ideal season for hybridization and seed multiplication by observing pollen sterility and spikelet sterility.

Analysis of weather data revealed that the mean temperature during the critical thermosensitive stage *i.e*., 15-22 days before flowering of all the monthly sown TGMS red rice were above the critical sterility inducing average temperature of 26.9^{0}C under both conditions. Since the mean temperature was above the critical sterility temperature (CST), the newly developed TGMS line on red rice background exhibited stable sterility throughout the study period at both the experimental conditions viz. plain and high altitude. The same line EC720903 displayed acceptable seed setting percentage (>80%) in the high altitude zone where the mean temperature is below the critical sterility inducing average temperature.

The season showing partial sterility was identified and the TGMS line EC720903 seeds were sown at RARS, Ambalavayal during June, 2017 to November, 2017. Three plant growth regulators (PGR) namely ethrel (400, 800 and 1200 mg L^{-1}), salicylic acid (400, 600 and 800 mg L^{-1}) and maleic hydrazide (600, 800 and 1000 mg L^{-1})were applied as foliar spray at two stages *viz.*, panicle initiation and two weeks after panicle initiation and water spray was kept as control. The results had shown that PGR - MH, ethrel and salicylic acid at different concentrations were effective in increasing the pollen sterility . Spraying of MH (1000 mg L^{-1}) two times at the time of panicle initiation and fifteen days after panicle initiation is more effective followed by salicylic acid 600 mg L^{-1}.

The season suitable for hybridization was selected and the TGMS line EC720903 was evaluated for its potential to be used as a female parent. The TGMS line was crossed with two rice varieties of Kerala Aiswarya (medium duration, grain colour red with long bold grain) and Swetha (long duration, with short bold grain). The hybridization was done using proximal hybridization method. The female parent TGMS line EC720903, male parents Aiswarya and Swetha were sown in the third crop season (December-January to March-April) for hybridization. The mean temperature during the third crop season was above the CST and complete male sterility was obtained in the TGMS line which favoured the hybrid seed production. The seed setting percentage was 40.07% for the cross involving Swetha as male parent whereas it was 30.18% for Aiswarya and EC720903. The F_1 progenies obtained from two crosses Aiswarya x EC720903 and Swetha x EC720903 along with male parents Aiswarya, Swetha and the female parent EC720903were sown in pots during the first crop season (April-May to September-October). The outcrossing potential of TGMS line EC720903 was in the satisfactory range and the two F_1 hybrids were performed better. Based on the morphological, phenological, physiological and yield parameters, among the two F_1 hybrids developed, F_1 progenies of

SwethaxEC720903 performed better. Based on the stable sterility throughout the study period, preferred CST, satisfactory seed setting percentage, physiological and agronomic acceptability and outcrossing potential, the TGMS line EC720903 is a better option for developing suitable hybrids in any background. Studies on molecular mechanisms are in progress.

50. Physiological, biochemical and molecular studies in medicinal rice (*Oryza sativa* L.) Njavara, as influenced by abiotic stresses(BBP-08-00-04-2016 -ACV(21)-KAU-PG)

Wagh Yogesh Sahebrao (2015-21-013)

The objective was to elicit information on the physiological, biochemical and molecular attributes associated with secondary metabolites accumulation due to abiotic stresses *viz.* shade, drought, and UV-B stress in medicinal rice njavara. Two medicinal njavara rice viz. black glumed and yellow glumed were included in the study Two levels of shades and two levels of field capacity were studied in the two genotypes. . Plants were subjected to UV-B (280-320 nm) radiation for 4 hours per day (10am - 2pm) at different critical stages of plants *vis.* vegetative stage, panicle initiation stage and flowering stage. The molecular analysis was carried out at the grain filling stage of the crop. The project is in progress

51. Identification of molecular markers and Quantitative Trait Loci (QTLs) associated with drought tolerant and plant production traits in rice (*Oryza sativa* L.) using association genetic analysis (BBP-02-00-06-2017-ACV(21)-KAU-PG)

Nithya N. (2016-21-008)

The objective was toidentify molecular markers, Quantitative Trait Loci (QTLs) associated with drought tolerance and plant production traits in rice under drought condition. Phenotyping of selected 81 rice genotypes for drought tolerance and plant production traits under control and drought condition were done. Eighty one rice genotypes were also evaluated under field conditions. At the time of panicle initiation, irrigation was withdrawn for 25 consecutive days. Observations were taken on morphological and physiological parameters after induction of stress. After 25th day, re-watering was done and plants were kept upto maturity. Genotyping of 81 rice genotypes using 100 SSR primers is in progress.

52. Validation of Temperature Induction Response (TIR) technique for inducing drought and heat stress tolerance in rice (*Oryza sativa* L.)(BBP-08-00-01-2017-ACV(21)-KAU-PG)

Reshma Mohan (Adm. No. 2016-11-063)

The objective was tostudy the effect of Temperature Induction Response (TIR) for combined drought and heat stress tolerance in rice. Rice varieties Jyothi and Vaishak were used for the standardization of lethal and induction temperature. Ten rice genotypes (N22, Apo, CR Dhan 305, CR Dhan 307, Ptb-7, Ptb-15, Ptb-30, Ptb-39, Ptb-43 and Ptb-60) were used to study the effect of TIR technique on combined drought and heat stress tolerance. 100% mortality was observed in the rice genotypes for the treatment 52°C for 3 hrs and the same was selected as lethal temperature. Maximum recovery growth and least reduction in recovery growth were observed for 32-42 ºC for 5 hrs & 42-52 ºC for 30 min and this treatment was selected as induction temperature. TIR induced plants exhibited better

biochemical and physiological traits than non-induced plants in all the genotypes that had better stress tolerance. N22 and Apo were selected as the best genotypes under stress for the physiological traits. Apart from these Ptb-15 under heat stress and Ptb-7 under drought performed well and under combined stress Ptb-30 and Ptb-15 showed the best performance as compared to other genotypes. Ptb39(Jyothi) was identified as the most susceptible genotype for both drought and heat stress.
Changes in the molecular level were studied by SDS PAGE and RT PCR in TIR induced and non-induced plants of genotypes, Ptb-39 (most susceptible) and N22 (tolerant) under combined drought and heat stress. The results revealed that protein expression showed variation between tolerant and susceptible genotypes and also between induced and non-induced plants. Expression level of PSTOL 1 and DRO 1 also showed variation between induced and non-induced plants of tolerant and susceptible genotypes. Protein synthesis was maintained significantly higher in the induced plants as compared to non-induced plants on being exposed to severe stress. Tolerance of genotypes towards stress has been attributed to changing transcript levels of stress induced genes.

53. Physiological and biochemical studies on growth, development and yield of ginger (*Zingiber officinale* Rosc.) as influenced by bioinoculants and phosphorus fertilization (BBP-08-00-02-2017-ACV(21)-KAU-PG)

Amritha Lekshmi M. G. (2016-11-075)

The objective of the study was to elicit information on the physiological, biochemical attributes on plant growth, development and yield of ginger as influenced by bioinoculants such as mycorrhiza and trichoderma combined with phosphours fertilization. In this study ginger cultivar maran was grown in pots under completely randomized block design (CRD). Different levels of 'P' were applied to soil in pots viz. low (P_2O_5-50% POP), medium (P_2O_5as per POP) and high (P_2O_5 double dose of POP). The pots were inoculated with AMF or Trichoderma or both together in combination during the time of planting. Throughout the growth stages, T8 (P_2O_5-50% of POP+AMF+ Trichoderma) recorded significantly higher value for chlorophyll a and total chlorophyll content. Treatment T8 with combined inoculation of AMF and trichoderma and half dose of 'P' showed 49.2%, 58.4%, 120.6% and 20% increase in total protein, total sugar, phenol and reducing sugar content respectively at maturity stage. Uptake of major nutrients such as N, P, K, Ca and Mg increased with microbial inoculation. Treatment T8 recorded 35.5% and 39.2% increase in fresh and dry ginger yield over control. Arbuscular mycorrhizal and trichoderma inoculation along with phosphorous fertilization has significantly improved growth, yield and quality of ginger not only through increasing nutrient uptake, but also viz. stimulating photosynthetic parameters and biochemical properties of the ginger particularly under low phosphorous fertilization.

54. Physiological approaches for alleviating the effect of water stress in upland rice (*Oriza sativa* L.)(BBP-08-00-03-2017-ACV(21)-KAU-PG)

Saranya. P. (2016-11-085)

Objective of the study was to standardize suitable physiological approaches to mitigate the effect of water stress in upland rice.

55. Assessment of water stress tolerance in selectively fertilized coconut (*Cocos nucifera* L.) hybrids.(BBP-08-00-04-2017-ACV(21)-KAU-PG)

Rahul Gupta (2016-11-118)

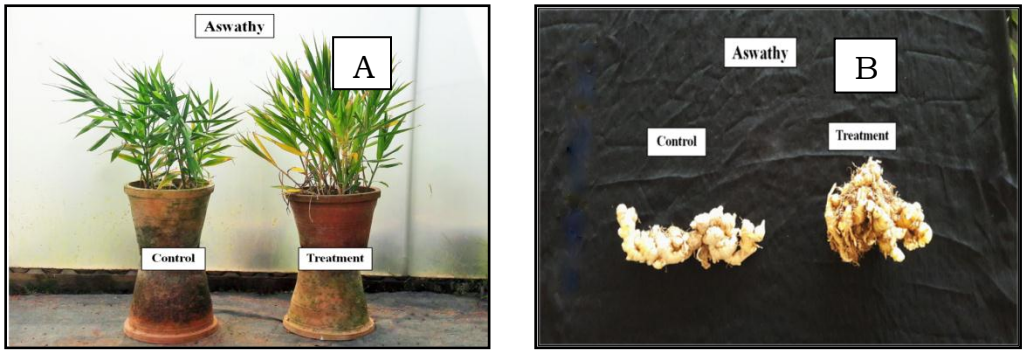
Objective of the study wasphysiological and molecular assessment of water stress tolerance in selectively fertilized coconut hybrids and to screen coconut genotypes for water stress tolerance through critical water potential for pollen germination. Selectively fertilized hybrids had high water use efficiency, highest membrane stability and lower percentage of leakage. Genetic variation of critical water potential for pollen germination was observed in 30 coconut genotypes that included Tall, dwarf and hybrids. In WCT, there was expression of a heat shock protein with a molecular weight of 66-70 KDa.

56. Evaluation of CO_2 enrichment on growth, development and soft rot tolerance in ginger (*Zingiber officinale* Rose(BBP-09-00-03-2017-ACV(21)-KAU-PG)

Manasa R. (2016-21-023)

Objective of the study was to assess the impact of elevated CO_2 on rhizome development, yield, quality and tolerance to soft rot in ginger through morphological, physiological, biochemical and molecular analysis.

Three ginger varieties Aswathy, Athira, Maran were procured from Regional Agricultural Research Station (RARS), Ambalavayal, Wayanad. Three month old Ginger plants were transferred and maintained in replicates in Open Top Chamber (OTC) facility available at Department of Plant Physiology, enriched with 500 ppm of CO_2 and another set at natural conditions as control plants. Ginger plants were harvested at 4^{th}, 5^{th}, 7^{th} and 8^{th} month after planting to assess the influence of elevated CO_2 of growth, quality and yield. Plants grown under elevated CO_2 performed better in terms of growth and yield parameters in contrast to the natural environmental conditions and varietal differences were also evident.



Ginger variety Aswathy indicating plant growth (A) and rhizome yield (B) under control (natural) and treatment (OTC) conditions.

To assess the impact of elevated CO_2 on the response of ginger to *Pythium* sp. on soft rot development. A protocol was standardized to view the extent and number of days taken for soft rot

disease development and its progress at different concentrations of inoculum for conducting the next experiment and to understand the disease complex. Three varieties Aswathy, Athira and Maran and wild species *Zingiber zerumbet* arebeing raised and will be transferred to OTC after 3 1/2 months. Pathogen inoculation was done on four month old plants through soil inoculation and plant pathogen interactions under OTC will be assesed. The experiment is in progress

57. Physiological and molecular studies on genera of Loranthaceae and their management
(BBP-02-00-11-2016-VKA(21)-KAU-PG)

Garggi G (2015-21-011)

Objectives of the project were to study the genetic diversity of common Loranthus genera in Kerala, to understand the dynamics of host parasite interaction and to modify and improve their management strategies

Morphological studies of Loranthus Species viz. viz. Dendropthoe, Helicanthus, Macrosolen, Scurulla and Taxillus. Haustorial anatomical studies of LoranthusspecicesDendrophthoe and Helicanthus. Host parasitic interaction studies between parasites Dendrophothoe and Helicanthus and host Cocoa revealed probable two way communication between the host and parasite. The management of Loranthus can be improved by addition of non-ionic surfactants in suitable concentration.

58. Evaluation of CO_2 enrichment effects on resource utilization in cowpea (*Vigna unguiculata* L.) and amaranthus (*Amaranthus tricolor* L.).(NRM-01-00-08-2015-ACV(21)-KAU-PG)

Srikanth G. A. (2015-21-010)

Objective of the project was to study the impact of CO_2 enrichment in cowpea and amaranthus under varying moisture, temperature and nutrient regimes. Experiments were conducted in two varieties of cowpea, Lola and Vellayani Jyothika and Arun variety of amaranthus. The technology used for CO_2 enrichment was Open Top Chamber (OTC) system . Carbon dioxide was released from CO_2 cylinders to one of the two OTC's bringing the CO_2 level to 600 ppm and the second OTC worked as control at ambient CO_2 for chamber effect. Among the two varieties of cowpea, Vellayani Jyothika was found as the best responding variety to elevated CO_2 in terms of yield parameters.

Evaluation of plant response to elevated CO_2 under different soil moisture regimes were studied. Two weeks old potted plants were shifted to OTCs. All the three sets of plants were maintained at field capacity (FC) initially. Soil moisture levels were brought down to 80% and 70%, in the second and third sets, 30 days after planting and were maintained for a period of 30 days at these soil moisture regimes in OTCs. An improvement in growth performances of cowpea and amaranthus under mild and severe moisture stress conditions (80% and 70% FC) was observed. In the case of cowpea, CO_2 enrichment induced early flowering in all the three soil moisture conditions and improved yield.

Evaluation of plant responses to elevated CO_2 under different soil nutrient regimes was studied. Potted plants of cowpea and amaranthus (Variety Arun) were used for conducting the experiment. Plants were maintained at FC at four nutrient levels throughout the crop period. The best performance was observed in plants receiving nutrients as per POP recommendation along with 25% extra nitrogen in

cowpea. C_4 plant like amaranthus also responded to CO_2 enrichment but the increase in growth and dry matter production was less compared to cowpea, which can be due to the innate CO_2 enrichment mechanism present in C_4 systems.

The temperature and humidity interaction with CO_2 enrichment was also studied. Plants were maintained at FC throughout the crop period as per POP recommendations of KAU. One set of plants were exposed to mist and the second set was maintained without exposure to mist. Significant improvement in growth and increase in yield were observed under CO_2 enrichment with exposure to mist in cowpea and amaranthus. Elevated CO_2 concentration is found to improve stress tolerance through better photosynthetic rate and activation of defence mechanism.

59. Physiological studies on growth, yield and quality enhancement of chilli (*Capsicum annuum* (L.) under different nutrient management(BBP-08-00-01-2018-VKA(21)-KAU-PG)

Amrutha E. A (2017-11- 147)

Objective of the study was to investigate the influence of soil and foliar application of nano NPK and compare with conventional fertilizer for enhancing growth, yield and quality attributes of chilli.Nano NPK 4 G granules were applied at basal, 30 and 60 days after planting @ 0.33 g / Plant for each dose. Foliar sprays of Nano- NPK 4 G and NPK 19: 19: 19 were done at 35, 65, 80 and 95 days after planting.

Plant height, number of branches per plant, root volume increased in the treatment (T6) with nano granule with 19:19:19 - 0.5 % foliar spray. The same treatment recorded maximum leaf area index, releative water content, chlorophyll content, SPAD chlorophyll , leaf area duration, transpiration , stomatal conductance, F_v / F_m ratio and electron transport rate . Fruit length, number of fruits per plant and yield were also more in the treatment. The project is in progress

60. Physiological evaluation of herbicidal effects on rice, broadleaved weeds and sedges. (BBP-08-00-02-2018-VKA(21)-KAU-PG)

Linu. C (2017-11- 081)

Objectives of the study were to identify broad leaved weeds and sedges that are selectively controlled by Almix®, penoxsulam and 2,4-D and also to evaluate the effect of these herbicides on the growth, physiology and yield of rice. The experiment was conducted in ARS Mannuthy. The rice variety jyothi was used for the trial. The experiment contained eight treatments and 3 replications. Herbicide applied 20 DAS. One week after herbicide applications, Almix® @ 0.008 kg ai ha^{-1} showed lower grain yield and straw yield as compared to hand weeded control. But after one month of herbicide application, penoxsulam @ 0.05 kg ai ha^{-1}showed lower yield attributes. In case of biochemical analysis, Almix® @ 0.008kg ai ha^{-1} showed least soluble protein content, IAA content, Chlorophyll content, Nitrate reductase content, total amino acid content and higher proline content as compared to hand weeded condition. But after one month of herbicide application, penoxsulam @0.05 kg ai ha^{-1} showed least soluble protein content, IAA content, Chlorophyll content, Nitrate reductase content, total amino acid content and higher proline content compared to hand weeded condition. Pot culture study is in progress.

61. Evaluation and characterization of selected rice genotypes for high temperature stress tolerance(BBP-08-00-03-2018-VKA(21)-KAU-PG)

Mohammed Jazeel M (2017-11- 111)

Objectives of the project were **t**o study the morpho-physiological response of rice genotypes to high temperature stress and to characterize the tolerant genotypes using OsHSP genes. Two days old seedlings belonging to 16 varieties of rice were maintained in a growth chamber to a standardized temperature induction response (TIR) wherein the temperature was raised from 32^0C to 42^0C for 5 hours gradually and then challenged by a lethal temperature of 49^0C for 3 hours. Then the seedlings were allowed to recover for 72 hours at 30^0C. At the end of recovery period, the genotypes were classified as susceptible, moderately tolerant, and tolerant genotypes based on actual growth.The genotypes SUPRIYA, AKSHAYA, VYTILLA 10, VAISHAK, ILN 150, ILN 236, N22 showed more tolerance towards heat stress and genotypes such asCULTURE 06-7, KALLURULI, JYOTHI, ILN 368, MATTATHRIVENI, PARAMBUVATTAN were found moderately tolerant to heat stress and genotypes MO23, NAVARA, UMA were found susceptible to heat stress. For analyzing the genetic variability for thermo-tolerance, the tolerant genotypes were grown in field conditions as control and in the heat tolerance nursery (as treatment) wherein the temperature maintained was $+5^0$ c than that of the ambient temperature. The PCR was performed for all gene specific primers. Heat shock proteins were constitutively expressed in all genotypes. The project is in progress.

***62.* Spectral manipulation on the growth and physiology of *Gerbera jamesonii.*(**BBP-07-00-01-2018-VKA(21)-KAU-PG)

Anil A S (2017-11- 136)

Objectives of the study were to understand the influence of spectral light intensities on the morphological, phenological, physiological characters, yield and flower quality of gerbera (*Gerbera jamesonii*). Red and blue light appears to be contributing better to the vegetative growth and flower production respectively. Detailed analysis is in progress.

63. Physiological approaches for enhancing the *ex vitro* establishment of tissue cultured orchid (*Phalaenopsis* sp.) (BBP-01-01-02-2018-ACV(21)-KAU-PG)

Sayooj S. (Adm. No. 2017-11-088)

Objectives of the project were to study the physiological changes that occur during *ex vitro* establishment of orchid (*Phalaenopsis* sp.) and to find out measures to overcome the field mortality rate and improve propagation efficiency.

Tissue cultured derived rooted *Phalaenopsis* plantlets obtained from Biotechnology & Model Floriculture Centre (BMFC) Kazhakuttam were used for the *ex vitro* studies. Plantlets subjected to different treatments were kept in sterilized coconut husk balls and maintained for 45 days under controlled conditions in the mist chamber. In the mist chamber the plantlets were supplemented with foliar spray of NPK mixture 19:19:19 (0.10%) on 15th day after planting and 30th day after planting. After 45th day the plants were potted in small pots containing charcoal, brick, coconut husk in the

ratio of 1:1:1 and the plants were maintained in shade upto 70 days.Field experiment was laid out with 11 treatments including control. The field experiment was completed. Chemical and statistical analysis is in progress.

64. Influence of CO_2 enrichment and associated high temperature on reproductive physiology of tomato (*Solanum lycopersicum* L.) (BBP-09-00-01-2018-ACV(21)- KAU- PG)

Lakshmi G Ajay

Objective of the project was to study the effect of CO2 enrichment and associated high temperature on flowering and fruiting in tomato and their improvement through growth regulators and nutrient applications and through temperature induction response technique. . In nutrient management, T6 (POP 125% N: 100% P: 100%K) showed better result in case of yield parameters in tomato and T3 (50 ppm Boron) showed better result in case of pollen viability and fruit setting. Statistical analysis is still in progress.

65. Physiological and anatomical plasticity of root traits under water stress and molecular characterization using root specific genes in rice (*Oryza sativa* L.)(BBP-09-00-02-2018-ACV(21)-KAU-PG)

Chennamsetti Lakshmi Naga Manikanta (2017-11-100)

Objectives were to quantify the adaptive plasticity in root-shoot morphology and physiology, root anatomical plasticity under water stress in selected rice genotypes and molecular characterization using root specific genes.

Selected six rice genotypes were evaluated for their adaptive plasticity in root shoot morphology, physiology and biomass partitioning. Root anatomical plasticity under control and stressed condition were studied.

Selected rice genotypes were genotyped using 12 *DEEPER ROOTING QTL* specific microsatellite primers. As polymorphism was not noticed among the varieties, samples were genotyped using other available drought specific markers and found SSR primer RM518 showed polymorphism in the tolerant and susceptible genotypes. Transcriptome analysis is in progress.

66.Impact of foliar application of plant growth regulators and micronutrients on high temperature stress mitigation in rice (*Oryza sativa* L.)(BBP-08-00-04-2018-ACV(21)-KAU-PG)

Raghunath M. P. (2017-11-137)

Objectives of the project were to study the effect of foliar application of plant growth regulators and nutrients on high temperature mitigation and to advance the flowering time by using methyl jasmonate (MeJA) in rice (*Oryza sativa* L.).Paddy seedlings [uma (Mo-18) variety] was raised in pot trays and transplanted to mud pots on 18th DAS. The pots were kept under high temperature condition (5-6°C more than ambient condition) in a temperature controlled polyhouse from seedling to maturity stage. Maximum and minimum temperature was measured daily using a thermo-hygrometer. Foliar spray of plant growth regulators and nutrients were given on panicle initiation, heading and flowering stage. Physiological observations were taken at 50% flowering stage and yield parameters were taken at harvest stage. Methyl jasmonate was sprayed to the spikelets in varying concentrations . Physiological

observations were taken at 50% flowering stage and yield parameters were taken at harvest stage. The project is in progress

67.Effect of foliar application of selected nutrients and growth regulators on tuber development, yield and fortification status of sweet potato (*Ipomea batatas* L.).(BBP-08-00-05-2018-ACV(21)-KAU-PG)

Arya S. R. (Adm. No. 2017-11-146)

Objectives were to enhance qualitative and quantitative attributes in sweet potato (*Ipomea batatas* L.,). by foliar application of selected micronutrients and growth regulators and to study their effect on growth, development and changes in fortification status of sweet potato tubers and leaves. Crop was raised and treatments were imposed. Physiological parameters such asestimation of pigments (Caroteinoids, Chlorophyll) (mg g^{-1})**,** Stomatal conductance (mmole H_2Om^{-2} s^{-1})**,** Photosynthetic rate (µmole CO_2 m^{-2} s^{-1})**,** Transpiration rate (mmole H_2O m^{-2} s^{-1})**, and** Water use efficiency (g Kg^{-1}) was recorded and crop was harvested. Quality parameters such as estimation of mineral constituents (N, P, K, B) (mg g^{-1})**,t**otal sugar (mg g^{-1})**,s**tarch(mg g^{-1}), **c**rude protein (mg g^{-1}) etc.were done and analysis is in progress.

68.Developing high temperature tolerance in tomato (*Solanum lycopersicum* L.) through selective fertilization technique.(BBP-08-00-06-2018-ACV(21)-KAU-PG)

Ammu Alphonsa John (2017-11-147)

Objective of the project wasto identify the critical temperature for pollen germination and to evaluate the selectively fertilized tomato hybrids for high temperature tolerance Mature pollen grains from the selected five varieties were collected and incubated at different temperature ie from 34-44^{o}C for two hours in the pollen germination media and evaluated the pollen germination percentage. From that the critical temperature were identified and the tolerant and susceptible varieties were selected. Manuprabha was selected as the susceptible one as it has the least germination percentage and Anagha as the tolerant one having high germination percentage.By selective fertilization (SF) technique the pollen from the male parent (tolerant one) were collected and exposed to the specific critical temperature in a medium and pollinated the emasculated flowers of female parent (susceptible one). Another set of cross were also made with same parental combination without pollen selection. The selfing within the male and female parents were also done with and without pollen selection. The seeds from the selectively fertilized and normal fruits were collected and sown in the nursey . Project is in progress.

69.**Evaluation of sesame genotypes for tolerance to waterlogging and development of mitigation strategies**(BBP-08-00-07-2018-VKA(21)-KAU-PG)

Sreepriya S (2017-21- 020)

Objective of the project was to study the morpho-physiological and molecular characterization of sesame genotypes to water logging and its mitigation by ameliorants. Pot culture study for the amelioration of waterlogging stress was done. The variety Thilak was selected for the experiment. Ameliorants sprayed 20 DAS and waterlogged for 72 hr. Plants treated with potassium nitrate, salicylic acid and *pseudomonas florescence* were found to exhibit more survival compared to control. Field evaluation is in progress.

Name of Project Coordination Group: (09)
Soil Health and Organic Farming

Compiled by:
Dr. K. Ushakumari, Project Coordinator

Plan & External Aided Projects
Ongoing Projects :31 Nos.

Post Graduate Projects
Concluded Projects: 14 Nos.
Ongoing Projects: 12Nos.

Ongoing Projects

1. Strengthening Facilities for Quality assessment of Organic Manures

Dr. P. Sureshkumar,
Professor and Head, RTL

The analysis of the manure samples showed that some of them did not satisfy the specifications as per FCO. Specifications have been formulated for the manures which are available in state but not specified in the FCO as well as for dolomite and other liming materials. Moisture content in all the samples was high. For reducing the moisture content it is recommended that the samples should be dried in shade and packed in airtight containers. The pH of the compost samples prepared from vegetable wastes was above 8. Though it does not satisfy the specification of FCO, it might be beneficial under Kerala conditions where acidity is the inherent problem. However the electrical conductivity should be assured to be below 4 dSm^{-1}. Measures should be adopted to reduce the EC of the compost to avoid damage to crops. The concerned research stations from where the samples were received were informed with the details of analysis and about the parameters which were not satisfying the FCO specification. The research stations under KAU should be directed to assure quality as per FCO before sale.

Being the expert member in assuring the quality of organic manures and liming materials to be purchased by VFPCK, the quality analysis was done at RTL under the project before accepting the quotations. It was strictly observed that the quality parameters are satisfied before purchase of materials by VFPCK.

For liming materials like lime or dolomite, though there are no specification in FCO, KAU has formulated specification. The recommendations should be as per the KAU specification. KAU has also formulated specifications for coir pith compost which is not included in FCO.

2.Rock dust nutrition for yield enhancement in rice in iron toxic laterite soils of Kollam district through a farmer participatory research

Dr. Poornima Yadav. P.I

The experiment was conducted at KVK, Kollam to study the effect of rock dust on growth and productivity of rice and to work out the economics of rice production under new nutrient package for developing a cost effective nutrient package for rice grown in iron toxic laterite soils.

The experiments revealed that application of fine silica @100kg/ha along with 90:45:120kg NPK/ha and 150 kg lime (nutrient recommendation of Kerala Agricultural University for iron toxic laterite soils) significantly increased the growth and yield of rice. The same nutrient recommendation but fine silica replaced with 300 kg rock dust also gave a comparable yield. The performance of treatments involving biofertilizer potash solubilizing bacteria was found to be better(with respect to growth and yield) when compared to silicon solubilizing biofertilizer but lower than the treatments involving 100 kg fine silica and 300 kg rock dust along with 90:45:120 kg NPK/ha and 150 kg lime.

The experiments also revealed that the economically viable option was the application of fine silica @100kg/ha along with 90:45:120 kg NPK/ha and 150 kg lime (nutrient recommendation of Kerala Agricultural University for iron toxic laterite soils) with the highest net return and benefit

cost ratio during *kharif* (Rs 66464/-and 1.89) and *rabi* seasons (Rs. 70644/- and 1.94). The treatment involving 300 kg rock dust, 90:45:120 kg NPK/ha and 150 kg lime resulted in a net return of Rs. 61296/- and BCR of 1.77 during *kharif* season and a net return of Rs. 56590/- and BCR of 1.71 during *rabi* season.

3. Permanent Manurial Trial of rice in acid Saline soils under flooded condition (pokkali tract).

Dr.Sreelatha.A.K,
Assistant Professor &PI
RRS, Vyttila

The experiment was started during 1979. The results obtained so far indicated that the application of inorganic fertilizers with or without lime do not have any positive influence on grain yield of pokkali varieties. The low fertilizer responsiveness of the pokkali varieties and the high fertility status of the soil can be attributed to this results. The pokkali fields are highly suited for organic farming. The high fertility of the field and poor fertilizer response of the variety Vyttila 4 resulted in non significant difference in yield in the treatments. So this experiment may be continued with recently released variety Vtl 11(Jyotsna) which is fertilizer responsive with modification in treatments including soil test based treatments. The entire crop in the experiment was damaged in August 2018 floods. As a result no observation was recorded from the experiment

4.Permanent Manurial Trial- Tall

Dr.Moossa PP
Assistant Professor
RARS, Pattambi

The permanent manurial trial has completed 57 years of experimentation to find out the effect of continuous application of cattle manure, green leaf and Ammonium sulphate individually and in combination with and without P and K on the yield of tall Indica rice and soil properties using PTB 2 as test crop in Kharif and PTB 20 as test crop in Rabi. Brief summary of the findingsduring the period under report.

Highest grain and straw yield was obtained from the plots which received integrated nutrient management system. Plots which received inorganic nitrogen alone in the form of ammonium sulphate recorded the lowest yield followed by NPK from chemical fertilizers. Continuous application of nitrogenous fertilisers alone or NPK in the form of inorganic fertilizers alone were found to have detrimental effect on the growth and yield of rice. Biological parameters analysed indicated that there is no detrimental effects of fertilizers if applied along with enough organics.PMT (T) has completed 57 years of experimentation and provide an opportunity to evaluate the sustainability of agricultural practices

5.Permanent Manurial Trial- Dwarf

Dr.Thulasi. V
Assistant Professor
RARS,Pattambi

The permanent manurial trial has completed 46 years of experimentation to find out the effect of continuous application of cattle manure, green leaf and Ammonium sulphate individually and in combination with and without P and K on the yield of dwarf Indica rice and soil properties using Jaya as test crop in Kharif and Rabi.

Highest grain and straw yield was obtained from the plots which received organic manures alone and is on par with INM. Plots which received inorganic nitrogen in the form of ammonium sulphate recorded the lowest yield followed by NPK from chemical fertilizers alone. Continuous application of nitrogenous fertilisers alone or NPK in the form of inorganic fertilizers alone were found to have detrimental effect on yield of rice.

6. AICRP on Long Term Fertilizer Experiments

Dr.Moossa PP , Assistant Professor
Dr. Thulasi V, Assistant Professor
RARS, Pattambi

The experiment is continuing from 1997 Rabi to evaluate the effect of continuous application of plant nutrients in organic and inorganic forms on crop yield, nutrient uptake and soil quality and changes in pest and pathogens in response to long term fertilizer application. The study is in its 22^{nd} year and the data provide on opportunity to evaluate the sustainability of agricultural practices. The result during the current period indicated that INM and *insitu* green manuring with daincha recorded higher grain and straw yields and *Insitu* green manuring is a cost effective and farmer friendly technology, which could save cost of 5 tonnes of farmyard manure. The study indicated that significantly positive linear correlation between carbon inputs and SOC sequestration rate under LTFE.

7.Drip fertigation technology for enhancing water and nutrient use efficiency – (AICRP on IWM Co-ordinated Experiment)

Dr. Bindhu.P.S

Fertigation is a new technology wherein nutrients are applied along with the irrigation water and opens new possibilities for controlling water and nutrient supplies to crop besides maintaining the deserved concentration and distribution of water and nutrients to soil with higher water productivity. The present study was conducted to assess the influence of fertigation on water productivity of chilli. Significantly higher yield was recorded in the treatment where 75 % of the recommended dose of N and K was given through fertigation and 75% of basal as P. Water productivity, irrigation water productivity and nutrient use efficiency was highest for chilli receiving 75% N and K as fertigation and 75% P as basal. From the result it was inferred that applying N and K through fertigation and P as basal application could enhance the yield and also could save 25 per cent NPK without affecting the productivity and profit of chilli crop.

8.Permanent Manurial Trial

Dr. Mini V,
Assistant Professor

The experiment is ongoing as the permanent manorial trial to find out the effect of continuous application of nitrogen as organic and inorganic as well as P and K on soil fertility and yield of rice using Jaya as the test crop. Treatments where 25% N substituted by cattle manure along with 75% N as ammonium sulphate + full dose of P and K and where N is applied as cattle manure alone are on par. The optimum dose of N is 80 kg ha^{-1} and the entire dose can be given as cattle manure alone. For optimum production, at least 25% of N should be given as FYM and the remaining N, full P_2O_5 and K_2O as fertilizers. Treatment where N is applied as cattle manure alone recorded the highest population of Trichoderma and Azospirillum. The trial is being continued.

9. Permanent Manurial trial

Dr. Nimmy Jose
RRS Moncompu

The experiment which started in the year 1987 is being continued for more than 30 years at RARS, Moncompu as a station wise funding project. To study the effect of continuous application of N, P, K and lime over incorporation of straw on soil fertility, yield and quality and incidence of pests and diseases.

Even after the floods of 2018, the trend in the performance of the crop in the permanent manurial plot has not changed. The experimental results during the last 31 years revealed severe nutritional deficiency and yield reduction in the nitrogen and phosphorous omission plots from the eighth season and consequent significant reduction in grain and straw yield from the 10^{th} year onwards. Omission of potassium fertiliser in the double cropped paddy fields for the last 31 years gave on par yield with that of crop fertilised based on soil test data. Nitrogenous fertiliser application is highly essential in paddy fields as the mineralization process is slow from the high carbon Kuttanad soils. The crop response in the field fertilised based on soil test basis reveals that INM favours better nutrient absorption and crop yield.

10.Evaluation of surface and ground water quality across the State of Kerala and its effect on vegetation (AICRP on Irrigation and Water Management)

Dr.Mini Abraham,
Dr.Kurien E.K
Dr.Bhindhu P.S
ARS,Chalakkudy

The experiment is ongoing at ARS, Chalakudy to evaluate the quality of both surface and ground water bodies of Kerala, to study the effect of water quality on soil and crop health and to suggest the ameliorative techniques for improving water quality.

Water samples were collected from 14 identified sampling locations along the length of Chalakudy River. Analysis of samples collected for three years showed Elanthikkara areas of Chalakudy River to have poor quality irrigation water. Water from open wells can be utilized for irrigating crops, but river water is of poor in quality for irrigation. Salinity in Elanthikkara is due to saline water intrusion from the sea after monsoon period. Check dam (Regulator cum bridge) constructed at Kanakkan Kadavu had inherent errors which could not reduce intrusion of saline water. In 2016 and 2017a sand bridge was made as a temporary measure to reduce intrusion. Most of the paddy fields are kept fallow. In paddy fields where the normal HYV cannot be cultivated, field demonstrations were conducted using salt tolerant varieties (*Vytilla and Ezhom*varities) . It was found that suitable season for rice ultivation in the salt affected areas of Puthenvelikkara is from January to April.

11. Soil Nutrient dynamics under varying moisture regimes in Banana under Open Field Precision Farming Condition (AICRP on Irrigation and Water Management)

Dr.Mini Abraham,
Dr.Kurien E.K
Dr.Bhindhu P.S
ARS chalakudy

The investigation is ongoing at ARS, Chalakudy to study the soil moisture status and nutrient uptake pattern of banana under varying levels of fertilizer application under drip irrigation and drip fertigated conditions and to evaluate the changes in the physical and chemical properties of soil under drip irrigated and drip fertigated conditions.

Treatments include Standardization of dose of fertilizer (D1- 125% RDF, D2- 100% RDF, D3- 75% RDF), Precision farming with and without mulching (M0- Without plastic mulching; M1- With Plastic mulching), and Standardization of source of fertilizers(S1- urea, mono ammonium phosphate and MOP; S2- 19:19:19, 12:61:0 (MAP), 13:0:45).

Study on soil nutrient dynamics under varying moisture regimes in banana under open field precision farming condition during secondyear showed that fertilizer level could be reduced to 75 per cent by fertigation. Both common fertilizers and water soluble high priced fertilizers performed similar which shows that cheap source of fertilizer like common fertilizer s are better option. Yield was significantly higher under non-mulched situation. The effect of mulching though not significant in terms of yield was found effective in terms of weed population.

12. Effect of hydro-gel on water use efficiency of tomato under soil less cultivation

Dr.Mini Abraham,
Dr.Kurien E.K
Dr.Bhindhu P.S
ARS chalakkudy

The experiment is conducted at ARS, Chalakudy to study the stabilities of various medium for soil less cultivation and to study the effectiveness of additive (hydro-gel) in conserving water and reducing the irrigation frequency in soil less cultivation.

Soilless cultivation offers a valuable option to substitute soil based vegetable cultivation. Observations on yield characters such as no. of flowers and weight of fruits showed that the

additive hydrogel is having significant effect on fruit yield. Yield was highest in M-sand and coir pith combination treatment and lowest in coir pith applied treatment.

13.Water conservation and soil amelioration properties of biochar under fertigation

Dr.Anitha S,
Dr.Kurien E.K
Dr.Mini Abraham
ARS Chalakkudy

The experiment is ongoing at ARS, Chalakudy to study the water conservation and soil amelioration effect of biochar, to study the effect of treatments on water use efficiency and to study the long term effect of biochar using brinjal variety Haritha as the test crop.

Application of *biochar* helped to reduce water use by 67 per cent during the 1st year and 33 per cent during the 2nd year without affecting the yield of brinjal. Application of *biochar* (4 t/ha) as soil amendment resulted in a yield increase of 28 per cent and 11 per cent respectively during the 1st and 2nd year compared to lime application. During the 2nd year *biochar* application @2t/ ha increased the yield by 33 per cent. Application of *biochar* (4 t/ha) as soil amendment increased the WUE during both years. Brinjalratoon crop yield and residual crop yield of cowpea obtained without application of nutrients during both the years revealed the long term effect of *biochar* in holding the nutrients. Results revealed the water holding capacity and soil amelioration property of *biochar*.

14.Standardization of water management practices for productivity Improvement of nutmeg under different moisture regimes

Dr.Mini Abraham
Dr.Kurien E.K
Dr.Bhindhu P.S
ARS chalakudy

The investigation is ongoing at ARS, Chalakudy to study the effect of fertigation on yield and quality of nutmeg and to study the effect of irrigation and mulching on soil moisture status and water use efficiency.

In nutmeg, mulching of the crop basin increased yield and improves the microclimate. Results showed that treatments receiving drip irrigation at 100 per cent PE recorded significantly higher yield which was on par with basin irrigation. Mulching with coconut husk was superior to leaf mulching. Treatments receiving drip irrigation at 100 per cent PE with coconut husk mulching recorded the highest nut yield (862.46 kg/ha) Mace yield also showed the same trend. Irrigation at 60 per cent caused severe fruit drop and wilting of the nutmeg tree during the month of April. Relative leaf water content was significantly low in 80per cent and 60per cent irrigated plots.

15.Development of cultivation practices for irrigated Amorphophallus

Dr.Mini Abraham,
Dr.Kurien E.K and
Dr.Bhindhu P.S
ARS Chalakkudy

The experiment is ongoing at ARS, Chalakudy to study the effect of different mulches on water conservation efficiency, weed control efficiency and productivity of Amorphophallus and to standardize spacing and irrigation requirement for irrigated Amorphophallus. Amorphophallus corm weight was greatly influenced by irrigation levels, mulching and spacing. Daily irrigation of irrigated amorphophallus may lead to the infection of fungal diseases. Mulching greatly influences yield of amorphophallus, reduces the weed dry matter production. Yield in leaf mulched plot was 51041kg/ha while in plastic mulched and no mulched plots the yields were 34375and 26875kg/ha respectively.

16.Water and nutrient scheduling for drip fertigatedRasthali (AAB)/Poovan (local) banana

Dr.Mini Abraham
Dr.Kurien E.K
Dr.Bhindhu P.S
ARS Chalakkudy

The experiment is ongoing at ARS, Chalakudy to standardize the water requirement of Rasthali and to develop irrigation schedule for the variety and to standardize the nutrient scheduling for drip fertigated Rasthali banana.

Study on water and nutrient scheduling for drip fertigated Poovan banana showed that different levels of irrigation was not found to influence the crop yield, which implies that the application of irrigation at 50 per cent PE at 2 days interval is sufficient to sustain the crop. Significantly higher yield was obtained where fertigation was scheduled with P as basal and drip fertigation at weekly interval with 75 per cent RDF of NPK + 25 per cent foliar spray. An increase in 61 per cent of yield could be recorded over control.

17.Resource use efficiency of vegetable intercropping system under different water and nutrient regime

Dr.Bhindu P.S
Dr.Kurien E.K
Dr. Mini Abraham
ARS chalakkudy

The experiment is ongoing at ARS, Chalakudy to study the bio economics of suitability of vegetable intercropping system under different nutrient and water level and to study the water productivity and nutrient use efficiency of high density intercropping system using base crop chilli variety Ujwala intercrop Amaranthus variety Arun.

In terms of productivity and profitability, intercropping of chilli - amaranth is a viable system compared to pure crop of chilli. Gross return, net return and BC ratio were higher for chilli-amaranth intercropping system. Chilli and amaranth planted at normal row planting received

irrigation at 75 per cent PE and nutrients at 75 per cent NPK to both the crops through fertigation increased the productivity and profitability. By inter cropping chilli with amaranth there was an efficient utilization of space, water and nutrients.

18.Drip fertigation technology for enhancing water and nutrient use efficiency – (AICRP on IWM Coordinated Experiment)

Dr.Bhindu P.S
Dr.Kurien E.K
Dr.Mini Abraham
ARS chalakkudy

The experiment is ongoing at ARS, Chalakudy to study the yield performance, water productivity and nutrient use efficiency of chilli grown under fertigation. From the results it was inferred that during dry season chilli grown under copious amount of water resulted in better productivity and profitability. Application of nutrients through fertigation could save 25 per cent NPK without affecting the productivity and profit of chilli crop. Among the fertigation treatments, application of 75 per cent recommended dose NPK for chilli and out of which 25per cent NPK of applied as basal and remaining NPK through fertigation resulted in higher yield, WUE, NUE and benefit cost ratio.

19.AICRP on management of salt affect soils and use of saline water in agriculture- Survey, characterization and mapping ofground water quality in the coastal areas of Kerala

Dr.Sreelatha, A. K.,
Assistant Professor
sreelatha.ak@kau.in

In this study, it was observed that the ground water samples collected from places, which are near to sea, have more salinity. It may be due to intrusion of sea water/brackish water into these places. Salinity can be reduced to a certain level by adoption of proper management techniques such as mixing up of saline water with fresh water/rain water, rainwater harvesting, use of surface or sub-surface drainage systems, bunds to prevent the intrusion of saline water, etc.

20.Delineation and mapping of salt affected soils in the coastal areas of Kerala

Dr.Sreelatha, A. K.
RRS, Vyttila

The experiment was conducted to survey the salt affected soil using GPS, to study the chemical properties of soil and to prepare geo referred map of salt affected soils of coastal belts of Kerala Collection and analysis of soil samples of Kannur, Kozhikode, Malappuram and Kasargod was started during third phase. A total of 26 soil samples from Kasargod, 15 from Kannur, 19 from Kozhikode, 20 from Malappuram district were collected along with GPS readings. Soil samples collected from all districts were acidic and EC values were in the good category but some exemptions were also reported. Five per cent of samples ofMalappuram were slightly saline and 26.6 % of samples in Kannur were moderately saline. Saline soils were observed in the places near to sea which is subject to salinity. Prevention and reclamation of salt affected soils require an integrated management approach, monitoring and maintenance, implementation of efficient irrigation and drainage systems and good farming practices including proper crop selection and rotation for sustainable development of agriculture in these salt affected areas.

21.Integrated farming system for sustainable land use in Pokkali lands – vegetable cultivation

Dr.Sreelatha, A. K.
RRS, Vyttila

The experiment was conducted to study the effect of plastic mulch on reducing salinity in Pokkali lands, to analyze the changes in soil properties and to find out the best vegetable crop suitable for pokkali lands during summer.

With the support of analytical data, it was very evident that mulching with polythene sheet was having a significant effect on crop growth and yield of vegetables viz. cauliflower, cabbage, cowpea and bhindi. The effect of mulching and drip fertigation was evident from the higher yields obtained. Treatments with mulch was found to have significantly higher yield than treatments without mulch. Hence we can go forward for vegetable cultivation with mulch and drip fertigation for more pronounced yield on *Pokkali* bunds. It was also observed that yield obtained from cool season vegetable were very low and this reduction in yield might be due to the very high temperature. Hence the experiment shows that growth as well as productivity of cool season vegetables is not as expected in typical *Pokkali* lands. This can be resolved to an extend by the adoption of proper management techniques to reduce this salinity thereby ensuring sustained yield from the crops.

22.Rice – prawn integration in *Pokkali*

Dr.Sreelatha, A. K.

The study was conducted to evaluate the rice –fish/prawn integration in pokkali lands for maximum productivity and to analyze the changes in soil properties. August 2018 flood completely damaged the rice crop at farmers field at Thathappily and partially damaged at farmers field, Kumbalangi prawn released during December at Thathapilly were not survived resulting in complete loss. Prawn was released in the farmers field at Kumabalangy. The rice-prawn integration was found to very beneficial and successful in *Pokkali* lands. As the left over's of prawn cultivation become manure for rice cultivation, there would not be any additional application of fertilizers. It may enhance the soil qualities as well as the growth and yield of following rice crop.

23.Developing a customized nutrient formulation for yield maximization in vegetables of upper Kuttanad

Dr. Mini V.

The experiment was conducted at ORARS, Kayamkulam to assess the available macro and micronutrient status of vegetable growing area of upper Kuttanad and to develop a multi nutrient mixture for balanced nutrition and to study the effect of multi nutrient mixture on growth and yield of vegetables.

Results revealed that there is deficiency of K, Ca, Mg,S and B in the vegetable growing areas of Upper Kuttanad. Based on soil and plant analysis and already available data on soil status a customized multi nutrient formulation containing macro and micro nutrient was developed for boosting vegetable production in this area. Application of Soil test based POP and secondary

nutrients along with foliar application 25 % more dose of customized formulation improved the yield significantly in vegetable cowpea and bitter gourd. The trial has to be continued for getting conclusive results.

24.Integrated crop management strategies for enhancing rice productivity in Orumundakan tract

Dr. Mini V.

The investigation has been conducted at ORARS, Kayamkulam to assess the soil fertility constraints to screen the suitable rice variety and enhance the rice production in Orumundakan tracts through integrated nutrient management strategies.

Results revealed that acidity, salinity and nutritional stress are the major soil fertility constraints in the Orumundakan tracts. Among the various salt and acid tolerant varieties screened for suitability to the Orumundakan tracts, Ezhome-2 and Vytila-6 performed well. A customized foliar formulation was developed for providing supplementary foliar nutrition to avoid nutritional stress. An integrated crop management strategy was developed for crop production in Orumundakan tract with soil test based fertilizer application and foliar application of a customized foliar formulation to provide supplementary nutrition at critical growth stages of the crop. The trial has to be continued for getting conclusive results.

25.Development and standardisation of nutrient capsules for vegetable cultivation.

Dr.Biju Joseph
IF,Vellayani

The study was undertaken to develop nutrient capsules for vegetable grown home gardens and to evaluate the nutrient capsules in vegetables and to standardize the dose and time of application. Purchased capsule filling machine, developed nutrient capsules for vegetables, started pot culture experiments and are to be continued in the field to standardize nutrient capsules for vegetables viz. tomato, brinjal and chilli.

26.Development and evaluation of multi nutrient tablets / spikes for vegetables grown in home gardens.

Dr.R.Gladis, Assistant Professor
CoA, Vellayani

The experiment was develop multi nutrient tabletes for vegetable grown home gardens and to evaluate the multi nutrient tablets in vegetables and to standardize the dose and time of application. Purchased tablet making machine, developed multi nutrient tablets for vegetables, started pot culture experiments and are to be continued in the field to standardize multi nutrient tablets for vegetables viz. tomato, brinjal and chilli.

27.Continuation of mobile soil testing service to farmers

Dr. B. Aparna, Assistant Professor
CoA Vellayani

The project was undertaken as a station wise funding programme to provide need based insitu soil testing service to the farmers of any locality, to provide soil test based recommendation and to develop and computerized soil test recommendation programme.

During the period from 2018 -19, several field visits were undertaken and soil samples collected from farmers field and insitu analysis was done and Soil Test based recommendations were provided to nearly 200 farmers of the district. The remaining soil samples were taken to the stationary soil testing facility attached to the Department for further analysis .The purchase of Rapid soil testing kit was effected for carrying out the analysis in farmers fields .A rapid water testing kit was also purchased for carrying out the routine analysis for water .The Mobile soil testing lab was utilized for collecting the soil samples in the rampant flood affected areas of the state especially in Southern districts for further detailed investigation and also was engaged for soil sample collection in RAWE (Rural Agricultural Work Experience)

28.All India Co-ordinated Research Project for Investigations on Soil Test Crop Response Correlation(AICRP on STCR)

Dr. Rajalakshmi,
Assistant Professor

Developing targeted yield equations for crop sequence experiment for vegetables (Ash gourd) and rice (Kharif) are progressing. Maximum yield was obtained for the treatment STCR+IPNS with yield target of 30 t/ha in tomato var. Anagha. The STCR+IPNS with the yield target of 30t/ha was found to be the best in all locations. STCR+ IPNS treatments gave yield almost near to the targeted yield and maximum yield was obtained for the treatment STCR+IPNS with a targeted yield of 5 t/ha for cowpea variety cv. Anaswara.

Maximum yield was obtained for the treatment STCR+IPNS with a yield target of 3 t/ha using the cv. K-6. The STCR+IPNS with a yield target of 3 t/ha was found to be the best in all locations.

29.Establishment of Plant Health Clinic at ARS, Thiruvalla

Dr.M.Indira,
Professor and Head

The experiment was conducted at ARS, Thiruvalla to diagonise macro and micronutrient deficiencies and toxicities of crop plants and also to diagonise pest and diseases. Soil samples were collected analyzed for major, secondary and micronutrients and recommendation was given based on soil test data. Field visit was conducted in the disease affected sugarcane field at Kanghazha block of Kottayam district and suggested suitable remedial measures. The post flood management activities were conducted and the following recommendations were given to the farmers by conducting field visits. i. Loosening the soil to improve the aeration

ii. Application of lime or dolomite at the rate of 1kg/cent
iii. Mulching the soil for moisture conservation
iv. Soil testing before the next crop to schedule balanced fertilizer application
v. Application of Trichoderma and PGPR Mix
vi. Special care should be taken against the incidence of fungal diseases.

30.Evaluation of rapid organic fertilizer (Suchitha) as a potting medium for soil less culture

Dr. K. C. ManoramaThampatti, Professor
CoA,Vellayani

The investigation was conducted to evaluate the suitability of ROF as a potting medium for soil less cultivation, to find out the ideal ingredients and optimum mixing ratio for soil less potting mix and nutrient budgeting for different crops under soilless cultivation.

Salient findings of the experiments carried out indicated that the performance of thermochemical organic fertilizer was better in the presence of soil than in soilless combination. Highest yield was recorded for vegetables by the treatment combination of thermochemical organic fertilizer mixed with cocoa peat and soil in the ratio 1:1:1. Developed suitable potting media for okra and cowpea as rapid organic fertilizer :coirpith compost : soil in 1:1:1 ratio. Trial is to be continued.

31.Strengthening and mainteneance of lead centers for organic farming

Dr. K. Ushakumari, Professor and Head
COA,Vellayani

The project was undertaken to maintain the existing Lead Centre for Organic Farming at College of Agriculture, Vellayani to promote teaching, research and extension activities in the field of organic farming and good agricultural practices and also to evaluate organically certified nano fertilizers for growth and yield on slecte vegetable crops.

Strengthening and maintenance of Certified Model Organic Farm under the Department of Soil Science & Agricultural Chemistry, College of Agriculture as a permanent field study centre for demonstration and training purpose in the area of Organic Farming is undergoing.

Lead centre acts as a permanent knowledge and learning centre for all aspects of Organic Agriculture & Agribusiness with a mission to build competence for organizations and individuals which contribute to ecologically, economically and socially sustainable agriculture and livelihood system.

Facilities in the certified model organic farm (certified by accredited certifying agency – INDOCERT) are utilized by students of UG, PG and Diploma in Organic Agriculture for their study purposes.

Evaluation of certified nano organic fertilizers indicated that foliar application was found to be better than soil application with respect to yield and yield attributes in okra in pot culture experiment and soil application was better than foliar application for chilli on field evaluation.

PG Projects

Concluded PG Projects

1. **Management of soil salinity with calcium salts in rice–prawn farming system in *Pokkali* lands**

Student :Diya P.V
Major Adviser: Dr. Sreelatha A.K, Assistant Professor

The study entitled "Management of soil salinity with calcium salts in rice–prawn farming system in *Pokkali* lands" was carried out to evaluate the effect of calcium salts on the growth and nutrition of rice, yield of prawn and soil properties, which was conducted in the Thathapillipadasekharamof Kottuvally Panchayath in Ernakulam district. The experiment was laid out in randomized block design with six treatments and four replications having plot size of 100 m^2. The treatments consisted of absolute control, calcium nitrate, calcium chloride, calcium sulphate, rock phosphate and dolomite at the rate of 45, 30, 34, 27 and 25 kg per plot so as to adjust the ratio of 1:5 for Na : Ca in the exchange complex on the basis of content of Na and Ca in soils.The Ca salts were applied before the rice crop only. Rice variety, Vyttila 6 was raised in the first crop season. Soil samples were collected from the treatment plots during three stages; before the sowing of crop, after the harvest of rice and after the harvest of prawn. The soil samples are analysed for various physical (soil texture, bulk density), chemical (pH, EC, organic carbon, available N, P, K, Ca, Mg, S, Fe, Cu, Mn, Zn, B and exchangeable Na and Al) and biological parameters (microbial biomass carbon). The main findings from the experiments are summarised below. Soil texture of the experimental field was found to be sandy loam with bulk density of 1.25 Mg m^{-3}. Among the six treatments soil pHwas significantly lower in absolute control compared to all other calcium salt treatments after the harvest of rice. Electrical conductivity values ranged from 1.5 dSm^{-1} to 8.32 dSm^{-1} in the field.Organic carbon status of soil was not affected by application of calcium salts after the rice cultivation. But variations was noticed after prawn cultivation in the different treatments due to high dry matter content. Higher content of available P and K were observed in all treatments. Application of Ca salts increased the Ca content in soil after the harvest of rice even though significant difference was absent and amount of available Ca almost doubled after the harvest of prawn due to deposition of Ca rich exuvia of prawns. Available Mg content of all the treatments was found to be low after the rice and prawn harvest, even after application of dolomite as one of the treatments. Available sulphur content was extremely high in all the treatments after the rice as well as prawn harvest due to the acid sulphate nature of soil. Available Fe and Mn in *Pokkali* soil were found to be high in both rice and prawn harvesting stage and it can be reduced by application of calcium salts. Chelation of Cu by organic colloids and increased organic matter content favoured chelation process after prawn cultivation resulted in Cu deficiency. Exchangeable Na content was comparatively high in absolute control. Reduction in exchangeable Al content was observed in all calcium salt treatments after the harvest of rice. Significant reduction in MBC was observed in control treatmentand all the calcium treated plots recorded highest MBC after the harvest of rice and prawn. Higher shoot N content was recorded in calcium nitrate treatment. Shoot and root Pcontent showed higher value in all the treatments except control. An increased content of plant Ca was reported in all the treatments over control. Plant Mg content was found to be deficient in all the treatment including control. Na content in shoot and root of plant was higher in control

and Na concentration in roots was higher than in shoots. Significant increase inshoot Ca: Mg and K : Na ratios were observed in all calcium treatments except control, indicated salinity tolerance. Highest grain yield was recorded in calcium nitrate treatment (3300 kg ha^{-1}) which was significantly higher from other treatments. Highest dry matter content were recorded in calcium nitrate treatment. The calcium treated plots recorded highest productivity of 300 kg ha^{-1} and control registered 180 kg ha^{-1} of prawns. Dolomite treatment recorded highest BC ratio followed by rock phosphate because of the low input cost.

2. **Soil and nutrient management for suppression of *Fusarium*wilt disease of yard long bean *(Vignaunguiculata*subsp.*sesquipedalis (L.)* Verdcourt)"**

Student : Sooraj R.S

Major Adviser: Dr. Biju Joseph, Assistant Professor

The study entitled "Soil and nutrient management for suppression of *Fusarium*wilt disease of yard long bean *(Vignaunguiculata*subsp.*sesquipedalis (L.)* Verdcourt)" was conducted at Instructional Farm, College of Agriculture, Vellayani during February to May 2017 with the objective to assess the impact of liming practices, organic manure addition and nutrient management on the suppression of *Fusarium* wilt disease of yard long bean.

The experiment was laid out in RBD with thirteen treatments and three replications. The treatments were T_1 - soil test based POP (control),T_2 - T_1+ foliar fertilization of 19:19:19 (0.5%), KNO_3 (0.3%), $MgSO_4$ (1%) and borax (0.5%) at fortnightly interval, T_3 - organic package (cow dung 20 t ha^{-1} as basal followed by additional dose of 1.5 t ha^{-1} poultry manure + 50 kg ha^{-1} rock phosphate as 4 equal splits at fortnightly intervals), T_4 - fortified organic fertilizer (4 t ha^{-1} as basal, followed by 5 top dressings @ 50g/plant at fortnightly interval), T_5 - IDM package (Seed treatment with carbendazim @ 2g/kg seed + burning of pits prior to sowing + soil incorporation of *Trichoderma*enriched neem cake organic manure mixture @ 1 kg/pit at twinning stage + mancozeb and carbendazim (0.3%) at 20, 40 and 50 DAS), T_6 - T_2 + lime 250 kg ha^{-1} + cow dung 20 t ha^{-1},T_7 - T_2 + lime 250 kg ha^{-1} + *Trichoderma* enriched cow dung 20 t ha^{-1}, T_8 - T_2 + lime as per LR (basal) + cow dung 20 t ha^{-1}, T_9 - T_2 + lime as per LR (basal) + *Trichoderma* enriched cow dung 20 t ha^{-1}, T_{10} - T_2 + lime as per LR (2 equal splits – basal and at flowering) + cow dung 20 t ha^{-1}, T_{11} - T_2 + lime as per LR (2 equal splits – basal and at flowering) + *Trichoderma* enriched cow dung 20 t ha^{-1}, T_{12} - T_2 + dolomite 400 kg ha^{-1}+ cow dung 20 t ha^{-1} andT_{13} - T_2 + dolomite 400 kg ha^{-1}+ *Trichoderma* enriched cow dung 20 t ha^{-1}.

From the study it can be concluded that increased growth and yield of yard long bean through the suppression of Fusarium wilt disease can be achieved by the basal application of *Trichoderma* enriched cow dung @ 20 t ha^{-1} as organic manure, lime @ LR in 2 splits at basal and flowering stage as soil amendment and soil test based dose of fertilizers as soil application along with foliar fertilization of 19:19:19 (0.5 %), KNO_3 (0.3 %), $MgSO_4$ (1 %) and borax (0.5 %) at fortnightly interval as nutrient source.

3. **Quality assessment of organic manures and their effect on okra**

Student:K. Santhiya

Major advisor:Dr.Usha K.E, Professor

The project aims to study the physical, chemical and biological properties of different organic manures and their effect on soil quality and crop productivity using Okraas test crop. The particle size of elephant dung (30% passed through 0.5mm sieve) was the highest among the organic

manures. All the manures were neutral to alkaline with a pH ranging from 7.3 to 8.6 and the electrical conductivity ranged from 0.01 to 0.16 dS m^{-1}. The organic carbon content was high in elephant dung (49.12 %) and thereby the C: N ratio wasalso the highest (98:1) in elephant dung. The macro and micro nutrients content in organic manures showed significant difference. The highest N(1.8%) was in rabbit manure and vermicompost while the pig and quail manure contained the highest P(0.8%). Rabbit manure recorded the highest K content (1.3%).Chicken manure had the highest calcium (2971.3 ppm) and sulphur (1242.1 ppm) content whereas the magnesium (111 ppm) content was the highest in pig manure. The Indole-3-acetic acid in vermicompost and pig manure showed the highest value (17.5 µg g^{-1}) while the dehydrogenase (18.11 TPF g^{-1} soil day $^{-1}$) was more in vermicompost. Though heavy metals *viz*., Cd, Cr, Ni, Pb, As and Hg were detected in most of the manures, the content was below the permissible limit specified in the FCO.The chicken manure applied treatment showed the highest pH and EC whereas the OC was the highest in vermicompost applied treatment.The C: N ratio of soil varied from 8 to 12: 1 in all the treatment plots. Bacterial and fungal population were the highest in vermicompost applied soil (68.67 x10^4cfu g^{-1} and 57.00 x 10^3 cfu g^{-1} respectively). The highest value of 9.67 x 10^4cfu g^{-1} was observed in the treatments receiving goat manure, chicken manure, pig manure and vermicompost with respect to the population of actinomycetes. Presence of cadmium, chromium and mercury was not detected in the soil with the application of organic manures. Dry matter production of okra at last harvest (5.3 t ha^{-1}), total number of fruits per plant (26.3).The highest yield (25.24 t ha^{-1}) was found in chicken manure (@6.7 t ha^{-1}) applied plot followed by vermicompost(@ 5.6 t ha^{-1}) treated soil (25.09 t ha^{-1}).The crude fibre content was the highest in elephant dung applied soil (13.96%) followed by KAU POPR. The lowest crude fibre content was noticed in vermicompost (8.40 %) applied plot.Application of chicken manure showed the highest gross (Rs.10, 09, 600 ha^{-1}) return, net return (Rs.5, 78, 105 ha^{-1}) and B: C ratio (2.34) followed by vermicompost (2.3).

4. Effect of phosphorus solubilisers on the availability of native P in phosphorus rich soil

Student : Sreelakshmi.M.M

Major Advisor :Dr. B. Aparna, Assistant Professor

The study entitled "Effect of phosphorus solubilizers on the availability of native P in phosphorus rich soil" was carried out in the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani during 2017-18. The study was envisaged to evaluate the effect of phosphate solubilizers on the solubility and availability of native phosphorus and its impact on crop growth and yield of test crop tomato *var*. VellayaniVijai.

From the study, it can be concluded that a soil test based P management should be followed to optimize the use of phosphorus in the soil. Since the soils of Kerala accounts high P levels, non judicious application of phosphaticfertlisers should be knocked off. Reducing the application dose of inorganic P fertlisers and employing microbial inoculants in crop production may aid us to reduce the chemical effect of high P on the soil health. It is observed from the study that, the application of P solubilisershas improved not only the physio-chemical properties, but also the biological health of the soil. Based on the study it can be concluded that application of 75% P along with AM fungi has improved available P content of soil, saloid P fraction, enzymatic activity, microbial population, ultimately yield and yield parameters.

5. **Calcium, magnesium and boron nutrition for grow bag cultivationof cabbage (*Brassica oleracea*L. *var.capitata*)**

Student :Parvathy P J
Major Adviser :Dr.R.Gladis, Assistant Professor

The experiment was conducted to studythe effect of soil and foliar application of calcium, magnesium and boron on growth, yield and quality of cabbage cultivated in growbag. From the results , it can be concluded that the treatment receivedfoliar application of calcium chloride @1% and borax @ 0.5 % on 15^{th} and 45^{th} DAP and soil application of $MgSO_4.7H_2O$ @ 20 g $plant^{-1}$ in two equal splits on 15^{th} and 30^{th} DAP significantly increased plant growth, yield , nutrient content, nutrient uptake and quality of cabbage.

6. **Evaluation of fertigation*vis a vis* nutrient stick and foliar silicon in oriental pickling melon (*Cucumismelo*var. *conomon*).**

Student : Mubarack. O.P
Major Adviser: Dr. P. R. Suresh, Professor and Head

The study was conducted to evaluate the performance of nutrient stick, compare its effect with fertigation and evaluate the effect of foliar silicon on growth, yield and nutrient uptake in oriental pickling melon (*Cucumismelo* var. conomon). The results obtained from this experiment clearly indicate that application of fertilizers through nutrient stick along with foliar silicon was found to be highly effective. In fertigation treatments residual available soil nutrients were higher as compared to fertilizer through nutrient stick, indicating better efficiency of nutrient sticks. Therefore application of nutrient along with foliar spray of potassium silicate can be recommended to the farmers for a cost effective and eco friendly crop production in oriental pickling melon. The effect can be further evaluated under poly house condition and other crops.

7. **Effect of agrochemicals on biological activity in lateritic soil**

Student :Nisha Paul
Major Advisor: Dr. K. M. Durga Devi,
Professor

The investigation was conducted to determine the impact of 3 agrochemical viz., oxyfluorfen, copper oxychloride and chlorpyriphos on the population of soil microflora and dehydrogenase enzyme activities in lateritic soil collected from 2 land use types viz., land under cultivated grass and cocoa plantation. The results indicate that the application of agrochemicals did not alter the availability of nutrients in the soil. The extent of reduction in biological activity (dehydrogenase activity and microbial population) after application of agrochemicals was comparatively lower in cocoa plantation (LUT 2) than in soil samples from land under cultivated grass (LUT 1) and the decline was maximum at 7 DAS in both the land use types.

Greater reduction in dehydrogenase activity as well as soil microflora was registered with agrochemicals applied at higher doses (OXY 0.30, COC 1.50 and CHL 0.60) than their lower doses (OXY 0.15, COC 0.75 and CHL 0.30), irrespective of the kind of agrochemicals sprayed.The fungicidal effect of copper oxychloride was well manifested at both 7 and 90 DAS. The adverse effect of agrochemicals on soil fungi followed the order: COC > OXY >CHL.Bacterial population was adversely effected by oxyflourfen to a greater magnitude at 7 DAS, followed by copper oxychloride and chlorpyriphos. However at 90 DAS, chlorpyriphos

exerted greater impact on soil bacteria. The adverse effect of oxyflourfen on soil bacteria was minimum at this stage.In the case of actinomycetes population, oxyflourfen treatment showed greater adverse effect at both 7 and 90 DAS. The effect of chlorpyriphos on actinomycetes was minimum at both the stages. The inhibitory effect of all the agrochemicals were comparatively lower for bacteria than fungi and actinomycetes. Higher doses of agrochemicals reduced the number of root nodules in cowpea and the yield was not affected by the pesticide treatments and land use types.

8. Carbon:nitrogen dynamics in acid sulphate and acid saline rice soils of Kerala

Student: Irene Elizabeth John

Major Advisor: Dr. P. Sureshkumar, Professor and Head, RTL

The study was conducted to unravel the chemistry of carbon-nitrogen dynamics in submerged acid sulphate and acid saline soils, to identify the labile fractions of these element contributing to soil fertility and to modify the organic carbon based fertility ratings for nitrogen recommendation in kole lands.

Forty-five representative soil samples from 4 different rice growing acid saline and acid sulphate soils of Kerala were collected and characterized for pH, EC, OC, total carbon, total nitrogen, available nutrients (N, P, K, Ca, Mg, S, Fe, Cu, Mn, Zn and B) and microbial biomass carbon. The soil samples were analysed as such after sampling on wet basis and the results were expressed on moisture free basis to have uniformity. The organic carbon status of the soils varied from 0.81 to 7.58 per cent. Soils from *Kaipad* recorded the lowest and soils from Vechoor *Kari* of *Kuttanad* recorded the highest value of organic carbon. The total nitrogen ranged from 0.05 per cent in upper *Kuttanad* to 0.42 per cent in Vechur *Kari*.

Soil samples were subjected to fractionation studies (both physical and chemical) to quantify the carbon and nitrogen that is associated with different inorganic and organic constituents in soil. In physical fractionation, soil carbon and nitrogen preferentially recovered from the sand, silt and clay size fractions were estimated. Of this, carbon recovered from clay size fraction was the dominant independent variable that explained 64.6 per cent variability of organic carbon. The different chemical carbon fractions studied were water soluble carbon (WSC), hot water extractable carbon (HWEC) and permanganate oxidizable carbon (POC). Among the organic pools of nitrogen, the total hydrolysable nitrogen contributed significantly to mineralizable N. Among the inorganic fractions of nitrogen, ammoniacal nitrogen was contributing more to the available pool of nitrogen than nitrate nitrogen fraction probably because of high solubility and losses of latter by leaching.

A field experiment was conducted to investigate the response of rice to different levels of nitrogen in Adattu*Kole* with an initial C:N ratio of 20:1.The treatments with increased levels of nitrogen based on C:N ratio (treatments T_5-T_{10}) produced significant effect on plant height, number of productive tillers, number of grains per panicle, straw yield and grain yield. Among the carbon fractions, hot water extractable carbon contributed more to the mineralizable pool than water soluble carbon. The direct effect of total hydrolysable nitrogen on total and available nitrogen was very high. Ammoniacal nitrogen being a dynamic and time dependent variable, though contributing significantly to available N content, its effect on total nitrogen was negligible. This was in conformity with the results of experiment in characterization of soil samples collected from 45 locations.

The maximum grain yield of 8.22 Mg ha^{-1} was recorded in the treatment where nitrogen was applied based on C:N ratio (wet analysis). An increase of 1.15 Mg ha^{-1} of grain yield was recorded over the treatment where soil test based fertilizer recommendation was applied. The highest straw yield of 17.47 Mg ha^{-1} was recorded in treatment where nitrogen applied was double that of C:N ratio based recommendation. The highest net return was obtained in treatment where nitrogen was applied as per the C:N ratio in soil.

9. Response of bhindi (*AbelmoschusesculentusL.Moench*) to fertigation and foliar nutrition in red loam soil of Kasaragod

Student :Ashwini B. N

Major Advisor: Dr. BinithaN.K, Assistant Professor

The investigation was conducted to standardize the time and site specific dose of nutrient application in sub humid red loam soil and evaluate the effect of fertigation of major nutrients and foliar nutrition of micronutrients on growth, yield and fruit quality of bhindi (*Abelmoschus esculentus* L. Moench) variety Arka Anamika. The treatments include time of fertigation, levels of fertigation and foliar spray of micronutrient mixture.

The findings revealed that time of fertigation at once in two days, levels of fertigation at the rate of 100 per cent NPK and foliar application of micronutrients at4 per cent concentration had remarkable influence on growth, yield and quality of bhindi, the same treatments recorded maximum soil nutrient status and leaf nutrient content of bhindi. The economic analysis of field experiment revealed that the treatmentcombination $T_1 L_1 S_2$ recorded the height net income compared to all other treatments andtreatments. Hence a current nutrient recommendation of KAU POP through fertigation at 2days interval along with foliar application of micronutrients has doubled the yield, when compared with the reported values of state averages of productivity of bhindi.

10. Phosphorous and boron interactions in black cotton soils of Kerala with respect to groundnut (*Arachis hypogaea* L.)

Student: Shaniba.M

Major advisor: Dr. Beena.V.I

Field experiment was conducted in black cotton soil at Chittur, Palakkad using groundnut variety K-6 as the test crop to find out the interactions of boron and phosphorous and to assess the treatment level of boron and phosphorous for maximizing the yield.

Application of P at 90 kg/ha and B at 5 kg/ha resulted in highest yield. P and B have negative interaction due to anionic competition. K content was decreased with increased dose of P and B application. Ca content and S content was increased with increased dose of P and B. Application of P reduced the availability of Fe, Mn and Zn due to the formation of insoluble compounds. Application of P at 90 kg/ha and B at 0 kg/ha resulted in highest protein content. P and B showed a negative interaction in black cotton soil of Kerala.

11. Carbon sequestration and soil health under different organic sources in wetland rice

Student:Rajalekshmi K.

Major Adviser: Dr. Betty Bastin

The experiment was conducted at College of Horticulture, Vellanikkara to assess the effect of different organic sources on carbon sequestration and soil health in wet land soil (Ultisol) under rice rice cropping system and to compare carbon distribution and fluxes with that of adjoining fallow land.

The salient features of the present study are summarized below:

Adequate improvement in soil quality with particular reference to soil reaction was observed by using rice husk biochar as organic source in a field trial with rice as test crop. Thus biochar can be used as a neutralizing material instead of lime in acid soil.The physical pools of soil organic carbon on size and density basis were found to be higher with rice husk biochar. Hence, soil carbon sequestration can be improved by use of biochar, which reduces the recent increasein atmospheric carbon di oxide. Mitigation of GHG emission from agriculture can be achieved, since the greenhouse gas (GHG) particularly methane mission was very minimal with RHB.

12. Secondary and micronutrient management for enhancing soil health and productivity in upland rice

Student :Shamsida P.

Major Advisor :Dr.Rani B, Professor

The experiment was conducted to study the effect of effect of secondary and micronutrient application on the productivity of upland rice under organic and integrated nutrient management practices and its effect on soil health. Foliar application of micronutrients along with KAU POP (dolomite or lime) was more economical, resulting in significantly higher B: C ratio with the highest value. Based on the study, it can be concluded that foliar micronutrient application (sampoorna multimix or micronutrient solution) along with KAU PoP (lime or dolomite) significantly enhanced the growth, yield and nutrient uptake in upland rice.

13. Nutrients and tillage interactions in rice-fallow cowpea (*Vigna unguiculata*(L.) Walp.) production

Student: Vandana G. Pai

Major Advisor: Dr. P. Prameel

Pot culture and Field experiment was conducted at College of Horticulture. Biometric observations on growth and yield parameters of crop were recorded at specified growth stages. Soil and plant samples were collected from each pot and plot. Soil and plant analysis till first field experiment is completed. Analysis of confirmation study part (Field experiment II) is on-going. Statistical analysis yet to be finished.

14. Effect of zinc fertilization on major plant and soil enzymes in Southern laterites.

Student: Aswathy. U A

Major Adviser: Dr. B. Aparna

The investigations on “Effect of zinc fertilization on major plant and soil enzymes in southern laterites” were carried out at College of Agriculture, Vellayani and farmers field in Vawamoola,

Nellivilla during April 2018 to March 2019. The study was conducted in the tomato variety Anagha to assess the effect of various sources and methods of application of zinc on the activities of major plant enzymes, soil enzymes, biochemical and microbial parameters in laterite soils.

A soil test database has been developed by the Department of Soil Science & Agricultural Chemistry under the project RF- Stationary Soil Testing Lab. From the Database, laterite soil in Neyyatinkkara series with Zn deficiency was located and soil samples were collected and subjected to analysis of major and micro nutrients to confirm the deficiency of Zn. The experiment was laid out in Randomised Block Design (RBD) with eight treatments and each were replicated three times. Farm yard manure @ 20 t ha^{-1} and lime @ 350 kg ha^{-1} were applied uniformly to all plots. The nutrient status of soil was analysed for pH, EC, N, P, K, Ca, Mg, S, Fe,Cu, Zn, B and biological characteristics like dehydrogenase, Soil respiration rate, β-glucosidase, and Microbial biomass carbon. An incubation study was also carried out from December 2018 to March 2019 out in the laboratory using5 kg of soil. Different doses of Zn was applied and incubated for three months. Enzymes such as Oxidoreductases (dehydrogenases, peroxidases) and carboxylases (carbonic anhydrase) were assayed at biweekly intervals for a period of three months. A sterile soil was also incubated for periodical assay of enzymes.

Ongoing PG Projects

1. Characterization and evaluation of herbal and nonherbal Kunapajala on soil health and crop nutrition
2. Assesment of soil health and status of heavy metals in the certified organic farms of Kerala
3. Heavy metals stabilized sewage sludge compost as the growth medium for ornaments
4. Sorption and movement of flupyradifurone in sandy loam soil with and without organic amendments
5. Organic manure seed pelleting for enhancing soil health and productivity of rice
6. Development of multi nutrient fertilizer tablet and its evaluation in tomato
7. Root phenomics and soil biological activities in response to thermochemical organic fertilizer application
8. Matrix based slow release fertilizer for increasing nutrient use efficiency in the Onattuar sandy plains
9. Carbon pools in lateritic soil amended with coirpith- vermicompost and its effect on tomato
10. Organic nano NPK formulations for enhancing sil health and productivity
11. Assessment and management of micronutrients in the rubber (*Hevea brasiliensis*) growing tracts of Thiruvananthapuram
12. Sulphur dynamics in major rice soils of Kerala

Name of Project Coordination Group: (10)
Farming Systems Research

Compiled by:
Dr.Jacob John, Project Coordinator

Plan & External Aided Projects

Concluded Project: 3 Nos.
Ongoing Projects :13Nos.

Post Graduate Projects

Concluded Projects: 2 Nos.
Ongoing Project: 12 Nos.

Concluded Projects

1. Developing an Integrated farming system model at Vellayani

Dr.Elizabeth K. Syriac
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An Integrated Farming System Model suited to low lands in Vellayani, was developed in an area of 0.2 ha (0.5 acre). The unit comprises of crops (Banana- Nendran intercropped with cucumber and red banana), duckery (*Chara* and *Chempalli* varieties of duck) and fishery (rohu, catla mrigal, carps, pearl spot and tilapia) enterprises.The ancillary units viz, solar light, light trap, aeration unit etc also has demonstration value, for those farmers venturing integration of various enterprises. Chemical analysis of water, soil and channel silt collected from the unit indicates substantial improvement in pH, EC and major nutrients viz. nitrogen, phosphorus and potassium, due to integration of enterprises viz. cropping, fishery and duckery.

2. Formulation of crop specific ready to use nutrient based substrates and production package for green roofs in urban agriculture

Dr.Ameena M.
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A soilless growth media completely excluding soil and sand was standardized and the best base media identified in terms of physical characteristics was compressed coir pith and FYM in 2:1 ratio. The best soil based growth media, completely excluding sand, in terms of yield was soil : [Coir pith compost (CC) + rock sand + VC (Vermi compost (VC)] : FYM 1:1:1 ratio

Ready to use soil based growth media for container grown bhindi is modified base media Soil: (CC + rock sand + VC): FYM 1:1:1 with 25 % NPK supplied as basal followed by 75 % N supplied in 2 splits at fortnightly interval as fermented manure preferably groundnut cake.

For tomato, the most economic soil based media was modified base media viz: soil : (CC + rock sand + VC) : FYM in 1:1:1 with 75% N, full P and K applied as basal dose after incubation and remaining N in 2 splits at fortnightly interval as fermented manure.

The most economic ready to use soil based growth media for container grown amaranthus was modified base media viz: Soil : (CC + rock sand + VC) : FYM in 1:1:1 with 150% N, full P and K applied as basal dose followed by 75% N, full P and K applied as basal dose after incubation and remaining N in 2 splits at fortnightly interval as fermented manure.

For chilli, the most economic soil based ready to use media identified was modified base media viz: Soil : (CC + rock sand + VC) : FYM in 1:1:1 with 25% NPK supplied as basal dose + 75% N in 2 splits.

For brinjal, the most economic soil based media identified was modified base media viz: soil : (CC + rock sand + VC) : FYM in 1:1:1 with 75% N, full P and K applied as basal dose after incubation and remaining N in 2 splits at fortnightly interval as fermented manure. For tomato, the best soil less media identified was base media with compressed coir pith and FYM in 2:1

ratio supplied with 75% N, full P and K applied as basal dose after incubation and remaining N in 2 splits at fortnightly interval as fermented manure.

In bhindi, the most economic ready to use soil less growth media was base media with compressed coir pith and FYM in 2:1 ratio supplied with 75% N, P and K as basal dose followed by N in 2 splits. It was also on par with 200% NPK as basal dose as it recorded higher fruit yield per bag.

In amaranthus, the most economic ready to use soil less growth media was base media with compressed coir pith and FYM in 2:1 ratio supplied with 200% NPK as basal dose as it recorded higher leaf yield per bag. It was on par with either 75% or 25 % of N, P and K as basal dose followed by application of remaining N in 2 splits.

In chilli, the most economic ready to use soil less growth media was base media with compressed coir pith and FYM in 2:1 ratio supplied with 50 or 25% NPK supplied as basal dose and remaining N in 2 splits.

In brinjal, the most economic ready to use soil less growth media is base media with compressed coir pith and FYM in 2:1 ratio supplied with 75% N, full P and K applied as basal dose after incubation and remaining N in 2 splits at fortnightly interval as fermented manure. Among the vegetables, tomato and amaranthus recorded better performance in soil less growth media than soil based media.

The varieties that performed better in grow bag cultivation under organic management were identified as **'**Ujwala' in chilly , 'Salkeerthi' in bhindi , 'AMT-1' in amaranthus , 'Akshaya' and 'Vellayani Vijay' in tomato and 'Haritha' in brinjal

3. Evaluation of suitable crop combination under organic farming in coconut garden

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Inter row spaces available between the coconut palms (>50 years) can be successfully utilized for intercropping more than one crop. Upland rice, tomato, Napier grass, palisade grass, tapioca, amorphophallus, ginger and turmeric can be successfully raised in the inter row spaces of Nendran banana planted at a spacing of 2.5 m x 2.5 m, as intercrop in coconut.

The most profitable crop combinations identified under organic farming in coconut garden was coconut +Nendran banana+turmeric. It recorded an additional returns of Rs.2,14,631/- ha^{-1}.

Crop combination of coconut + Nendran banana + turmeric

Ongoing Projects

1. **Improving production from terrace garden in urban households through vertical farming**

Dr. Jacob John,
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Seven different structures for vertical farming developed were evaluated for suitability of growing bush cowpea. The highest total yield was obtained from the rotating type pyramid structure (21 grow bags: Area occupied: 2.09m^2) followed by the fixed type pyramid structure (21 grow bags: Area occupied: 1.72 m^2).

The suitability of different growing media was examined using bush cowpea as test crop. Highest yield was obtained from bags filled with suchitha manure+coir pith+rock dust (1:1`:1) followed by media comprising of soil+rock dust+cow dung (1:1:1).

A new structure for vertical farming capable of housing 29 grow bags with different vegetables (except trailing type) integrated with wick irrigation was developed.

Structure for vertical farming integrated with wick irrigation

2. Climate resilient rice production technology for Kuttanad

Dr.Nimmy Jose,
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Survey revealed that the weed population in Kuttanad region has decreased drastically in paddy fields during the post flood period. The soil weed seed bank was completely destroyed. Hence, the post flood cropping done during October 2018, without ploughing the fields had no infestation of aquatic weeds even at land preparation stage and in the cropped situation. The infestation of certain weeds like *Cyperusiria*, *C. distans*, *C. esculantus* have increased in the bunds and paddy fields. Though most of the emerged weeds were completely destroyed during the flood, *Ludwigia hyssopifolia* escaped the flooded situation due to the presence of spongy respiratory roots. So the infestation of this weed is expected to increase in the coming years.

Major aquatic weeds present in the Kuttanad ecosystem after the flood include *Eichhorniacrassipes*, *Salviniamolesta*, *Cabombacaroliniana*, *C. furcata*, *Pistiastratioites*, *UtriculariaChara vulgaris* (Stonewort), *Ipomoea aquatic*, *Nymphaeastellata*, *Limnophyllaheterophylla* etc. Unlike in the previous years, the growth and spread of *Eichhorniacrassipes* was less in the September - October months in the water bodies because of the heavy wash out of all weeds from channels during floods of 2018. The situation has changed in the summer months due to the high temperature and absence of heavy rains. By the month of February –March 2019 the infestation of *Eichhornia* in the water bodies has increased drastically.

For the management of aquatic weeds *viz*., *Eichhornia* and *Pista*, the green labeled herbicides, Penoxsulam and Carfentrazone was found effective in drying and withering of leaves compared to the blue and yellow labeled herbicides, glyphosate and 2,4-D,both under pot and field conditions. Application of the above herbicides followed by deep tillage can be recommended as a management strategy prior to sowing in infested paddy fields. Inundating saline water for long periods depending on the electrical conductivity of river water can also reduce the proliferation and spread of aquatic weeds.

3. Nutrient Management of Rice in Integrated farming system in below sea level farming system

Dr.Geetha K.,
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Four nutrient management, treatments were imposed in the experiment laid out with variety Sreyas under Rice-Fish rotation. The treatments were 100, 75 and 50 per cent of POP (Package of Practices recommendation) in comparison with a control without fertiliser. The highest yield was obtained for 75 per cent POP. The experiment has to be repeated for confirmation since it

was conducted after flood. The yields recorded under 100 and 50 per cent were, but significantly less than 75 per cent.

4. Monitoring of heavy metals and pesticide residues in Kuttanadu ecosystem

Dr.Sailaja M.S.,
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There was a slight increase in the zinc content in the sediment from March 2018 to February 2019 in all sampling stations. Zinc content in all the samples were below the safe limit of 75 ppm. An increasing trend was observed in the manganese content of sediments after floods in 2018. Maximum content of 322 ppm was observed in Pathiramanal in February 2019 which was less than 1 ppm in March 2018. There was not much variation in the iron content in sediment before and after floods.

Concentration of trace elements *viz*. zinc, copper, and manganese in water was in general below the safe limit in all sampling stations. However iron content in water collected from Veeyapuram and Vaikom in during February 2019 were 0.17 ppm and 0.13 ppm respectively which is above the safe limit (safe limit of iron is 0.1 ppm according to WHO).

Residues of gamma HCH was detected in sediment samples collected from Meenachil, Thanneermukkam, Vaikom, 24000 kayal, Punnamada, Kumarakom, Pathiramanal and Pallathuruthy during November and December 2018. No other pesticide residues were detected in the samples during the sampling period of September 2018 to February, 2019. No pesticide residues were detected in water and clam samples during 2018-19.

5. Comprehensive investigation of prominent integrated farming system models in different agro ecological units (AEUs) of Thiruvananthapuram district

Dr. Jacob John,
Professor (Agronomy),
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Farmers' fields were selected in the predominant AEU of Thiruvananthapuram district viz., south central laterite. Soil and plant samples were collected from field their analysis is in progress. Observation on weeds and pest/disease incidence were recorded in the field. Various aspects to ascertain the sustainability of the selected systems and the already developed models are being investigated

6. Integrated farming system-solution to mitigate climate change in *Pokkali* ecosystem(RKVY)

Dr.Deepa Thomas,
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Duckery was found to be an ideal component in pokkali ecosystem apart from the traditional rice-fish/prawn system followed in this ecosystem. A new economic model-floating duck cage which can carry 50 ducks was developed with a dimension of 4m x 2m x 1.3m (12ft x 6ft x 4ft) at a cost of Rs. 70000. Four duck cages were constructed for one acre pond. Addition of 7-8 kg organic matter per day (with an org. c content of 25.7%) by 200 ducks to the pond/field favoured fish culture. Rice-fish+duck farming system formed a workable solution for climate mitigation by an additional transfer of C to the soil. This enhanced employment generation and provided additional income.

7. Development of region specific Integrated Farming System (IFS) models (4 sub projects: each model of 0.20 ha) - AICRP on Integrated Farming Systems

Main Centre: On Station Research (OSR)

Dr.Jacob John, Professor (Agronomy),
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a.Homestead based IFS
b.Coconut based IFS
c.Rice based IFS
d.Banana based IFS

Rice based IFS model recorded the highest gross returns of Rs.265884/- from 0.2 ha followed by coconut (242663), homestead (233221) and banana (220923)
Energy efficiency (output energy/input energy) was highest for banana based IFS model (1.86) followed by coconut based (1.17), homestead based (1.05) and rice based (0.97) models.
Nutrient generation (for recycling) was highest for rice based IFS model and equivalent to 579 kg urea, 664.05 kg Rajphos and 225.73 kg MOP.

8. Carbon crediting and GHG (green house gas) emission in IFS models

Net GHG emission was the lowest in homestead based IFS model (-69422 kg CO_2 equivalent) followed by coconut based (-18296.7), banana based (-11089.5) and rice based (269.7) models.

Carbon sequestration in soils through crop residue incorporation and application of composts was highest for rice based IFS model (1487 CO_2 equivalent) followed by coconut based (1576), homestead (1029) and banana based (221) models.

9. Identification of cropping systems module for different cropping systems

Different rice based cropping sequences were evaluated and rice-cassava-amaranthus generated highest return (Rs.6.4 lakhs ha^{-1}) which was nearly 200 per cent more than the conventional rice-rice-fallow, followed by rice-bhindi-cucumber (Rs.5.90 lakhs ha^{-1}).
During second crop season, significantly higher rice equivalent yield (REY) was from cassava. During summer, significantly higher REY was from cucumber.

10. On-farm crop response to plant nutrients in predominant cropping systems

On Farm Research (OFR) Centre, Vellayani

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In rice-rice-fallow cropping system having medium duration rice, application of recommended N:P2O5:K2O @ 90:45:45 kg/ha to both kharif and rabi recorded highest grain yield of 10214 kg/ha/annum. Rice grain yield in treatments with recommended NPK, recommended NPK+Zn and farmers practice were comparable.

11. Diversification of existing farming systems under marginal household conditions

Hort (Coconut Banana)+ Crop(Rice) + Dairy, Hort (Coconut Banana)+ Poultry and Hort (Coconut Banana)+ Dairy with mean holding size of 0.5, 0.3 and 0.4 ha respectively were the three farming systems identified among marginal farmers in Varkala and Chairayinkeezhu blocks of Thiruvananthapuram district. Average family consisted of 2 male adults, 2 female adults and 1 child. Annual food consumption of family was 741 kg cereals, 146 kg pulses, 74 kg oilseeds, 94 kg vegetables, 385 kg fruits, 370 litre milk, 147 kg meat and 92 eggs.

During first year of study, Hort (Coconut Banana)+ Dairy, Hort (Coconut Banana)+ Crop(Rice) + Dairy and Hort (Coconut Banana)+ Poultry recorded net income of Rs. 1.01, 0.82 and 0.59 lakhs respectively which resulted in an increase of 39, 51 and 32 % respectively over benchmark.

12. On-farm evaluation of farming system modules for improving profitability and livelihood of small and marginal farmers.

Horticulture (Coconut Banana)+ Crop (Rice) + Dairy and Horticulture (Coconut Banana)+ Poultry with mean holding size of 1.0, and 0.9 ha respectively were the three farming systems identified among small and marginal farmers in Varkala and Chairayinkeezhu blocks of Thiruvananthapuram district. Average family consisted of 2 male adults, 2 female adults and 1 child. Annual food consumption of family was 750 kg cereals, 149 kg pulses, 75 kg oilseeds, 97 kg vegetables, 381 kg fruits, 379 l milk, 151kg meat and 97 eggs.
During first year of study, Horticulture (Coconut Banana)+ Crop (Rice)+ Dairy and Horticulture + Poultry recorded net income of Rs. 2.14 and 1.77 lakhs respectively which resulted in an increase of 121 and 107 % respectively over benchmark.

13. Resource use efficiency of vegetable intercropping system under different water and nutrient regime - AICRP on Irrigation Water Management

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Intercropping of chilli and amaranth is a viable system, in terms of productivity and profitability, compared to pure crop of chilli. Water productivity, irrigation water productivity, gross return, net return ad BC ratio were higher for chilli+amaranth intercropping system when compared to pure crop of chilli. Chilli and amaranth planted at normal row planting received irrigation at 75 per cent PE and nutrients at 75 per cent NPK to both crops through fertigation increased the productivity and profitability. By intercropping chilli with amaranth there was efficient utilization of space, water and nutrients.

PG Projects

Concluded PG Projects

1. Chilli + amaranth intercropping system under fertigation

Anitrosa Innazent **(**2016-11-037)
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Chilli + amaranth intercropping system under fertigation is a biologically efficient and economically viable system compared to pure cropping systems. To reap the maximum benefit from chilli + amaranth intercropping system under fertigation, planting should be done at normal row and both the crops should be given their 100 per cent NPK recommendations and irrigation should be given at 100 per cent E pan under fertigation.

2. Nutrient scheduling for upland rice intercropped in coconut

Suman B.M. (2016-11-121)
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NPK @ 90:30:45 kg ha^{-1} applied as N in three equal splits (15 DAS, active tillering and panicle initiation stage), P as basal and K in two equal splits (15 DAS and active tillering stage) along with foliar spray of 0.2 per cent zinc sulphate and 0.04 per cent sodium borate (n_3s_3) recorded the highest rice grain (3.25 t ha^{-1}) and straw yield (4.33 t ha^{-1}), net returns (35, 637 Rs. ha^{-1}) and B: C ratio 1.57) and hence, can be recommended for higher yield in upland rice intercropped in coconut.

Ongoing PG Projects

1. Seed priming and foliar nutrition of upland rice in coconut garden
2. Standardization of crop establishment technique for upland rice (*Oryza sativa* L.) in coconut garden
3. Bio recycling of paddy straw for quality manure production
4. Productivity enhancement of rice based cropping system with fodder crops
5. Nutrient recycling of selected tree leaf litters in homesteads
6. Soil carbon dynamics in a rice based cropping system
7. Productivity enhancement of rice based cropping system with pulses
8. Standardisation of growth media and organic nutrient schedule for container cultivation of spinach beet (*Beta vulgaris* var. *bengalensis*)
9. Intercropping vegetables in baby corn (*Zea mays* L.)
10. Performance evaluation of rice varieties and their response to zinc nutrition in uplands.

11. Crop residue recycling for organic production of fodder maize in rice based integrated farming system.
12. Productivity and biological efficiency of intercropping finger millet (*Eleusine coracana* (L.) Gaertn.) with pulses

Name of Project Coordination Group: (11)
Crop Pests and Beneficial Insects

Compiled by:
Dr. Anitha N, Project Coordinator

Plan & External Aided Projects

Concluded Project: 9 Nos.
OngoingProject: 19 Nos.

Post Graduate Projects

Concluded Projects: 16 Nos.
Ongoing Project:30 Nos.

Concluded Projects

1. Identification and molecular characterization of species and isolates of the entomopathogenic fungi *Metarhizium* and *Beauveria* and evaluation of their infectivity to crop pests (PP-03-00-18-2015 ACV (4) KSCSTE)

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Identified four indigenous isolates of *Metarhizium anisopliae* from soil. The most potent isolate *M. anisopliae* (SP10) was sent to IARI for deposition and the accession number received for the isolate was ITCC No.7994. *M. anisopliae* (SP10) was pathogenic to pumpkin caterpillar, *Diaphania indica*, snakegourd bug, *Leptoglossus australis*, brinjal lace wing, *Urentius hystricellus*, bittergourd epilachna beetle, *Henosepilachna septima* and fruit fly, *Bactrocera cucurbitae*. SP10 caused cent per cent mortality at 2nd day after treatment in *D. indica*. It caused cent per cent mortality at 6th day after treatment in *L. australis.* Accession numbers of ten isolates were obtained from National Centre for Biotechnology Information (NCBI), USA.

2. Development and validation of integrated pest management for major polyhouse vegetables (CPBI-03-02-02-2014-VKA (04)-KSCSTE)

Dr. Mani Chellappan, Professor
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Bio intensive and chemical modules were tested for the management of aphid *Aphis gossypii*, serpentine leaf miner, *Liriomyza trifoli* and red spider mite *Tetranychus* spin salad cucumber in polyhouses.The highest per cent reduction in aphid population was observed in thiamethoxam25WG (91.15%) followed by *Lecanicillium lecanii* 2% (90.12%), NSKE 5% (88.84.%), Neem oil soap (87.67%) and *Beauveria bassiana* (85.81%) at 7days after spraying (DAS). In case of American serpentine leaf miner, highest reduction was observed with Chlorantraniliprole 18.5 SC (99.00%) followed by NSKE 5% (98.59.%), Neem oil soap (95.90%), *Beauveria bassiana* (94.54%) and *Lecanicillium lecanii* 2% (89.09%) at 7 DAS.The chemical spiromesifen 22.7 SC recorded cent per cent reduction in red spider mite population at 3DAS. Subsequently the population enhanced and all the treatments were on par at15 DAS and differed significantly from control. Application of neem cake @200g/m^2+*Paceilomyces lilacinus* (1×10^7/g) @50g/m^2,15 days prior to planting and at monthly intervals till the end of the crop was effective to manage root knot nematode in field with moderate infestation. In field with high infestation of root knot nematode**,** Soil fumigation with dazomet 97% GR @ 40g/m^2 two weeks before planting followed by neem cake+ *Paceilomyces lilacinus* (1×10^7/g) @50g/m^{2}at planting and at monthly intervals till the end of the crop was the most effective treatment. Detection of dehydrogenase activity of soil revealed that there was drastic reduction in enzyme activity of soil one week after the application of chemicals, but enzyme activity slowly enhanced from second week onwards and recovered in due course of time.

3. Development of technologies including alternatives for banned pesticides for the management of pests and diseases of major crops in Kerala. Sub project-8 Development of substitutes for banned pesticides or alternative technologies for the management of nematodes in vegetables and banana. (Sub Project 8)(PP-01-01-08-2013-ACV(4) RKVY)

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For managing root-knot nematode in brinjal nursery carbosulfan @ 0.3 g a.i/m^2 is equally effective to carbosulfan @ 0.3 g a.i/m^2 in reducing the nematode population and increasing the yield in brinjal. Number of galls in the seedlings also showed significant reduction in carbosulfan and carbofuran treatments which ranged from 84 to 97 percent.

Three field trials were conducted in brinjal to evaluate the effect of bio agents (*Purpureocillium lilacinum, Pseudomonas fluorescens* and *Bacillus macreans*) in nursery alone @ 25 g/m^2 and combination of nursey and mainfield treatments. Results revealed that maximum reduction in nematode population (96.93 %) was observed in chemical application followed by nursery application of *P.lilacinum* @ 25g/m^2 + main field application of *P. lilacinum* @ 5g/m^2 and nursery application of *B.macerans* @ 25g/m^2 + main field application of *B. macerans* @ 5g/m^2 and the effect of these two treatments was statistically on par. Percentage reduction in nematode population in these treatments ranged from 90.64 to 92.99. Maximum number of fruits was recorded in the plants treated with chemical and the effect was statistically on par with *P. lilacinum* nursery application + main field. Highest fruit weight was recorded by chemical treatment and it was statistically on par with *P. lilacinum* nursery application @ 25g/m^2 + main field application of *P. lilacinum* @ 5g/m^2 and nursery application of *B. macerans* @ 25g/m^2 + main field application of *B. macerans* @ 5g/m^2 giving 20.98, 19.05 and 18.58 tones/ha respectively .

Study was undertaken to evaluate the efficacy of bio agents (*Purpureocillium lilacinum*, *Trichoderma harzianum, Pseudomonas fluorescens*) and organic amendment (neem cake) alone and in combination for the management of *M. incognita* on salad cucumber in polyhouse. Results revealed that soil application of neem cake @200g/m^2 three weeks prior to sowing +soil application of *P. lilacinum*(2x 10^6 cfu/g) @50g/m^2 at sowing significantly reduced the population of *M. incognita* in soil (94 %) and root (88 %). Highest fruit weight was observed in soil application of neem cake @200g/m^2 three weeks prior to sowing + soil application of *P. lilacinum* @ 50g/m^2 at sowing. Highest ICBR ratio (1:2.79) was also observed in this treatment. *P. lilacinum* is a potentially important fungal biocontrol agent capable of parasitizing nematode eggs. In this study the potential of *P. lilacinum* was boosted by combining with partially decomposed neem cake as evidenced by the result on reduction of *M. incognita* population in soil and root. Hence soil application of neemcake@200g/m^2 three weeks prior to sowing +soil application of *P. lilacinum*(2x10^6 cfu/g) @ 50g/m^2 at sowing can be recommended to manage root- knot nematode in salad cucumber.

4. Development of Technologies Including Alternatives for Banned Pesticides for the Management of Pests and Diseases of Major Crops in Kerala. Sub project-8 Development of substitutes for banned pesticides or alternative technologies for the management of nematode in Pepper (PP-01-01-08-2013-ACV (4) RKVY)

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The experiment was conducted in farmers field located in Balagram area of Idukki district with an initial nematode population of 1028 J_2/200 cc soil. The results of the experiment showed that the treatment with carbosulfan 6% G @16.7 kg/ha was the most effective treatment in increasing the dry weight of pepper (813.1 g/plant) followed by cartap hydrochloride 4% G @ 25kg/ha (730.8g/plant). Carbosulfan 6% G @16.7 kg/ha was the superior treatment in reducing the number of nematodes (595.4) in 200cc soil followed by cartap hydrochloride 4% G @ 25kg/ha (1123.4) and thiamethoxam 25% WG (1847.5).

5. Research on new molecules of plant protection chemicals Sub Project 1- Screening of new generation insecticides, bio-pesticides and other non chemical insecticides for the management of pests of cole crops. (PP-01-01-09-2015ACV(4)KAU-P(1))

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Spraying Sl NPV 2 mL/L or aqueous garlic extract 2% at fortnightly intervals is found effective when infestation level of*Spodoptera litura*is mild to moderate. Under heavy infestations spraying Chlorantraniliprole 18.5 SC 0.05% @ 2mL/10L or Spinosad 45 SC 0.1% @ 2mL/10L at true leaf stage and at curd or head inititation, effectively managed the pest. For the management diamond back moth, spraying Spinosad 45 SC 0.1% @ 2mL/10L or Chlorantraniliprole 18.5 SC 0.05% @ 2mL/10L at true leaf stage, curd or head initiation and heading/ curding stage is effective.

6. Research on new molecules of plant protection chemicals Sub Project 3: Evaluation of insecticides, for the management of pests of coccinia and tomato. (PP-01-01-09-2015 ACV(3) KAU-P(3)

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Chlorantraniliprole 18.5% SC 30g ai/ha and flubendiamide 20% WG 50g ai/ha were found effective in reducing the population of *Spodoptera litura* in coccinia and the number of larvae /plant was 16.38 and 15.81 respectively against 139.42 in control plot. Among the four newer insecticide molecules tested for their efficacy in managing aphids infesting coccinia, Imidacloprid 17.8% SL 20g ai/ha and Thiamethoxam 25% WG 25g ai/ha recorded a population of 6.84 and 8.64 respectively against 82.53 in control plots. Indoxacarb14.5% SC 75g ai/ha and Chlorantraniliprole18.5% SC 30g ai/ha were effective in reducing the infestation by epilachna beetle in tomato and Acetamiprid 20% SP 10ga i/ha and Thiamethoxam 25% WG 25g ai/ha were effective in reducing the infestation by the tomato leaf miner .

7. Research on New Molecules of Plant protection chemicals Sub Project 4: Newer and safer chemicals and biopesticides for the management of pests of mango. (PP-01-01-09-2015ACV(4)KAU-P(4)

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Imidacloprid 17.8% SL (0.005%) showed highest efficacy followed by Thiamethoxam 25%WG (0.005%) against the hopper in mango. Among the botanicals Oxuron 0.5% and biopesticides *Beauveria bassiana* WP2% (ITCC 6063) were found effective for the management of hopper. Male annihilation technique (MAT) for the management of fruit flies in mango using newer molecule, Spinosad (6:4:0.2 V/V) was found effective. Spinosad 0.02%was found equally effective as Malathion in bait application technique also.

8. Severity of mealybug studies in Kerala (CPBI-03-02-01 -2014-VKA (04)-KAU –Plan)

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Thirty four mealy bug species, nine predators and 26 parasitioids of mealy bugs were collected and identified from 14 districts of Kerala. Morphological and biochemical basis of resistance in host plants showed that there was a positive correlation between the trichome density and the mealy bug infestation on the host plant. Genomic analysis was done for 30 mealy bug species and the sequences generated from this study was analyzed for sequence homology using the nucleotide BLAST at NCBI, submitted to BankIt, GenBank and the accession numbers were generated. Further the specimen details and sequences were submitted to BOLD database and a unique barcode was generated for each species. To check the genetic diversity, the dominant mealy bugs *Phenacoccus solenopsis*, *Ferrisia virgata* and *Paracoccus marginatus* were collected from different districts of Kerala, genomic DNA isolated and amplified with 25 ISSR primers to screen the best performing one. The scored marker data matrix was analyzed using the standard procedure in NTsys Pc 2.0 package and the genetic distance or similarity was determined using the Dice coefficient. A dendrogram was constructed after cluster analysis of the similarity coefficients by the un-weighted pair-group method analysis, UPGMA. Both laboratory and field studies were carried out to screen the effective management method to combat mealy bug infestation. Chlorpyriphos, imidachloprid and thimethoxam were effective against the mealy bugs compared to buprofezin and fipronil

9. Assessment of insect biodiversity and habitat management in cowpea with special emphasis to manage cowpea stem borer in the Western Ghat tracts of Kollam district (CPBI-01-01-02-2015 KTR/WGD)

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The result of the survey showed that almost all the farmers are relying on insecticides for crop protection. Eventhough some of the farmers were using the microbial/ biocontrol agents for disease management but solely the farmers rely on chemical insecticides for insect pest

management. The non judicious use of insecticide cause severe damage to the ecosystem result in the biodiversity change and increase in pest diversity and change in the natural enemy population. From this study a new major pest of cowpea was recorded and identified and this can cause complete damage or even 100% loss of the crop. The symptoms are just like that of the cowpea wilt. The new pest is a cerambycid beetle found to damage cowpea by girdling the stem for oviposition and was identified as *Nupserha* sp. This was reported to be serious pest of soybean in North India. This was the first report of *Nupserha* sp from Kerala. The season of infestation is from July to January- February. One parasite of *Nupserha* was also recorded. The parasitized pupa of *Nupserha* was collected from the field and it was an ichneumonid pupal parasite. The experiments for the pest management showed that the incorporation of hyptis act as a good repellent for the oviposition of girdle beetle and the CNSL 0.5% application reduced the larval development within the stem.

Ongoing Projects

1. AICRP on Nematodes in Agriculture (PP/05-01-01-2010/ACV(4) ICAR)

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a. Diversity and distribution mapping of economically important nematodes in the country

In banana, *Pratylenchus coffeae* was the prominent nematode observed in areas of Alappuzaha and Ernakulam districts.In vegetable growing areas of Ernakulam and Alappuzha districts, the most important nematode was *Meloidogyne incognita* followed by *Rotylenchulus reniformis*. In Thodupuzha area of Ernakulum also high population *M. incognita* was observed in ginger. High population of *M. incognita*and *R. reniformis* was observed in Pepper in Pompakuda, Vadavucodu and Kodikulum area in Ernakulam district.Occurrence of *Scutellonema brady*swas observed in amorphophallus and yam in Ernakulam district. In sweet potato presence of *M. incognita* was observed. In Coffee high population of *P. coffeae* (80-520 with 50% frequency of occurrence) was observed in Avoly area of Ernakulam district. Occurrence of *M. graminicola* and *Hirchmanniella oryzae*observed in Alappuzha district in rice.

b. Screening, confirmation and evaluation of rice genotypes for resistance against rice root-knot nematode (*Meloidogyne graminicola*)

Among the 44 rice genotypes, tested to assess their reaction to rice root knot nematode *M. graminicola* OG-6 was resistant, Fifteen lines were moderately resistant, 25 lines were susceptible and three were highly susceptible. Thirty five rice cultivars were screened to assess their reaction against root knot nematode *M. graminicola*, including the highly susceptible check TN1. Among the lines tested 3 were found to be resistant.

c. Determination of host races of *Meloidogyne graminicola*

Host reaction based on Rf value revealed that rice varieties OG-6, OG-44, PB 1121, Sorghum (HJ 541), Pearl millet (HHB 67) and *Dactylotenium aegyptium* were categorized as hosts. In tomato, small galls were produced but without any egg mass indicating that *M. graminicola* cannot complete lifecycle in tomato. So it can be rated as a poor host of *M. graminicola*. In Brinjal and onion no eggmasses were observed and they are categorized as poor hosts.

d. Demonstration on management of root-knot nematode (*Meloidogyne graminicola*) in rice

In rice, result of the demonstration trial conducted in farmer's field revealed that soil solarization of nursery bed with 25µm polythene sheet for 15 days during May/June significantly reduced the nematode population (62.73 % reduction over untreated) and increased the yield (71.14 % increase over untreated)

e. Screening, confirmation and field evaluation of promising resistant germplasm of vegetable crops against root-knot nematode

In brinjal among the 50 varieties tested, 30 were germinated and all found susceptible to *Meloidogyne incognita.*

f. Management of root-knot nematode, *M. incognita* infesting vegetable cowpea using bioagents.

In cowpea, soil application of *Purpureocillium lilacinum* ($2x10^6$/g) @ 20 g/m^2+ neem cake @100 g/m^2 was the most effective treatment in reducing the nematode population (85.84 per cent reduction over untreated) and increasing the yield (55.55 per cent increase over untreated). So *P.lilacinum* in combination with neem cake can be recommended for the management of *M. incognita* in cowpea.

g. Management of *Meloidogyne incognita*/*M. javanica* in okra through bioagents

In okra, the effect of bio fumigation for the management root-knot nematode revealed that biofumigation with cauliflower crop residues @25t/ha+seed treatment with *P.lilacinum* @5g/kg seed and biofumigation with cauliflower crop residues @25t/ha+seed treatment with *P. chlamydosporium* @5g/kg seed are equally effective in reducing the population of *M. incognita* in the rhizhosphere and increasing the yield .

h. Demonstration of Efficacy of bioagents in the management of *Meloidogyne* species in bitter gourd

Result of the demonstration trial to test the efficacy of bioagent conducted in two locations in farmer's field revealed that application of *P. lilacinum* (cfu 2x 10^6) @ 2.5 kg along with 2.5 tons of FYM / ha + *Pseudomonas fluorescens* (cfu 2x 10^6) @ 2.5 kg along with 2.5 tons of FYM / ha reduced nematode population and increased yield in bittergourd.

i. Bio-intensive management of Root-knot nematode attacking ginger

Rhizome treatment with *P.lilacinum* @3% w/w in combination of green leaf mulching with glyricidia@ 1kg/m^2 found to be the best treatment in reducing the nematode population and increasing the yield in ginger. Effect of rhizome treatment with *Trichoderma viride* @ 3% w/w +mulching with green leaves of glyricidia @ 1kg/m^2, rhizome treatment with *Pseudomonas fluorescens* @ 3% w/w +mulching with green leaves of glyricidia @ 1kg/m^2 and rhizome treatment with *P.lilacinum* alone @3% w/w was statistically on par

j. Evaluation of new chemical molecules against *Meloidogyne incognita*infecting cucumber in polyhouse

Fluensulfone @ 1.5 g/plant one DAT, again 25 DAT by ring method manually and fluopyram 400 SC @ 250 g a.i./ha one DAT, again 25 DAT (200 ml/plant) manually are equally effective in reducing the nematode population and increasing yield in salad cucumber under polyhouse condition.

2. All India Network Project on Vertebrate Pest Management **(CPBI-07-01-01 -2015-VKA (04)-ICAR)**

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a. Agricultural Ornithology

The study on Surveillance of depredatory bird was carried out in rice fields of Thrissur district. From Enamavu 59 species of birds belonging to 27 families and from SSF 33 species fewer than 23 families were observed. The predominant bird in both study area was Egret with relative abundance 33.96 per cent in Enamavu and 26.30 per cent in SSF. Purple moorhen roost was observed from Enamavu, Chalakkudy, Puzhakkal and Irinjalakkuda kole fields from the month of November onwards. The roosts of Cormorants, Asian open bill stork, Lesser whistling duck were also observed during the study period. During the month of November and December bird species count as well as individual count was comparatively less. Even though the bird count was less in November, the species diversity index was more in November (3.055) followed by December (2.550). Omnivorus birds viz., Mynas and Starlings were seen feeding on fruits of *Bridelia retusa* and nectar of bombax flower. When compared to Rosy starling roost, Myna roost was rarely observed.Purple moorhen occur in marshy reed beds and flooded rice fields and reported in large numbers from kole rice fields during the period under report. The availability of food and undisturbed roosting and breeding sites enhanced its number in the kole and pokali fields. The birds roost on the bushy areas or marshy region, where human interference was less. Purple moorhens had seen in abundance in the regions with invasive growth of water hyacinth. Nestlings were observed from December onwards. Purple swamphen fed on the soft shoots, grains, insects, frogs and molluscans. The birds had been observed foraging on water hyacinth for most of the time. It fed on tender shoots of rice and caused severe damage during the early stages of the crop. Physical deterrent like strobe light, reflective ribbon and nylon nets were used to ward off the birds from rice fields.

b. Rodents

Significant rat damage started in rice at the time of active tillering and panicle maturation stages where the animal feeding switched over from vegetative tissue to the more nutritive panicles. A direct relationship between the number of live burrow (1 – 38.46%) and damage existed in the rice. In addition to damage to the tillers, rodents hoard the grains in their burrows in special chambers. The extent of the hoarding ranges from 0.5 to 7 kg per burrow by the lesser bandicoot rat *(Bandicota bengalensis)*. Snap trap, Multi catch trap, Trap barrier system, zinc phophide 2%, bromodioone 0.003% or coconut petiole @25/ha can be recommended for the management of rat in rice. In cassava, to repel the rats, neem cake powder @ 50g per burrow is used. Traditional trap 'kumbham' was used to trap the *B. bengalensis*. To kill the rodents, zinc phosphide @ 2 per cent bait application was done. In coconut, BoRep @50g per coconut crown and neem oil @ 5 ml/lit of water were used . In cocoa Snap and Sherman traps were used to trap the rodents. Use of neem oil @ 5ml/liter of water and spraying the same on maturing pods reduced the damage caused by rodents. Trapped rodents were subjected to anatomical characterization and send to the Zoological Survey of India, Jabalpur and Pune. 11 rodent species were got identified by the experts. DNA barcoding was done for *Rattus wroghton, Vandeleuria oleraceae, Rattus rattus Rattus renjineae* by extracting the total genomic DNA.

3. AICRP on biocontrol of crop pests and weeds

Dr. Madhu Subramonian, Professor
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a. Biodiversity of natural enemies from various agro-ecological zones

Spiders were collected from rice ecosystem in Thrissur, Palghat and Ernakulam district and were sent to NBAIR for identification.

b. Surveillance for pest outbreak and alien invasive pests

Outbreaks of *Spodoptera litura* in banana and vegetables in Alwaye, Chalakudy, *Spodoptera mauritia* in Thrissur Kole and Palghat, Flower thrips in mango at Muthalamada in Palghat and Thrips incidence in little gourd in Vaniampara, Palghat were reported. Alien invasive species reported were *Paraleurodes bondari* from coconut in Thrissur, *Euplatypus parallelus* in rubber in Irutty, Kannur and *Spodoptera frugiperda* from Malappuram and Thrissur on Maize

c. Management of rice stem borer and leaf-folder using entomopathogenic nematodes and entomopathogenic fungi

Trials conducted at RARS, Pattambi revealed that both *Bacillus thuringiensis* and *Beauveria bassiana* were as effective as the insecticide flubendiamide in managing stem borer as well as leaf folder damage in rice.

d. Large scale validation of bio-intensive pest management on rice

Adoption of BIPM practices led to substantial reduction in infestation by major pests. The mean stem borer population in BIPM plots was 70 per cent lower as compared to non BIPM plots. The

population of natural enemies was higher in BIPM plots. While mean spider population in BIPM plots was 12.5/m^2, the same for non BIPM plots was only 8.5/m^2. Greater parasitoid activity was observed in BIPM plots. The yield obtained from BIPM plots, (8000 kg/ha) was approximately 14.5 per cent more than that obtained from non BIPM plots (7000 kg/ha). The cost of cultivation also was nearly 8 per cent lower in the former. The increased yield as well as reduced cost resulted in an increase in profit by Rs 46,210/ha. The cost benefit ratio, 2.24 for BIPM fields compared quite favorably with 1.90 for non BIPM fields.

e. Field evaluation of ICAR-NBAIR entomopathogenic strains against cowpea aphid (*Aphis craccivora*)

The VI-8 strain of *Lecanicillium lecanii* was as effective as imidacloprid 30 g ai/ha in managing cowpea aphid *Aphis craccivora* though it was initially slow in inducing mortality of the aphids.

f. Survey and monitoring of rugose whitefly and their natural enemies on coconut

Infestation by *Aleurodicus rugioperculatus* (RSW) broadly followed the pattern observed in 2017-18 as well. However, parasitic activity appeared to be much lower in 2018-2019 taking longer time to reach significant levels. One reason that could have contributed to lower values for parasitism could be the presence of one or probably more species of whiteflies, namely *Paraleurodes bondari* and *P. minei* (reported by CPCRI, Kayamkulam) which were hardly parasitized by *Encarsia guadeloupae.*

g. Bio-intensive insect pest management in brinjal

BIPM package was effective in managing shoot and fruit borer infestation in brinjal and registered reduction in mealybug populations as well. BIPM plots also recorded yields significantly superior to untreated plots and on par with plots treated with insecticides.

4. AICRP on biocontrol of crop pests and weeds (CPB1 – 05-01-02 – ACV(04) - AICRP)

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a. Improved formulation of *B.bassiana* against rice leaf roller *Cnaphalocrocis medinalis*

Fourteen days after first spray, least population of rice leaf roller was recorded in plots treated with chitin enriched oil formulation of KAU isolate of *Beauveria bassiana*, followed by its conidial suspension spray. Performance of NBAIR isolate was on par with the formulated and unformulated application of conidia, which ranked second. Effect of second spraying was reflected even at seven days after treatment. The average population in treated pots ranged from 9.0 to 22 per 10 hills per plot while it was 26 in untreated plots. After the third spraying, there was no infestation in chitin enriched Bb (KAU) formulation. The effect of NBAIR isolate was on par with that of Flubendiamide 18.5 SC.

b. Comparative efficacy of entomopathogenic fungi against sucking pests of rice,

Leptocorisa acuta

Analysis of data revealed that seven days after first spraying, plots treated with *L.saksenae* @ 10^7 spores /mL was the superior treatment, closely followed by NBAIR isolate Bb5 @10^8 spores/mL, where the mean population per sweep is 5 and 6.75 respectively. Bb 5and *M.anisopliae* @10^8 spores/mL was on par and also with Thiamethoxam. Among the four biocontrol agents *L.saksenae* was most effective for rice bug with mean population 1.75noper sweep., followed by *B.bassiana* (2.75) .

c. Survey and monitoring of rugose whitefly and their natural enemies on coconut

The population just re-appeared after the flood, in September 2018. It gradually started increasing thereafter and is rated as moderate during January- February. More than 70 percent of the pupal colonies were found parasitized by *Encarsia guadeloupae.*

5. AICRP on biocontrol of crop pests and weeds

Dr. Sible George Varghese, Assistant Professor
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a. Surveillance of rugose whitefly in coconut and assessing the population of natural biocontrol agents

Survey on infestation by rugose spiraling whitefly and parasitism by *E. guadalopae* was conducted at monthly intervals from September 2018 to March 2019 at three locations in Kottayam, Alapuzha and Ernakulam. High infestation ranging from 53 -73 % was observed at Kumarakom. The highest infestation was during the month of September (73.54%) which later decreased up to 53.60% in December and further increased up to 61.91% during March. At Kumarakom, infestation was seen on the nuts and base of the fronds. Percentage of parasitism by *Encarsia guadalopae* was found to be high in the month of March (42.1%). At Moncompu, low to medium infestation ranging from 37 to 51 per cent was observed with percentage of parasitism ranging from 12-58 per cent. At Vyttila medium to high infestation which ranged from 44-57% and parasitism by *E. guadalopae* was 27-47 percent.

b. Screening of promising isolates of entomopathogenic fungi for management of white flies in chillies

Three sprays of the entomopathogenic fungi were given. The white fly count was very low during the period of experiment. Significant results have not been obtained till now.

c. Testing the efficacy of *Isaria fumosorosea* (ICAR-NBAIR Pfu-5) formulation in the management of rugose whitefly in coconut

Percentage reduction of live colonies ranged from 4.3 to 53 (3^{rd} DAT). An increasing trend in percent reduction was observed which ranged from 3.4 to 59% on 10^{th} DAT. After second spray percentage reduction live colonies ranged from 6.49 to 78.79 (3^{rd} DAT) when compared to initial

count. At 7th day it ranged from 8.78 to 75 per cent. Up to a maximum of 75 per cent reduction was observed in the number of live colonies when compared to pre- count.

6. AICRP on Fruits

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a. Survey

Slug caterpillar *(Miresa decendens*) on cv. Nendran and Njalipoovan in monsoon period and banana leaf thrips (*Helionothrips kadaliphilus*) and lace wing bugs (*Stephanitistypicus*), along with Rugose Spiralling Whitefly in summer months are emerging as pests of concern in Kerala. Coconut Rhinoceros beetle infestation was on rise in banana cv. Nendran from central Kerala.

b. Integrated management of banana pseudostem weevil (*Odoiporus longicollis*)

Among the treatments, Swabbing chlorpyriphos 0.05% (2.5ml/litre at 5th, 6th and 7th months after planting, Stem injection with triazaphos 0.05% , 2 injections per plant @ 4 ml/plant (150 ml triazaphos in 350 ml water) at 5th , 6th and 7th months after planting and Pseudostem trapping with EPF, *Beauveria bassiana* (1x 10^{7} spores/ml) 15 g/trap at 5th , 6th and 7th months after planting, recorded the bunch weight of 12.44 kg, 12.03 kg and 11.45 kg respectively, which were significantly higher than the untreated control plants.

c. Survey of plant parasitic nematodes associated with banana

Severe infections of burrowing nematodes were recorded from Ernakulam district leading to decay and death of roots, yellowing of leaves, stunted growth and in some cases toppling of banana plants. Similarly high incidences of *Meloidogyne* spp. was observed in banana monoculture or in banana plants intercropped with vegetables. In Thiruvananthapuram district, *M. incognita* was predominant whereas *M. javanica* was predominant in Idukki. Banana spiral nematode, *Helicotylenchus multicinctus* was more in districts of central Kerala. The incidence of *Pratylenchus coffea* was more at Thrissur, Ernakulam, Malappuram and Kozhikode. Idukki, Kottayam, Wayanad and Alappuzha districts, *Radopholus similis* was observed to heavily infest banana roots along with *Pratylenchus sp.* in Ernakulam and Thrissur Districts.

d. Biorationals for the management of nematodes of banana

Bunch weight showed significant differences with highest values recorded in biointensive management option of application of *Paecilomyces lilacinus* @ 25g/plant (12.00 kg) which was on par with treated check cartap hydrochloride @ 10g/ plant (12.84 kg). Among the biointensive management options, application of *P. lilacinus*@25g/plant effectively reduced the nematode population in both soil and root. The least root necrosis was recorded in the application of *P. lilacinus*@ 25g/ plant

e. Management of Rugose Spiraling Whitefly, *Aleurodicus rugio perculatus* Martin in Banana

The experiment was laid out in a farmer's field and treatments were imposed, but could not be continued due to plant damages associated with heavy rainfall and flood that occurred in the state of Kerala. New layout and planting initiated.

f. Management of banana skipper butterfly-*Erionota torus*

Foliar application of Chlorantraniliprole 18.5 SC effectively reduced the banana skipper butterfly population. Among the biological control methods, foliar application of Bt @ 3ml/l ($1x10^{t8}$cfu) was better.

g. Biological management of nematodes in tissue culture banana

The layout of the experiment was done in the nematode sick plot and treatments were imposed as per the technical programme during 2017-18. The experiment was forced to be abandoned due to heavy flood related plant damages during August, 2018. A new layout was done. Treatments are being imposed

h. Survey for new and emerging insect pests of jackfruit

Macrochenus isabellinus Aurivillius, 1920 (Coleoptera: Cerambycidae) was recorded as a new pest of jackfruit *Artocarpus heterophyllus*. The adult beetles feeds extensively on the leaves of medium maturity, leaving large shot holes, leading to shoot death. The life cycle of the beetle was 7-10 days of egg period, 1-3 months of larval period and 22-24 days of pupal period in jackfruit. The adult beetles lived for 1.5 to 3 months.High incidence of leaf eating cerambycid beetles (*Olenecamptus bilobus)* was observed across the surveyed areas during the monsoon period.*Glenea multiguttata*, a cerambycid
beetle was reported from Ernakulam, Idukki, Wayanadu, Palakkad, Kottayamand Alappuzha districts. Young plantations were infested by *Oberea artocarpi,* leading to shoot death, from Thrissur and Palakkad districts.Jack fruit aphid (*Greenidia artocarpii),* tingid bug and spittle bug (*Clovia lineaticollis*), were observed as mild but regular pests on growing young shoots and causes crinkling of leaves. Defoliation by Long horned Grasshoppers/Katydids and leaf caterpillars were of sporadic occurrence.

i. Fixed plot surveys

Coleopteran defoliators like *Oberea artocarpi, Epepeotes uncinatus, Macrochenus isabellinus* and *Glenea mulitiguttata* were high during monsoon period.Fruit borer/ shoot borer infestation was insignificant in the fixed plots. Sporadic incidences of breadfruit mealy bug (*Icerya aegyptica*), and leaf caterpillar (*Margaronia bivitralis*) closely followed the attack of cerambycid defoliatiors. Jack fruit mealy bugs were keenly attended by red ants for the honey dew they secrete and protected them from predators and parasitoids. The Large stem borer, *Batocera rufomaculata* was noticed on older primary branches during July-September with adults feeding on tender leaves and larvae as borers. Attacks of long horned grasshoppers (katydids) were high in the wet season.

7. AINP on Pesticide Residues (PP-06-00-03-2012-ACV(4)ICAR)

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AINP on Pesticide Residues is the core laboratory in south India under the Central Sector Scheme on Monitoring of Pesticide Residue at National Level. To comply with the requirements specified in ISO/IEC 17025:2005, the method validation for the pesticides like Organochlorine (OC), Organophosphorous (OP), synthetic Pyrethroid (SP) and new generation insecticides in salad cucumber, tomato and pepper were carried out by PRRAL, AINP on Pesticide residues, College of Agriculture, Vellayani. Satisfactory recovery (70-120 %), precision (<20 %) and measuring range (0.01-0.5 mg/kg) was obtained in all these commodities. An amount of Rs. 1, 87, 700/- (One lakh eighty seven thousand seven hundred only) has been generated through the analysis of pesticide residues in different commodities to the public. Safety interval of new generation molecules (10 nos.) has been fixed through supervised trials. The NABL accreditation of the laboratory got extended up to Feb-2020 in accordance with ISO/IEC 17025:2005 conducted on Jan-2018 by NABL.

8. AICRP on Honey bees and Pollinators (BO-07-00-02-2011-ACV(4)AICRP).

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To enhance the fruit set and crop yield in vegetable crops like bitter gourd, cucumber, capsicum, tomato, cowpea in protected cultivation, trials were conducted by using Stingless bees (*Tetragonulair idipennis*). Maximum foraging activity by the stingless bees was recorded during 6.00 to 10.00 am where the total number of returning pollen foragers is 23.50 numbers while compared to that of 10.00 am to 2.00 pm (14.50) and 2.00 to 6.00 pm (10.75). The experiment is in progress.Studies on the effect of different types of feed on the bee strength and brood area of Indian bee colonies during the lean season were assessed. Observations at weekly intervals on the above parameters revealed that there is no significant variation among the treatments. The results revealed that a gradual increase in bee strength and brood area development in the colonies fed with sugar syrup and cost of the treatment required per hive was also low when compared to the other treatments. The colonies fed with sugarcane syrup and sugar syrup also showed an increase in bee strength and brood area but the expenditure for the sugarcane syrup per hive was more than that of the sugar syrup.To characterize, identify and confirm the infectivity of the microbial isolate from diseased Indian honey bee brood and also to test the efficacy of botanicals and bio agents the larvae of Indian honey bee (3 to 4 days old) were collected randomly from the diseased as well as the healthy hives during 206-17 from the Indian bee apiaries localized at Nedumangad, Thiruvananthapuram. The collected larvae were subjected to histopathology studies. The sections after staining using haematoxylin eosin (H&E) were mounted and the morphological analysis was carried out using an optical microscope. The midgut of normal honey bee larvae has a single layered columnar epithelium which lies on a thin basal membrane. The epithelium possesses brush border like microvilli and the silk gland are seen lying on the ventral side of the larva. The peritrophic membrane covering the food particles can also be observed in the gut

lumen. The histopathological analysis of the internal organs of diseased Indian honey bee larvae revealed significant morphological variations in the midgut whereas the foregut and hindgut remained intact. Necrosis cell death of the internal lining of mid gut and uncleared microvilli was observed in the diseased larvae compared to the normal ones. The cell disintegration occurred in the epithelium towards the lumen which later spread to the haemolymph leading to the leakage of the gut contents. Under normal conditions, the epithelium deposition as well as the microvilli in the gastric caeca performs the nutrient and water absorption through secretion of the digestive enzymes. Thus, disruption of the ventricular cells hinders the absorption of nutrients and water which leads to the sudden death of the honey bee larvae.

To study the different native stingless bee species, Specimens were collected directly from live colonies and preserved in 98- 100 % ethyl alcohol. Species identifications were confirmed using morphological characters and published records. A new subgenus of Stingless bees, *Flavotetragonula* Shanas, subgen.n.is established and three new species , *Tetragonula* (*Flavotetragonula*) *calophyllae* Shanas and Faseeh, n. sp., *Tetragonula* (*Tetragonula*) *perlucipinnae* Faseeh and Shanas, n.sp. and*Tetragonula (Tetragonula) travancorica* Shanas and Faseeh, n.sp. are described from southern India, based on workers. It is established that *T.* (*Tetragonula*) *iridipennis* (Smith 1854) does not occur in India. The most widespread species in peninsular India is *Tetragonula (Tetragonula) travancorica* Shanas and Faseeh, n. sp. Keys to the subgenera of *Tetragonula moure*, 1961 and species of *Flavotetragonula* and *Tetragonula* of the Indian subcontinent are provided. The descriptions of the species are supplemented with characters of foreleg and hindleg.

9. Supervised field trials **(PP-06-00-04-2012-ACV(4)ICAR)**

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The following supervised field trials were allotted during 2018-19

Pesticide	**Crop**	Status of the trial
UPH-814 (Avancer Glo)	Paddy	Completed
Fipronil40%+Imidacloprid40%WG (lesenta80WG)(1stSeason)	Chilli	Completed
Flupyradifurone200 SL (Sivanto200 SL)	Brinjal	On going
Betacyfluthrin90 +Imidacloprid210OD (Solomon300OD)	Chilli	Completed
Propineb61.3%+Trifloxystrobin 3.5%WG (FlintPro)	Chilli	Completed
Crop pests and Beneficial Insects		
Propineb61.3%+Trifloxystrobin 3.5%WG (FlintPro)	Tomato	Completed

Azoxystrobin8.3%+ Mancozeb66.7% WG(Avancerglow)	Paddy	On going
Tebuconazole50%+Trifloxystrobin 25%WG(Nativo)	Brinjal	Completed
Tebuconazole430 SC	Tomato	On going
Mancozeb52.6%+Hexaconazole 2.4%WG(UPF209b)	Paddy	On going
Mancozeb52.6%+Hexaconazole 2.4%WG(UPF209b)	Chilli	On going
Fipronil40%+Imidacloprid40%WG (Lesenta)	Chilli	Completed
Flubendiamide240+Thiacloprid240 CS(BeltExpert)	Cucumber	On going
Flubendiamide90+ Deltamethrin60 SC(FameQuick)	Tomato	Completed
Novaluron9.45%+ Lambda Cyhalothrin1.9%ZC(GPI 1316)	Tomato	Completed
Azoxystrobin8.3%+ Mancozeb66.7% WZ(Avancerglow)	Tomato	On going
Azoxystrobin4.7%+ Mancozeb59.7% +Tebuconazole5.6%WZ(GPF215)	Cucumber	On going
Flupyrimin [ME5382(10%SC)]	Paddy	Completed
Flupyrimin [ME5382(2%Granular)]	Paddy	Completed
Newly sanctioned trials		
Cyantraniliprole +Diafenthiuron	Brinjal	Initiated
Cyantraniliprole +Diafenthiuron	Okra	Initiated
Cyantraniliprole +Diafenthiuron	Tomato	Initiated
Thiamethoxam 25 WG	Paddy	Initiated
Fluopyram +Tebuconazole (Luna experience)	Banana	Initiated
Fluopyram +Trifloxystrobin (Luna sensation)	Chilli	Initiated
Spirotetramat (Movento)	Cabbage	Initiated

10. All India Network Project on Agricultural Acarology (PP-03-00-20-2014-VKA(4)KAU)

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a.Diversity of spider mites associated with economically important plants of Kerala

Periodic surveys were carried out to study the diversity of spider mites associated with vegetables ornamentals and medicinal plants in Thrissur district. The study recorded eight species of spider mites viz. *Tetranychustruncatus, T. okinawanus, T. udaipurensis, T. neocalidonychus, T. fijiensis, Oligonychus biharensis, O. tylus* and *Eutetetranychus orientalis* associated with various crops. The study identified Marigold and Ipomea as new host records for *T. okinawanus* and rice is a new host record for *O. tylus*.

b. Bioefficacy of horticultural mineral oil (HMO) against *Tetranychus truncatus*

Laboratory bioassays were conducted to evaluate the efficacy of horticultural mineral oil (HMO) against *T. truncatus* and to test its safety to the predatory mite, *Neoseiulus longispinosus* at six concentrations of HMO, six combinations of HMO + neem oil, HMO 2.5%+ neem oil 2% and HMO 3 %+ neem oil 2% and neem oil alone at 2 % with an untreated control. Four days after treatment, 100 per cent mortality of eggs was recorded in the treatments HMO 1.5, 2, 2.5 and 3% and in the treatment combinations of HMO + neem oil at 1, 2, and 3%. Though with increase in the concentration of HMO, a significant increase in the mortality of adult predator was recorded, at the highest concentration of 3%, HMO recorded a mortality of only 27.78 per cent which was on par with neem oil 2% (33.33%). The study revealed that HMO possess very high efficacy against *T. truncatus* and is relatively safer to the predatory mite. Phytotoxic effect of HMO at 2, 3, 4, 5 and 6 per cent was tested on 45 days old potted okra plant along with an untreated control. The treated plants did not show any phytotoxic symptoms like scorching, yellowing, wilting, vein clearing or necrosis. In the field experiment, plots treated with HMO at 2.5 (92.60%) and 3.0 per cent (93.90%) as well as combination treatments HMO 2.5 per cent + neem oil 2.0 per cent (94.14%) and HMO 3.0 per cent + neem oil 2.0 per cent (96.79%) recorded significant reduction in mite population and were superior to plots treated with either spiromesifen (91.08%) or neem oil alone at 2.0 per cent (90.42%).

c. Status of acaricide resistance in *Tetranychus truncatus* on vegetable crops in Thrissur district

Susceptibility of three field strains of *T. truncatus* collected from different crops namely, okra (VkOk1), amaranthus (VkAm3) and pumpkin (VkPm3) to three commonly used acaricides, *viz*., spiromesifen 240 SC, fenazaquin 10EC and diafenthiuron 50WP was evaluated with a laboratory maintained susceptible strain (SS). Bioassay study revealed that the level of resistance varied among the strains for different acaricides evaluated. The strain VkOk1 recorded highest LC50 value and has
developed 8, 13 and 10 fold resistance to spiromesifen, fenazaquin and diafenthiuron, while VkAm3 recorded 7.0, and 5.53 fold resistance to spiromesifen and fenazaquin respectively. The strain VkPm3 showed susceptibility on par with the SS to all the acaricides evaluated. The activity of the detoxifying enzymes viz., cytochrome P450 and carboxylesterase, was significantly higher in VkOk1strain followed by VkAm3. The strains VkOk1, VkAm3 and VkPm3 showed 2.69, 1.24 and 1.09 fold enhanced activity of Cytochrome P450, respectively compared to SS, while carboxylesterase in VkOk1 and VkAm3 showed an increased activity by 2.59 and 1.18 fold. However, the strain VkPm3 recorded a decrease in activity of carboxyleasterase by 0.78 fold compared to the susceptible strain.

d. Efficacy of selected botanicals and oils against *Tetranychus truncatus*

Laboratory bioassay was conducted to evaluate the efficacy of plant extract of *Hyptis suaveolens* at different concentrations (5%, 10%, 15%), Nanma - a tapioca based pesticide (0.7%), Horticultural Mineral Oil (HMO- 2.5%), oil based formulation of *Wrightia tinctoria* (1.5%), and neem oil emulsion (2%) along with a control against *T. truncatus.* 72 hours after treatment,

HMO showed significantly higher ovicidal action by recording 96.66 per cent mortality followed by neem oil (76.66%) which was on par with Nanma (75%). One day after application, HMO and nanma recorded 100 per cent mortality of the adult mite followed by *Wrightia* (85.33%) and neem oil (75.99%). The study identified horticultural mineral oil and the botanical formulation, Nanma as potential alternatives to synthetic acaricides in mite management.

e. Identification of safer alternatives for mite management in protected cultivation

An experiment was conducted in the polyhouse to evaluate the efficacy of horticultural mineral oil @ 25 ml/l (Cristol), Nanma@ 7ml/l ,Cosmo @ 2ml/l and a novel acaricide, spirotetramat@ 0.8 ml/l (Movento 100 SC) along with spiromesifen @ 0.8 ml/l (Oberon) and a control against *Tetranychus truncatus* on cucumber. Horticultural mineral oil, nanma and movento significantly reduced the mite population by third day of treatment and were found to be on par with the standard check, spiromesifen.

11. Strengthening the NABL Accredited Pesticide residue laboratory to the status of a state referral lab.

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Established full-fledged ISO 17025:2005 accredited Pesticide Residue Testing Laboratory to monitor pesticide residues in food & agricultural commodities and Development of Trained personnel for establishing such laboratories throughout the state. Purchased and installed state of art equipments *viz*. LC MS/MS (Triple Quad), GC MS/MS, HRMS-ORBITRAP and FT-IR and the laboratory recorded considerable progress during the period in terms of state of art equipments and infrastructure facilities.

These instruments of the project are being utilized to impart quality analysis and to get accurate results, and to provide capacity building programmes to different stake holders to cater to the pesticide related issues.

Instruments purchased under RKVY

Liquid chromatography-Mass Spectrometer - Orbitrap

Liquid chromatography-Mass Spectrometer- Thermo Scientific TSQ Quativa

Gas Chromatography- Tandem Mass Spectrometer

Fourier-transform infrared spectroscopy (FTIR)

12. Establishment of Pesticide Residue Lab at College of Horticulture, Vellanikkara(CPBI-04-01-2018-VKA(4)-RKVY)

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The pesticide residue lab established was made functional in the year 2018-19. All the equipment like GC-MS/MS, HPLC, and GC-ECD was operationalised. In GC-ECD and GC-MS/MS a method was developed for the multiresidue analysis of 13 pesticides . The multiresidue method was standardised for the analysis of pesticide residues in vegetables. Limit of detection (LoD) and limit of quantification (LoQ) was also worked out for the various pesticides. In HPLC also, a multiresidue method was developed and validated for the analysis of new generation pesticides like thiamethoxam, imidacloprid, flubendiamide and spinosad in vegetables.

13 Establishment of National Level Quality Control Lab for Honey

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Objectives of the project is to establish laboratory facility for analysis of honey upto enzymatic level to assess the quality and serve as certifying laboratory for honey as per the approved national and international standards. Construction work of the building (6000 sq. ft.) is in the final stage. Tender procedure for purchase of the equipment (LC-MS/MS and HPLC) up to the financial bid evaluation is over.

14. Depredatory bird management in rice and vegetables (CPBI-07-01-01-2016-VKA (04)-DAK)

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The study focused on two important depredatory birds, the purple moorhen (*Porpyrio porpyrio*) and Indian peafowl (*Pavo cristatus)* as they cause extensive damages at different stages of rice and vegetable crops in various parts of Kerala. Purple moorhen damages the rice crop in the vegetative as well as in the reproductive stage. During vegetative stage of the crop, plants were cut down and the inner soft part of the culnm would be extracted for feeding. In the reproductive stage of the crop, birds use the plants to construct the nest. Erect the reflective ribbon @ 25 rolls/ ha; should be erected on poles firmly fixed at 5 m interval. Inter rows of ribbon can be 2m apart and the ribbon should be not more than 45 above the canopy of the crop and twisted for every 1m. Pulsating LED light flashes are also used to manage the purple moorhen. Roosting site clearance reduced the purple moorhen damage significantly

The Indian peafowl are mainly ground dwelling birds preferred forests and farming lands. They forage on ground in small groups and they eat both plants and animals. In Kerala the birds make high damage to agriculture fields like rice, vegetables and other crops. They are also beneficial in some cases like they consume large quantities of pestiferous animals including insects. They also damage cause structural damage in gardens and houses by braking glasses and mirrors. For the management of peafowl in the vegetable fields methyl anthranalite based repellent, whole egg, *Andrographis, Ipomea*, ecodon treatments were given. Methyl anthranilate based repellent treated rice seeds were not preferred by the birds in the rice nursery for more than 20 days. Two rows of nylon rope as tied around the vegetable field with the support of poles at 2m interval at a

height of 30 cm between the ropes and single row of reflective ribbon was also tied over nylon rope as a fence around the field. Reflective ribbon was also tied over the crop at a height of 60 cm with an interval of 1.5m in NS direction to scare the peafowl from the field. From the experiment it was evident that peafowl management technique was significantly effective in reducing the bird. Both fruit and seed yield of cowpea were significantly higher in the protected field compared to the unprotected plots.

15. Popularization of bio intensive integrated pest management (BIPM) in Kerala

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Seven two day training programmes on "On farm production of biocontrol agents" were conducted. A total of 130 farmers belonging to thirty four panchayats in the five districts of Palakkad, Thrissur, Ernakulam, Kottayam and Alapuzha took part in the hands on training programmes. Seven trainings were conducted successfully. After the training, eight units have started the in-situ production of biocontrol agents on large scale in Palakkad, Thrissur and Ernakulam districts. For large scale validation of BIPM technology, about five farmers were identified from the three districts of Palakkad, Thrissur and Ernakulam. Demonstration plots were established under BIPM for paddy (5 acres) as well as vegetables (25 cents). BIPM plots record greater yield as well as significant reduction in cost of cultivation than the conventional plots which used pesticides.

16. Production and marketing of "Safe to Eat" vegetables and fruits for sale through government outlets (PP-04-00-01-2014-ACV(4))

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Monitoring of pesticide residues in vegetables and fruits collected from government outlets, hyper markets, organic shops ecoshops and also from farmers field and to provide the results in public domain (www. kerala.gov.in) periodically so as to make the consumers aware of high risk, low risk and risk free commodities to choose. Forty two reports have been published through Govt. web site. Among the total of 1201samples analyzed during 2018-19, 133 samples (11%) had pesticides. Of which 115 vegetables out of 1104 (10.4%), 7 fruits out of 32 (11.2%), 11 spices out of 22 (50%) were contaminated with pesticides. Most of the insecticides detected having no label claim under CIB &RC on particular crop. However, fruit samples sold in Kerala markets were found relatively safe with very few exceptions. The implementation of the scheme from 1-1-2013 to till date has helped to create strong public awareness on pesticide residues in vegetables, fruits and other food commodities brought from other states, as well as items produced in the state, through publication of 42 periodic reports and also helped to standardize and popularize methods to reduce pesticide residues. It is also established that the awareness about presence of pesticide residues on vegetables/spices imported from neighboring states has sensitized people of Kerala to take up organic agriculture, terrace/balcony/backyard cultivation, vegetable cultivation in schools, offices and even in fallow lands, under the auspices of residents associations, NGO's and even political or socio-political organizations.

17. Effect of various entomo-pathogens and synthetic insecticides on the management of sucking pests in black pepper

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Among treatments the least infestations of soft scale was noticed for application of Thiamethoxam 25 WG @ 0.005% (6.96 %), Acephate 75 SP @ 0.15% (9.38 %), Dimethoate 30 EC @ 0.14% (9.38 %) and Imidacloprid 17.8 SL @ 0.006% (10.42) and they were statistically on par with each other followed by *Lecanicillium lecanii* 10 8 Spores/g @ 10% (14.58 %). The effect of *L. lecanii* was on par with the effect of Buprofezin 25 SC

18. Monitoring of pesticide residues in/on vegetables in central districts of Kerala- State Plan

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Market samples of vegetables were drawn from Ernakulam, Thrissur, Palakkad and Malappuram districts. The samples were extracted with QuEChERS method and anylsed in GC and HPLC. Samples, which were tested positive for the presence of pesticide residues were confirmed in GC-MS/MS. Samples were drawn from October 2018 onwards and till date 620 vegetable samples were analyzed.

19. Monitoring the susceptibility of insect pests to insecticides in different parts of Kerala - State Plan Project

Dr. Berin Pathrose, Assistant Professor
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In order to ascertain the baseline susceptibility of fruit flies to insecticides, fruit fly infested fruits were collected from ARS, Mannuthy. Upto six generations of fruit flies from the initial culture was maintained in the lab and film residue method of bioassay was standardised for assessing the susceptibility of flies to insecticides. Bioassays were carried out with the organophosphates dimethoate and malathion and with synthetic pyrethroids like deltamethrin and lambda cyhalothrin. The LC_{50} calculated was 1 ppm for dimethoate and deltamethrin , 2 ppm for lambda cyhalothrin and it was 7 ppm for malathion. Hence fruit flies are more susceptible to dimethoate and deltamethrin and least susceptible to malathion.

PG Projects

Concluded PG Projects

1. Dissipation and risk assessment of insecticides used for pest management in cabbage and cauliflower (CPBI-04-01-01-2016-ACV (04)-KAU-PG)

Student: Anju Padmanabhan
Major Advisor: Dr. Ambily Paul,
ambily.paul@kau.in

Dissipation studies revealed that the dissipation pattern of insecticides varied with crop, agro climatic areas, and chemistry of the molecules. Risk assessment study shown that insecticides *viz.*, fipronil and dimethoate posed risk on human health even at recommended dose. Studies on effect of insecticides on soil enzyme revealed that except fipronil and indoxacarb, all other insecticides under present study have less impact on soil enzymes. Decontamination studies showed that cooking at 15 min. removed 50-60 per cent of insecticides and "Veggie Wash" removed 12-40 per cent of treated insecticides.

2. Insecticide mixtures for the management of pest complex in cowpea (CPBI-05-02-01-2017-ACV(4)KAU-PG)

Student: Banka Kanda Kishore Reddy-
Major Advisor: Dr. Ambily Paul,
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The infestation of sucking pests, borers and leaf feeders are simultaneously occurred in cowpea especially in pod bearing stage. The results of the study revealed that spraying of blue labeled insecticide mixture, chlorantraniliprole 8.8 % + thiamethoxam 17.5 % SC @ 0.30 mL L^{-1} could effectively manage pest complex in cowpea with less risk to the consumers.

3. Insecticide resistance in cowpea aphid, *Aphis craccivora* (Koch) and its management (CPBI-04-05-01-2017-ACV(4)KAU-PG)

Student: Jangam Hampaiah
Major Advisor: Dr. Ambily Paul,
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The study revealed the development of insecticide resistance in the field populations of *Aphis craccivora* against fenvalerate and imidacloprid. Considering the less mammalian toxicity, good aphicidal activity, consumer safety and high dissipation rate, thiamethoxam 25 g a.i.ha^{-1} followed by thiamethoxam + lambda cyhalothrin 27.5 g a.i.ha^{-1} and thiacloprid 24 g a.i.ha^{-1}could be recommended against *A. craccivora* in cowpea.

3. Eco-friendly management of major pests of upland rice ecosystem (CPBI-03-02-04-2017-ACV(4)KAU-PG)

Student: Shobha Y.B
Major Advisor: Dr. Suja. G
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Experiment on management of BPH and rice bug revealed that rice bug population and grain damage was effectively controlled by dasagavya 3%. Cashew nut shell liquid 0.1%, fish jaggery extract 0.6%
and chitin based Pseudomonas 2.5 kg ha^{-1} were also recorded to be effective against rice bug. Significantly high population of parasitoids was observed in the treatments fish jaggery extract 0.6% and dasagavya 3%. Higher grain yield was recorded in the treatments cashew nut shell liquid 0.1%, dasagavya 3% with a marginal B: C ratio of 2.8 and 2.6 respectively.

5. Biosystematic studies on stingless bees (Apidae: Meliponini) of Kerala (CPBI-06-05-01-2017-ACV(4)KAU-PG)

Student:Faseeh, P.
Major Advisor: Dr. Shanas. S
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Tetragonula sp. nov. 1,and*Tetragonula* sp. nov. 2 of stingless bees based on adult worker specimens were described and illustrated with the help of photographs. Along with the description, an analysis of their phylogenetic relatedness is provided. The genetic analysis revealed that, *Tetragonula*sp. nov. 1is closely related to the common species *T. iridipennis*whereas *Tetragonula* sp. nov. 2is distantly related.

6. Management of beetle pests in stored rice using botanicals (CPBI-03-02-01-2017-ACV(4)KAU-PG)

Student: Binseena, S.R.
Major Advisor: Dr. N.Anitha,
anitha.n@kau.in

The rice weevil *S. oryzae* was found to be the major beetle pest associated with stored rice. Among the plant extracts, treatment with tulsi leaves 10 % showed the highest reduction of weevils with decreased progeny emergence and grain damage. Treatment with dried plant parts, mint leaves (4 %) showed the highest reduction of weevils whereas the lowest progeny emergence and grain damage were observed in treatment with dried nutmeg mace 4 %. Among the essential volatile oils, pepper oil 200 µl 500 cm^{-3} caused cent per cent mortality of rice weevil at four days after treatment without any progeny emergence.

7. Novel bioformulations of entomopathogenic fungi and their efficacy against banana weevils. (CPBI-05-02-01-2017-ACV(4)KAU-PG)

Student: Remya, S.
Major Advisor: Dr. Reji Rani. O. P,
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The study could standardize the protocol for capsule and gel formulations of entomopathogenic fungi, retaining the viability and infectivity upto three months of storage. It is concluded that

placement of *Beauveria* capsules in leaf axils prophylactically and curatively can effectively control pseudostem weevil and *Metarhizium* capsules and gels placed in the rhizosphere could manage the rhizome weevil moderately.

8. Management of sucking pest complex in chilli using botanical and microbial pesticides. (CPBI-03-02-01-2017-ACV(4)KAU-PG)

Student: Priyatha Sundaran C.
Major Advisor: Dr. Faizal. M. H,
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The results of the study indicated the suitability of Cashew nut shell liquid 0.2 %, 0.075 % and the combination treatment of Cashew nut shell liquid 0.2 % + *L. lecanii* @ 10^7 spores mL^{-1}in sucking pest complex management. Considering the effectiveness in managing the sucking pests and their effect on plant growth attributes, Cashew nut shell liquid 0.075 % and *L. lecanii* @ 10^7 spores $mL^{-1}$are better choices for eco-friendly management of sucking pest complex of chilli.

9. Field toxicity of new generation insecticides to bee pollinators (CPBI-04-02-02-2017-ACV (4) KAU-PG)

Student: Raeesa, P.
Major Advisor: Dr. Amritha V. S,
amritha.vs@kau.in

The study could establish that the new generation insecticides, cyantraniliprole 20 SC@ 1.2 $mLL^{-1}$and novaluron 10 EC @ 2.0 mLL^{-1} which recorded the lowest mortality in the laboratory are safe to the pollinators in terms of their foraging behaviour when compared to the dimethoate 30 EC @ 0.5 mLL^{-1}. Considering the safety of new generation insecticides to the dominant pollinators, they can be used for effective pest management in cucurbits.

10. Etiology of honey brood disease in Southern Kerala (CPBI-06-02-01-2017-ACV(4)KAU-PG)

Student: Jyothis, P. Joseph
Major Advisor: Dr.Amritha V.
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Indian bee apiaries of Kollam district recorded the highest incidence of brood disease in southern Kerala during the dearth and brood rearing season, with a mean percentage infection of 44.36 followed by Thiruvananthapuram district (4.45) and Pathanamthitta district (1.07) Two bacterial isolates which proved the pathogenicity were identified as *Bacillus pumilus* and *Achromobacter* sp. Crushed garlic 0.25 % and crushed leaves of *Ocimum* 0.05 % were found effective in the field evaluation of botanicals against brood disease, with a mean percentage reduction of 68.52 and 67.57 respectively.

11. Impact of new generation granular insecticides on beneficial fauna of paddy ecosystem (CPBI-04-02-01-2017-ACV(4)KAU-PG)

Student: Niranjan . S
Major Advisor: Dr. Suja. G,
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Fipronil 0.3G recorded the lowest damage and population of stem borer and leaf roller at the recommended and double the recommended doses. But it was found to be highly toxic to soil fauna *viz.* earthworms, nematodes, snails, spiders, and soil insects.

12. Exploitation of indigenous bacterial antagonists against root- knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood. (CPBI-03-02-03-2017-ACV (26) –KAU PG)

Student: Vishnu J.S
Major Advisor: Dr. Nisha. M. S,
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A total of sixty two soil and fifty eight root samples were collected from the rhizosphere of cardamom, pepper, rice and vegetables by random sampling. Thirty eight bacterial colonies showing characteristics similar to *Bacillus* and*Pseudomonas*were selected. Twelve isolates which showed 66.00 to 94.00 per cent mortality of *M. incognita* juveniles were selected for further screening under *in vitro* condition. Pot culture studies were conducted to evaluate the effect of Isolate 1 and 2 in comparison NBAIR isolate (*Bacillus subtilis).* Soil drenching of Isolate 2 ($1x10^7$ cfu mL^{-1}) @ 50mL pot^{-1} was significantly superior to all other treatments in reducing the nematode population in soil and root giving 72.69 and 82.23 per cent reduction in nematode population over control respectively. Molecular characterization of Isolate 1 and 2 was done. The blast analysis against NCBI revealed the
identity of Isolate 1 and 2 as *Bacillus thuringiensis* strain a57 and *Stenotrophomonas maltophilia* strain W2-7 respectively.

13. Systematics of the tribes Scymnini and Stethorini(Coleoptera: Coccinellidae) from South India (PP-03-00-43-2015-VKA(04)-KAU-PG)

Student: Vidya C.V.
Major Advisor: Dr. HaseenaBhaskar,
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An extensive survey was carried out in 22 districts of south Indian states of Kerala, Karnataka and Tamil Nadu. The study recognised 28 species underScymnini belonging to six genera *viz*., *Axinoscymnus*, *Cryptolaemus*, *Horniolus*, *Nephus*, *Sasajiscymnus* and *Scymnus*.Two species are recorded for the first time in India and two from south India and two are new records for Kerala. The tribe Stethorini was represented by 10 species in two genera *viz*., *Stethorus* and *Parastethorus.* Six species of Stethorini were recorded for the first time in Kerala.Twenty one species of prey in four families*viz*., Aphididae, Pseudococcidae, Aleurodidae and Diaspididae were recorded in association with the tribe Scymnini. Two new prey records for Scymnini in the study include *Toxopteraodinae* for *Scymnuspyrocheilus*and *Saccharicoccussacchari* for *Nephustagiapatus*. Seven species of five genera were identified as prey for species of Stethorini.Species distribution map was prepared for the species of Scymnini and Stethorini using QuantumGIS software.All the taxa treated are described and illustrated. Keys have been provided for the tribes, genera and species.Twenty one accessions belonging to nine species of Stethorini were used for barcoding studies.A phylogenetic tree was constructed with 21 sequences in MEGA 7 using the maximum likelihood method. The sequences were submitted to GenBank (NCBI) and to BOLD for the generation of species specific barcodes.

14. Bio-efficacy of horticultural mineral oil against the spider mite *Tetranychus truncates* (Prostigmata Tetranychidae) in okra(CPBI 03-02-06-2017-VKA(04)-KAU – PG)

Student: Kavya Yadav
Major Advisor: Dr. Haseena Bhaskar,
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Plots treated with HMO at 2.5 (92.60%) and 3.0 per cent (93.90%) as well as HMO 2.5 per cent + neem oil 2.0 per cent (94.14%) and HMO 3.0 per cent + neem oil 2.0 per cent (96.79%) recorded significant reduction in mite population and were superior to plots treated with either spiromesifen (91.08%) or neem oil alone at 2.0 per cent (90.42%). Laboratory bioassay to evaluate the safety of HMO to the predatory mite, *Neoseiuluslongispinosus*revealed that HMO is relatively safer to the predator than to *Tetranychus truncatus*.The high efficacy of HMO against the spider mite *T. truncatus*as well as its relative safety to the predominant natural enemy brought out in the study suggests that HMO can be an effective tool for mite management in vegetable crops.

15. Eluciding the biochemical basis of interaction between tea mosquito bug *Helopeltis antonii* Sign. (Hemiptera Miridae and cashew (*Anacardium occidentale*)(CPBI -03-05-01-2017-VKA(04)-KAU – PG)

Nimisha.T

The total leaf protein was found to be highest in the less susceptible variety Damodar (0.9925 mgg^{-1}) and the lowest in the highly susceptible Madakkathara-1 (0.6729 mgg^{-1}). Total phenol content was highest in the less susceptible Damodar (69.834 mgg^{-1})and Raghav (67.207 mg g^{-1}) and the lowest was recorded in Anagha (29.625 mgg^{-1}). Regardless of the varieties, highest phenol content was recorded in samples taken after 72 h of TMB infestation. Tannin content was also high in the less susceptible varieties Raghav (4.420 mgg^{-1}) and Damodar (4.276 mgg^{-1}) while highly susceptible varieties Anagha and Madakkathara-1 recorded lower values. Irrespective of the varieties, the highest tannin content was recorded in samples before the release of TMB (6.662 mgg^{-1}). The detoxifying enzyme specific activity of PPO was highest in Damodar (0.003158 EU $g^{-1}min^{-1}$) and observed lowest value in Anagha (0.001406 $EUg^{-1}min^{-1}$). Irrespective of the varieties, enzyme activity reached highest at 48 h of release ($0.00367EUg^{1}min^{-1}$). PAL specific activity was highest in Madakkathara-1 (0.575µgg^{-1} min^{-1}) and lowest in Anagha and was on par with Raghav and Damodar. The study revealed that, the secondary metabolites *viz*., phenol, tannin and PPO have a definite role in imparting resistance in cashew to TMB attack. These metabolites have potential use in early detection of resistance in cashew against TMB. The enhanced levels of detoxification enzymes in TMB indicate plasticity of the pest against host plant defense and chance of resistance development against synthetic insecticides

16. Insecticide based bait formulation against tobacco caterpillar *Spodoptera litura* (Fab.) Lepidoptera Noctuidae (CPBI -03-02-05-2017-VKA(04)-KAU – PG).

Shahanaz

In order to identify a base material preferred by *Spodoptera litura*,baits were prepared by using different substrate, *viz.,* rice bran, maize bran and wheat bran along with jaggery and water. Mean consumption of bait by the *S.litura*larvae after 48h were recorded and results revealed superiority of bait containing wheat bran and jaggery in 8:2 ratio, followed by maize bran. Bait

containing starch (0.2%)was found to be very attractive and resulted indoubling of the consumption of bait. Observation on leaf defoliation revealed that inemamectin benzoate baited plots consumption was very low (2.95 cm^2/5 plants/plot) after 10 days of treatment followed by thiodicarb (8.44cm^2/5 plants/plot), chlorpyriphos (12.38 cm^2/5 plants/plot), fipronil (12.69 cm^2/5 plants/plot) and spinosad (30.61cm^2/5 plants/plot). Poison baiting with insecticides was found to be beneficial in reducing the damage caused by *S. litura*at levels lower than the recommended dose with minimum disturbance to non-target organisms.

Ongoing PG Projects

1. The Eumolpinae (Coleoptera: Chrysomelidae) of southern India (CPBI-01-01-02-2016-ACV (04)-KAU-PG)

Student: Amrithakumari. S
Major Advisor: Dr. K. D.Prathapan,
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The eumolpine leaf beetles were collected from representative areas of southern India. The information on host plant is gathered in all possible cases. The specimens were identified in consultation with the relevant literature upto Genus level. Now Species level identification along with description of species going on with the help of morphological and anatomical features. Endophallus inflation / eversion technique is standardized for Eumolpinae. Species complexes are differentiated by endophallus inflation without eversion/endophallus eversion. In very complicated cases, we are depending on DNA barcoding for segregating species.

2. The Lamiinae (Coleoptera: Cerambycidae) of southern India (CPBI-01-01-03-2016-ACV (04)-KAU-PG)

Student: Sangamesh
Major Advisor: Dr.K. D.Prathapan,
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The purposive sampling of flat faced long-horned beetles was made from south India. The taxon descriptions have been prepared. Identification Key preparation is undergoing.

3. The galerucine leaf beetles (Colepotrea: Chrysomelidae : Galerucinae : Galerucini of southern India CPBI-01-03-02-2017-ACV (04)-KAU-PG)

Student: Viswajyothi K
Major Advisor: Dr.K. D.Prathapan,
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Collected specimens from Vellayani, Ponmudi, Kallar, CRS, Pampadumpara, JNTBGRI Palode, Mudigere, Mazhuvannur, Kammana, Cherkara, Pulpara, Peruvannamuzhi, Panniyur, Malappattom, Padannakkad, Kakkayam, Shendurney WLS, Munnar and Yercaud and collected galerucine leaf beetles. Recorded the host data in all possible cases. The collection includes the following genera, *Monolepta, Oides, Pseudoscelida, Pyrrhalta, Spenoraia, Trichomimastra, Doryscus, Erganoides, Hoplosoma, Hoplosaenidea, Hyphaenia, Kanarella, Mimastra, Galerucida, Aulacophora, Apophylia, Cassena, Charaea, Arthrotus*and*Dercetina.* Detailed studies on head, thorax, elytra and ventrites are being carried out for each and every species

collected. The male and female genitalia is being dissected and studied. Majority of the specimens obtained belong to the genus*Monolepta.* Though many of these species could be new to science, extensive revision of the literature and comparative study of the specimens with type specimens deposited in various museums is a must.The descriptions and illustrations are being prepared.

4. Leaf footed bugs (Hemiptera : Heteroptera Coreidae) of southern India and the Andaman Islands CPBI-01-03-01-2017-ACV (04)-KAU-PG)

Student: Bharathimeena
Major Advisor: Dr. Shanas S
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The collected specimens were identified using the relevant literature and the identity was cross checked with the holotypes wherever available.

5. Mycotoxins and enzymes of entomopathogenic fungus *Lecanicillium saksenae* (Kushwaha) Kurihara and Sukarno and their bioefficacy on crop pests CPBI-05-01-01-2017-ACV (04)-KAU-PG)

Student: Sreeja P
Major Advisor: Dr.Reji Rani O.P
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Cuticle degrading enzymes produced by the entomopathogenic fungus *Lecanicillium saksenae*were detected by plate assay method. Enzymes *viz* chitinase, chitosanase, chitin deacetylase, protease, lipase, amylase, keratinase and collagenase were detected. Quantification of different enzymes was done by calorimetric.All the three major cuticle degrading enzymes exhibited bioefficacy against brinjal mealy bug *Coccidohystrix insolitus*. Combined application of partially purified chitinase, protease and lipase at protein concentration of 0.8 mg mL-1 resulted in cent per cent inhibition of nematode eggs. SEM analysis revealed aberrations on egg surface. In vitro studies proved the pathogenicity of *L. saksenae* on root knot nematode egg mass. The fungi infected and colonized egg mass within seven days after inoculation. Mycotoxins of the fungus were extracted through solvent extraction method from both culture filtrate and mycelia. Secondary metabolites belonging to alkaloids, sesquiterpenes, flavonoids, carboxylic acids and cyclic peptides were identified. GCMS, HRGCMS, LCMS , and HR LCMS analysis revealed the presence of an array of bioactive secondary metabolites. Bioefficacy studies with the crude toxins @1000 ppm on brinjal mealy bug *C. insolitus*recorded a mortality of 81.25 per cent and cent per cent at 24 and 72 hrs after treatment respectively. Bioassay conducted with mycelia toxin on cowpea aphid *Aphis craccivora* resulted in 87.15 per cent mortality at 900 ppm. Adverse effect of crude toxin were studied on a generalist predator *Cheilomenes sexmaculata* and on Hymenopteran parasitoid *Trichogrammachilonis* and *T.japonicum.*Crude toxinexhibited ovicidal action against *C.sexmaculata* at 4000 ppm where as no significant reduction in parasitism was observed with *T.chilonis.*Bioefficacy of the culture filtrate of *L saksenae* were tested at different dilutions of 1/2, 1/4, 1/10, 1/100 against J2 of *M.incognita*. Juvenile mortality was inversely proportional to the dilutions of culture filtrate.

6. Cashew nut shell liquid based botanical insecticides for pest management in yard long bean (*Vigna unguiculata subsp. sesquipedalis* (L.Verdc). (CPBI-03-02-09-2017-ACV (04)-KAU-PG)

Student: Lekha M .
Major Advisor: Dr. M. H.Faizal
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CNSL obtained by two different cashew nut processing technique, drum roasting (CNSL-DR) and steam boiling (CNSL- SB) emulsified in water at various concentrations from 0.05 to 0.2% using vegetable soap(0.6%) as emulsifier and tested against two important pests, leaf caterpillar, *Spodoptera litura* F. and cowpea aphid, *Aphis craccivora* Koch. separately under laboratory conditions. The results showed CNSL at 0.1 and 0.2 % was found to be very effective against cowpea aphids and pod bugs. An EC formulation was prepared out of CNSL using organic solvents. CNSL and a combination product of CNSL and pongam oil was also prepared. The bioefficacy of the formulations were assessed on cowpea aphids, pod bugs and spodoptera. The experiments to test the phytotoxicity of the formulation in cowpea was done at recommended and double the recommended dose in the field. The results showed none of the formulation turned out to be phytotoxic both in physical appearance and yield wise.

7. Insecticide mixtures for the management of sucking pest complex in chilli CPBI-04-03-01-2018-ACV(04)-KAU-PG

Student: Anju Viswanathan, K. -
Major Advisor: Dr. Ambily Paul,
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The insecticide mixture, fipronil 40% + imidacloprid 40% WG @ 175 + 175 g ai ha^{-1} waseffective in the management of chilli thrips, aphids, whiteflies and fruit borers followed by betacyfluthrin 8.91% + imidacloprid 19.81 % @ 15.75 + 36.75 g ai ha^{-1} . Spiromesifen 22.9 SC @ 96 g ai ha^{-1} found as effective acaricide followed by fipronil 40% + imidacloprid 40% WG @ 175 + 175 g ai ha^{-1} for the management of chilli mite. Among different insecticide treated, spiromesifen 22.9 SC @ 96 g ai ha^{-1} found as the safe chemical to natural enemy population followed by fipronil 40% + imidacloprid 40% WG @ 175 + 175 g ai ha^{-1}.

8. Insecticide resistance in spiralling whitefly, *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae) and its management. CPBI-04-05-01-2018-ACV(04)-KAU-PG

Student: Aura Senson -
Major Advisor: Dr. Ambily Paul,
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Development of Insecticide resistance in field population of spiraling whitefly, *Aleurodicus dispersus* against three insecticides *viz*., fenvalerate, quinalphos and dimethoate has been studied and the resistant population was identified. Laboratory studies on the management of resistant population of spiraling whitefly using new generation insecticides revealed that flonicamid @75g a.i ha^{-1}, clothianidin 20 g a.i ha^{-1} and thiamethoxam + lambda cyhalothrin 33 + 15.75 g a.i ha^{-1} were found to be effective for the management of resistant population of spiraling whitefly.

9. Histomorphology of Indian bee (*Apis cerana indica* Fab.) supplemented with probiotics (CPBI-06-02-01-2018-ACV(04)-KAU-PG)

Student: Akhila Pahee
Major Advisor: Dr. Amritha V.S.
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Samples were collected purposively from different parts of Kerala and its evaluation is done at Sree Chithra Thirunal Institute for Medical Science and Technology, Poojappura. Critical anatomical variations of midgut histology were analysed . The midgut of feral colony samples and colonies fed without sugar syrup were found to be healthier than other samples. The study on effect of probiotics are in progress.

10. Augmentation of pollination in oriental pickling melon (*Cucumis melo* var. *conomon*) with Indian bee (*Apis cerana indica* Fab.) (CPBI-06-01-01-2018-ACV(04)-KAU-PG)

Student: Aneetta, M.R.
Major Advisor: Dr. Amritha V.S.
amritha.vs@kau.in

Observations on foraging behaviour of dominant pollinator and floral biology of culinary melon have been completed. Work is in progress

11. Morphological and molecular characterization of eastern honey bee (*Apis cerana* Fabricius) in Kerala (CPBI-01-03-01-2018-ACV(04)-KAU-PG)

Student: Chinchu P. Babu
Major Advisor: Dr. Amritha V.S.
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Honey bee samples (workers and drones) were collected from feral colonies from Thiruvananthapuram, Kollam and Idukki districts. Morphological and molecular analysis of the samples are going on.

12. Evaluation of native isolates of nematode antagonistic fungi against *Meloidogyne incognita* in tomato CPBI-03-06-01-2018-ACV(26)-KAU-PG.

Student: Jithoop, D
Major Advisor: Dr. R. Narayana,
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Nematode antagonistic fungi were isolated from soils infested with root-knot nematode. Five isolates were tested for their effect against the nematodes under *in-vitro* conditions. The same fungi were also evaluated against hatching of nematode eggs after 1,3,5 and 7 days of incubation. Three isolates have shown more than fifty per cent reduction in hatching of eggs after 7 days of treatment. These isolates also recorded more than 30 percent mortality of J2 of *M. incognita.* Five isolates of the fungi has been isolated from egg masses of the nematodes and are being tested for their pathogenicity against nematode eggs.

13. Pathogenicity of indi genous entomopatho genic nematodes against select insect pests. **CPBI-03-02-07-2018-ACV(26)-KAU-PG**

Student: Sooraj,S.
Major Advisor: Dr.M.S. Nisha,
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Soil samples were collected from different crop habitats *viz.* vegetables, banana and coconut in Thiruvanathapuram, Kollam, Pathanamthitta and Alappuzha districts of Kerala by random sampling. Three indigenous EPN isolates were obtained from soil using live hosts (*Corcyra cephalonica*) by insect trap method. The infectivity of indigenous isolates to different groups of pests (termites, aphids, *Spodoptera litura* and pseudostem weevil) were assessed at an inoculum level of 300 IJs. Pathogenicity studies were conducted with10, 50, 100 and 200 IJs of native isolates against select insect pests i.e., termites, aphids, *Spodoptera litura* and pseudostem weevil. All the native isolates were found to cause mortality of the test insects in Petri plate assay with Isolate 2. As per the various measurements of nematodes, Isolate 1 was identified as *Rhabditis* sp. and Isolate 2 as *Heterorhabditis* sp.

14. Compatibility and synergism of the entomopathogenic fungus *Lecanicillium saksenae* (Kushwaha) Kurihara and Sukarno with other crop protectants. **(CPBI-03-02-04-2018-ACV(04)-KAU-PG)**

Student: Keerthana, K.
Major Advisor: Dr. Reji Rani, O.P.
reji.rani@kau.in

Neem based botanicals like NSKE (aqueous) and NSKE (solvent) at 0.5% and 1% were found to be compatible with *L. saksenae*, neem oil emulsion at 0.5% and neem leaf solvent extract at 1% were compatible with *L. saksenae.* Insecticides such as Imidacloprid 17.8% SL, Thiamethoxam 25% WG, Chlorantraniliprole 18.5% SC, Flubendiamide 39.35% SC were found compatible with *L. saksenae* at recommended field dose and the half the recommended dose. Dimethoate 30EC at half the recommended field dose was compatible with *L. saksenae. B. bassiana* is found to be compatible with
L. saksenae .Thiamethoxam 25% WG at 0.0025%, NSKE (aqueous) at 0.5%, *B. bassiana* at 10^7 spores mL^{-1} were found to have synergistic interaction with *L. saksenae*

15. Endophytic association of entomopathogenic fungi with rice and cowpea **(CPBI-03-02-05-2018-ACV(04)-KAU-PG)**

Student: Divyashree C
Major Advisor: Dr. Reji Rani, O.P.
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In vitro studies in rice showed that *B. bassiana* colonizes the plant in stem and roots endophytically, through seed soaking method.*In vitro* studies in cowpea showed that *B. bassiana* colonizes the plant in leaf, stem and roots in case of foliar spray method, whereas in seed soaking only leaf was colonized. Endophytic colonization was confirmed by re-isolation from plant parts. Twenty natural fungal endophytes and one bacterial endophyte were isolated from rice and cowpea. Re-isolated fungal entomopathogens were characterised by molecular characterization at Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram.

16. Tolerance of entomopathogenic fungi *Lecanicillium saksenae* (Kushwaha) Kurihara and Sukarno and *Lecanicillium lecanii* (Zimm.) Zare and Gams to abiotic stress. (CPBI-03-02-10-2018-ACV(04)-KAU-PG)

Student: Tejaswi G. Gowda
Major Advisor: Dr. Reji Rani, O.P.
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Among insecticides Dimethoate 30 EC, Flubendiamide 39.35 SC, Chlorantraniliprole 18.5 SC and Thiamethoxam 25 WG were found to be compatible with *L. saksenae.* Three insecticides Thiamethoxam 25 WG, Imidacloprid 17.8 SL and Quinalphos 25 EC are selected to induce tolerance in *L. saksenae.* Among fungicides tested Mancozeb 75 WP, Carbendazim 50 WP, Hexaconazole 5 EC, and Tebuconazole 25 EC caused 100 per cent inhibition upto 10 times lower dose of recommended dose. Two fungicide Azoxystrobin 23 SC and Copper oxychloride 50 WP were selected to induce tolerance in *L. saksenae*. Different regimes of temperature tested between 30-42^{o} C, 100 per cent inhibition was observed at 42^{o}C thus 40 ^{o}C is selected to induce tolerance in *L. saksenae.L. saksenae* tolerant to UV C (253 nm) exposure time of 40minutes, thus same dose was used to induce tolerance

17. Ecological management of coconut root grub*, Leucopholis coneophora* Burm. (CPBI-03-02-03-2018-ACV(04)-KAU-PG)

Student: Melvin Mohan.
Major Advisor: Dr. Santhosh Kumar T
santhoshkumar.t@kau.in

Screening of entomopathogenic fungi, entomopathogenic nematode, botanical insecticides and chemical insecticides were done at laboratory conditions against coconut root grub *L. coneophora*. Biocontrol agents failed to produce significant mortality on the third instar gubs. Laboratory and pot culture experiments on lower instar are remaining.

18. Oil based formulation of Andrographis paniculata (Burm.f.) Nees against sucking pests of chilli. (CPBI-03-02-06-2018-ACV(04)-KAU-PG)

Student: Bhavyasree, K.
Major Advisor: Dr. Santhosh Kumar T
santhoshkumar.t@kau.in

Neem oil, castor oil and pongamia oil based formulations of *Andrographis paniculata*at 5% concentration was found to be highly effective against the *Aphis gossypii* under laboratory conditions.1% 2 %, 3%, 4% and 5% doses of neem oil , castor oil and pongamia oil based formulations of *A. paniculata* were found to be highly effective against *Aphis gosspii, Scirtothrips dorsalis, Bemisia tabaci and Polyphagotarsonemus latus* and they also found to have little or no effect on natural enemies especially coccinellids and spiders under field situations.

19. Biosystematics and barcoding of Pteromalidae (Hymenoptera: Chalcidoidea) of Kerala (CPBI-01-01-01-2018-ACV(04)-KAU-PG)

Student: Manu Govind, K.K.
Major Advisor: Dr. Shanas, S.
shanas.sudheer@kau.in

Purposive sampling of pteromalids from all districts of Kerala has been completed. The collected specimens were preserved in absolute alcohol. Family level sorting of samples have been completed. Specimens have been mounted and taxonomic identification is in progress. Molecular characterisation will also be performed

20. Barcoding and biosystematic studies on hymenopteran pollinators of cucurbitaceous vegetables. (CPBI-03-03-03-2018-ACV(04)-KAU-PG)

Student: Erra Harisha-
Major Advisor: Dr. Shanas, S.
shanas.sudheer@kau.in

Sampling of hymenopteran pollinators of cucurbitaceous vegetables from Thiruvananthapuram and other districts of Kerala has been completed. The collected specimens have been dry mounted and few specimens are preserved in alcohol for molecular characterization. Diurnal activity of pollinators of culinary melon was studied for two seasons. Morphological characterization of collected specimens is under progress. Molecular characterization of selected specimens will be carried out.

21. Melissopalynological studies on stingless bee *Tetragonula iridipennis* (Apidae: Meliponini). (CPBI-06-05-01-2018-ACV (04)-KAU-PG)

Student: Lincy Abraham-
Major Advisor: Dr. Shanas, S.
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Collection of pollen and honey samples for two seasons from 20 locations in Thiruvananthapuram has been completed. Collected samples have been preserved in separate vials. Pollen sample processing, slide preparation and identification of pollen types in the samples is being carried out. Foraging activity of stingless bees in two colonies is being recorded since last 5 months at fortnightly interval. Collection of pollen and honey samples for the third season and its identification has to be done. Studies on foraging activity is being continued.

22. Population dynamics and management of rice yellow stem borer *Scirpophaga incertulas* (Walker) and leaf folder *Cnaphalocrocis medinalis* (Guenee) in south Kerala (CPBI-03-02-09-2018-ACV(04)-KAU-PG)

Student: Sharanappa
Major Advisor: Dr. G. Suja
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Survey was conducted in Thiruvananthapuram and Alapuzha districts and collected the details of leaf feeders of rice.

23. Insecticide mixtures for the management of pest complex in brinjal CPBI-03-03-02-2018-ACV(04)-KAU-PG

Student: Bista Jeba Bakthiyar
Major Advisor: Dr. N. Anitha
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Bioassay studies were conducted using insecticide mixtures in epilachna beetle and brinjal mealy bug.

24. Biological control of the red spider mite *Tetranychus truncatus (*Prostigmata: Tetranychidae) using *Blaptostethus pallescens* Poppius (Hemiptera: Anthocoridae) CPBI-05-01-01-2018-VKA(04)-KAU-PG

Student: Anna Jose
Major Advisor: Dr. Madhu Subramanian,
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Studies on the biology of anthocorid bug revealed that eggs hatch after an incubation period of 5.7 days. Newly hatched nymphs when fed of UV irradiated rice meal moth eggs developed normally with five nymphal instars and become adult in about 14.1 days. Mean longevity of males and females was 40.18 and 52.03 days respectively. Females on an average laid 146.6 eggs. Functional response of final instar nymphsof *B. pallescens* wasstudied by exposing 0-24h old fifth instar nymphs to females of prey mite at seven different densities of 1:10, 1:20, 1:30, 1:40, 1:50, 1:60 and 1:70 for 24h. Highest feeding was observed at 1:60 with a mean consumption of 45.33 mites

25. Susceptibility of red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) to insecticides. (CPBI-03-03-01-2018-VKA(04)-KAU-PG)

Student: Anusree, R. P.
Major Advisor: Dr. Berin Pathrose,
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Resistance ratio of malathion, deltamethrin and DDVP in all strains of *Triboliumcastaneum* were obtained by bioassay. Total protein content and detoxifying enzymes such as carboxyl esterase, glutathione s transferase and cytochrome p 450 were estimated in all strains of *Triboliumcastaneum.* Relative toxicity of bifenthrin, chlorfenapyr, spinosad and flubendiamide were obtained by bioassay in all strains of *Triboliumcastaneum.*

26. Selection for abiotic stress tolerant isolates of *Metarhizium anisopliae* Sorokin (CPBI-05-02-01-2018-VKA (04)-KAU-PG)

Student: Jancy Merlin Johnson
Major Advisor: Dr. Deepthy, K. B,
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Soil samples were collected from five districts namely Thrissur, Palakkad, Alappuzha, Ernakulam and Idukki representing areas of drought, high temperature, acidity, salinity, insecticide and fungicide tolerance. Observations on soil characters like temperature, pH, EC, moisture content of the soil samples were made. Soil temperature of samples were taken using

soil thermometer at the site itself. pH of the samples were estimated using pH meter and electrical conductivity by EC meter. Gravimetric method was followed for calculating moisture content of soil samples. Isolation of *M. anisopliae* was carried out. Three isolates of *M. anisopliae* were obtained from Alappuzha district.

27. Pollination ecology of solitary pollen bees(CPBI-06-01-02-2018-VKA(04)-KAU-PG)

Student: Anusree Padmanabhan P.S
Major Advisor: Dr. Mani Chellappan,
mani.chellappan@kau.in

Roving surveys were conducted in Palakkad and Ernakulam districts of Kerala. Three different species of solitary bee species were identified under the subfamily Halictinae. Species level identification and molecular confirmation of identified species are ongoing. Artificial nests were prepared with available wood and plant materials and placed at cucurbit ecosystems to assess the per cent occupation of nests by solitary bees. Cucurbit crops *viz.,* bittergourd (var. Preethi) and oriental pickling melon (var. Saubhagya) were raised to assess the effect of commonly used pesticides on pollinator bees through exclusion experiment. Activities of solitary pollen bees were also assessed during flowering period to determine the peak foraging time, from 6.00 h to 12.00 h on

28. Mealybugs of vegetable ecosystem and tritrophic interactions of brinjal mealybugs (CPBI-01-02-01-2018-ACV(04)-KAU-PG)

Student: Mithra Mohan
Major Advisor: Dr. N. Anitha,
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Purposive sampling of mealybugs infesting vegetable crops were carried out at different districts of Kerala. Collected specimens were preserved in alcohol for taxonomic studies. Natural enemy fauna including predators and parasitoids were collected and preserved for identification. The ant species associated with mealy bugs were also collected preserved. Taxonomic studies on ants and categorization up to genus level are going on based on the keys published by Bolten (1994)..Host plants of *Phenacoccus* sp., (40)*Coccidohystrix* sp. (4), *Paracoccus* sp.(6), *Ferrisia* sp.(15) were recorded. Genomic DNA was isolated from two species of mealybugs collected from cucurbits and brinjal. The amplified DNA fragments were sent to RGCB, Trivandrum for nucleotide sequencing. A field experiment was carried out in Instructional Farm, Vellayani to study the host genotype-pest-natural enemy interactions of mealybugs infesting brinjal. A total of ten cultivars were selected and screened for their tolerance to mealybug infestation. Interaction of natural enemy species to various genotypes were also noted. Morphological characters like trichome density, plant height, total number of leaves, number of leaves damaged and number of branches were recorded.

29. Bioecology of major coccinellid predators of Kerala (CPBI-01-01-02-2018-ACV(04)-KAU-PG)

Student: Anusree, S.S
Major Advisor: Dr. N. Anitha,
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Purposive sampling was conducted from different agro climatic zones of Kerala covering major agricultural crops such as rice, vegetables, plantation crops, fruit crops, ornamental plants etc. for

collecting coccinellid predators. A total of 21 locations in 9 districts covered and around 30 species of predatory coccinellids were collected. The investigation on the external morphology and identity of these collected specimens are going on. Observations were also recorded on the associated prey species and respective host plants and natural enemies of collected coccinellids. Studies on the biology, prey preference and predatory potential of coccinellids are remaining.

30. Characterization, evaluation and formulation of *Beauveria bassiana* (Bals.) strains against rice bug *Leptocorisa* spp.(Hemiptera: Alydidae).

Student: Nasiya Beegum A. N.
Major Advisor:Dr. Madhu Subramanian,
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Roving surveys was conducted in the rice growing tracts of Alappuzha, Ernakulam Thrissur, and Palakkad districts of Kerala during the milky grain stage of rice crop. Cadavers of rice bugs infected by *B. bassiana*was collected from the field and fungus were isolated. Molecular characterization of fungus was done by sequence analysis of the ribosomal spacer (ITS). ITS region was amplified by PCR using specific primers from genomic DNA extracted from the isolates. Laboratory, pot culture as well as field bioassay were conducted. The compatibility of the *B. bassiana* strain with pesticides was assessed following the poison food technique. Two *B. bassiana* strains were formulated into talc based, oil based and liquid formulations following standard procedures. The formulations were evaluated for their efficacy through a field trial. The shelf life of the formulations were also assessed by checking the viability of the spores at monthly intervals for one year.

Name of Project Coordination Group: (12)
Plant Pathogens and Beneficial Microbes

Compiled by:
Dr. Anita Cherian K., Project Coordinator

Plan & External Aided Projects

Ongoing Projects :29 Nos.

Post Graduate Projects

Ongoing Project:27 Nos.

Ongoing Projects

1. Liquid biopesticides – the way forward for sustainable agriculture

Dr. ReshmyVijayaraghavan,
Asst. Professor.
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Objectives of the project are to study the efficacy of liquid formulations of biocontrol agents, assess the shelf life of biocontrol agents liquid formulation at different time intervals, assess the efficacy of liquid formulation against *Rhizoctonia solani* of cowpea and to standardize the rate of application. In the study 3 liquid formulations at all concentration of *Pseudomonas* showed cent percent inhibition against *Pythium aphanidermatum* & *Phytophthora capsici* whereas 50 % and above was observed with *Fusarium solani.* The 3 liquid formulations at all concentrations of *Trichoderma* also showed cent percent inhibition against *Fusarium solani* & *Phytophthora capsici.* However, 1% concentration of all three media showed cent percent inhibition against *Sclerotium rolfsii* and above 60 % inhibition was observed with *Pythium aphanidermatum* and 50 % with *Rhizoctonia solani*. Shelf life of both the formulations were recorded at monthly intervals and it was observed that M-2 of the both *Pseudomonas* & *Trichoderma* showed a population of 9.8 x 10^9 and 1.5 x 10^9 at 8 months after inoculation (MAI) respectively. Under *in vivo* conditions, all the formulations of both *Trichoderma* and *Pseudomonas* were found effective against collar rot of cowpea when compared to control. Similarly, compared to control all formulations of *Pseudomonas* showed a growth promotion in contrast to the formulations of *Tricohderma*. Under *in vivo* conditions, all the formulations of both *Trichoderma* and *Pseudomonas* were found effective against collar rot of cowpea when compared to control.

2. Commercialization and distribution of liquid formulation of microbial biopesticides for plant disease management.

Dr. Reshmy Vijayaraghavan,
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Mass production cum distribution of quality and economically viable liquid bioformulations to the farming community of Kerala is the prime objective of the project. Along with this, encourage and equip the entrepreneurs in mass production of liquid bioformulations, generation of additional income to the KAU by sale of the liquid bioformulations, promote capacity-building and Human Resource Development at all levels are also focused.

Shelf life of the formulations was recorded at monthly intervals and it was observed that population of the biocontrol agents were found viable at 8 months and the work is being continued. Also due to lack of facilities in the existing biocontrol laboratory of the Department of Plant Pathology on the roof top, a separate storage room was raised (approx. 300 sq.ft) for storage of chemicals, glasswares and equipment related to the project and the Dept. of Plant Pathology. Renovation of the existing room of the department to Molecular Bio-lab for

maintenance, preservation, regular monitoring and periodical assessment as well as checking the quality of the bioformulations. Construction of the biocontrol lab for mass production of liquid formulations of biocontrol agents and the work is in progress.

3. Comparative account of some defense related bio chemicals in resistant and susceptible black pepper varieties/cultivars in response to infection by *Colletotrichumgloeosporioides.*

Dr. Dhanya MK
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Identifying the black pepper varieties/cultivars showing tolerance/resistance to *Colletotrichum gloeosporioides* (pollu disease) and study the defense related biochemical changes in tolerant/resistant ones were the objectives. Surveys were conducted during the report period in major pepper growing areas of the district to identify the black pepper cultivar / varieties having field tolerance to *Colletotrichum.* Based on the survey of the farmers fields the following areas were identified as hot spots for the disease .

- Anakkara (Kattappana block)
- Cumbummettu (Nedumkandam)
- Upputhara (Kattappana block)

Twenty different cultivars of black pepper showing field tolerance to pollu disease were collected randomly from these fields. The collected plants were grouped on the basis of disease symptoms noticed in the field as highly tolerant, moderately tolerant, susceptible and highly susceptible varieties and they were planted and maintained at CRS farm. The details of the type are given below.

Sl.No	Highly Tolerant	Moderately tolerant	Susceptible	Highly Susceptible
1	Jeerakamundi	Varikkamunda-1	Myladimundi	Panniyur-3
2	Narayakkodi	Vellakarimunda-2	Pattanimundi	Arayamundi
3	Jeerakamundi-2	Narayakkodi-2	Marampadathy	Thevamundi
4	Karimunda-3	Karimunda-2	-	Karimunda
5	Vellamundi	-	-	Panniyur-6
6	Appappi	-	-	Panniyur-1

Pure culture of *Colletotrichum gloesporioide* was inoculated into the leaves of established plants maintained in the CRS, farm using pin prick method. The inoculated plants were observed at periodical interval upto five days for symptom development. During this period biochemical defense mechanisms in pathogen inoculated plants were also analysed daily. Peroxidase, Polyphenol oxidase, Chlorophyll content, Carotenoid content and Carbohydrate contents were assayed. The effect of these biochemicals in disease tolerance of plants was variable lightly for different varieties collected during the survey.

4. Development of pest and disease control products from medicinal plants

Dr. Beena S., Dr. Anita Cherian K.
Dr. Ancy Joseph (AMPRS,Odakali)
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Objective of the project is to develop potent eco-friendly pest and disease control products from medicinal and aromatic plants for organic management of pests and diseases in selected vegetables crops. Twenty three medicinal plant extracts were analyzed against *Pythium sp.* The extracts showed various degree of sensitivity to the pathogen *P.aphanidermatum*. Karimanjal, Kacholam and Vayamb showed maximum inhibition of pathogen growth at 0.05% and 0.10 %. Manjal showed maximum inhibition of pathogen growth at 0.15%. Minimum inhibition exhibited by Vaathakodi (0.05%), Mango leaf (0.1%) and (0.15%). Among the twenty three treatments used, Karimanjal, Kacholam and Vayambwere best developed formulation against selected pathogen *Pythium aphanidermatum* at lower and recommended concentrations. Manjal is the best against *P.apahanidermatum* at higher concentration.

5. Establishment of an advanced research centre for crop disease diagnosis and management.

Dr. Anita Cherian K.
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To set up an Advanced Research cum Disease diagnostic centre in the Department of Plant Pathology and to utilize the facility for the benefit of students and farming community of Central and Northern Kerala the project was initiated.

Strengthening research on molecular diagnosis and an ecofriendly management of major crops of Kerala through Post Graduate research projects and to serve as an Advance Centre of Excellence for disease Diagnosis and management and for Post-Graduate education and training in Plant Pathology. Technical advice given to 70 for getting advice on plant disease management measures. PCR amplification using specific primers of infected samples of Sigatoka leaf spot, *Fusarium* wilt of banana, *Chilli leaf curl virus* and *Bhindi mosaic virus*. Infected ornamental plant (*Liriope spicata)* sample was analyzed for the molecular identification of pathogen. Facilities at the centre are being utilized for undertaking research work by Ph.D and M.Sc. students.

Diagnosis of infected samples brought from the farmers, extension officers, teachers and students were carried out and also recommendations for disease management were given. *Mycosphaerella* sp. identified as the pathogen for Sigatoka leaf spot in Banana**.** *Didymella* sp.identified as the pathogen for infection on ornamental plant.

6. Commercial micropropogation of high value crops as per National certification system for Tissue culture plants.

Dr.K.Umamaheswaran,
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Objectives of the project are virus indexing of major crops of Kerala, Detection and Certification of Imported Plants, Development and standardization of kits for detection of Plant Viruses, Production of Disease planting materials. Major Research Highlights were Mass multiplication of Arachnis orchids and Quintal Nendran variety which are in progress. Arachinis orchid variety is in primary stage of hardening and Quintal Nendran variety is in rooting stage of Tissue culture for distribution of disease free banana planting materials to farmers.

7. Development of biocontrol technology for the management of postharvest crown rot of banana.

Dr. Susha S. Thara,
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Objectives of the project were to isolate and identify the fungal pathogens associated with crown rot of banana fruits, to take up the qualitative study of the naturally occurring mycoflora on banana fruit, to evaluate the antagonistic potential of the natural mycoflora and biocontrol agents developed by KAU against crown rot causing pathogen, to understand the mechanism of action of antagonist, to study the effect of selected mycoparasite against important crown rot pathogens on fruit, to evaluate the physical changes and organoleptic properties of the treated fruits by the action of antagonist, to study the survival of biocontrol agent on the fruit and to examine the shelf life of the fruits treated with biocontrol agents. Survey was conducted in Thiruvananthapuram and Alappuzha districts and diseased specimens of Robusta variety banana (Musa AAA) were collected from the local markets in three different locations each and symptoms were studied. Survey was conducted in three locations in Thiruvananthapuram namely - Pallichal, Kazhakkuttam and Varkala. Similarly survey was conducted in Alappuzha district at three different locations namely-Edathua, Cherthala and Kayamkulam. The pathogens were isolated from the diseased fruits and pathogenicity was proved by Koch's postulates. The morphological characteristics of each pathogen were studied and tentative naming was made. The isolates were subjected to virulence rating. The most virulent pathogen from each district was identified and this will be subjected to further molecular characterization. From different locations in Thiruvananthapuram district 4 fungi were isolated. Similarly, from Alappuzha district, 10 fungi and 4 bacteria were isolated from fruit surface. These isolated microflora along with the others yet to get isolated during rest of the survey will be subjected to dual culture against the most virulent pathogen.

8. Evolving strategies for integrated management of diseases of salad cucumber and vegetable cowpea under polyhouse cultivation in terraces.

Dr. Sajeena A
Assistant Professor
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A survey conducted among 30 farmers having polyhouse cultivation. Powdery mildew, rust, anthracnose, mosaic & leaf spots- important diseases of cowpea. Eight vegetable cowpea varieties *viz*., Lola, Vellayani Jyothika, NS 621, Vybhav, Hari rani, Reenu, Githika and Babli were screened to assess their performance in polyhouse on terrace. Powdery mildew was the most serious disease observed during the trial. A comparative trial conducted in open field conditions also revealed that NS 621 was the highest yielding variety. *Cercospora* leaf spot, anthracnose, rust, mosaic and vascular wilt by *Fusarium oxysporum* were the most important diseases observed in open field conditions. Vellayani Jyothika and Gitika were found susceptible to vascular wilt by *F. oxysporum* Stem/ collar rot by *Sclerotium rolfsii* was observed in Gitika in open field conditions for the first time. Thepathogen was isolated and pathogenicity proved. A trial done as part of the M. Sc (Plant Pathology) thesis work revealed that foliar spray at 30, 45 and 60 DAS of sodium bicarbonate (0.5%), fermented extract of *Setaria barbata* (10%) and the fungicide nativo (0.04%) resulted in the maximum yield and minimum incidence of powdery mildew disease as well as the fungal leaf spot observed during the trial.

The integrated strategy for yield maximisation and disease management was Soil application of AMF (KAU) at sowing, soil application of *Trichoderma viride* (KAU) (in cow dung+ neem cake) at 30 DAS and foliar spray of papaya leaf extract in cow urine (1;1:5) at 30, 45 and 60 DAS followed by Soil application of AMF at sowing, soil application of *Trichodermaviride* (KAU) at 30 DAS and foliar spray of fermented weed extract (10%) at 30, 45 and 60DAS and Soil application of AMF at sowing, soil application of *Trichoderma viride* (KAU) at 30 DAS and foliar spray of lime solution (12.5%) at 30, 45 and 60 DAS.

9. AICRP Mushrooms

Dr. Susha S Thara (from 01.04.2018 to 31.08.2018)
Dr. Heera G (from 01.09.2018)
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About 30 specimens of edible and non edible mushrooms were collected and preserved in mushroom museum of AICRP. These include Ganoderma, Marasmius, Dictyophora, Tricholomopsis, Stereum, Mycena, Schizophyllum, Calocybe, Postia, Termitomyces, Boletus, *Cordyceps militarius*, Clitocybe, Tremella, *Agaricus bisporus*, *Oudemansiellacanarii*, *Pleurotus eous*, *Agaricus bingensis, Agaricus xanthodermus,* Volvariella etc. Duplicates were discarded and 20 cultures were sent to DMR, Solan and accession numbers were obtained for 18 cultures which will be presented with photos in the forth coming Annual Workshop. ITS sequencing (DNA barcoding) of three economically important and promising species of mushrooms obtained during the survey were done at RGCB centre and was identified as *Pleurotus djamor,*

Cordyceps militarius and *Oudemansiella canarii* (Highly edible cultivating mushroom). Comparative trials on three strains of *Pleurotus djamor* were laid out. Also three Pleurotus sp viz. *P. florida, P. eous* and *P. sajor-caju* were laid on coconut agro wastes as substrates. Maximum yield of *P. florida* was obtained from coconut leaf stalk. Trials chartered out from DMR were laid out with 8 strains of Pleurotus (PL-17-01 to PL-17-08) . Among these PL-17-05 and PL-17-06 were the best Pleurotus strains. Trials on strains of Pleurotus sp (PL-18-01 to 18-10) were laid out as another set. PL-18-01, PL-18-05, PL-18-10 were found to be better than the other strains.

Spent mushroom substrate and coirpith has been converted to compost using spawn. Several value added products using oyster mushrooms have been formulated in the centre and popularized during trainings conducted under AICRP and as part of Experiential learning course**.**

10. AINP on Soil Biodiversity- Biofertilizers - "Integration of Biofertilizer Technology with farming practices of tribal farmers of Attappady".

Dr. K.S.Meenakumari
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Mass production and distribution of Biofertilizer organisms such as *Azospirillum*, *Azotobacter*, AMF, P solubilizers and PGPR MIX-I developed by KAU for cashew , milletsand vegetables cultivated by tribal farmers. Field trials at different locations of Attappady to demonstrate the beneficial effects of microbial inoculants. Training to create awareness on beneficial aspects and method of application of biofertilizers to tribal farmers, SHG's and Extension officials. Publication of bulletins in vernacular language for dissemination of biofertilizer technology among tribal farmers. Isolation and evaluation of native efficient strains of biofertilizer organisms such as *Azospirillum*, *Azotobacter* and *Rhizobium* from Attappady hill tract. A consortium of NPK biofertilizers (PGPR Mix- I) developed by Kerala Agricultural University was mass multiplied and distributed to selected farmers of Attappady area. During 2018-19, a total quantity of 650 kg of PGPR Mix -I and 10 kg of AMF was distributed to 650 tribal farmers engaged in the cultivation of vegetables, pulses, banana, sorghum, groundnut, ragi etc. One kg each of PGPR Mix- I was distributed uniformly to the selected farmers. A technical leaflet in Malayalam was published covering different aspects of biofertilizers for the benefit of farmers and it was distributed to the farmers during the training. During 2018-19, in order to demonstrate the beneficial effect of the consortium of Biofertilizers (PGPR Mix-I) field trials were laid out at different locations of Attappady. Brinjal, Chilli and ground nut were chosen as the target crops. There was significant increase in height of chilli plants in PGPR Mix –I applied plots compared to control. Significant increase in the number of flowers per plant was also obtained due to PGPR Mix –I application. However, the observation on number of branches per plant was not significant. The yield per plot was also significantly superior to the control plots.

11. Centre of Excellence in Microbial Technology

Dr. K.S. Meenakumari,
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To act as a nodal center for catering the technological requirement of the State by supplying mother cultures of biocontrol and biofertilizer organisms, development of Liquid formulations of Biocontrol agents and Biofertilizers-PGPR's, evaluation of shelf life of the liquid and bead formulations developed and its efficiency and conducting training for creating awareness on microbial technology to farmers, extension officials, private entrepreneurs, job trainees were the objectives.

The Centre is functioning as a nodal center of the State by providing mother cultures of Biocontrol agents and biofertilizers, catering the technological requirement of all the production centers in Kerala. Liquid formulation of consortium of biofertilizers- PGPR Mix-I was developed and the shelf life studies revealed significant population even after nineteen months of storage. The study is being continued. The efficiency of the liquid formulation was evaluated under field conditions in Amaranthus at College of Agriculture, Vellayani and in Paddy at FSRS, Karamana.

In Amaranthus, the plant height, fresh weight of shoot and root were significantly superior in plants treated with liquid formulation of PGPR Mix- I compared to control and talc formulation. In paddy, the total number of tillers and grain yield in treatments with liquid formulation of PGPR Mix –I were significantly superior to the untreated control. Twenty isolates of Pink Pigmented Facultative Methylotrophs (PPFMs) were selected based on preliminary studies for evaluation of their drought tolerance efficiency. The isolates were screened by using paper towel method for water stress tolerance under *in vitro* conditions using mannitol for inducing osmotic stress. Observations on germination percentage (%), shoot length (cm), root length (cm), shoot fresh weight (g), shoot dry
weight (g), root fresh weight (g), root dry weight (g) and seedling vigour index were recorded. Five promising isolates were selected for further studies.

12. Biotech Kerala Revolving fund

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Mass multiplication of microbial inoculants (Biofertilizers, Biocontrol agents, Organisms for waste management), quality analysis of marketed microbial products, training on microbial inoculant technology are the objectives of the project. Total Production (kg) of Biofertilizers, Biocontrol agents, Organisms for waste management is 19582.447 with 17,02,668 rupees turn over during April 2018 to March -2019

13. Establishment of an Advanced Research Centre for Plant Disease Diagnosis

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The objectives are to establishment of an Advanced Research Centre for Plant Disease Diagnosis, to establish a referral quarantine facility for the State, whenever Government need additional facilities, consultancy / Advisory Services, training for Scientists working in this field of specialization, Maintain a type culture collection and cryptogrammic herbarium for reference during diagnosis and production of antiserum for major plant pathogens.

More than 60 farmers visited the lab for getting advice on plant health management measures. In collaboration with the Karshaka Santhwanam programme field visits and advisory services through mobile phones and internet facilities were also undertaken. Conducted training for 27 Agriculture officers (RATTC kazhakootam) on 31/8/18. Training for 36 Agriculture officers on 31/10/2018 (Crop health management block level training Attingal Kollam)& for 21 Agriculture officers on 29/11/2018. Training for 31 SC farmers by ATMA with dist training on JAN 17 2019 (Pulimath Block) &Training on pest scout and surveillance on 24/01/2019. 23 Infected orchid samples(PEQ from Thrissur, Trivandrum, Kottayam, Cherthala) were analyzed for the presence of virus. Facilities at the centre are being utilized for undertaking research work by Ph.D and M.Sc students of various departments of this University. Presently more than 10 research scholars have utilized this facility. 3 farmers visited the centre for disease diagnosis and management. Consultancy services through mobile and mail. Conducted seminar on 14-03-2019 at Inter University centre for Genomics & Gene Technology Department of Biotechnology. Topic : National seminar on viral genomics and its implication in viral diagnosis and disease control. Conducted seminar on 18.03.2019 to 25.03.2019 at ARCPDD centre Topic: Training on integrated pest and disease management on vegetables **(**Vegetable Varieties, Precision system of vegetable cultivation (open and polyhouse), Pests of vegetables, Nutrient management in vegetable cultivation, Diseases on vegetables, Nematode problems and their management, Valedictory Function).

14. Identification of pathotypes of red rot pathogen (AICRP)

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To gather information on the major pathotypes of red rot pathogen from the different areas /zones the project was initiated. Three new isolates *viz*., CfC24 (Thandavarayanpattu), Cf 06022 (Pennadam), Cf 0265 (RK Pet Thiruthani Coop Sugars) and five old isolates *viz*., CfV 09356 (Keerangudi), Cf 86027 (Nathakadu), Cf 2001-13 (Perampakkam), Cf 06022 (Kuthalam), Cf 99006 (Mundiampakkam) along with the designated pathotypes for Peninsular zone CF06 and Cf94012-0 were inoculated and tested for red rot resistance against nineteen differentials by plug

method of artificial inoculation. The disease development on different differentials indicated that, among the isolates, CfV 09356 (Keerangudi), Cf 2001-13 (Perampakkam), Cf 06022 (Kuthalam) and Cf 0265 (RK Pet Thiruthani Coop Sugars) behaved differently from the standard pathotypes CF06 and Cf94012-0. These isolates exhibited more virulence than standard pathotypes. All the other isolates showed almost similar reactions to that of CF06 and Cf 94012-0.

15. Evaluation of zonal varieties for resistance to red rot

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Objective was to gather information on the relative resistance to red rot of the entries in zonal varietal trials of the respective zones.

In Advanced Varietal Trial (1st Plant), out of the seventeen entries, three varieties *viz.*, Co 13013, CoN 13073, CoSnk 13101 exhibited R reaction, seven varieties *viz.*, Co13002, Co13009, CoN13072, MS 13081, CoSnk 13103, CoSnk 13106, PI 13132 exhibited MR reaction, six varieties *viz.*, Co 13003, Co 13004, Co 13006, Co 13008, Co 13014, Co 13020, exhibited MS reaction, one variety *viz.*, Co 13018 exhibited S reaction against the standard isolate CF06 in plug method of inoculation. Out of the seventeen entries tested against Cf94012-O, by plug method of inoculation, one variety *viz*., Co13009 showed R reaction, ten varieties *viz.*, Co13002, Co13003, Co13008, Co13013, CoN13072, CoN13073, MS 13081, CoSnk 13101, CoSnk 13103, PI 13132 showed MR reaction, four varieties *viz.*, Co 13004, Co 13014, Co 13020, CoSnk 13106 showed MS reaction, two varieties *viz.*, Co 13006, Co 13018 showed S reaction. In Nodal cotton swab method of inoculation, except five varieties *viz*., Co 13004, Co 13006, Co13014, Co 13018, Co 13020 showed resistant reaction to both CF06 and Cf94012-0.

In Advanced Varietal Trial (IInd Plant), Out of the eight entries tested in AVT (IInd Plant) with the standard isolate CF06, MR reaction was recorded in two varieties *viz.,* Co 12009 and Co 12019, MS reaction in two varieties *viz*., Co 12008, Co 12012 and S reaction in four varieties *viz*., Co 12007, Co 12024, CoM 12085, VSI 12121 by plug method of inoculation. Againstthe isolate Cf94012-O, two varieties *viz.*, Co 12008, Co 12012 recorded MR reaction, three varieties *viz.*, Co 12009 and Co 12019, VSI 12121 recorded MS reaction and three varieties *viz.*, Co 12007, Co 12024, CoM 12085 recorded S reaction in plug method of inoculation. InNodal cotton swab method of inoculation, five varieties *viz.*, Co 12007, Co 12008, Co 12009, Co 12012, Co 12019 showed resistant (R) reaction to both the isolates CF06 and Cf94012-O.

16. Survey of sugarcane diseases naturally occurring in the area on important sugarcane varieties

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Gather information on the diseases naturally occurring in the area on varieties for compiling an all India disease status report yearly was the objective. During the current year (2018–19), the most predominant diseases were and the foliar diseases *viz*., ring spot, rust and sheath blight. But

they were not found in such a severe form to cause any drastic yield loss. Proper field sanitation and detrashing for 2-3 times controlled the foliar diseases. The other diseases observed were Pokkah Boeng and mosaic. But none of the diseases were in a severe stage to cause any drastic yield decline.

17. Development of IDM package with special emphasis to biorationales for the management of leaf blight diseases of amaranthus under homestead cultivation (State plan)

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Formulation of an integrated and healthy disease management package for combating leaf blight diseases of amaranthus under homestead cultivation in the tract was the objective.

The results indicated that all the treatments were significantly superior over control in reducing leaf blight disease in amaranthus. Among the different biocontrol agents evaluated, soil drenching and foliar spray with PGPM @ 2% (T5) recorded least disease intensity (15.5%) whereas in control the disease severity recorded was 32.8%. It was followed by the treatment 6 ie., soil drenching and foliar spray with PGPR II @ 2% where PDI recorded was 16.8%. Soil drenching and foliar spray with chitin enriched *Pseudomonas* @ 2% also recorded significantly less disease severity (17.8%). The effect of these biocontrol agents was found comparable with the chemical check.

18. All India Network project on Soil Biodiversity and Biofertilizers.

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A total of 1325 kg of biofertilizers including *Azospirillum lipoferum*, *Azotobacterchroococcum* and Plant Growth Promoting Rhizobacteria (PGPR) Mix I were supplied to different tribal settlements in Wayanad**.** To create awareness among farmers, thirteen training programme on biofertilizers were organized in different locations of Wayanad district. A total 357 of tribal farmers participated in the training programme. Field experiments were conducted in black pepper and ginger for evaluating the efficiency of three novel nitrogen fixing bacteria obtained from the rhizosphere of black pepper from Wayanad. In black pepper, among the different biofertilizers used, *Paenibacillus* recorded increase in growth parameters and yield. Similarly in ginger also inoculated plants showed increase in growth parameters and yield compared to uninoculated plants. Effect of stress tolerant nitrogen fixers including two actinobacteria (*Microbacterium* and *Cellulosimicrobium*) along with *Paenibacillus* on plant growth and physiological status under stress was evaluated usingtomato (variety Anagha) as a test plant under controlled condition. Improved physiological properties as well as growth parameters were observed in inoculated plants compared to control. A PGPR consortium was developed by combining *Azotobacter*, *Azospirillum*, *Microbacterium* and *Cellulosimicrobium* after testing the

compatibility. Effect of thisconsortium on growth promotion in amaranthus and brinjal were tested. It was observed that PGPR consortium increased both growth parameters and yield in both the crops compared to control.

19. Centre of Excellence in Microbial Technology (State Planning Board)

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Liquid formulation of biofertilizers and biocontrol agents *viz*., *Azospirillum* sp., *Azotobacter* sp., *Rhizobium* sp., *Pseudomonas* sp. and *Trichoderma viride* were impregnated with coir pith and survival studies were carried out by serial dilution and plating technique at 15 days intervals. It was observed that all the biofertilizers and biocontrol agents were surviving in coir pith as indicated by the growth in respective medium. Regular consultancy services on waste management and use of biofertilizers and biocontrol agents were given to farmers visiting the Department (266 no.s). Quality analysis was done in the Department of Agricultural Microbiology before selling of biofertilizers and biocontrol agents. For *Pseudomonas fluorescens, Azotobacter, Azospirillum* and *Rhizobium* more than $2x10^8$c.f.u/g cells and for *Trichoderma viride* , more than $2x10^6$c.f.u/g cells were maintained.

Cultivation of *Spirulina* was initiated at the Department of Agricultural Microbiology. Mother culture of *Spirulina* was purchased from Shibin exports, Chennai. Different media *viz*., BG11, Zarrouk's and Fog's medium were initially used for cultivation. Protein content of *Spirulina* was estimated in BG11, Zarrouk's and Fog's medium. A higher protein content and growth was observed in Zarrouk's medium and fu rther standardization was done. A temperature of 32^0 C was found to be optimum for the growth and multiplication of *Spirulina*.

20. Utilization of human hair as fertilizer (State Plan)

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Human hair waste, treated using chemical and thermal methods were given as foliar spray on bhindi (variety: Aruna) at 5 X and 10 X concentrations. Human hair waste, treated using chemical and thermal methods were given as foliar spray on bhindi (variety: Aruna) at 5 X and 10 X concentrations. In 5 X and 10 X treated plants, 21% and 17 % increase in total yield were observed respectively when compared to control. Hair nutrient solution was prepared at two different concentrations i.e, 5 X and 10 X and sprayed in amaranthus. Application of hair nutrient solution in amaranthus resulted in 15 and 10 percent increase in the weight of the plant and number of roots respectively at harvest. The apparatus for production of fertilizer from human hair was assembled with the addition of mechanical stirrer and inlet for acid and alkali.

21. Native actinobacteria for exploitation in biosolid waste management

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Soil samples were collected from Onattukara, Kayamkulam, Palakkad, Chalakkudy, Ambalavayal, Madakkathara and Vellanikkara for the isolation of actinomycetes. A total of 75 actinobacterial isolates were obtained and were further subjected to *in vitro* screening for its capacity for degradation of cellulose, protein, lipid, starch, pectin, lignin and chitin. Quantitative assay for enzyme production was done for the isolates and the efficient isolates in the respective categories were selected. Isolate EK9K1 was found to exhibit degradation of cellulose, starch and protein. Various other isolates including PR1, A2OK3 and Unk-Act3 were found to degrade cellulose and lipid.

22. Biological Management of slow decline in black pepper (PEP/CP/5.6) - AICRP

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The experiment was started during 2014. During 2018-19 three treatments T1, T2, T3 were significantly superior in reducing yellowing due to slow decline disease in black pepper. Soil application of *Trichoderma viride* followed by soil drenching with *P.fluorescens* @ 2% (T2) recorded minimum disease incidence (2.77%) but maximumyield of 2.19 kg/vine and maximum spike number (650)was for Soil application of *Trichoderma viride* + Neem cake @ 2kg/vine(T1). Number of spikes and green berryyield were not significantly different among treatments.

23. Studies on management of *Phytophthora* causing foot rot in black pepper (PEP/CP/5.7)- AICRP

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The Percentage Disease Incidence was minimum in T3 (Application of fosetyl Aluminium amended fertilizer brickets at the onset of rain and post monsoon) T5 (RIL070/F1 -72% WP 100ppm soil drenching). The biometric characters *viz.,* plant height and no of leaves didn't not show significant variation among different treatments.

24. Strengthening of six production units of KAU-(GOK Plan)

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Trichoderma, *Pseudomonas* and VAM have a production of 802 Kg, 537 Kg and 1950 Kg respectively with a total amount of 2,76,106 rupees.

25. Studies on sheath blight and false smut diseases of rice in Kuttanad region and their management by a PGPR consortium

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The objective of the project is development of consortium using the potential rhizobacterial isolates maintained in the station for the control of sheath blight and false smut pathogens in rice. Four efficient *Bacillus* cultures namely B 15, B17, B 33 and B 42 isolated in two different projects were found effective against sheath blight, sheath rot, BLB and false smut pathogens. The field experiment was conducted at Rice Research Station, Moncompu during Rabi 2018-19 with nine treatments of four replications. The treatments were B 15, B 17, B 33, B 42, B15+B 17+B33+B42, PF 1(KAU culture) with standard check fungicide Tebuconazole 50% + Trifloxystrobin 25% (Nativo 75 WG) and Copper hydroxide (Kochide 101 77 WP). The biocontrol agent was applied as seed treatment, soil (35 DAS) and foliar application (55 DAS) as prophylactic control of sheath blight and false smut diseases. The results of Rabi 2018-19 showed that all biocontrol treatments and standard check fungicide were equally effective against sheath blight and false smut disease and recorded highest yield in the plots treated with consortium of four Bacillus cultures (7384 kg ha^{-1}) followed by B 15 (7030 kg ha^{-1}) and B 17(6698 kg ha^{-1}).

26. AICRP on Biological Control of Crop Pests.

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To test the efficacy of promising fungal and bacterial isolates for management of anthracnose disease in cowpea was the objective. Screening of promising fungal and bacterial isolates such as *Pichia guilliermondi*, *Hanseniaspora uvarum*, *Trichoderma harzianum, Trichoderma viride* and *Pseudomonas fluorescens* for management of anthracnose disease in cowpea. It is found that the fungal isolate *Hanseniaspora uvarum* (Y-73) gave 59 percent control of the disease and was on par with chemical check. The efficacy of *Trichoderma harzianum* (Th-3), *Trichoderma viride* (KAU strain) and *Pseudomonas fluorescens* (KAU strain) were the next best effective treatments.

27. Development of technologies including alternatives for banned pesticides for the management of pests and diseases of major crops in Kerala.

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Objective was to develop eco-friendly management measures for the control of amaranth leaf blight caused by *Colletotrichum gloeosporioides* and *Rhizoctonia solani*, the major diseases threatening the cultivation of amaranth in the State.

Based on the pooled result of the experiments conducted at different centres and farm trials, the following recommendations were included in POP. For vegetable production, foliar spray and soil drenching of turmeric powder (5 g) - baking soda (1 g) mixture in 1 l of water could control amaranth leaf blight and is followed by CDS supernatant 2% + *P.fluorescens* - 2% (soil drenching and foliar spray) or foliar spray of *P. fluorescens* - 2%and soil drenching of *T. viride* - 2% at 20 and 40 days after sowing. The experiment was conducted at CRS Balaramapuram, College of Agriculture Vellayani, RARS Kayamkulam and CoH Vellanikkara. The higher dose of copper hydroxide (0.3%) did not cause any phytotoxicity and this treatment gave the best control against amaranth leaf blight.

To develop eco-friendly management measures for the control of Fusarium wilt, Rhizoctonia root rot and web blight and Pythium collar rot of vegetable cowpea, serious threats in the cultivation of cowpea in the state. Residues of hexaconazole and carbendazim were detected only upto 3 days after drenching in normal recommended dose (2 ml/ l and 3 g/l respectively) whereas its presence was detected upto 5 days in the double the recommended dose (4 ml/l and 6 g/l respectively) (Table 1 and 3). Residue of flusilazole was detected only up to 3 days after drenching in both the normal recommended dose (1 ml/ l) and double the recommended dose (2 ml/l) (Table 2). Based on the residue analysis results of 2015-16, as a common recommendation, the pods / fruits of vegetable cowpea can be harvested for the consumption purpose at 3 days after soil drenching with the recommended dose and 5 days with the double the recommended dose. To develop eco-friendly management measures for the control of downy mildew and powdery mildew diseases of cucurbits (bitter gourd and snake gourd) seriously affecting the cultivation of cucurbits in the state. The higher dose of azoxystrobin (0.3 %), pyraclostrobin (0.1 %) and cymoxanil (0.4 %) did not cause any phytotoxicity. The data analysis is progressing. Farm trials are being carried out in farmer's field in three different panchayaths viz. Pallichal, Kalliyoor and Venganoor in Thiruvananthapuram dist. for 2015-16. The residue analysis with azoxystrobin revealed that after 3 days of spraying at recommended dose, the residue of azoxystrobin in the fruits was BDL at 5 days of spraying in both experiments. But at double dose, the fungicide could persist infruits even upto 10 days of spraying. The residue analysis with other fungicides are progressing.

For the management of powdery mildew disease of cucurbits (bitter gourd or snake gourd), experiments were conducted at Instructional Farm of College of Agriculture Vellayani. The higher dose of wet table sulphur (0.4 %) and tebuconazole (0.2 %) did not cause any phytotoxicity. The data analysis is progressing. These fungicides were selected as they gave the best results in powdery mildew disease management in cucurbits. To develop eco-friendly management measures for the control of Cercospora leaf spot of bhindi which is becoming a serious problem affecting the cultivation of bhindi in the state. The residual studies of fungicides are progressing for 2017-18 with pesticide residue lab.

28. Synergism in defense and growth: Exploration of a root endophytic fungus *Piriformospora indica* for the management of *Fusarium* wilt in banana with enhanced crop production.

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Survey was undertaken at ten different panchayats in Thiruvananthapuram district to determine incidence and severity of *Fusarium* wilt in banana caused by *F. oxysporum f.sp. cubens (Foc)*. The incidence and severity of the disease were determined. The isolated cultures of *Foc* are maintained in Potato Dextrose Agar (PDA). Other pathogenic micro-organisms causing diseases in banana has also been isolated and maintained in the lab. Pure cultures of *Foc* were also collected from Banana Research Station, Kannara and College of Horticulture Vellanikkara. The virulence of these cultures is maintained by periodic sub-culturing, inoculation and re-isolation.

Antagonistic properties of *P. indica* were screened against *Foc* and other pathogens infecting banana through the dual culture technique. *P. indica* could antagonize different foliar pathogens of banana through antibiosis, lysis, coiling and overgrowth. *In vitro* studies revealed that *P. indica*-water diffusible exudate(s) and culture filtrates were inhibitory to different fungal pathogens of banana. The colonization and priming of *P.indica* on roots of TC banana seedlings were standardized in major banana varieties viz. nendran, red banana, robusta, quintal, monthan etc. The optimum stage of TC plants for priming of *P. indica* was also standardized. *P. indica* could promote growth of TC banana plants under *in vitro* and *in vivo* conditions by increased biomass of roots and shoots. *P. indica*-colonized or -primed TC plants could produce more number of leaves with increased leaf area. Evaluation of the *P. indica*-primed banana seedling against the burrowing nematode *Rhadopholus similis* and different foliar pathogens is progressing.

In vitro compatibility study of *P. indica* with different contact and systemic pesticides(viz. carbosulfan, chlorpyriphos, methyl parathion, imidachlorpid, Flubendamide, etc. at 100, 500, 1000, 1500 and 2000 ppm) used in banana cultivation is progressing. Initial results indicated that *P. indica* is compatible with most of the insecticides used in bananacultivation. Efficient methodology for the mass multiplication of *P. indica* has been standardized. The best substrate for the growth of *P. indica* including potting mixture has also been standardized. The experiment

on assessing the shelf life of *P. indica* on different substrate is progressing. Standardization of the co-cultivation and priming of *P. indica* with major banana varieties viz. nendran, red banana, robusta, quintal and monthan. Antagonistic properties of *P. indica* and its water diffusible exudates against *Foc* and other foliar fungal pathogens infecting banana. Growth promotion of *P. indica* in TC banana plants under *invitro* and *in vivo* conditions was established. *P. indica*-colonized or -primed banana TCplants produced increased biomass of roots and shoots, and more number of leaves with increased leaf area. *P. indica* is compatible with most of the insecticides used in the banana cultivation at different concentrations. Efficient methodology for the mass multiplication of *P. indica* has been standardized. The best substrate for the growth of *P.indica* including the potting mixture has also been standardized. These are the newfindings from the project.

29. Investigation on etiology of yellowing disease in coconut (GoK Project)

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Identified different yellowing / mid whorl yellowing affected palms in IF Vellayani and Trivandrum district. Correlated the severity of the symptoms with the yield loss.

PG Projects

Ongoing PG Projects

1. ***Piriformospora indica* and new generation fungicides for the management ofanthracnose incited by *Colletotrichum gloeosporioides* (Penz.) Sacc. in vegetable cowpea"**

P. Amrutha (2017-21-022)
Major advisor : Dr. Joy M.

The research was carried out with an objective to study the host range of *C.gloeosporioides* (Penz.) Sacc. causing anthracnose disease of vegetable cowpea and toevaluate the efficacy of fungal root endophyte *P. indica*and new generation fungicides for its management. Thus, surveys were carried out in different agro-climatic zones like northern zone (Kasargod), central zone (Thrissur), high range zone (Idukki), special problem zone (Kumarakom) and southern zone (Trivandrum and Kollam) for the collection of diseased cowpea plants incited by anthracnose. The per cent disease index and size of the lesions on cowpea plants was calculated. The samples were brought to laboratory and isolated under artificial conditions based on standard protocol. Pathogen obtained in the culture was purified by single spore isolation and the cultural and morphological characteristics were studied. Cowpea seeds were co-cultivated with *P.indica*to standardise the time taken for the colonisation of the roots under *in vitro* conditions. The best medium for *P. indica* multiplication and colonisation under *in vivo* conditions is in progress.

Host range, varietal evaluation, fungicidal studies, pot culture, field studies and biochemical and molecular characterisation is in progress.

2. *Piriformospora indica* and its water diffusible exudates for the management of chillianthracnose incited by *Colletotrichum capsici* (Syd.) Butler and Bisby(ongoing)

Elizabeth T Jojy (2017-21-026)

Major advisor : Dr. Joy M.

A survey was conducted and diseased specimens of chilli were collected from districts representing the fiveagro climatic zones of kerala namely northern zone (Kasargod), high range zone (Idukki), central zone (Thrissur), special problem zone (Kumarakom) and southern zone (Trivandrum). Lesion size and Percent disease index (PDI) wascalculated for each zone and the highest PDI was recorded at Kasargod district. The collected specimens were isolated in the laboratory and brought into pure culture. Morphological and cultural characters of the obtained isolates were studied. Chilli seeds were co-cultivated *in vitro* with *P. indica*to study colonization in the seedlings at different time intervals. Different proportions of vermiculite, coirpith compost and maize flour were inoculated with *P. indica* to record the mixture that gives maximum colonization in the *invivo* study. Varietal screening, *in vitro* evaluation of *P. indica*-water diffusible exudates(Pi-WDE) and *P. indica*-primed seedlings against *C. capsici*, *in vivo* evaluation of *P.indica*-primed seedlings against *C. capsici* in pot culture and field conditions, biochemical and molecular studies is in progress.

3. Characterization of viruses infecting small cardamom (*Elettaria cardamomum* Maton) and production of disease free plants. PPBM-01-00-09-2018-ACV (05)- KAU-PG

VangalaBhavana(2017-11-152)

Major advisor : Dr. Radhika N. S.

The objectives of research work are collection of infected samples as a part of survey, observing the viral symptoms on collateral hosts, performing Enzyme Linked Immunosorbent Assay(ELISA), Dot Immune Binding Assay(DIBA), RNA isolation and Reverse Transcriptase Polymerase Chain Reaction(RT-PCR) with specific primers and production of disease free plants through tissue culture. Survey for viral diseases in cardamom was conducted in two major cardamom cultivated blocks in Idukki district viz., Kattapana and Nedumkandam .Samples were collected with the symptoms of *Cardamommosaic virus and Banana bract mosaic virus*.. ELISA and DIBA were done in order toconfirm the presence of virus. RNA isolation was done with Trizol method. The products were converted to cDNA and observed for the bands under gel documentation.PCR amplification with specific coat protein primers of *Cardamom mosaic virus* and *Bananabract mosaic virus* is in progress. Infected plants rhizomes were collected and themeristems were inoculated into MS media supplemented with hormones. Shoots have proliferated. Transferring to rooting media, hardening and finally testing the plants for the presence of virus by ELISA and PCR method is in progress.

4. Diversity of begomo viruses infecting major vegetable crops

Bincy S. Basheer(2017-11-034)

Major advisor : Dr. K. Umamaheswaran

Begomoviruses infecting tomato (*Tomato leaf curl virus*), okra (*Bhindi yellow vein mosaicvirus*) and pumpkin (Pumpkin yellow vein mosaic virus) were collected fromThiruvananthapuram district and it is found that vulnerability index of ToLCD in tomato is 62.3, BYVMD in okra is 65.4 and PYVMD in pumpkin is 76.7; while all crops showed disease incidence of more than 95%. Under symptomatological study different symptoms shown by plants as a result of infection by the virus involved was recorded like vein clearing, stunted growth, yellowish or bleached leaves and fruits, and vein thickening in case of BYVMD in okra. Upward cupping and curling of leaf, purplish discoloration of shoot tip, stunted growth, slight yellowing of leaf and reduced fruit size and production in case of ToLCD in tomato and in case of PYVMD symptoms included vein clearing, vein thickening, bleached appearance of leaves, mosaic symptom reduced fruit size and stunted growth. Transmission study of viruses was done in their respective crops. Graft transmission study of BYVMV in okra when done typical symptoms of BYVMD appeared in the healthy root stock of the graft about 14 days after grafting, similarly in tomato also typical symptoms of ToLCD appeared about 12 days after grafting was done. Like-wise insect transmission study when done on okra and tomato and it was found that symptoms started appearing after 20-25 days after inoculating healthy plants with viruliferous whiteflies. When seed transmission study of viruses were done on seeds collected from diseased okra and plants showed lack of transmission of virus through seeds. Cross-infection study of the ToLCV and BYVMV when done on the three crops showed that no cross-infection is possible since there is lack of any type of symptoms in the crops. Immunological detection of viruses were done using ToLCNDV antiserum and it was found that all infected crops gave and optical density reading of more than 2, indicating presence of virus. Similarly, isolates of viruses collected from different places were isolated and amplified in PCR using two universal primers of begomoviruses namely DENG (Forward and Reverse) and AVAC and the viruses were confirmed to be begomoviruses since all the isolates gave 500bp (DENG) and 550bp (AVAC) bands when the PCR products were observed in Gel documentation system after gel electrophoresis. The confirmed PCR products were sent for sequencing of coat protein genes. Sequencing of four isolates have been done till now.

5. Management of *Blackeye cowpea mosaic virus* using natural products from botanicals and the fungal root endophyte *Piriformospora indica*.

Chandran K (2017-11-065)

Major advisor : Dr. Joy M

First objectives of research work done was maintaining of *Blackeye cowpea mosaic virus* in cowpea variety Sharika (from Dept. of Vegetable Science) and local lesion host *Chenapodium amaranticolor* (from Dept. of Plant Pathology). The fungal rootendophyte *Piriformospora indica* (from Dept. of Plant Pathology) is maintaining in PDA by continuous culturing in every ten days. The virus was detected by serological method of Enzyme Linked Immunosorbent Assay

(ELISA) and Dot immune binding assay (DIBA) and the intensity of colour development was measured. The RNA of viral genome was extracted by TRIsol method, it was converted into C-DNA and observed in gel document unit. With respect to screening of AVP'S, anitiviral principles from plants like *Phyllanthus niruri, Boerharvia diffusa, Prosopis juliflora, Punica granatum, Eucalyptus globulus, Chinnamomum cassia, Phyllanthus emblica, Moringa olerifera and Vitex trifolia*in were evaluated by pre-inoculation and post-inoculation at 0.25, 0.5 and 1.0%concentrations (w/v). The colonizing pattern of *Piriformospora indica* with cowpea and *Chenapodium amaranticolor* was studied. The protocol prescribed by Johnson *et al*.,(2013) was followed for *in vitro* studies. The transplanted seedling carried *in vivo*, the fungus and colonisation on cowpea roots was 46% in 14 days after sowing and in *Chenapodium,* it colonised 70% of roots after 21days after sowing. Screening of *Datura metel* and water diffusible exudates of *P. indica*, physical and chemical property of besttwo AVP's and the evaluation of the best treatment applied to cowpea plants and the various mechanism like total soluble protein, total phenol, peroxidase, polyphenol oxidase, phenylalanine amonialyase and the pathogenesis related protein by SDS-PAGE is in progress.

6. Management of postharvest crown rot of banana using biocontrol agents and essential oil.

Deepa R. Chandran (2017-11-011)

Major advisor : Dr. Susha S. Thara

The fructospheremicroflora was isolated from the healthy banana fruits by serial dilution of fruit surface washing and subsequent plating. 22 fungal isolates and 11 bacterial isolates were obtained –

4 fungi from Thiruvananthapuram, 10 fungi and 4 bacteria from Alappuzha, 3 fungi and 3 bacteria from Pathanamthitta, 2 fungi and 1 bacteria from Palakkad and 3 fungi and 3 bacteria from Wayanad.

When the 22 fungal as well as 11 bacterial isolates were subjected to dual culture, fungal isolates namely W3B, K1A, A3B and A1A was observed to have inhibitory effect on the growth of pathogen (T2C) with 55.55, 33.33, 22.22 and 11.11 percentage of inhibition respectively. Inhibition of mycelia growth of pathogen was noticed in certain KAU isolates i.e., 44.44, 40, 11.11 and no percent inhibition respectively by *Trichoderma harzianum, T. viride, Pseudomonas fluorescens* and *Bacillus subtilis* respectively.

7. Ecofriendly management of major fungal foliar diseases affecting yard long bean in polyhouse

Deepthi S. Nair (2017-11-053)

Major advisor : Dr. Sajeena A.

Visited 25 farmers cultivating in polyhouse condition in Thiruvananthapuram district. Noted foliar disease incidence and severity from the surveyed polyhouses. Identified major prospects in polyhouse cultivation. In varietal trial experiment, the varieties tested includes Lola, Vellayani Jyothika, Gitika, VS 50 and NS 621. Recorded foliar disease incidence and severity and

compared the same within these varieties. Yield parameters and other biometric observations were recorded and compared. A novel leaf spot disease with a characteristic white spot having brown margin were observed in a severe form in all the varieties tested. The fungus was isolated and pathogenicity test was proved. Identification of the fungus is in progress. Also, tested the *in-vitro* mycelial inhibition of the fungus using poissoned food technique. Cent percent mycelial inhibition was observed for 0.5% sodium bicarbonate, 10% weed extract and the combination of 10% egg lemon juice extract plus 10% weed extract and the treated control Tebuconazole 50% + Trifloxystrobin 25% WG @ 0.04%. Samples of weed extract, combinations of egg lemon juice extract plus weed extract were sent for analysis of major nutrients at radiotracer lab, Vellanikkara. Highest yielding NS 621 was found to be susceptible to both powdery mildew and novel leaf spot disease. And hence advanced for *in vivo* studies in polyhouse at IFSRS, Karamana using the treatments specified in the technical programme.

8. Development of improved strain in Oyster mushroom (*Pleurotus*spp.)

Jyothi K. R. (2017-11-060)

Major advisor : Dr. Susha S. Thara

Three native isolates were collected from the mushroom unit of Instructional farm, Vellayani. Macroscopical observations of the Sporocarp *viz.* Pileus, stipe, gills were done. Single spores from the natives isolates were obtained and crossing was done to obtain the respective dikaryon.

***9.* Seed biopriming and spraying at fruit set for the management of chilli anthracnose caused by *Colletotrichum capsici* (Sydow.) Butler nd Bisby**

Athira P V (2017-11-032)

Major advisor : Dr. N. V. Radhakrishnan

Chilli fruits affected with anthracnose caused by *Colletotrichum capsici* were collected from five different zones of Kerala and the pathogen was isolated. Koch's postulates were proved on all the five isolates. A pure culture of all the isolates are maintained. Characteistics of the five cultures were studied like the appearance and colour of the cultures, size of the mycelium, shape and size of the spores and size of acervuli. Later virulence test was done on the isolates and it was found that the isolate from Vellayani showed the highest virulence. This was measured in terms of days to develop symptom and lesion length. This isolate was used for further studies. Dual culture was done between the virulent isolate and six biocontrol agents namely *Trichoderma viride, Pseudomonasfluorescens, Bacillus subtilis, Bacillus pumilus, Bacillus amyloliquefaciens* and *Piriformospora indica*. It was observed that all the biocontrol agents except *Pseudomonas fluorescens* inhibited the growth of *Colleotrichum capsici*. Detatched fruits were alsotreated with the biocontrol agents and further inoculated with the pathogen to find out the progress of the symptom. The symptom was progressing slowly in the treated fruits compared to the untreated control. Further priming studies were done on chilli seeds treated with biocontrol agents. The seeds were treated for different durations like 20 minutes, 1 hour, 2 hours, 4 hours, 8 hours, 12 hours and 16 hours. It was observed that in most of the cases the seedling growth was optimum at 4 hours duration. This was based on observations on seed germination

percentage, time taken for germination, shoot length of seedlings, root length, seedling length, dry weigth and vigour index of seedlings.

10. Management of brown spot disease of rice using fungal root endophyte *Piriformospora indica* and new generation fungicides.

Safana Ashar V (2017-11-069)

Major advisor : Dr. Joy M.

Completed survey and collection of brown spot affected leaf samples from six different research stations of KAU (RARS Mancombu, RARS Vytilla, CoA Vellayani, IFSRS Karamana, RARS Kumarakom and RARS Pattambi) maintained the pure cultures of each isolates after proving Koch's postulates. Maintenance of *P. indica* culture, evaluation of itsroot colonization efficiency and co-cultivation with rice seedlings were done. Dual culture assay of *P. indica* against *H. oryzae* was also performed. *In vitro* screening of different isolates of *H. oryzae* in Uma variety and *in vitro* evaluation of *P. indica*-primed rice seedlings against *H. oryzae* is in progress. *In vitro* and *in vivo* evaluation of fungicides and *in vivo* evaluation of *P. indica*-primed rice seedlings against *H. oryzae* is remaining.

11. Etiology, molecular characterization and management of viral diseases of Dendrobium.

Safeer M. M. (2015-21-012)

Major advisor : Dr. K Umamaheswaran

A survey was conducted among orchid importers in different parts of Kerala to study about viral diseases in Orchids. Majority of the plants kept in quarantine facilities had Cymbidium mosaic virus (CymMV) disease and in one place Odontoglossum ringspot virus (ORSV) disease was observed. The diseased plants were brought to lab and tested using immunological detection technique (ELISA and DIBA). Infected plant samples were subjected to transmission electron microscopy (TEM) and the flexuous rod particles of CymMV were observed. The virus inhibitory effects of the above mentioned antiviral chemicals were evaluated on orchid plants available in grower's greenhouse at Grace orchids, Kattakada, Trivandrum. The treatments were applied on plants that showed visible symptoms of CymMV and tested positive for the virus through DAC-ELISA. The treatments were applied at monthly intervals in selected plants and the biochemical changes, protein profile and change in virus titer were monitored at monthly intervals. The treatments with Virus Ex foliar spray + root inoculation and *P. indica* Acibenzolar-S-methyl foliar spray + root inoculation with *P. indica* were found to be effective in reducing virus titre in plants after 4 consecutive sprays. Protein profile by SDS-PAGE also showed new protein synthesis during the treatments.

12. Nutrient based management of *Chilli leaf curl virus* in Chilli (*Capsicum annuum* L).

Shilpa Sankar(2017-11-103)

Major advisor : Dr.Radhika N.S.

Begomovirus infected chilli plant samples were collected from Palakkad (Vadakarapathy and Kozhinjanpara) and Thiruvananthapuram (College of Agriculture, Vellayani) districts. Disease incidence of virus were recorded with 67%-77% in Vadakarapathy, 65%-77% in Kozhinjanpara

and 59%-80% in College of Agriculture, Vellayani. Typical symptoms such as upward curling and puckering of leaves, shortening of internodes, yellowing of leaves and stunting of plants were recorded and documented. Serological diagnosis and molecular characterization of Chilli leaf curl virus were done through Enzyme linked immunosorbent assay (Triple antibody sandwich- ELISA) with *African cassava mosaicvirus*(ACMV)and *Sri Lankan cassava mosaic virus*(SLCMV) antiserum. The OpticalDensity (OD) value of both healthy and diseased plants were read to analyse the presence of virus. The samples collected from Palakkad and Thiruvananthapuram showed positive results. The positive samples were then allowed for amplification by Polymerase Chain Reaction (PCR) with specific primers such as AV-AC and Deng primers. After gelelectrophoresis, gel documentation was done and bands were seen 550 bp (AV-AC) and 400 bp (Deng) which showed the presence of DNA in the samples. The PCR products were given for sequencing for the further construction of phylogenetic tree. Soil and plant samples are being analysed for both macro and micronutrients.

13. Ecofriendly management of sheath blight disease of rice

K. Sree Pavan (2017-11-049)

Major advisor : Dr. Sajeena. A

Pathogenicity and cultural studies of the virulent isolate of sheath blight fungus *viz.,Rhizoctonia solani* Kuhn (accession no. KX674527) have been done. The observationswhich were mentioned in TP were noted.Effect of botanicals (1), organic preparations (2) and non- hazardous chemicals(1) on the suppression of mycelial growth and sclerotial germination of *R.solaniin vitro*is done and 4 best effective treatments (Fermented egg-lemon juice extract+ potassium silicate, Fermented weed extract+ potassium silicate, Garlic extract+ potassium silicate @ 0.5%+1% each and Garlic extract @10% mixed in equal amounts of water and starch) were found which were subjected for pot culture experiment. The pot culture experiment has started and crop is at 60 days old and all agronomic practices according to POP are followed till now. Two sprayings of effective treatments and two challenge inoculations were given. Enzymes analysis of PO, PPO and PAL are also done. Samples of the effective treatments were sent to radiotracer lab, Vellanikkara for the analysis of major nutrients.

14. Characterization and evaluation of *Pseudomonas* spp. for abiotic stress tolerance

Reshma, K. S.(2017-11-129)

Major advisor : Dr. Reshmy Vijayaraghavan

The objective of the research work is to isolate, evaluate and identify the abiotic stress tolerant strains of *Pseudomonas* spp. for the management of soil borne fungal pathogens. Soil samples were collected from various locations of Kerala representing different abiotic stressed ecosystems *viz.*,Vyttila, Palakkad, Moncompu and Thrissur. Soil samples were analysed for pH, EC and soil moisture content. *Pseudomonas* spp. were isolated and enumerated from the collected soil samples. Isolated strains of *Pseudomonas* spp. were subjected to various abiotic stresses like salinity, acidity, high temperature, drought, selected fungicides under *in vitro*

conditions. *In vitro* antagonistic studies were carried out to select the isolates with better antagonistic action against major soil borne fungal pathogens viz., *Phytophthora capsici, Pythium aphanidermatum, Sclerotium rolfssi,Fusarium oxysporum* and *Rhizoctonia solani.*The efficacy of these cultures in terms ofantagonistic potential and abiotic stress tolerance was evaluated in comparison with reference biocontrol agent *Pseudomonas fluorescens* of KAU. The biochemical analysis for production of enzymes like cellulase, b-1, 3- glucanase, ACC deaminase are in progress. The promosing isolates were chosen for pot culture experiment for *Invivo* studies. Grow bags with readymade potting mixtures were sterilized with formalin. Pot culture experiment is planning to conduct soon.

15. Molecular characterization, host range and integrated management of *Bhindi yellowvein mosaic virus* (BYVMV)

Chinju E. A.(2017-11-030)

Major advisor : Dr. Anita Cherian K.

The objectives of the study are to undertake the molecular characterization of BYVMV, to study the host range, seed and vector transmission and management of bhindi yellow vein mosaic disease. A purposive sampling survey was conducted in three locations of Thrissur to assess the disease incidence and to collect infected samples for further studies. The collected samples were maintained in an insect proof net house through graft inoculation. For seed transmission studies seeds were collected from the fruits of infected bhindi plants and germinated in pro trays in the insect proof net house and the seedlings were monitored for the development of symptoms. Vector transmission was conducted by releasing the viruliferous whiteflies into healthy bhindi plants and observed the symptom development under insect proof conditions. DNA isolation of the collected samples were standardized using modified CTAB method. PCR condition is also standardized using reported primers specific to coat protein gene of the virus. Sequencing of the PCR product is in progress. The experiment for the management of bhindi yellow vein mosaic disease under field conditions and host range studies is in progress. Survey is going on for collection of more isolates.

16. Characterization and integrated management of *Fusarium oxysporum* f. sp. *cubense* (E. F. Smith) Snyder and Hansen causing fusarium wilt disease of banana

Lishma N P (2017-21-018)

Major advisor : Dr. Anita Cherian K.

The objectives of the study are to characterize the pathogen causing fusarium wilt disease of banana, to study the pathogenic diversity and to develop quick detection techniques and management strategy against the disease. A purposive sampling survey was conducted in selected banana growing areas of Kerala *viz.,*Thiruvanathapuram, Ernakulam, Thrissur, Palakad, Kozhikode and Wayanad to assess the disease incidence and to collect infected samples for further studies.The pathogen was isolated from infected samples collected from different locations and pure cultures are maintaining.Cultural characters such as colour, shape, texture and rate of mycelial growth, development of spores and fruiting body were noted. Morphological

characters such as size, shape, colour, septation of hypha and spore and sporodochium were observed.DNA of the collected samples was extracted. Molecular characterization of the pathogen by sequence analysis of the internal transcribed spacer (ITS) region amplified through PCR is in progress. Screening of selected accessions of gene bank of BRS, Kannara for assessing the level of disease resistance by artificial inoculation under pot culture is going on. Biochemical basis of disease resistance of selected resistant and susceptible accessions is in progress. Efficacy of the selected fungicides and bio-agents/botanical at three levels of concentrations *viz*., recommended dose, lower dose and higher dose was evaluated by poisoned food technique and the efficient ones are selected for field trials. The experiment for the management of fusarium wilt of banana under field conditions is in progress.

17. Development of recombinant coat protein for immunodetection of *Cucumber mosaic virus*.

Alan C. Antony (2017-11-037)

Major advisor : Dr. Vimi Louis

The objectives of the study are number and size of amplicons of coat protein gene, quantity and banding pattern of recombinant protein in SDS-PAGE gel, Absorbance in DAC-ELISA, antiserum titre, quantity and quality of antiserum. The pGEM- T/ CMV- CP plasmid is isolated from *Escherichia coli* DH5α using Alkali lysis method. The confirmation of recombination in pGEM- T vector by CMV- CP was done by colony PCR and restriction digestion by *EcoR1*.Designed primer for expression studies by adding sequences responsible for *BamH*1 and *Nhe*1. Using the designed primer Phusion PCR was conducted and the PCR product has purified. Purified PCR product and the pRSET- C vector together kept for restriction digestion and later kept for ligation. Since pRSET- C has no blue/white screening confirmed the recombination through plasmid- shift observation and Phusion PCR and at last send for sequencing for the final confirmation of expression clone. After getting the results of PCR we transformed the pRSET-C/CMV-CP to *E. coli* DH5α for the multiplication of recombinant plasmid. Transformed the multiplied recombinant plasmid to *E. coli* BL21 (DE3) cells, *E. coli* BL21 pLysS cells and *E. coli* Rosetta (DE3) pLysS cells. Checked the overexpression and only E. coli BL21pLysS cells show positive results. Done western blot and confirmed a bacterial contaminant along with viral coat protein is also expressing. In order to rectify the contaminant protein from the expressed protein I have checked, whether the protein form any Virus like particle (VLPs) using 10- 40% sucrose density gradient. It doesn't form any VLPs under the condition provided. Protein production, Ni NTA purification, antiserum production in rabbit Newzealand white and testing the quantity and quality of antiserum is remaining.

18. Microencapsulation of *Trichoderma viride* for management of major soil borne fungal pathogens.

Saleena M. (2017-11-026)

Major advisor : Dr. Reshmy Vijayaraghavan

The objective of the research work is to prepare sodium alginate bead based formulation of *Trichoderma viride* and to evaluate its efficacy under *in vivo* conditions. Sodium alginate beads were prepared using different concentrations of sodium alginate solution mixed with conidial suspension of *T. viride* and different concentrations of calcium chloride solution. Additives like manitol, trehalose, PVP, CMC, PEG, liquid paraffin and Tween 20 were added to enhance the shelf life. Prepared beads were stored in air tight containers for shelf life evaluation. *T. viride* culture is also maintained in Potato Dextrose Broth with the above mentioned additives to study the enhancement in shelf life. For the same, dilution plate technique will be carried out in monthly intervals. Pot culture experiments will be conducted soon.

19. Characterization of *Ralstoniasolanacearum* (Smith) Yabuuchi*et al.* infecting solanaceous vegetables in relation to physico-chemical and biological properties of soil.

Anjali V.A. (2017-11-015)

Major advisor : Dr. Sainamole Kurian P.

The objective of the study is to isolate and characterize *Ralstonia solanacearum* (Smith) Yabuuchi *et al.* of solanaceous vegetables from four different agro ecological units of Kerala and to study the soil physico-chemical and biological properties influencing the pathogen. A purposive sampling survey was conducted in four agro ecological units namely, Palakkad Central Plains, North Central laterite, Southern laterite and Maryur hills. The rhizosphere soil samples of diseased and healthy plants was collected. The per cent disease incidence was noted down for each location. The pathogen was isolated from diseased plant samples and eight isolates were collected in total (two from each agro ecological units). The population of *Ralstonia solanacearum* in soil was enumerated by serial dilution and plating in TZC medium. The cultural characters of the isolates was studied. The morphology of the bacteria was studied using scanning electron microscopy. Biovar identification was done by sugar (cellulose, maltose, lactose) and alcohol (sorbitol, dulcitol, mannitol) utilisation tests. Race identification was done by cross inoculation on differential hosts, that is, tomato, potato, banana and mulberry. The rhizosphere soil of diseased and healthy plants collected during survey was subjected to analysis for physical and chemical properties. The physical properties of soil such as core bulk density, soil texture, soil temperature and water holding capacity were calculated and chemical properties such as pH, organic carbon, available P, K, Ca, Fe, Mn content were analysed using standard protocols. Also, the population of soil microflora (fungi, bacteria, actinomycetes and pseudomonads) in the rhizosphere soil of healthy and diseased plants collected during the survey was enumerated by serial dilution and plating technique. The cross inoculation studies on one of the host, that is, ginger is in progress. The molecular characterization of the eight isolates needs to be carried out.

20. Characterization and bio intensive management of fungal fruit rots of cucurbits.

Muhammad Suhaib Ismayil M. (2017-11-009)

Major advisor : Dr. Yamini Varma C. K.

The objective of research work are identification and characterization of various fungal pathogens causing fungal fruit rots in cucurbits and the evaluation of various biocontrol agents, botanicals and chemical fungicides against major pathogens. As per the technical programme sampling survey were conducted in northern zone of Kerala *viz.,* Kasargod, Kannur and Kozhikode districts and disease incidence were recorded. Preliminary Identification of fungal pathogens up to generic level were done based on the morphological characteristics and further confirmation up to species level were done by molecular characterization at RGCB, Trivandrum. Pathogenicity were proved for each pathogen. Symptomatology of diseases were studied both under natural and field condition. *In vitro* analysis of five selected pathogen against five biocontrol agents, three botanicals and four chemical fungicides and in *vivo* analysis of most severe and predominant fruit rot disease against two selected chemical, biocontrol and botanicals were conducted. Percent disease incidence were recorded from each plot. Study on cultural characters of the pathogen and morphological characters of the pathogen is on pending.

21. Analysis of pathotypic variability of *Xanthomonas oryzae* pv. *oryzae,* the bacterial blight pathogen of rice and identification of new sources of resistance.

Aparna, V .S. (2017-21-019)

Major advisor : Dr. Raji, P.

Surveyed and collected rice bacterial leaf blight samples from Palakkad, Thrissur, Malappuram and Alleppy. Ninety two isolates of *Xanthomonas oryzae* pv. *oryzae* were collected, isolated and stored. For proving pathogenicity of collected isolates, rice seedlings (Jyothi) were grown in pots and isolates were inoculated on seedlings. Twentyone isolates were tested for pathogenicity and all of them shown bacterial leaf blight symptom and proven pathogenicity.

22. Assessment of microclimatic and soil parameters on the population and functional efficiency of Pseudomonas fluorescens in the rhizosphere of Pokkali rice (Oryza sativa L.).
(PPBM-08-00-01-2017-VKA(24)-KAU-PG)

Reshma Francis (2016-11-065)

Major advisor : Dr. K. Surendra Gopal

The main objectives were to study the effect of soil temperature and soil parameters on the population and functional efficiency of *P. fluorescens* / fluorescent *Pseudomonas* in *Pokkali* rice. The rhizosphere soils of *Pokkali* rice were collected at monthly interval from June, 2017 to October, 2017. The population of fluorescent *Pseudomonas* sp. in the rhizosphere soils of *Pokkali* rice was recorded at monthly interval. The population was absent before the start of the experiment in treated plot. However, the highest population (3×103cfu g-1) was recorded at 90 DAS (August, 2017). However, the lowest population was recorded at 60 DAS (July, 2017). The population was not found at 30 DAS (June, 2017), 120 DAS (September, 2017) and 150 DAS (October, 2017). In the case of control plot, population of fluorescent *Pseudomonas* was absent

before the start of experiment. At 30 DAS (June, 2017) population of fluorescent *Pseudomonas* was 3.3×102 cfu g-1. However, no fluorescent *Pseudomonas* were found at 60 DAS (July, 2017), 90 DAS (August, 2017), 120 DAS (September, 2017) and 150 DAS (October, 2017). The present studies indicated that the inoculated *P. fluorescens* did not survive in *Pokkali* fields. The population of fluorescent *Pseudomonas* showed negative correlation with soil pH and EC. However, soil temperature and CO2 evolution did not had any effect on population. The functional efficiency of fluorescent *Pseudomonas* was not affected by soil temperature, soil pH, EC and CO2 evolution. However, further studies on influence of soil edaphic factors and weather variables on host plant and *P. fluorescens* needs to be studied and develop a suitable PGPR for *Pokkali* rice.

23. Microbial inoculants for enhancing degradation of biosolid waste in aerobic composting
PPBM-10-00-01-2017-VKA(24)-KAU-PG

Shilpa. P. (2016-11-047)
Major advisor : Dr.D.Girija

The study entitled 'Microbial inoculants for enhancing degradation of biosolid waste in aerobic composting' was conducted in the Department of Agricultural Microbiology, College of Horticulture, Vellanikkara, during 2016- 2018. The major objective of the study was exploring the possibility of enhancing degradation of biosolid waste using microbial inoculants in aerobic composting. The study revealed that, microbial consortium formulated with *B. subtilis* BaBc-1, *T. asperellum* and *Bacillus* sp. BaOu-1 could be exploited for enhancing degradation of biosolid waste in aerobic composting.

24. Screening of Pink Pigmented Facultative Methylotroph (PPFM) isolates for water stress tolerance and yield in paddy.

Riyas. N.K (2017-11-096)
Major advisor : Dr. K.S. Meenakumari

Twenty isolates of PPFMs were procured from the Dept. of Agrl. Microbiology, College of Agriculture, Vellayani. Stock cultures of each of the isolates were prepared for preliminary studies. The PPFM isolates were screened by using paper towel method for water stress tolerance under *in vitro* conditions using mannitol for inducing osmotic stress. Observations on germination percentage (%), shoot length (cm), root length (cm), shoot fresh weight (g), shoot dry weight (g), root fresh weight (g), root dry weight (g) and seedling vigour index were recorded. Five promising isolates were selected to study the effect of Pink Pigmented Facultative Methylotroph (PPFM) isolates on growth and yield of paddy under water stress conditions. The experiment is progressing.

25. Development of encapsulated formulation of *Azospirillum lipoferum* and its evaluation for growth and yield in *Amaranthus tricolor* L.

ShubhamKumar.N (2017-11-140)

Major advisor : Dr. K.S. Meenakumari

The culture of *Azospirillum lipoferrum* was procured from the Dept. of Agrl. Microbiology. The encapsulation matrix was standardized with various filler materials such as standard starch, white flour, corn starch and talc. Different concentrations of filler materials were tested. The trials are progressing.

26. Development of encapsulated formulation of PGPR mix-I and its evaluation for growth and yield in bush cowpea (*Vigna unguiculata* sub sp. *unguiculata* (L.) Verdcourt).

Ayisha Y. L.(2018-11-084)

Major advisor : Dr. K.S. Meenakumari

The component cultures of PGPR mix-I were procured from the Department of Agricultural Microbiology, College of Agriculture, Vellayani. Studies have been initiated to standardize filler materials for bead preparation.

27. Isolation, screening and evaluation of silicate solubilizing bacteria for growth and yield in rice.

Akhila. P. Subhash (2018-11-093)

Major advisor : Dr. K.S. Meenakumari

Soil samples were collected from the rice fields of Vellayani and Integrated Farming System Research Station (IFSRS), Karamana and initiated the isolation of silicate solubilizing bacteria.

Name of Project Coordination Group: (13)
Postharvest Technology and Value Addition

Compiled by:
Dr. Mini C., Project Coordinator

Plan & External Aided Projects

Concluded Project: 1 Nos.
Ongoing Projects :6 Nos.

Post Graduate Projects

Concluded Projects: 5 Nos.
Ongoing Project: 8 Nos.

Concluded Projects

1. **Establishment of centre for postharvest management and value addition for underexploited fruits and vegetables of southern Kerala. (State Network Project-Centre of Excellence in Postharvest Technology)**
   PHTV-01-01-01-2015-ACV-KAU PLAN

P.I : Dr. Mini C
Professor & Head

The objective of the project was to establish a centre for post harvest management and value addition for under exploited fruits and vegetables of southern Kerala, thereby to reduce the post harvest losses and commercial production and sale of value added products. Process protocols were standardized for spray dried cashew apple powder, value chain management practices to reduce post-harvest loss in papaya for local market and fresh cut papaya production.

Spray dried cashew

Technology for development of spray dried cashew apple juice powder could be developed with a recovery of 72.09 % of total solid content from juice carrier mix using suitable carrier and by adopting optimum juice solid to carrier ratio and inlet temperature. The resulting powder had optimum quality parameters with six month shelf stability under refrigeration.

Possibility of utilization of an underutilized fruit, Gamboge,*Garcinia tinctoria* (False/Yellow mangosteen) for value addition was proved.

Yellow mangosteen for value addition

Harvesting good quality papaya fruit at ¼ yellow maturity (144 DAF), washing, sanitization using hot water at 50 ^{0} C for 20 minutes, followed by cooling and coating with 6% carnauba wax had a shelf life of 14 days under ambient condition when packaged in corrugated fibre board box with ethylene absorbent @ 8g/kg of fruit. Products were standardized from under exploited fruits of southern Kerala including traditional fruits viz., spondias, karakka etc. Production of beverages from under exploited fruits such as bilimbi, carambola, passion fruit, sapota and west Indian cherry was undertaken along with storage stability analysis of prepared products. Osmodehydrated carambola could be prepared by osmotic treatment of blanched slices of 1mm thick with 70^{0}brix sucrose at 50^{0} C for 24hour, followed by cabinet drying at 60^{0} C for 5 hours till moisture of 15-20 % is attained. Major value added products developed were beverages; sugar based and fermented products giving emphasis to waste utilization. Blending was found as a better option for quality product development from under exploited fruits by improving sensory parameters and incorporating nutritional parameters.

Velvet apple could be utilized for production of squash having 0.23% acidity and 10.2^{0} brix with 14.27 and 11.7% % total and reducing sugars respectively. It was nutritionally rich with 0.24µg/100g β carotene, 146 mg/100g vitamin C and with 0.14 % total antioxidant activity. Clarification of the fruit pulp was possible using pectinase enzyme (0.5%).

Utilization of unutilized fruit, Velvet apple

Continuing Projects

1. Establishment of Centre of Excellence in post harvest technology & allied schemes-Strengthening of Food Quality Control Laboratory - PHTV-02-01-02-2016-VKA-KAU-Plan

Dr. Saji Gomez
Asst Professor

Analysis of quality parameters of different products viz.,Nutrispreads, Banana flour, Mushroom powder, curry pastes, virgin coconut oil, Banana products, Nannarisarbath, Dehydrated pineapple,

Dried ginger powder, Tamarind paste, Banana flower buds, Cashewnuts, Naruneendi syrup, Extruded samples, coconut products etc. submitted by different Govt. and private Institutions have been done in detail in the Food Quality Control Laboratory. An amount of Rs.1,83,950/- (Rupees One lakh eighty three thousand nine hundred and fifty only) has been generated in

connection with the testing of quality of various food items received from entrepreneurs/ institutions utilizing the facilities created at the Quality Control Laboratory.

2. Interventions for augmenting Neera & Neera based products

PI: Dr. Sujatha.R,
Professor & ADR, Coconut Mission,

A pilot plant on neera is functioning under Coconut Mission for standardization of the technology for tapping and processing neera and other products from it on commercial scale. The technology involves different steps like initial filtration, pH satbilisation, centrifugation, clarification and final filtration, carbonation etc. The existing system needs to be improved to reduce the labour involvement in each step and increase efficiency of these different steps for better recovery after processing. Presently the recovery is only 70-80 percent and the loss is high during centrifugation process. The final clarification and filtration step is also labour intensive. All these reduce the profit when carried out in a commercial scale.

Hence the project envisages modifications of the machinery used and fine tuning of the processing protocol to suit the entrepreneurs. Also there are several brands of neera available in market though in a limited quantity. Quality analysis (chemical and sensory evaluation) of samples collected from the different sale points in Kerala is also one of the objectives under the project. Standardization of diverse products using neera such as palm sugar, chocolates, halva, cookies, ice cream etc. is another objective as the diversity of products is necessary for any successful commercial ventures.

A new machine (Clarifier) was designed for carrying out the centrifugation and filtration in one step and which can function in a continuous flow system so that it can fit into the "end-to-end processing" mode in a commercial unit. Main parts of the developed model consist of a 3 hp electric motor, Stainless steel vessel 20" (304 SS) with double wall jacket and lid, cotton micro filters, pully and belt for power transmission box etc. The recovery percent has increased to more than 90 percent and there is saving of time and labour also compared to the existing system.

Clarifier

Quality analysis of different neera brands available in the market was carried out along with the brand from KAU – *Keraamrutham* the result of which is provided in Table1. The other brands

available in market include Keraneera marketed by Kerala State Coconut Development Corporation (KSCDC), and by various Coconut Producer Companies under Coconut Development Board.

Quality analysis of different neera samples available in the market

Nutrient	Keramrutham (Carbonated) KAU	Keramrutham RTS KAU	Keraneera KSC-DC	Kaipuzhaneera (Kollam cpc)	Thirucochineera (Thirukochicpc,)	Kerapunch (Tirurcpc)	de Cocos	Engandiyur RTS	Tetra pack by Palakkad cpc
pH	5.56	6.03	4.6	4	4.58	5.28	5.0	3.68	5.28
Total sugars (brix)	12.8	13	14.75	19.7	10.32	14-16			
electrolyte concn (EC) Ds/m	4.88	3.79	3.8	4.96	4.1	4.0 -	1.7	3.4	4.3
Minerals (mg/ 100ml)									
Potassium	202.8	195.9	232.3	242.5	202.6	207.7	223.8	208.8	171.9
Sodium	29.1	30	22.6	54	26	29.5	23.6	24.5	13.8
Calcium	4.61	4.76	3.86	2.86	2.79	-	-	-	0.10
Iron	6	5.5	0.9	0.85	0.14	-	-	-	-
Phosphorus	2.5	2.31	2.23	-	-	3.6	2.8	0.04	-
Sulphur	18.56	18.5	13.63	-	-	20.35	5.8	13.01	0.59
Magnesium	0.46	0.46	0.57	0.56	0.54	-	-	-	0.51

The acidity is found higher in other samples compared to *Keraamrutham*. The sugar content is very high in KaippuzhaNeera. As the samples available were limited in quantity, the analysis needs to be repeated during 19-20 also.

Various other products are being tried by using Neera and Neera jaggery such as Peanut and Neera jiggery Chikki, Neera jaggery chocolate, Neera jaggery and banana halwa , icecream with Neera etc, and the standardization of protocol is continuing. A fully equipped lab was set up in the neera processing unit for carrying out the research in processing aspects of neera.

3. Development and Validation of Post–Harvest Handling Technologies in Banana and Plantain- PHTV-01-05- 01-2018-VZK-KAU plan

Dr. Maya. T.,
Assistant Professor and Head,PRS,Vazhakkulam

Objective of the project was to standardise / validate technologies to reduce post-harvest losses of banana (Cultivar Nendran)

Experiment 1: Effect of postharvest treatments on shelf life of banana cultivar Nendran

Pre-treatment of banana with *Trichoderma viride* (1%) promised an additional shelf life of 3 days to Nendran Banana when open stored under ambient conditions at [30-34˚C and 65-76% RH]. The mean average length, diameter and firmness of the fingers used for storage studies was 20.45 cm, 12.48 cm and 95.78 kg/cm^2 respectively. Calcium chloride (1%) dip for 10 minutes and hot water treatment (50˚C for 5 minutes) were found to be the next best treatments to delay ripening and retard decay of the fruits.

12 Days after storage

14 Days after storage

Effect of postharvest treatments on shelf life of banana

[T1- Control;T2- *Pseudomonas fluorescence*;T3- Hot water treatment; T4- KAU edible bee

Experiment 2: Development of value added products from banana

Unripe Banana Peel Powder: Nendran banana chips are most popular product in Kerala. This industry generates large quantities of peel as wastage. Peel of unripe banana has high nutritional qualities and has potential to be incorporated into maida to improve nutraceutical qualities of bakery products. Hot water blanching of peel of unripe banana and subsequent hot air drying at 70^{0}C for 6 hours yielded high quality powder.

Ripe Banana Peel Powder: Banana peels of ripe fruits yielded good quality powder by hot air drying at 70^0C for 18 hours of peel pre-treated by hot water blanching. Unripe Whole Banana Powder could be obtained without removing peel with pre-treatment with citric acid (0.3%) and hot air drying at 70^0C for 6 hours

Ripe Whole Banana Powder: Tasty ripe banana powder could be obtained without removing peel with hot water blanching followed by hot air drying at 70^0C for 24 hours

.Dehydrated Nendran banana products

(UP T_2- Unripe peel RP T_2- Ripe peel; UW T_5- Unripe whole fruit; RW T_2- Ripe whole fruit)

4. Station funding for Strengthening R &D activities at RARS (SZ), Vellayani: Development of ready to serve functional beverages

Dr. P.R.Geetha Lekshmi,
Asst. professor

Preliminary studies on pulp/ juice extraction from jackfruit and osmo dehydrated aloe were completed. Blended RTS beverages from jackfruit, pine apple and lime with aloe juice, osmo dehydrated aloe gel and ginger extract were prepared. Sensory and biochemical analysis are completed and storage stability studies are in progress.

5. Establishment of Techno-incubation centre for the commercialization of value added products from under exploited fruits and vegetables- PHTV-02-02-01-2017-ACV (17)- KAU- Plan

Dr. Mini C
Professor & Head, Dept. of PHT

The objectives of the project were setting up of a Techno-Incubation centre at College of Agriculture, Vellayani for helping the prospective entrepreneurs and SHG groups to utilize the facility ensuring sustainable income, effective dissemination of value addition technologies and providing an idea on the essential infrastructural requirement for setting up a processing unit. Work for the establishment of Techno- incubation centre has been started. Refinement and perfection of technologies were done for producing safe and quality value added products from

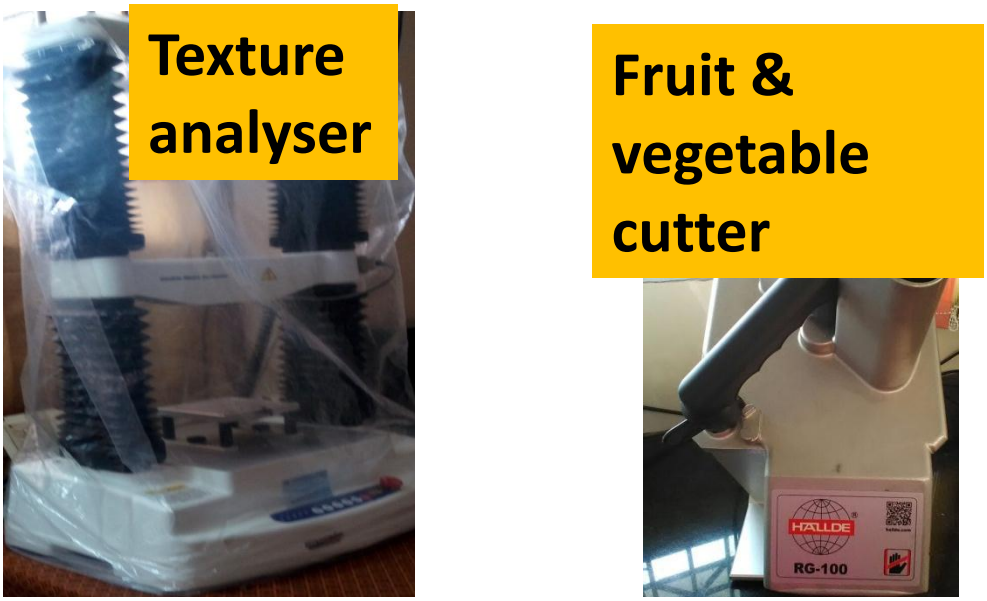
under exploited fruits viz., papaya, rose apple, guava, pumpkin, bilimbi, amla, carambola and sapota.

.Quality analysis of minor fruit beverages

6. Establishment of centre for formulation of convenient foods (Developmental project) - PHTV-02-05-01-2015-ACV-RKVY

Dr. Mini C
Professor & Head, Dept of PHT

No research component is involved. A Centre for formulation of convenient foods will be established at COA, Vellayani which could serve as a model minimal processing unit fulfilling the requirement of FSSAI standards. The following equipments were purchased under the project



Equipments purchased

PG Projects

Concluded Projects

1. ***Aloe vera* based edible film coating for shelf life extension in tomato *(Solanum lycopersicum)*- PHT – 03-00-03-2015.ACV (17)-KAU- PG**

Experiment on Aloe vera based edible film coating for shelf life extension in tomato (*Solanum lycopersicum*) was carried out at the Department of Post Harvest Technology, College of Agriculture, Vellayani during the period of 2014-2017, with the objective to standardise an Aloe veragel based edible film coating for tomato fruits to withstand storage and transportation losses and thereby formulate a viable and efficient post harvest management practice for extending shelf life of tomato.

Based on a preliminary trial conducted for standardization of *Aloe vera* gel based edible film using four different gelling agents (INS 401, 402, 440 and 508), seven concentrations (1, 2, 5, 10, 15, 25 and 35%) and five durations (1, 2, 5,10 and 15 minutes) for extending shelf life of tomatoes, 12 superior treatment combinations including INS 401 and 402 at 1 and 2% concentrations dipped for 1, 2 and 5 minutes were selected for further study of the experiment based on the physiological loss in weight and shelf life.

Further experiments were carried out as four different steps using tomato variety Akshaya, harvested independently at two different maturity stages *viz*., mature green and firm ripe which were meant for distant and local market transportation respectively. Evaluation of the selected 12 aloe gel based edible filmson quality parameters revealed the superiority of aloe gel based treatments over untreated fruits harvested in both the maturity stages. Shelf life of aloe gel based edible film coated mature green and firm ripe tomatoes were 36 and 24 days respectively.

On the 36^{th} day of storage all the aloe gel based treatments were equally effective in maintaining chemical and microbial quality parameters of the mature green tomato fruits, but fruits dipped in 2% aloe gel + INS 402 for two minutes recorded least PLW and percent leakage and hence had higher scores for sensory parameters. Firm ripe fruits dipped in aloe gel +INS 402 (1%) for one minute had superior physical and physiological parameters on 24^{th} day of storage.

The possibility of increasing the efficiency of aloe gel based formulation by incorporation of natural and cheap plant leaf extracts from papaya, guava and ocimum in 1:1 and 1:2 ratios for shelf life extension in tomato was assessed. Considering the economics and efficiency in maintaining better physiological quality parameters, 2% papaya leaf incorporated aloe gel (1:2) + INS 402 for two minutes was selected as the best plant leaf extract incorporated aloe gel (PLEAG) treatment for mature green fruits and 1% papaya leaf incorporated aloe gel (1:2) + INS 402 for one minute for firm ripe tomatoes.

Quality evaluation of edible coatings revealed better efficiency of papaya leaf incorporated aloe gel (1:2) in reducing the activity of texture affecting enzymes *viz.,* pectin methyl esterase and polygalactouronase and increasing total pectin content resulting in higher fruit firmness in both

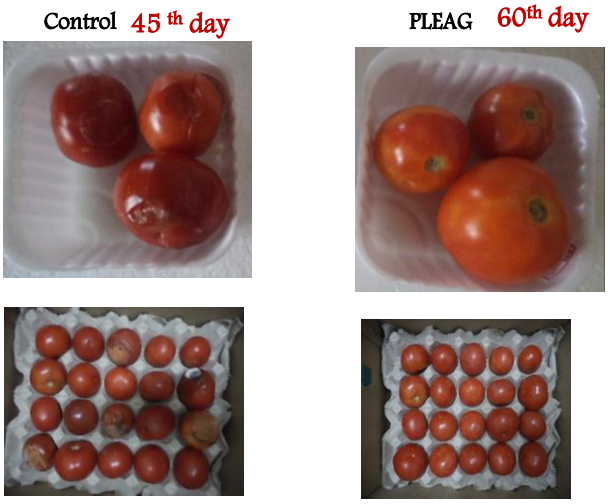
mature green and firm ripe tomatoes. Even though no antimicrobial activity against *Erwinia* and *Rhizopus* was noticed when tested under *in vitro* condition, the aloe based extracts had suppressed the post harvest infection by these pathogens *in vivo*.

Efficiency of the selected papaya leaf incorporated aloe gel (1:2) in reducing post harvest loss during storage and transportation was compared with that of a commercial wax formulation independently for mature green and firm ripe tomato fruits after packaging in 5% ventilated corrugated fiber board (CFB) boxes with and without moulded tray.

When packaged fruits were stored under optimum low temperature (12-20^{0}C for mature green and 10-15^{0}C for firm ripe) and ambient temperature (28-30^0), low temperature storage was superior in maintaining the quality parameters for both the maturity stages of tomato. Packaging in 5% ventilated CFB boxes with moulded tray was effective in maintaining thephysical and physiological parameters of mature green tomato during storage. Papaya leaf incorporated aloe gel (1:2) was equally effective as the commercial bee wax formulation in maintaining the physiological, chemical, and microbial parameters. Fruits coated with commercial bee wax had reduced lycopene content and a non- uniform fruit colour development and hence recorded poor sensory scores. Though both the packaging systems were equally effective in maintaining all the quality parameters during storage of firm ripe tomatoes, overall acceptability was higher for fruits kept in 5 % ventilated CFB box with molded trays. Papaya leaf incorporated aloe gel (1:2) was equally effective as the commercial wax formulation for the stored firm ripe tomatoes too.

Studies to analyze the efficiency of aloe gel based coatings to withstand transportation losses revealed the superiority of 5% ventilated CFB box with moulded tray and effectiveness of papaya leaf extract incorporated aloe gel (1:2) in maintaining all the quality parameters in fruits of both maturity stages. Cost of production for coating the standardized papaya leaf incorporated aloe gel was Rs45.87/- for 100 kg mature green tomatoes and Rs.23.65/- for 100 kg firm ripe tomatoes.

Based on the study, an efficient postharvest management practice for shelf life extension in tomato fruits of both maturity stages could be formulated. Mature green tomato fruits cv. Akshaya after washing and surface sanitization using 2ppm ozonized water for five minutes followed by coating with papaya leaf incorporated aloe gel (1:2) + INS 402, (2%) for two minutes, air drying and packaging in 5% ventilated CFB boxes with moulded tray had a storage life of 60 days under optimum low temperature (12-20^{0}C) or could be transported to distant markets without transportation hazards. Firm ripe tomato fruits cv. Akshaya could be stored for 36 days using the same protocol except coating with papaya leaf incorporated aloe gel (1:2) + INS 402, (1%) for one minute and storing at an optimum low temperature of 10-15^{0}C or could be transported to local markets without any hazards.



Shelf life extension using edible film coating in Tomato

2. **Evaluation and utilisation of edible lichen *Parmotrema tinctorum* (Nyl.) Hale. for food preservation - PHT-03-00-04-2015-VKA(17)-KAU-PG.**

Investigation on "Evaluation and utilisation of edible lichen *Parmotrema tinctorum* (Nyl.) Hale for food preservation" was carried out in the Department of Post Harvest Technology, College of Horticulture ,Vellanikkara during 2014-2017. The main objectives of the study were to evaluate the biochemical constituents, proximate composition, antimicrobial activity, feasibility for food preservation and to study the toxicological effect of the lichen *Parmotrema tinctorum*. The lichen samples were collected from Chembra, Meppadi, Moolankavu and Ambalavayal areas in Wayanad district, and they were identified as *Parmotrema tinctorum* by colour spot tests. The samples read K-, C+, KC+ and Pd- for the lichen *Parmotrema tinctorum*. The habitat of lichen was found to be the shady places of the evergreen forests at 736m -2100m above MSL. *Parmotrema tinctorum* is found to be corticolous (growing on the surface of trees) in habit. Thallus of the lichen is foliose, loosely attached, lobes irregular, margins entire, upper surface grey, smooth, shining; lower surface black and marginal area brown. Proximate analysis of *Parmotrema tinctorum* revealed a high content of total protein (15.70 %), crude fibre (14.16%), ash (10.50%) and total phenols (322 mg/100g).

Parmotrema tinctorum also contained total carbohydrate (20.03 g/100g), crude fat (1.28%), ascorbic acid (4.66 mg/100g) and total free amino acids (8.25 mg/g). High content of calcium, magnesium, potassium and iron were found in the mineral analysis of Parmotrema tinctorum. Methanol, ethyl acetate and acetone extracts of *Parmotrema tinctorum* were analysed for antioxidant activity by DPPH and ABTS assays, and the highest scavenging action was detected in the methanol extract against the DPPH free radicals (IC50-1.47 mg/ml) and the ABTS radicals (IC50-1.27 mg/ml). Preliminary phytochemical screening of *Parmotrema tinctorum* revealed maximum phytochemicals in methanol extract viz. carbohydrates, phenols, flavonoids, tannins,

terpenoids, fixed oils and coumarins. The TLC profiling of lichen extracts (hexane, methanol and acetone) showed maximum compounds in acetone extract, and the spots indicated the presence of phenols and terpenoids. A range of volatile compounds were observed when the lichen extracts (methanol, hexane, acetone, chloroform and ethanol) were subjected to GC-MS analysis. Volatile compounds with antimicrobial properties identified were orcinol, methyl orsellinate, atraric acid, atranorin, methyl haematommate, glyceryltrilaurate, lauric acid vinyl ester and gamma-sitosterol. In vitro testing of antimicrobial activity of acetone, ethanol and chloroform extracts of *Parmotrematinctorum* using disc and well diffusion methods revealed their inhibitory action against the selected food spoilage organisms. Ethanol extract (EE) of *Parmotrematinctorum* produced maximum inhibition of *Aspergillus niger*, while chloroform extract (CE) produced maximum inhibition of *Aspergillus oryzae*. The growth of both yeast species, *Saccharomyces cerevisiae* and *Zygosaccharomyces bailii*, was found to be inhibited maximum by the ethanol extract followed by the chloroform extract of the lichen *Parmotrema tinctorum*. In both disc diffusion and well diffusion methods, the growth of *Bacillus subtilis* and Staphylococcus aureus were remarkably inhibited by the acetone extract (AE) followed by chloroform extract (CE) forming zones of inhibition at all the concentrations tested. Feasibility of utilizing *Parmotrema tinctorum* for food preservation was evaluated by adding in powder and in ethanol extract form in two processed products viz. lime pickle and tomato sauce. In lime pickle, bacterial count was least in treatments T8 and T7 (added with 0.3% and 0.2% ethanol extracts respectively). Product preserved with 250 ppm sodium benzoate (T2) revealed least fungal count (0.6x103 CFU/g), which was on par with that containing 0.3% ethanol extract (1.0x103 CFU/g). Lowest yeast count was observed in T8, followed by T2 (0.3 x103 CFU/g). The shelf life of lime pickle treated with T2 (product preserved with 250 ppm sodium benzoate) was estimated to be six months, while that of T8 (product treated with 0.3% ethanol extract) was found to be five months. Unpasteurised tomato sauce in which 0.1% ethanol extract was added had significantly lower bacterial count (5.2X106 CFU/g). The tomato sauce preserved with 750 ppm sodium benzoate recorded lowest fungal and yeast count. The products added with 0.05% and 0.1% ethanol extract of lichen also recorded lower fungal and yeast counts. Microbial analysis of products showed the relevance of ethanol extract as an alternative to sodium benzoate in preventing the microbial spoilage of foods. Sensory analysis revealed that lichen extract added products were acceptable for consumption. Acute oral toxicity study of the ethanol extract of *Parmotrema tinctorum* conducted in Wistar rats revealed the absence of clinical signs of toxicity and mortalities. There were no treatment related changes in body weight and gross pathological changes in the test animals. Single dosing of ethanol extract of *Parmotrema tinctorum* upto a dose of 2000 mg/kg body weight orally was found to be safe in Wistar rats.

Edible lichen *Parmotrema tinctorum*

Lichen (*Parmotrema)* Natural habitat Upper view Lower view

3. **Portion packaging and storage of jackfruit *(Artocarpus heterophyllus* Lam.) - PHTV- 01-01-02-2017-ACV (17)-KAU-PG**

The investigation entitled "Portion packaging and storage of jackfruit (*Artocarpus heterophyllus* Lam.)" was conducted at the Department of Post Harvest Technology, College of Agriculture, Vellayani, during the year 2016-2018, with the objective to standardize portion packaging and storage techniques for extending shelf life of jackfruit types. Experiment was carried out independently for mature varikka, ripe varikka and mature koozha jack fruit types.

Good quality jackfruit types were harvested, cleaned, outer spiny rind removed, cut in to portions of 200-250 g weight, pre-treated using 0.5% potassium meta bisulphite (KMS) and citric acid, surface drainedand subjected to seven different packaging conditions, and stored under ambient and refrigerated storage conditions. The seven different packaging systems included use of polypropylene film with 5% ventilation, cling film wrapping, shrink wrapping, vacuum packaging in laminated pouches, modified atmospheric packaging (MAP) in laminated pouches with $KMnO_4$, MAP with silica gel and unwrapped portions.

Based on efficiency in maintaining physiological parameters, organoletic quality and marketability, portions under vacuum packaging in laminated pouches of PP/LDPE under refrigeration was selected as best treatment for further quality evaluation. MAP in laminated pouches with silica gel sachet was considered as the second best packaging treatment. Jackfruit portions stored under ambient condition were spoilt within a day in all types.

Quality evaluation of jackfruit portions stored under refrigeration after vacuum packaging in laminated pouches of PP/LDPE revealed that mature varikkaportions had 21 days shelf life with 2.34% physiological loss in weight and 80% marketability. Vacuum packed mature koozha portions under refrigeration exhibited 15.71 days shelf life with 2.89% PLW and 75% marketability. Ripevarikka portions had 12.28 days shelf life with 3.42% PLW and 70% marketability under similar packaging and storage. Unwrapped jack fruit portions under refrigeration were spoilt within 3 days after storage.

.Comparison between vacuum packaging and open storage

Oxygen concentration gradually decreased and CO_2 concentration gradually increased in all the vacuum packaged jackfruit portions, indicating high respiration rate of the fresh cut commodity. TSS, reducing sugars and total sugars increased during storage, where as vitamin C and acidity showed a decrease during storage. Vacuum packed refrigerated jackfruit portions had good sensory acceptability even at the end of shelf life, though there was reduction in firmness. Despite an increase in the carotenoid content, vacuum packed refrigerated jack fruit bulbs retained their natural colour, which stayed even during the storage period. The mature varikka bulbs held a cream colour while the ripe varikka ones were a deep yellow, and the mature koozha bulbs remained yellow even at the end of storage. Cost of production of vacuum packed jack fruit portion was calculated and the BC ratio was found to be 1.37. Vacuum packaging in laminated pouches of PP/LDPE and storage under refrigeration was standardized as the best packaging and storage treatment for all jack fruit portions. Adoption of the standardized technology may help to transform the current trend of total unhygienic marketing system into a totally different style, where hygienically packed quality jackfruit portions with sufficient prolonged shelf life can be marketed through the current retail outlets having refrigerated storage facility.

4. Postharvest treatments for delayed ripening in Nendran banana (*Musa spp*.) - PHTV-01-01-01-2017-ACV(17)-KAU-PG.

Application of ethylene inhibitors as postharvest treatments reduced the rate of physiological activities and extended the shelf life of Nendran banana. Based on physiological, biochemical, physical and sensory analysis, dipping of Nendran banana hands in 50 ppm Benzyl Adenine for 10 minutes was standardized as the best postharvest treatment for delayed ripening and extended shelf life up to 16.75 days under room temperature storage. Whereas dipping of Nendran banana in 2 mM Salicylic Acid for 10 minutes recorded a shelf life of 15.75 days and was found cost effective as compared to BA (50 ppm).

Nendran banana dipped in BA 50 ppm after 15 days

Control fruits

Nendran banana dipped in SA 2 mM after 15 days of storage

Delayed ripening in Nendran banana

5. Standardisation of packaging and storage techniques for green chillies spp. *Capsicum annuum*.

The study carried out in the Department of Post Harvest Technology, College of Horticulture, Vellanikkara during 2016-2018 was with the objectives of standardisation of pre-storage treatments, packaging and storage methods for green chillies. Six accessions of green chillies belonging to three species of *Capsicum viz C. annuum, C. frutescens and C. chinense* were selected for the study. Variety Ujwala, belonging to the species *Capsicum annuum* was selected for the surface sanitisation studies. The fruits were surface sanitised with tap water, brine solution (2%), Veggie Wash (1%), sodium hypochlorite (100ppm) and ozone (2 ppm). Fruits sanitised with sodium hypochlorite (100 ppm) recorded the longest shelf life (15days) and lowest microbial load. Lowest Physiological Loss in Weight (PLW %) was observed in fruits sanitised with 2 ppm ozone, followed by sodium hypochlorite. Hence sodium hypochlorite was selected as the best surface sanitisation treatment for further studies. The effect of clipping of pedicel on shelf life of fruits was studied in six accessions of chillies. The accessions selected were Ujwala and Vellayani Athulya (*Capsicum annuum*) Vellayani Samrudhi and local accession Green Chuna (*C. frutescens*) and Vellayani Thejus and local accession CC65 (*C. chinense*). Significant differences were not observed for PLW between the clipped and non clipped fruits. Non clipped fruits in C. annuum accessions registered higher microbial count, comparatively lower shelf life and poor appearance. Packaging and storage studies were conducted in six chilli accessions by subjecting fruits to five methods of packaging viz. controltender coconut and pineapple in 50:50 and tender coconut with sweet orange in 60:40 proportion was selected for storage studies.

Tender coconut RTS beverage blended with pineapple (T2) gave significantly longer shelf life (40 and 73 days) under ambient and refrigerated storage conditions respectively. The biochemical parameters such as highest TSS (14.23o brix) and total sugar content (14.58 %), lowest non-enzymatic browning (0.03) was observed in T2 (tender coconut RTS beverage blended with pineapple) and T3 (tender coconut RTS beverage blended with sweet orange) retained highest vitamin C content (47.66 mg 100 g-1), 30 days after storage, under refrigerated condition when compared to ambient condition. Sixty days after storage, the biochemical parameters such as TSS, sugars, pH, protein and overall acceptability score was highest in T2 (tender coconut RTS beverage blended with pineapple) under refrigerated condition. Tender coconut jelly was prepared from tender coconut by incorporating jellifying agents such as agaropectin, banana peel pectin, guava pectin and nutmeg rind pectin at different concentrations (0.5 %, 1.0 %, 1.5 % and 2 %). Treatments such as C3 (1.5 % agaropectin), C4 (2 % banana peel pectin), C3 (1.5 % guava pectin) and C4 (2 % nutmeg rind pectin) showed highest overall acceptability score of 7.5, 7.5, 7.2 and 7.5 respectively. Tender coconut jelly could be stored for 73 days under ambient condition whereas under refrigerated condition, the shelf life beyond 90 days. T4 (tender coconut jelly prepared from nutmeg rind pectin) showed lowest (0.75) water activity Highest vitamin C (11.93 mg 100 g-1) was observed in T3 (tender coconut from guava pectin) under both refrigerated storage conditions. Tender coconut jelly from nutmeg rind pectin (T4) showed highest overall acceptability value of 7.7 and 7.4, 2 months after storage under ambient condition and 3 months after storage under refrigerated condition respectively. The results of the study indicated that through scientific handling along with addition of preservatives, the tender coconut can be utilized as a potential source for the production of many novel value added and processed products.

Continuing Projects

1. **Jackfruit (*Artocarpus heterophyllus*Lam.) as a potential source of bioactive Compounds - PHTV-02-03-02-2018-ACV (17)-KAU-PG**

Work is in progress. Ideal temperature for drying of jackfruit waste in cabinet dryer was standardized based on total phenol, flavonoid and ascorbic acid content.

2. **Assessment of bioactive compounds and product development from major *Garcinia spp.* of Kerala - PHTV-02-03-03-2018-ACV (17)-KAU-PG**

Work in progress. Proximate analysis of pulp and pericarp of three *species G. gummi-gutta*var. *gummi-gutta* (Malabar tamarind) and *G. xanthochymus*(yellow mangosteen) were completed.

3. **Standardization of quality wine production from selected underexploited fruits- PHTV-02-01-03-2018-ACV(17)-KAU-PG**

Quality wine production from different under exploited fruits viz., carambola, papaya, jamun and rose apple was completed. Quality analysis of the prepared wine was done and storage studies are continued.

4. **Development of osmo dehydrated Red Banana (*Musa spp*.)- PHTV-02-01-02-2018-ACV(17)-KAU-PG**

Osmotic dehydration of red banana was tried with three different shapes *viz*ring, round and chunks) by immersing in sugar solutions of different concentrations (40°B, 60°B and 80°B) for three different treatment durations (60 min, 120 min and 180 min). Based on biochemical,sensory and textural analysis, the best treatment from each shape was selected($S_1OS_3IT_3$,$S_2OS_3IT_3$, $S_3OS_3IT_3$), subjected to binding agent, corn starch, at 2 and 4 %and analysed for its sensory qualities. Three best osmo dehydrated treatments ($S_1OS_3IT_3$, $S_2OS_3IT_3$, $S_3OS_3IT_3$)from first part were subjected to a storage study for a period of four months.

5. **Development of functional jackfruit pasta- PHTV-02-03-01-2018-ACV(17)-KAU-PG**

Jackfruit bulb and seed flour were prepared for the preparation of jackfruit pasta. Based on cooking qualities, nutritional parameters, textural characteristics and sensory qualities, three best combinations T_{10} (Jackfruit bulb flour (10%) + Jackfruit seed flour (30%) + cassava flour (25%)) T_9 (Jackfruit bulb flour (10%) + Jackfruit seed flour (30%) + cassava flour (25%)) and T_8 (Jackfruit bulb flour (20%) + Jackfruit seed flour (20%) + cassava flour (25%)) were selected for the development of functional pasta. The best formulation of functional jackfruit pasta was developed with the addition of vegetables viz, amaranthus, carrot and beetroot.

6. **Feasibility of Pusa Zero Energy Cool Chamber as low cost on- farm storage structure under Kerala condition - PHTV-01-01-02-2018-ACV(17)-KAU-PG**

Construction of zero energy chamber was done and storage studies of selected fruits and ZECC and open were completed for two seasons (October – February and March – May)vegetables viz., Papaya, Snake gourd, Cucumber, Bitter gourd, Amaranth and Cowpea under

7. **Characterization and value addition of male buds of banana cultivars - PHTV-01-01-01-2018-VKA(17)-KAU-PG**

Physio-chemical characterization, packaging and minimal processing studies were conducted. Statistical analysis is being done.

8. **Process standardization and quality evaluation of wine from banana (*Musa spp*.) - PHTV-02-01-01-2018-VKA(17)-KAU-PG**

Quality evaluation of wine from different banana **v**arieties completed. Sensory evaluation and storage studies started.

Name of Project Coordination Group: (14)
Community Science

Compiled by:
Dr. N. E. Safia, Project Coordinator

Plan & External Aided Projects

Concluded Project:3 Nos.
Ongoing Project:3 Nos.

Post Graduate Projects

Concluded Projects: 2 Nos.
Ongoing Project: 14 Nos.

Concluded Projects

1. Standardization of a health drink mix based on the outer skin of jackfruit- State Plan

Dr. Suma Divakar (Professor)
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Sensing the need among health conscious people for instant health alternatives, many companies have come up with various health drinks, health mixes etc., These products however are not good alternatives, as they contain harmful chemical additives and preservatives which are detrimental to health.These drinks are loaded with sugar are especially unhealthy choices as they contain a lot of calories and virtually no other nutrients. Jackfruit is an indigenous fruit crop of Kerala and is widely grown as an important tree in Kerala's homesteads. As no fertilizer is applied to jackfruit trees maintained in homesteads, it also has the potential to be identified as a therapeutic fruit, grown organically in Kerala by default.The skin of jackfruit is used in tribal areas as ingredients of various beverages. Hence in view of the above the project study entitled "Standardization of a health drink mix based on the outer skin of jackfruit" was undertaken. Three beverage mixes were standardised namely,

1. Jack skin based Dahashamini
2. Jack skin based Summer drink
3. Jack skin based Coffee

Jack skin based 'Dahashamini' formulation identified as the best with respect to appearance, colour, consistency, taste, flavour and overallacceptability comprised of jackfruit skin, tulsi and cardamom in the ratio 70 : 20 : 10

Jack skin based summer drink formulations selected by sensory panel had a composition (g) of Skin(50) + Salt(10) + Black salt (5) + Drymangopowder (10) + Cumin (5) + Blackpepper (2) + Mint (5) + Ginger (2) + Clove (2) + Cinnamon (2) + Asafoetida(2) + Cardamom(3) + Sugar(10).

It differed from Dahashamini in having a blend of saltiness and tanginess in taste.

The antioxidant activity of the mixes were analysed and higher activity was observed in summer drink. The hypocholestrolemic effect of 'dahashamini' was established through a supplementation

study on ten high cholesterol patients

Jack Coffee

Jack Summer drink

Dahasamini

2. Value addition and product diversification of matured coconut water - KSCSTE – BIRD project

Dr. Seeja Thomachan

a) Optimisation of technology for production of *Nata De Coco* using bacterial culture, mother vinegar

The technology has been standardised for the production of *Nata de Coco* using mother vinegar and bacterial culture. One litre of mother vinegar can be added to one litre of alchohol ferment or coconut water + 12% sugar and supplemented with 8% ammonium sulphate. It is then kept in trays for 14 days with the mouth covered with a voil cloth. Nata of 1 inch thickness can be harvested after 14 days.

Bacterial culture was procured from National Collection of Industrial Micro organisms CSIR – National Chemical Laboratory – Pune. Maximium thickness of *nata* was obtained at pH 4.0 with 10% sucrose and 0.5% ammonium sulphate concentrations. These conditions also produced good quality *nata de coco* with a smooth surface and soft chewy texture.

b) **Product development from *Nata De Coco***

The prepared *Nata De Coco* was evaluated for its organoleptic and nutritional qualities. Nata De Coco – flavoured sugar syrups and RTS beverages were prepared. Organoleptic evaluation was done for the products and all the products attained an organoleptic scores of more than seven, indicating that the products are highly acceptable.Shelf life studies were conducted for a duration of four months and the products were acceptable till the end of storage.

c) Training on production technology for small scale production of coconut water vinegar and *Nata de coco*

Trainings were imparted to 50 beneficiaries and have started their own units and is marketing their produce with FSSAI licence. This has been contributing to employment and income generation.

3. Process optimisation and popularisation of fruit based products using fruit pulp concentrator- KSCSTE – RTP

Dr. Sharon C.L

A processing cum training hall has been set up with the minimum requirement, with the developmental fund from the college. Standardized protocols for products like fruit based products like jackfruit concentrate, jackfruit cheese, banana cheese, banana halwa, pineapple halwa .Quality evaluation of developed products was carried out. Conducted training programmes on value addition and product diversification Popularisation of fruit processing through radio talk and booklets

Ongoing Projects

1. Horticulture therapy- a tool to rehabilitate the differently abled children at schools - Department of Agriculture Development and Family Welfare

Dr. Beela. G.K**,** Associate Professor,
Dept. of Community Science,
CoA, Vellayani.

Horticulture therapy garden is a plant- dominated environment purposefully designed to facilitate interaction with the healing elements of nature The objective of the project was to empower the physically and mentally challenged children at schools through horticulture therapy and enable them to generate income through the skills attained, to assess children's rehabilitation progress individually and to assess the social intelligence of physically and mentally challenged school going students undergoing horticultural therapy.

Pre-Post Interventional Design is used in this study. The study is conducted in nine schools/institutes located at various districts in Kerala where physically and mentally challenged students are studying. The main study is carried out through the following sessions:

Session I: Selection of schools and Training stake holders (school teachers) on horticultural therapy.

Session II: Pre assessment using Vineland Social Maturity Scale.

Session III: Raising Horticulture Therapy garden at schools (Ongoing)

Session IV: Capacity building through Horticulture therapy interventions (Ongoing)

Session V: Post assessment using Vineland Social Maturity Scale (yet to be done)

A training workshop was conducted to stake holders (school teachers on 3rd December 2018 as part of the commemoration of the International Day of Persons with Disabilities and National Agricultural Day. The workshop was inaugurated by Advocate V.S. Sunil Kumar (Hon'ble Minister for Agriculture Development and Farmers Welfare, Govt of Kerala). Hon'ble Vice Chancellor Dr. R. Chandra Babu delivered the key note address (Vice Chancellor in Kerala Agricultural University).

Landscape design of horticulture therapy garden

Rotating pots in the Horticulture Therapy garden

The adaptive techniques developed in the garden for horticulture therapy are Rotating pots, garden raised beds, hanging pots with pulley, wheel chair accessible pathway, pergola and sensory garden.

Schools and sample participants were selected on the basis of inclusion and exclusion criteria. MoU was signed between head of the institutions and Principle Investigator. Training program for stake holders (school teachers) was conducted. Pre Horticultural therapy assessment was carried out using the standardized tools .The process of raising the garden is in progress.

2. Empowering differently abled children through horticultural therapy and social farming- Kerala State Social Security Mission

Dr. Beela. G.K, Associate Professor
Dept. of Community Science
CoA, Vellayani.

Horticulture therapy describes a process, either active or passive, of purposefully using plants and gardens in therapeutic and rehabilitative activities designed to positively affect a set of defined health outcomes for individuals. The objectives of the project is to empower the differently abled children (15 years and above) through horticulture therapy and enable them to generate income through the skills attained. It also aimed to assess participant's rehabilitation progress individually to formulate an entrance level functional rating to begin prevocational training.

Pre-Post Interventional Design was used in this study. The Tools used to assess are Participation index scale and Bender gestalt test. The sample of the current study consisted of 14 children (above 15 years) with various types of developmental disabilities like Intellectual disability, Learning Disability, visually-impaired, Speech & Hearing impaired. Purposive sampling method was used to select the sample. The final selection of the subjects was strictly based on the inclusion and exclusion criteria and the Disability Certificate. Training included

sessions through which children can develop emotional attachment to the plants and thus streamline them towards self-confidence and esteem. Practical and theory classes related to health, nutrition and agriculture was given. A HT garden was raised at College of Agriculture, Vellayani. The garden consisted of the structures like wheel chair accessible pavements, separate gardens for vegetable plants, ornamental plants, sensory plants, herbal plants, adaptive structures for therapy like pergola, raised garden beds, hanging baskets, rotating pots, hanging baskets with pulley, vertical garden, round bench around the tree, hugging tree, garden bench, swing and umbrella.

Fourteen differently abled students were selected from Trivandrum district through media announcements. Different tools were developed to assess the social maturity, mental health, motor functioning, participation and interest in agricultural activities. Pre assessment was done using standardised scales. Various trainings and classes was conducted for capacity building and empowerment of the students. A horticulture therapy garden was raised at Dept. of Community science, College of Agriculture, Vellayani which is accessible for all differently abled children. Harvested vegetables cultivated by differently abled students from the horticulture therapy garden.

Landscape design of horticulture Therapy garden at the Dept of Community Science COA, Vellyani

Differently abled students enrolled in the Horticulture therapy project at the Dept of Community Science COA, Vellayani

3. Standardisation and documentation of traditional foods based on indigenous food sources- KSCSTE - BPA

Dr. Aneena E.R.

Initial data collection was completed. In the present study, KAP regarding various traditional foods among young generation home makers was assessed among 100 respondents. Details of

various indigenous food sources and traditional food preparations were collected from rural women groups of Thrissur district. The ingredients and the traditional method of preparation of various indigenous food based traditional preparations were collected from traditional food experts for validating the collected recipes. Standardised selected traditional food products in order to scale up the protocol to marketable condition. Details of rural women groups of Thrissur district were collected for giving training and further entrepreneur development.

PG Projects

Concluded PG Projects

1. Standardisation and quality evaluation of nutri spreads

Rammya Molu K
Major advisor : Aneena E.R.
Email id: aneenaer @gmail.com

The study found that good quality, nutritious and healthy nutri spreads using locally available ingredients could be prepared without adding any preservatives. The developed nutri spreads contain good amount of nutrients, which is essential for the growth and development of children. These nutri spreads were very cost effective compared to commercially available spreads. The developed nutri spreads have immense scope for popularisation and commercialisation through technology transfer.

2. Quality evaluation of tannia corm (*Xanthosoma sagitti*)

Amitha Elias
Major advisor : Aneena E.R.
Email id: aneenaer @gmail.com

The study showed that tannia corms contain good amount of starch, carbohydrate, protein and mineral constituents like sodium, phosphorus, calcium and potassium. Oxalate content and browning reactions were reduced by various pre treatments. The present study found that good quality flour and starch powder could be prepared from tannia corms. Tannia corm flour and starch powder were of good sensory qualities and can be used to prepare acceptable products like instant soup mix. The tannia corm flour and starch powder could be effectively utilised for the development of instant mixes and is very much suited for various food applications.

Ongoing PG Projects

1. Process optimization and quality evaluation of jackfruit based probiotic food products

Remya P.R.
Major advisor : Sharon C.L.
Email id: sharonlohi@gmail.com

2. Process optimization and quality evaluation of cocoa based chocolates

Shahanas E.
Major advisor : Seeja Thomachan Panjikkaran
Email id: seeja.t@kau.in

3. Determinants of nutritional status and lifestyle diseases among middle aged working women

Siji.M.S (2015-24-002)
Major advisor :.Dr.Aneena, (Asst. Professor)

4. Pre morbid nutritional status and development of nutrition software for Ischemic stroke patients.

Siji.S (2017-24-001)
Major advisor : Dr.Beela.G.K, (Assoc. Professor)

5. Value addition of Jackfruit through microbial processing

Bensi .P.S (2017-24-002)
Major advisor : Dr.Suma Divakar, Professor

6. Standardisation an quality evaluation of millet based probiotic yoghurts

Tessa Dominic
Major advisor : Sharon C.L.
Email id: sharonlohi@gmail.com

7. Nutritional and antioxidant potential of medicinal rice variety - Rakthashali

Aiswarya Girijan
Major advisor : Aneena E.R.
Email id: aneenaer @gmail.com

8. Process optimization and quality evaluation of fruit pulp based yoghurts

Lovely Maria Johny
Major advisor : Seeja Thomachan Panjikkaran
Email id: seeja.t@kau.in

9. Title of the Project: Quality evaluation of lotus rhizome and its suitability for product development

Sruthi A.
Major advisor : Seeja Thomachan Panjikkaran
Email id: seeja.t@kau.in

10. Garden based diet therapy for school going students with Attention Deficit Hyperactivity Disorder

Malavika.G (2017-16003)
Major advisor : Dr.Beela.G.K, Assoc.Prof

11. Development and quality evaluation of fruit spreads from avocado (Persea *americana* Mill)

Meera.M.V(2017-16-004)
Major advisor : Dr.Anitha Chandran.C , Asst.Prof .

12. Antioxidant and anti-carcinogenic potential of jackfruit based ready to cook curry mixes

Gayathri Mohan (2017-16-005)
Major advisor : Dr.Suma Divakar, Professor

13. Development of herbal drink mix from papaya leaves and evaluation of its anticancer potential

Sharadabai Motu Rathod (2017-16-008)
Major advisor : Dr.Beela.G.K, Assoc.Prof

14. Profiling Bioactive compounds in Avocado (*Persea americana* Mill.) cultivars and freeze dried fruit powder, and investigating its potential in cancer cell lines.

Archana.L (2017-16-009)
Major advisor : Dr.AnithaChandran.C, Asst.Prof.

Name of Project Coordination Group: (15)

Agricultural Economics, Agricultural Statistics and Agricultural Business Management (AESAM)

Compiled by:

Dr. A. Prema, Project Coordinator

Plan & External Aided Projects

Concluded Projects: 2 Nos.
Ongoing Projects: 7 Nos.

Concluded projects

1. Organic Farming in Kerala: Field Realities and Strategies for Future- State Plan

Dr. P. Indira Devi, Professor & Director,
Centre of Excellence in Environmental Economics
CoH, Vellanikkara

The existing practices of organic farming in Kerala were documented and the economic viability was assessed based on case studies. Major constraints and prospects of organic farming in Kerala were identified and a road map for promotion of organic farming in Kerala was developed.

Four existing practices, viz., Spiritual Farming/ Zero Budget Farming/ Natural Farming, Biodynamic Farming, Homeo treatment in Agriculture and Organic Farming were documented.

Results of the Economic analysis of organic cultivation of different crops are presented below:

A. Rice

In case of rice, the returns from Organic farms were less by 6 per cent. The price premium enjoyed by only a few growers, however resulted in higher returns. But generally, the premium which is enough to offset the production difference, is not enjoyed by many.

B. Banana

Though, organically produced banana fetches 20 per cent more price than the conventional method, average yield per hectare from organic fields was 13 per cent lower than the other. Banana cultivation under organic system was more profitable due to better price realization.

C. Coconut

Yield was almost similar in both cases but there was a variation of 20 per cent in the price obtained under two situations. Organic coconut farms in the study area have access to international market. They are selling their produce directly to the exporter. Farmers enjoy 10-30 per cent higher than conventional produce.

D. Pepper

Cost was slightly lower due to the use of homemade plant management solutions and household labour in organic farming. Cost was high in chemical farming since the house hold labour is not used for pest management practices and the extensive use of chemicals. Yield was slightly higher in those farms which followed chemical farming practices.

E. Price difference between organic and conventional produces paid by the consumer

Price of both organic and conventional produces was compared, inorder to evaluate the affordability of organic produce at the different income groups. For plantain and banana price variation was lower compared to the conventional produce. Vegetables like Tomato, Brinjal, Ladies Finger, Ivygourd, Cucumber and Amaranths had the highest price difference of more than 150 per cent. Chilly, Drumstick, Cabbage, Carrot, Bitter gourd, Elephant Foot Yam showed 100-150 per cent price difference, while Beans, Snake gourd, Cowpea, Ginger and Curry Leaf have a price difference of 51-100.

The major constraints and prospects of organic farming in Kerala are given below.

1. Farmer perceptions and production performance

44 per cent of the respondents reported no yield reduction. 52 per cent reported yield reduction varying from 13 to 40 per cent. One third of them opined that the yield get stabilized by three years while 61 percent says that it may take more time.

2. Organic inputs-Challenges in Supply Management

The small and marginal farmers face difficulties in getting organic manures. Only 15 per cent of the farmers were aware of the biofertiliser technology and a mere 9 per cent have ever tried it, even in organic farming methods.

3. Influence of external factors in production

The high gradient and undulating terrain of Kerala has created problems in following organic methods at least in certain farm holdings.

4. Problems in Marketing

Low-level of information about organic production is a major challenge especially for medium and small farmers. High transaction cost, lengthy and complex certification process is also a limiting factor.

5. Absence of appropriate institutional and policy support

There is no subsidy oriented to organic agriculture and there is no mechanism to ensure higher price for organic produce.

6. Lack of Financial Support

The financial support advanced in many of the developed countries for organic farming is not seen in developing countries like India. The credit policy presently does not differentiate organic farming with conventional agriculture. There is no scale of finance for organic farming.

7. Vested Interests

Strong oppositions from the seed, fertilizer and pesticide industries, imparts a great threat for the development of organic farming.

Policy Suggestions for promotion of organic farming in Kerala.

1. There should be policy interventions that map the prioritization of implementation of organic policy from highlands to low lands. Legal measures to popularize organic farming may be thought of.
2. KAU must take organic farming as a mandate and develop a protocol to bring maximum area under organic way of agriculture. Research should focus on developing varieties that perform high under organic management as well as soil health and management to facilitate soil biological activity. Courses like PG diploma in organic certification can be designed and offered by KAU. A scientifically designed 'Calendar of organic cultivation' for major crops of Kerala may be developed.
3. The existing protocol for different systems must be scientifically validated. Indigenous Technical Knowledge (ITKs) should also be scientifically validated. The organic farming technologies must be standardized and made amenable to commercial production.

4. Cultural, mechanical, agronomic and ecological engineering options are to be explored and scientifically tested for the management of Pest and disease in organic crops.
5. The existing subsidy systems must be extended to organic farming systems as well and appropriate compensation for the yield loss if any may be provided.
6. A scale of finance for organic farming may be developed.
7. Market support and market promotion strategies may be initiated. Uniform pricing based on cost of cultivation and value addition of organic produce can be thought of.
8. Social media can be effectively used for market promotion.

2. Institutional intervention for Sustainable Agriculture: A study on Farmer Producer Companies in Kerala

Dr.G.Veeerakumaran & Dr.E.Vinaikumar
Professor & Head, CCBM, Vellanikkara

Objectives include examining the impact of Producer Companies on farmers, analyzing the value chain perspective of Neera, and examining the consumer satisfaction of Neera.

Both primary and secondary data were used for the study. The primary data were collected through pre-tested structured interview schedule and secondary data from published books, journals and research reports. The study covered Coconut Producer Companies/Federations/Societies each randomly selected from three districts in Kerala. Case study analysis was done to understand the performance of selected FPC.

Based on the survey conducted among the farmer producers of Neera, the socio-economic characteristics and the impact of Producer Companies on farmers producing Neera were analyzed and depicted below.

1. Age plays a vital role in the farming sector. It is found that 49 % of farmers were between 25 to 50 years and are actively engaged in coconut cultivation. This phenomenon reflects the positive attitude of youths towards farming particularly coconut cultivation.
2. Since gender disparity can be observed in the rights over farmlands and production of goods, an attempt is made to understand the reality. The result shows that only nine percent of the respondents were females and it depicts the huge deviation of male and female participation in landholdings and farming.
3. Classification of respondents according to family type indicates that majority (79%) of the respondents belong to nuclear family which is a normal pattern in Kerala. Joint family type living has been reduced drastically.
4. Educational qualification is another major factor influencing the producer as it is directly linked with awareness regarding technology, new cultural methods, multiple cropping systems *etc*., Hence an attempt is made here and it is found that all the sample respondents from three CPCs had completed their Lower primary level of education. More than 20 % producers from Palakkad CPC and Vadakkara CPC had their graduation.

5. In most of the cases, income is a decision factor determining the success of the farming. It is observed that all the producers of Kaipuzha CPC fell in the annual income category of below Rs. 100000/- whereas, 37 % producers of Palakkad CPC fell in the range of Rs. 400000-Rs. 500000.
6. Landholdings of the producer are the most important factor which categorizes the farmers into Marginal, Small, Medium and large farmers and it is observed that more than 30 percent farmers are marginal farmers. Nearly 57 % producers from Kaipuzha CPC have owned less than 1 acre of land whereas, more than 50 percent farmers from Palakkad CPC and Vadakkara CPC owned more than 2 acres of land.
7. Type of land being used for cultivation is the most important factor deciding whether farming is a survival mechanism or growth oriented activity. With respect to the type of land cultivated, producers from Kaipuzha CPC have irrigated land whereas, producers from other two CPCs have dryland.

8. It is found that concentration has to be given for value addition process which will aid up in additional income. After the formation of FPC, Kaipuzha CPC farmers were successfully undertaking value addition process.
9. Among all the extension services rendered by the society, Training, Awareness programme and Seminar were found to be effective which benefits farmers in gaining more knowledge and adoption of new technology.
10. Though crop insurance allows farmers to manage their yield and price risks, only limited respondents had insurance. Thus, Crop Insurance facilities are need to be provided by the society in tie up with Crop Insurance Agency.
11. It is evident from the comparative study which was carried out for all the three CPCs with respect to average area under cultivation, average number of palms, average cost of cultivation, average annual income per palm *etc*., that average annual income from coconut cultivation per palm of producers of Kaipuzha CPC was Rs.1088.33, Palakkad CPC was Rs.1016.67 whereas, for Vadakkara CPC it was Rs.803.33 before the formation of producer company. It is found that after the formation of company, average net income per palm including Neera of producers of Kaipuzha CPC was Rs.4000.05, Palakkad CPC was Rs.8072.88 whereas, for Vadakkara CPC it was Rs.6767.90.
12. It is found that average annual income of the producers had increased three times than before the formation of company in KaipuzhaCPC , seven times in Palakkad CPC and six times in Vadakkara CPC.
Analysis of paired t test reveals that three CPCs are highly significant at 1% level of significance which means after the formation of CPCs, producers' income has increased considerably.

Value Chain Perspective of Neera

The second objective of the study was to analyse the value chain perspective of Neera. Based on the survey conducted, the following matrix was prepared to depict the value chain of Neera produced by the selected Coconut Producer Companies (CPC).

Consumer Satisfaction of Neera

The third objective of the study was to examine the consumer satisfaction of Neera. Based on the survey conducted among the consumers of Neera, the following results have emerged.

1. Since gender disparity can be observed in the consumption of many goods, an attempt is madeto understand the reality. The study found that there is not much gender disparity in the consumption of Neera among the sample respondents in the selected CPCs. A slight deviation can be observed only in the Vadakkara CPC where the male-female ratio was 60:40.

2. Age factor may influence the consumption pattern partially in the case of new items entering the market. It is found that maximum number of consumers in the three selected CPC belongs to the age group between 25-50 years and also none of the respondents under Kaipuzha CPC belong to the group below 25years.

3. Marital Status is another factor which may influence the consumer behavior and the study reveals that cent percent of the respondents under Kaipuzha CPC and more than 70 percent of respondents under Palakkad CPC and Vadakkara CPC respectively are unmarried.

4. Classification of respondents according to family type indicates that majority of the respondents belong to nuclear family which is a normal pattern in Kerala. However it can also be observed that around 36 percent of the respondents belong to joint family type.

5. Educational qualification is another major factor influencing the consumer behavior as it is directly linked with awareness regarding quality, medicinal values, presence of toxic substances, choices of products *etc*., and can be seen that all the respondents possess qualification up to upper primary level and above whereas, in the case of respondents of Kaipuzha CPC are qualified up to High School level and above. A good respondent are Gradates and some are even Post Graduates.

6. In most of the cases, income is a decision factor determining the behavior of consumers. It can be observed that around 75 percent of the respondents fall into the category of above Rs. 1 lakh annual family income. Maximum number of consumers fall between 1 lakh and 2 lakhs under Palakkad and Vadakkara CPC whereas in the Kaipuzha CPC maximum respondents have an annual income between Rs.2 to 3 lakhs.

7. Information regarding purchase behavior of consumers is very valuable for the strategies regarding production and marketing of the product. It is found that more than 80 % of consumers from all the three selected CPCs preferred 200-500 ml quantity of Neera.

8. Frequency of purchasing is an important indicator showing the loyalty consumer. It shows whether the customer uses the product frequently or occasionally. It can be observed that very few people purchase Neeraon weekly basis. Only under Palakkad CPC 10 % consumers buy Neera on weekly basis. This is mainly because non availability of Neerain all places throughout the year. 100 % of Consumers of Kaipuzha CPC purchasing occasionally.

9. Knowledge of factors affecting the purchase behavior is very critical for framing strategies for production & marketing. It is revealed that Brand and quality of Neera influences purchasing of Neera among consumers of Palakkad CPC and Vadakkara CPC. Consumers of Kaipuzha CPC prefer price factor while purchasing Neera.

10. Consumer preferences and loyalty depend on the awareness of a product and found that Consumers of Vadakkara CPC tops in the awareness about nutritive value of Neera. All districts consumers were aware of Neera as Non- alcoholic delicious health drink. Consumers of Kaipuzha CPC and Palakkad CPC were not aware that Neera contains amino acid good for protein synthesis and can be used as an ideal sweetener. Awareness need to be created about nutritive value of Neera.

11. The study found that the respondents are highly satisfied with the Neera drink for its quality and taste, but not satisfied with its price.

Ongoing Projects

1. **Organic Farming in Kerala: Feld Level Experiences on Soil Quality and Production Performance- State Plan**

Dr. P. Indira Devi, Professor &Director,
Centre of Excellence in Environmental Economics,
CoH, Vellanikkara

The study is to assess the biological and chemical status of the farm soils under organic farming and non-organic farming management regime in three major rice tracts- Kuttanad, Kole and Palakkad. Study is in progress

2. **Strengthening Centre for Intellectual Property Protection**

Dr. C.R. Elsy, Coordinator
IPR Cell, KAU & Professor
ARS Mannuthy.

Objectives include strengthening the "Centre for IP Protection and management" in Kerala Agricultural University, motivating and facilitating farmers to protect farmer varieties, farmer technologies and the right over traditional unique products as Geographical Indications. The project aims to develop guidelines for IP protection, management and technology transfer in Kerala Agricultural University and to document and compile data of IP protection in Kerala Agricultural University and to bring out suitable publications

3. **GI registration of Attapady thuvara and Aattukombuavara**

Dr. C.R. Elsy, Coordinator
IPR Cell, KAU & Professor
ARS Mannuthy.

Objective is to create awareness about GI registration of Attapady thuvara and Aattukombuavara about farmers, students and officials and to motivate and facilitate farmers to protect the right over traditional unique products by registering them as Geographical Indications, especially Attapady thuvara and Aattukombuavara.

4. Protection of Kanthalloor Vattavada Garlic as Geographical Indication by Kerala Agricultural University

Dr. C.R. Elsy, Coordinator
IPR Cell, KAU & Professor
ARS Mannuthy.

Objective is to create awareness about of GI registration of Vattavada- Kanthalloor garlic among farmers and other stake holders and to motivate and facilitate farmers to protect the right over traditional garlic cultivar by registering it as Geographical Indication, under GoI.

5. GI registration of Kodungallur PottuVellari and Edayurmulaku

Dr. C.R. Elsy, Coordinator
IPR Cell, KAU & Professor
ARS Mannuthy.

Objective is to create awareness among farmers, officials of Agrl. Dept., students and other stake holders about GI registration of goods especially Kodungallur PottuVellari and Edayur Mulaku and to motivate and facilitate farmers to protect the IP rights over Kodungallur Pottuvellari and Edayur Mulaku by registrating as Geographical Indications.

6. Strengthening Centre for IP Protection (387-31-20073)- State Plan

Objectives of the centre is given below.

1. To organize awareness programmes/training programmes/ workshops about IP protection and management for scientists, students and farmers.
2. To motivate and facilitate academia and farmers for IP protection over new crop varieties by registration.
3. To motivate the scientists and farmers to protect Breeders' rights and farmers' rights.
4. To motivate and support scientists, students to patent new technologies and products.
5. To motivate and facilitate farmers to protect farmer varieties, farmer technologies and the right over traditional unique products as Geographical Indications.

Achievements:

i. IPR Cell-KAU received a National recognition as "special citation" from the Controller General of Patents, Designs and Trade Marks on World IP Day for its remarkable achievements in GI related activities. Dr.C.R.Elsy, Co-ordinator of IPR Cell received the award on 26 April 2018.
ii. MarayoorJaggery received GI Certificate
iii. Application for Tirur Betel Leaf submitted
iv. Consultative Group Meetings attended as part of GI registration procedure.
v. Participation in Exhibitions Vaiga 2018
vi. Participation as Resource person in IP related awareness programmes

vii. Awareness programmes conducted
viii. Received 3 Plant Genome awards with support in documentation from IPR Cell

7. Cost Benefit analysis of Specialty fertilizers in selected vegetable crops of Kerala- IFFCO chair

Dr. K. Jessy Thomas, Professor& Head
Dept. of Agri. Economics

Objective is to compute the costs and returns of use of specialty fertilizers in selected vegetable crops, identify the marketing channels and work out the marketing costs and \margins and to examine the constraints in production and marketing. Study is in progress

Name of Project Coordination Group: (16) Agricultural Extension and Development studies

Compiled by:
Dr. Binoo P Bonny, Project Coordinator

Plan & External Aided Projects

Concluded Projects: 1 Nos.
Ongoing Projects:4 Nos.

Post Graduate Projects

Ongoing Projects: 25 Nos.

Concluded Projects

1. Development of a Farming System based Cyber Extension Model for the State of Kerala

Dr. V.G. Sunil,
Assistant Professor (Agrl. Extension),
KVK, Malappuram

It involved development of an information and decision support system to cover major crops and enterprises for the entire state of Kerala and launch the online and offline version of the software together with training support and opening of touch screen kiosks to improve the reach to farmers was the major achievement. It also helped in the use of mobile phone technology in all possible ways for technology dissemination and knowledge up gradation in agriculture and agricultural videos telecasted through visual media were also produced under this. The major achievement under this project are:

The FEM@Mobile, a mobile app containing information on cultivation of 100 major crops of Kerala was developed. The app covers information on crop production, plant protection, organic inputs, agro chemicals, contact directory, expert support and project details. Over 3000 pages of content information are presented in the app after three stages of expert validation. The application works in android platform and is available from Google play store. More than 25000 download is already there with user rating of 4.2. Five educational video of 25-minute duration covering scientific aspects of cultivation from planting to harvest of rice, coconut, banana, vegetable and preparation of organic inputs were completed. The produced video handed over to Department of Agriculture and telecasted through Noorumeni programme of Dooradarshan, also available in YouTube channel. Developed the "Farm extension manager" website. The online system contains information on 100 crop plants with photos on pest and disease problems. It also contains decision support system for identification of plant protection problems. The expert system contained in it help for fertilizer and credit calculation. It also contains the kiosk version of the information system. The five crop information system developed in the project help in plant identification using photos and botany of over 1300 plants. Developed a handbook on "Application of ICT in Agriculture" for the use of Agricultural Officers of the Department of Agriculture. Published a research paper also. SMS to Agricultural Officers and Agricultural Assistants of Malappuram district on various topics of current relevance were sent for more than two years. Learning materials on various topics were also prepared. Regular training programees were organized at various part of the state to make the ICT tools popular.

Ongoing Projects

1. KAU-UWA Project concerning food security and the governance of local knowledge in India and Indonesia

Dr. Jayasree Krishnankutty,
Professor & Head,
College of Horticulture, Vellanikkara

The project in collaboration with the University of Western Australia documented the indigenous cultivation of rice and other crops in selected locations of Kerala. Crop management, product handling and marketing behaviour of the farmers were analysed. Also the government and non-government support to these farmers and its utilization pattern by farmers were explored. Documentation of the constraints experienced by farmers with recommendations to improve the status of the traditional cultivating communities was also attempted. The important interim findings of the study include the following.

Study identified the major traditional varieties cultivated by the farmers in Wyanad, Palakkad and Malappuram districts as Valichhoori, Adukkan, Thondi, Chomal, Jeerakasala, Gandhakasala, Mullankayama, Navara, Chettadi, Chitteni, Thavalkkannan, Chenkazhama,, Kattamodan, Kochumannan, Vella kayma, Chitteni, Thavalakkannan, Rakthasali, Thekken cheera. However, the farmers who cultivated these traditional varieties had very poor awareness about the legal recognition status of the varieties and had no access to the Government support mechanisms for traditional rice farming. Though majority of these farmers were old some young farmers have also entered into farming of traditional rice varieties. Supplyco was the agency involved in the procurement of paddy and hence they were not getting any premium price. Absence of proper milling facility was main constraint faced by them. Though *Wayanad Jilla Sugandha Nellulpadaka Karshaka Samithi* which is the registered co-owner of the GI rice Jeerakasala and Gandhakasala was present in Wyanad, no active role to promote traditional rice cultivation has been taken up by them.

2. Partnering between local self govt. institutions and the KAU in the second phase of decentralized planning: An action research programme Susthira samrudhi R &D support for LSGI – State Plan project

Dr. Jiju P Alex,
Director of Extension, KAU

Partnering with the Alathur block panchayat, *Kathir* a popular participatory natural resource management programme was initiated integrating the constituency development fund of the Alathur MLA also. This surveyed the water resources of the area along with the Krishibhavans and KAU ensured technology support to these initiatives on local resource based farming in Alathur block. Organized four seminars on farmer producer organisation at Kongad Grama Panchayat. The Farmer producer company with farmers of all panchayats under Kongad

Blockhas initiated the registration process. Resource persons from the university is actively involved in all stages of FPO formation.

3. Farm women status study

Dr Binoo P Bonny
Professor & Project Coordinator,
CGSAFED, Vellanikkara

Assessing status of woman farmer inclusion in farmer support institutions and identifying good practices of convergence for woman farmer in agricultural development was taken up in the districts of Palakkad and Malappuram. Farm activities, product development and awareness activities under Ayushmati mission was also pursued. Data collection completed for the districts of Palakkad, Malappuram & Thrissur on levels of participation of women in farm activities. Kudumbasree and MNGRES emerged as the institutional mechanisms with best women empowerment programs in the district. Farmer Organizations at Krishibhavan level had the least women representations and inclusive norms. Participated in two national exhibitions to popularise the health benefits of minor leafy vegetables among women. Maintenance of the repository of identified leafy vegetables for demonstration purpose. Skill development training in farm enterprises like processing of passion fruit and gardening for selected women.

4. Biodiversity sensitization programme of students and farmers in the diverse wetland ecosystem in Kerala– State Wetlands Authority of Kerala

Dr. Allan Thomas,
Associate Professor,
College of Agriculture, Vellayani

The project aims to conduct seminar on best agricultural practices in the wetland farming at Thrissur and Thiruvananthapuram and biodiversity sensitization programmes in Vellayani fresh water lake ecosystem. An Agro- biodiversity assessment sample survey and action oriented outreach programmes based on pesticide residue analysis will also be taken up.

PG Projects

Ongoing PG Projects

Sl. No	**Student (Roll No.)**	**Project Title**	**Research Guide**
1.	Aashika Sasindran 2018-11-031	Impact of Participatory Guarantee System (PGS) certification for production of organic vegetables: analytical study among VFPCK farmers in Kerala	Dr. A.K. Sherief Professor Dept. of Agrl. Extension
2.	Chippy Xavier 2018-11-060	Assessment of socio psychological constructs in post flood situation: The case of Kuttanad rice farmers.	Dr. B. Seema Professor & Head Dept. of Agrl. Extension
3.	Rin Rose Antony 2018-11-071	Prospects and Problems of Agro Technology Incubators (ATI): A Multi-dimensional Analysis .	Dr. N. Kishore Kumar Professor Dept. of Agrl. Extension
4.	Dini. M. Das 2018-11-079	Technology assessment of rubber based intercropping systems (RBIS) in South Kerala.	Dr. Allan Thomas Asst. Professor Dept. of Agrl. Extension
5.	Reshma, R.S. 2018-11-080	A multidimensional analysis of awardee farmers of Department of Agriculture Development and Farmers' Welfare in South Kerala.	Dr. G. S. Sreedaya Asst. Professor Dept. of Agrl. Extension
6.	Krishnanunni, M.A. 2018-11-083	Post-Disaster Needs Assessment (PDNAs) of homestead farmers of Kottayam district in Kerala.	Dr. A.K. Sherief Professor Dept. of Agrl. Extension
7.	Devapriya S. Kaimal 2018-11-087	Multidimensional analysis of apipreneurship prospect in South Kerala.	Dr. Allan Thomas Asst. Professor Dept. of Agrl. Extension
8.	Asha Elizabeth Jose 2018-11-126	Entrepreneurial behaviour of Farmer Producer Organization (FPOs) for livelihood security.	Dr. G. Jayalekshmi Professor (RC) Faculty of Agriculture
9.	S. Raahalya 2018-11-128	Training need analysis of Agricultural Officers (AOs) of Department of	Dr. G.S. Sreedaya Asst. Professor

		Agriculture Development and Farmers' Welfare Kerala.	Dept. of Agrl. Extension
10.	Kavya, V.S. 2018-11-169	Technology adoption behavior of cassava growers in Kollam district.	Dr. Bindu Podikunju
11.	Namitha Reghunath 2018-21-011	Impact of land reforms on rice cultivation in North Malabar districts of Kerala – A Multidimensional analysis.	Dr. G.S. Sreedaya Asst. Professor Dept. of Agrl. Extension
12.	Dhanusha Balakrishnan 2018-21-013	Vulnerability Assessment for livelihood Inclusion and Social Empowerment (VALISE) of farmers- A post flood analysis of Kerala State.	Dr. N. Kishore Kumar Professor Dept. of Agrl. Extension
13.	Navitha Raj 2018-21-015	Risk behavior of vegetable farmers in Special Agricultural Zones in Kerala: An empirical analysis.	Dr. Allan Thomas Asst. Professor (Sr. Grade) Dept. of Agrl. Extension
14.	Shahlas Binth, T. 2018-21-048	Sustainable rice production in Wayanad district: A tribal perspective.	Dr. A. Anilkumar Dean Faculty of Agriculture
15.	Lakshmi Muralikrishna (2018-1 1-063)	Environmental Pollution experienced bY agricultural systems: a stakeholder perspective	Dr. Jayasree KrishnankuttY M. Professor
16.	Avsha Adhina M. (2018-11-075)	Entrepreneurial skills among the agricultural students in Kerala	Dr. S. Helen Professor (Agrt' Extension) Communication Centre
17.	Rashida V. K. (2018-11-082)	Performance analysis of Mahila Kisan Sashaktikaran Pariyojana (MKSP) scheme in Thrissur	Dr. MercYkuttY M. J. Associate Professor
18.	Gayathri B. R. (2018-11 - 112)	Analysis of Entrepreneurship Development Trainings of Krishi Vigyan Kendras (KVKs) in Kerala	Dr. Binoo P. BonnY Professor (Agr1. Extn)
19.	Joseph Timothy Before (2018-1 1-l l6)	Developing a framework of social audit for evaluating projects on climate resilient agriculture in Malawi	Dr. Jiju P. Alex Professor & DE
20.	Gugulothu Shiva Shankar (2018-11-29)	Performance analysis of (Farmer Producer Companies) FPCs in Telangana	Dr. Shanmugasundaram B. Professor RARS. Pattambi
21.	M. Mahesh Yadav (2018-11-	Utilization behavior of registered	Dr. R. Sendil Kumar

	127	farmers in selected Agricultural Produce Market Committee's (APMC) e-NAM portal of Telangana state	Professor (Agrl. Extension)
22.	Salisu Ahmed Dambazau (2018-21-001)	Exploratory study for resilient wheat farming in Nigeria	Dr.Jayasree Krishnankutty M Professor
23.	Salpriya Seby (2018-21-014)	Policy e and institutional support for agri-entrepreneurship development in Kerala	Dr. Jiju P. Alex Professor & DE
24.	Silpa R.C. (2018-21-016)	Natural Resource management and community participation –A study on watershed development projects in Kerala	Dr Mercikutty M.J. Associate Professor
25.	Akhil Ajith (2018-21-017)	Performance analysis of Farmer Producer Organizations in Kerala	Dr. Binoo P. BonnY Professor (Agr1. Extn)

Name of Project Coordination Group: (17)
Sugarcane and Tuber Crops

Compiled by:
Dr. Sheeba Rebecca Isaac, Project Coordinator

Plan & External Aided Projects

Concluded Project: 1 No.
Ongoing Projects:11 Nos.

Post Graduate Projects

Concluded Projects: 3 Nos.
Ongoing Project: 4 Nos.

Concluded Projects

1. **Exploitation of under-utilized root and tuber crops for food and nutritional security -** State Plan

Dr. Kumari O. Swadija,
Professor,
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Commercial cultivation of tuber crops in the state is limited to cassava, elephant foot yam and yams, while Kerala is the abode of tuber crops, diverse species have been used in traditional medicine and for culinary purposes. In this background the project attempted to exploit the under utilized root and tuber crops for food and nutritional security. The survey conducted in the tribal areas of Amboori and Kottur in Thiruvananthapuram. West Indian arrow root, Queensland arrowroot and different types of colocasia were collected nutritional quality was found to be superior (DM : 24 -28%, starch: 20.9-25.3%, crude protein : 0.5- 1% and crude fibre: 3-4.8% on fresh weight basis) and the nutrient management practices of the crop in coconut gardens was standardized through the field experiments conducted for two years. Higher rhizome yield of 18.06t ha^{-1} and net returns of Rs. 63150 ha with a benefit cost ratio 1: 3 was realized with FYM @15 t ha^{-1} + PGPR Mix 1. The INM strategy of 10 t FYM + 50:25:75 kg NPK ha^{-1} recorded superior yields and highest BC ratio. Organic nutrition (FYM@ 15t ha-1 + biofertilizers) can also be recommended for the cultivation of West Indian arrowroot in coconut gardens.

Ongoing Projects

1. State Plan Projects

1. Evolution of sugarcane varieties for the different agro climatic tracts of Kerala and fluff exchange programme 2010 series
2. Evolution of sugarcane varieties for the different agro climatic tracts of Kerala and fluff exchange programme 2011 series
3. Evolution of sugarcane varieties for the different agro climatic tracts of Kerala and fluff exchange programme 2012 series
4. Evolution of sugarcane varieties for the different agro climatic tracts of Kerala and fluff exchange programme 2013 series
5. Evolution of sugarcane varieties for the different agro climatic tracts of Kerala and fluff exchange programme 2014 series
6. Evolution of sugarcane varieties for the different agro climatic tracts of Kerala and fluff exchange programme 2015 series
7. Evolution of sugarcane varieties for the different agro climatic tracts of Kerala and fluff exchange programme 2016 series

2. Advanced Varietal Trial – I Plant, II Plant and Ratoon- AICRP projects

Dr. Shajan V.R
Professor
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Among quantitative characters, Entry VSI 12121(95.4) showed superiority over best standard for cane yield. For quantitative characters, entry Co 12008 showed numerical superiority among the entries.

3. Advanced Varietal Trial – I Plant,

Dr. Shajan V.R
Professor
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Among quantitative characters, Entry CoN 13073(12.03) recorded significantly higher CCS compared to best standard. Entry CoN 13073 (100.00) and PI 13132 (96.94) recorded significantly superior cane yield compared to best standard. Among qualitative characters, CCS % (12m), Sucrose % (12m) and Brix % (12 m) Entry CoSnk 13101 was on par with best standard.

4. Identification of pathotypes of red rot pathogen

Dr. Rini C. R
Assistant Professor
rini.cr@kau.in

The disease development on different differentials indicated that, among the isolates, CfV 09356 (Keerangudi), Cf 2001-13 (Perampakkam), Cf 06022 (Kuthalam) and Cf 0265 (RK Pet Thiruthani Coop Sugars) behaved differently from the standard pathotypes CF06 and Cf 94012-0. These isolates exhibited more virulence than standard pathotypes during the current year.

5. Evaluation of zonal varieties for resistance to red rot

Dr. Rini C. R
Assistant Professor
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Varieties which showed either Resistant (R) or Moderately Resistant (MR) red rot reactions are
Advanced Varietal Trial (1st Plant) : Co 13013, CoN 13073, CoSnk 13101, Co13002, Co13009, CoN13072, MS 13081, CoSnk 13103, CoSnk 13106, PI 13132, Co13003, Co13008
Advanced Varietal Trial (I1nd Plant) : Co 12009, Co 12019, Co 12008, Co 12012

6. Survey of sugarcane diseases naturally occurring in the area on important sugarcane varieties

Dr. Rini C. R
Assistant Professor
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During the current year (2018–19), the most predominant diseases were and the foliar diseases *viz*., ring spot, rust and sheath blight. The other diseases observed were Pokkah Boeng and mosaic. But none of the diseases were in a severe stage to cause any drastic yield decline.

7. Agronomic performance of elite sugarcane genotypes

Sri. Jayakumr G
Assistant Professor
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In the case of early varieties, the germination % and tiller count were influenced significantly by the various genotypes and the highest values for the said parameters were recorded by CoM 11082 followed by Co 94008 under both the spacings (120 and 150 cm)

The treatment variations due to various genotypes were significant for cane length, cane diameter, single cane weight, MCC, cane yield and sugar yield. CoM 11082 recorded the highest value for the said parameters (232.65 and 240.28 cm, 2.99 and 3.07cm, 1.31 and 1.35 kg, 69360 and 74430 nos/ha, 63.90 and 70.72 t/ha, 7.10 and 7.82 t/ha respectively) followed by Co 94008 (228.00 and 235.34 cm, 2.96 and 3.03 cm,1.29 and 1.32kg, 60210 and 65650 nos/ha,55.70 and 62.41t/ha ,5.88 and 6.28 t/ha respectively).

With regard to midlate varieties, both the growth and yield parameters were influenced significantly by the genotypes and the highest values for cane length, cane diameter, single cane weight, MCC, cane yield and sugar yield were recorded by Co11007 (255.33 and 262.74 cm, 3.03 and 3.10 cm, 1.52 and 1.57 kg, 72120 and 77770 nos./ha, 69.30 and 75.17 t/ha, 7.60 and 8.25 t/ha) followed by Co 86032(252.33 and 257.14cm, 2.91 and 2.96 cm, 1.49 and1.53 kg, 60180 and 65250 nos. ha^{-1}, 55.17 and 60.08 tha^{-1} respectively).

8. Impact of integrated application of organics and inorganics in improving soil health and sugarcane productivity

Mr. Jayakumar. G
Assistant Professor
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The experiment to study the impact of integrated application of organics and inorganics in improving soil health and sugarcane productivity was planted as specified in the technical programme. The ratoon crops (1^{st} and 2^{nd}) were also harvested subsequently.

The germination and tiller count remained unaffected due to various treatments tried. The variation due to different treatments was significant for growth and yield parameters. In both ratoon crops, among the various treatments, the combination of FYM /compost @ 10 tha^{-1} + biofertilizer (Acetobacter + PSB) +100% RDF) recorded significantly higher values for cane length, MCC and resulted in maximum yield. Brix % and sugar yield also followed the same trend and was followed by the treatment FYM/Compost @ 20 tha^{-1} + inorganic nutrient application based on soil test (rating chart). Slight variation in the soil fertility parameters were noticed before and after the conduct of the trial especially regarding the status of major nutrients where higher values were recorded in the soil after the conduct of the experiment. The nutrient composition of the farm yard manure used was 1.0:0.5:1.0 % N, P_2O_5 and K_2O. The integration of FYM with biofertilizer recorded the highest BC ratio (1.38).

9. Use of plant growth regulators (PGRs) for enhanced yield and quality of sugarcane

Mr. Jayakumar. G
Assistant Professor
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The results revealed that the different treatments significantly influenced the germination percentage, cane and sugar yield. Significantly higher yields (cane yield -111.23 t ha^{-1}, sugar yield- 11.6 t ha^{-1}) were recorded by planting setts that were soaked overnight in ethrel 100 ppm followed by GA_3 spray (35ppm) at 90,120 and 150 DAP) and the lowest value for the above parameters were recorded by treatment of planting setts after overnight soaking in water. The highest BC ratio of 1.40 was also recorded by this treatment.

10. Scheduling irrigation with mulch under different sugarcane planting methods

Mr. Jayakumar. G
Assistant Professor
jayakumar.g@kau.in

The experiment was conducted with the objective of enhancing crop and water productivity in sugarcane. The results of the last trial revealed that germination % and tiller count did not vary significantly with the planting methods and irrigation schedule tried. Furrow planting at 120 cm spacing with green manure mulching was found to be significantly superior in cane length (262.56 cm), cane diameter (3.18 cm), single cane weight (1.56kg), MCC (82000 nos per ha), cane yield (101.00 t ha^{-1}), and sugar yield (9.47tha^{-1}) were recorded. Among the irrigation schedules, the highest values for cane length (259.92 cm), cane diameter (3.10 cm), MCC (77020 nos. /ha), cane yield (81.55 t ha^{-1}), and sugar yield (7.994t ha^{-1}) were recorded with irrigation at IW/CPE ratio -1.00. The interaction effect was significant for the different parameters and the combination of furrow planting with alternate skip furrow irrigation IW/CPE - 1.00 + green manure mulching recorded maximum values for cane length (260.94 cm), MCC (88250 nos), cane yield (111.27 t ha^{-1}) and sugar yield (10.90 t $ha^{-}1$) and BC ratio (1.41).

The trial could not be completed on account of the replacement of Agronomist with Entomologist in AICRP on Sugarcane.

11. Carbon sequestration assessment in sugarcane based cropping system

Mr. Jayakumar.G
Assistant Professor
jayakumar.g@kau.in

The results showed that the variations due to different treatments were significant for growth and yield parameters. Sugarcane - ratoon (trash mulching with Trichoderma)-cowpea recorded the maximum cane length (260.68 cm), cane diameter (2.47 cm), single cane weight (1.70 kg) and significantly higher cane and sugar yield (77.17 and 8.23 t ha^{-1} respectively) followed by the Sugarcane-ratoon-cowpea (trash incorporation through rotavator and Trichoderma incorporation before sowing of cowpea) which recorded the values of 254.33 cm, 2.41 cm, 1.65 kg and 69.65 and 6.81 t/ha respectively for the said parameters. There was considerable variation in the fertility status of the soil before and after the conduct of the trial where the nutrient status was improved after imposing the various treatments.

PG Projects

Concluded PG Projects

1. Nutrient management for productivity enhancement of cassava var. Vellayani Hraswa in lowlands

Ms. Pooja A.P
2016-11-027

The study entitled "Nutrient management for productivity enhancement of cassava var. Vellayani Hraswa in lowlands" was conducted at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala during 2017-18 to standardize the nutrient management for cassava var. Vellayani Hraswa in lowlands. The field experiment was conducted at Integrated Farming System Research Station, Karamana, Thiruvananthapuram as 3 x 2 x 2 factorial experiment in randomized block design with three replications. The treatments consisted of three sources of organic manure (m_1- FYM @ 12.5 t ha^{-1}, m_2- FYM @ 6.25 t ha^{-1} + green manuring *in situ* and m_3-poultry manure (PM) @ 2.5 t ha^{-1} + green manuring *in situ*), two levels of N (50 and 75 kg ha^{-1}) and two levels of P (25 and 50 kg P_2O_5 ha^{-1}) along with a uniform dose of 100 kg K_2O ha^{-1}. The results of the study indicated the feasibility of 50 per cent substitution of FYM with green manuring *in situ* (cowpea) or full substitution of FYM with PM + green manuring *in situ* and sufficiency of a lower dose of P for cassava. The highest yield, net income and BCR was recorded in the application of PM @ 2.5 t ha^{-1} + green manuring *in situ* with cowpea + 75 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} combined with 100 kg K_2O ha^{-1}.

2. Standardisation of nursery techniques through field validation in minisett cassava *(Manihot esculenta Crantz.)*

Ms. Sruthy K.T.
2016-11-007

The investigation with the objectives to standardise the cassava minisett nursery technique by validating its field performance in comparison with normal sett planting included a nursery experiment (April 2017 to June 2017) and a field experiment (April 2017 to January 2018) conducted at College of Agriculture, Vellayani, Thiruvananthapuram. The results of the study indicated that raising three noded minisett cassava cuttings in potting medium containing coir pith compost and vermi compost in 3:1 ratio in the nursery followed by transplanting at 3 WAP was found to be economically and technically viable nursery technique for getting higher yield and income from cassava cultivation compared to the conventional practice of planting normal setts directly in the main field.

3. Performance of different planting materials of tannia *(Xanthosoma sagittifolium (L.) Schott)* under shade

Ms. Nayana, V.R
2016-11-002

The experiment to assess the effect different shade levels and planting materials on growth and yield of tannia was conducted at the Agronomy farm, Department of Agronomy, College of Horticulture, Vellanikkara during June 2017-January 2018. Maximum corm yield was obtained from top of corm under open (9.28 t ha^{-1}) which was on par with top of corm under 50 per cent shade (9.14 t/ha). Number of cormels increased with increase in shade intensity and was maximum in 50 per cent shade (10.29) followed by 25 per cent shade (9.61). Weight of cormels (fresh and dry) were maximum for 25 per cent shade (108.26 g/cormel), on par with that of 50 per cent shade (103.61 g/cormel. The highest cormel yield was noticed in plots provided with 50 per cent shade (13.47 t/ha) and 25 per cent shade condition (12.66 t/ha). Planting of top of corm under 50 per cent shade resulted in maximum cormel yield (14.85 t/ha) on par with planting of top of corm at 25 per cent shade (14.83 t/ha) and 50 per cent shade with split corm (13.71 t/ha). In terms of gross returns, 50 per cent shaded condition produced maximum returns, followed by 25 per cent shade. Among the three planting materials, top of corm produced maximum returns in all the shade levels. The highest B: C ratio was obtained from combination of 50 per cent shade with top of corm (4.86), followed by 25 per cent shade and top of corm (4.45). The lowest B: C ratio was noted in cormel planting under open condition (1.32) indicating the suitability of the crop for shade.

Ongoing PG Projects

1. Genetic variability in chinese potato *(Solenostemen rotundifolius Poir)* for yield and nematode tolerance

Ms. Ankita M.O
2017-11-044

The field experiment was conducted at College of Agriculture, Vellayani during 2017-18 and the crop has been harvested. Thirty accessions of Chinese potato collected from CTCRI, Sreekariyam and local markets and farmers fields of major coleus growing tracts were raised in a field trail with three replications: The tubers were harvested at maturity and pertinent biometric observations related to yield and nematode tolerance were taken. Pot culture study was conducted for assessing varietal reaction to root knot nematode (*Meloidogyne incognita*) of the different accessions. Second instar juveniles of the nematode was inoculated after planting cuttings and root and soil observations were taken after 45 days. Data analysis is in progress. Data tabulation and statistical analysis are in progress.

2. High density planting and seed tuber size on productivity of lesser yam *(Dioscorea esculenta)*

Ms. Anasooya Sebastian
2017-11-019

The objective of the experiment is to maximize the productivity of lesser yam *(Dioscorea esculanta)* by adjusting plant geometry and seed tuber size, and to work out the economics of production under high density planting. The experiment was laid out in May 2018 as per the technical programme and management practices (weeding, earthing up and fertilization) were done according to the Packages of Practices and Recommendations, KAU. Biometric and physiological observations were recorded. The crop was harvested in December 2018 and tuber yield and drymatter production were recorded. Soil and plant analysis are being carried out . Statistical analysis are yet to be done.

3. Crop-weather-nutrient relations in cassava under moisture stress

Ms Sreelakshmi, K
2014-21-103

The objective of the programme is to study the effect of weather on growth and yield of cassava. The study also aims to investigate the role of potassium, silicon and, calcium in mitigating moisture stress effects and develop a recommendation for cassava under such situations. For the first experiment, Short duration variety Sree Vijaya was found to be a more promising variety qualitatively with Sree Athulya regarded best quantitatively.

For experiment II, it could be concluded that the foliar application of chemicals has significant influence on the general growth pattern of cassava varieties, provided moisture limitations is not severe. The yield of cassava during 2016-17 planting season was comparatively low even under

the influence of chemical treatments due to no or less rainfall availability during the initial three months of growth. Thesis preparation is in progress.

4. Integrated nutrient management in minisett cultivation of elephant foot yam *[Amorphohallus paeniifolius (Dennst.) Nicolson]*

Ms. Dhanalakshmi V.N
2017-21-025

The study aims to standardise the minisett size in elephant foot yam and to investigate the effect of integrated nutrient management practices on growth, yield, quality and economics of cultivation. The first experiment entitled "Standardisation of minisett corm size and integrated nutrient management practices" was completed in December 2018. Chemical analysis is to be done. Second year field experiment is going on. The second experiment entitled "Rooting and tuberisation pattern study" is under progress.

Name of Project Coordination Group: (18)
Coconut and other Palms

Compiled by:

Dr. Sujatha. R ., Project Coordinator

Plan & External Aided Projects

Ongoing Projects :6 Nos.

Post Graduate Projects

Concluded Projects: 1 No

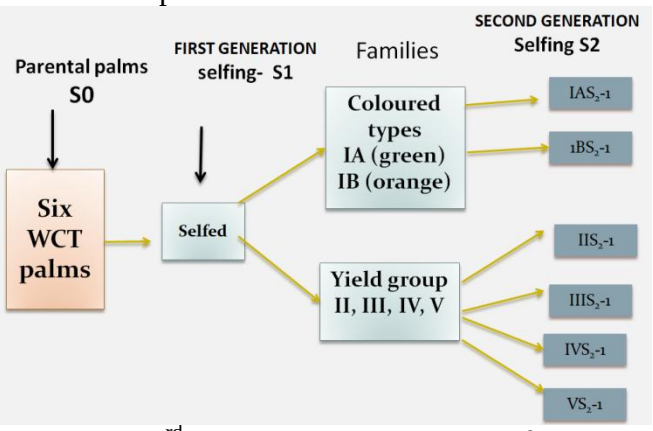
Ongoing Projects

1. Intensification of Research in coconut - Development of homozygous inbreds for hybrid production- State Plan Project

Dr. Sujatha. R.
ADR, Coconut Mission

Development of inbreds in coconut was started at RARS, Pilicode in 1924 and presently the 3rd generation selfed progenies are planted in field in replicated plots.

Development of inbreds in coconut



The DNA was isolated from all the 3rd generation inbreds in the field at RARS, Piliocde and the morphological and molecular characterization is progressing.

A promising 2nd generation inbred was crossed with Malayan Yellow Dwarf and the seednuts were sown in the nursery. The seedling characters are being evaluated.

A major problem faced in hybrid seed production of coconut is the dearth of sufficient pollen from dwarf palms during summer months due to severe drought. Experiments started to study the factors influencing storage of pollen using pollen bed drier. Pollen grains were collected and kept in pollen bed drier at different temperature (35-45^{0}C) and blower speed. The pollen viability and germination percentage is tested before and after the treatments. The work is in progress.

Pollen bed drier

2. Seed & planting material production & research - Hybrid seedling & dwarf coconut seed production

Dr. Sujatha. R.,
ADR, Coconut Mission

The projects aims at

1. Strengthening of existing coconut hybrid seed nut production programme in farmers field and distribution of quality seedlings
2. Identification of promising dwarf palms in farmers field for dwarf seednut production and distribution
3. Maintenance and further development of centenary memorial dwarf plantation

Pollination of selected 400 nos of elite West Coast Tall palms in farmers field and procuring of hybrid seed nuts is in progress. There are 10 trained pollination workers and the work was started in December 2018 and is being continued till 31st May, 2019.

Collection of open pollinated seed nuts from elite palms from farmers field is continuing and the collected seed nuts were sown in the nursery. A Centenary memorial dwarf plantation and a germplasm collection in the Farm at College of Agriculture, Padannakkad is being maintained under the project

3. Identification of dwarf ecotypes with high copra content

Dr. Vanaja T.
Plant Breeding & Genetics

Survey was conducted in 14 districts of Kerala with the help of Coconut Germplasm Conservation Unit (CGCU) of each district formed by RARS, Pilicode in 2015-16. Based on the data collected through survey we could locate 54 promising coconut ecotypes from 14 districts which could be categorized into 8 dwarf ecotypes, 16 semi tall ecotypes and 30 tall ecotypes. Further, seed nuts of 50 ecotypes shortlisted were procured from the selected plantations and were raised in nursery at RARS Pilicode. Out of these, thirty nine ecotypes from the nursery were planted in 'J', 'H', 'N 7' and 'N 8' blocks of RARS, Pilicode.

4. Strengthening Research on coconut and Developmental Activities at Coconut Research Station, Balaramapuram.

The project aims to strengthen the research and developmental activities viz., the agro-techniques of coconut mainly hybrid and dwarf palms; influence of secondary and micronutrients on yield, pest and disease incidence in WCT coconut palms; Performance evaluation of new and improved varieties of black pepper as intercrop in coconut; imparting training and providing infrastructure facilities at CRS, Balaramapuram.

Laying out and planting of WCT x MYD, COD x WCT hybrid coconut seedlings**,** dwarf coconut seedlings mainly, COD, CGD, MGD, MYD and MOD were carried out in the main field of CRS, Balaramapuram with an objective to study the most optimum spacing for dwarf palms, DxT and TxD for higher yield and to standardize the nutrient requirement for maximum yield from seedling stage. The seedlings were planted at four different spacing viz., 6m x 6m, 6.5m x 6.5m, 7m x 7m and 7.5m x 7.5m with two schedules of NPK fertilizer application. The experiment is in progress. The plants are at 5 to 7 new leaves stage with plant height of 127cm to

211cm. The seedlings are often infested by rhinoceros beetle. Though DxT, TxD and dwarf coconut palms start yielding 3-4 years, stable yield could be obtained after 8 years.

Black pepper rooted cuttings of new and improved varieties(PN I to VIII and Vijay) were planted and it is in progress with the objective to identify the best performing pepper variety for the region, from among the new releases from KAU and to compare the yield as well as quality advantage of the variety. The pepper vines put forth1-4 branches, with vine length of 18 to 100cm. The pepper vines will be trailed on to coconut tree. The treatments are laid out in Randomized block Design with 3 replications

Purchase of laboratory chemicals, manure and fertilizers, Pesticides, Renovation of existing open well at 'A' block, Widening the basins of young coconut palms and related research & farm developmental activities were carried out. Equipment such as Conductivity meter, pH meter, Reciprocating shaker, Viton fume hose for diacid and triacid digestion, single water distillation unit (4 l)Glassware like Volumetric flasks, conical flasks, plastic can and laboratory chemicals, Maintenance of farm machineries, Renovation of seed processing shed, farm machinery shed, potting mixture shed, vehicle shed etc.

Effect of secondary and micronutrients on yield, pest and disease incidence in coconut with objectives to study the effect of secondary nutrients *viz*., Calcium and Magnesium and micronutrients *viz*., B on the yield of coconut palm and to study the effect of secondary nutrients *viz*., Calcium and Magnesium and micronutrients viz., B on disease incidence in coconut palm. The infestation of major pest such as mite, coreid bug, rhinocerous beetle and diseases such as bud rot and leaf rot are being recorded. The percentage of infestation by mite ranges from 0 to 27.18 and coreid bug ranges from 22.61 to 66.33%. The study is in progress.

Trainings on transfer of improved technologies of hybridization in coconut, coconut production and plant protection practices, IFS, upland rice production technology and organic farming were conducted to rural youths, farmers, Agricultural Assistants and VHSE students on 10/10/2018, 16.10.2018, 22.10.2018 to 27.10.2018, 23/10/2018, 8/11/2018 to 14/11/2018, 27.11.2018 and 4.1.2019.

Under the state plan project," Evaluation of suitable crop combination under organic farming in coconut garden, the experiment was repeated during 2018-19 and concluded that the inter-row spaces between the bananas raised as intercrop in the coconut garden can be successfully utilized for growing other intercrops. Among the intercrops tested for suitability, ginger and turmeric performed better and recorded highest gross and net returns. Pooled analysis of data also gave confirmatory results.

5. Collection, conservation and evaluation of local germplasm of Coconut- AICRP –Palms

PI: Dr. Vanaja, T. (Plant Breeding & Genetics)

Two year old collections of six local dwarf germplasm of coconut namely RARS-DC-1, RARS-DC-2, RARS-DC-3, RARS-DC-5, RARS-DC-6, and RARS-DC-7 were compared with check variety CGD and analyzed for three juvenile growth parameters viz., plant height, number of leaves and girth. Among these, five collections exhibited significant dwarfing than the check variety CGD, the shortest being RARS- DC-1 and RARS-DC-7 which were on par.

All genotypes were susceptible to rhinoceros beetle with infestation ranging from 45.0% to 89.4% and there was no significant difference between the genotypes. However, the genotypes differed significantly with respect to incidence of grey blight disease that ranged from 0.62% to 41.7%. Incidence of grey blight disease was significantly lower (0.62%) in RARS-DC-3, RARS-DC-6, and RARS-DC-7 which were on par.

6. Performance of Dwarf x Dwarf hybrids of coconut in different agro- climatic regions

Dr. Vanaja, T. (Plant Breeding & Genetics)

Four years old dwarf X dwarf hybrids namely, GB X CGD, MYD X CGD, COD X MGD, COD X MYD, GB X MOD, CGD X MGD were compared with check variety GB for the traits such as plant height, average number of leaves, collar girth and third leaf length. There was no significant difference between the various dwarf hybrids for the characters studied. However, the hybrid GB x MOD recorded the longest 5^{th} leaf, and for the remaining hybrids, it was either on par with the check variety GB or less than check.

Pest and disease scoring for rhinoceros beetle and grey blight indicated that there was no incidence of grey blight, but there was rhinoceros attack ranging from 59.8% to 81.5% with no significant difference among genotypes.

PG Project

Concluded PG Projects

1. Developing D x T hybrids using promising second generation inbred and molecular characterization of the third generation inbreds of WCT coconut (*Cocos nucifera* L.)

Name of student: Hassain N (2016-11-113),
M.Sc. Ag, Dept. of Plant Breeding & Genetics,
COA , Padannakkad
Major Advisor: Dr. Sujatha. R.

Two palms from the promising inbred families viz., IIIS2 and VS2 were selected (Palm No, 313 and 225) and pollen was collected to pollinate two separate inflorescence of a superior palm of

MYD at College of Agriculture, Padannakkad. Though 25-35 flowers were pollinated, the seed set was very low which may be due to the in breeding depression in the male parent. Hybrid seed nuts (5nos) collected were sown in the nursery. Simultaneously, 15numbers of S3 seedlings from the IIIS2 family which were already planted in replicated trial during 2015 in the field at RARS Pilicode were characterized and compared with other tall and dwarf genotypes using RAPD.

Name of Project Coordination Group: (19)

Climate Studies

Compiled by:

Dr. P.O. Nameer, Project Coordinator

Plan & External Aided Projects

Ongoing Projects: 16 Nos.

Post Graduate Projects

Concluded Projects: 2 Nos.

Ongoing Projects: 24 Nos.

Ongoing Projects

1 All India Co-ordinated Research Project on Agrometeorology, Thrissur Centre

Dr. Ajith Kumar B
Asst. Professor & Head

The study on agro-climatic characterization was conducted on different agro-climatic zones of Kerala *viz.* Northern Zone, High Range Zone, Central Zone, Problem Area Zone and Southern Zone and the extreme weather events such as drought and heavy rainfall events were studied for all the agro-climatic zones of Kerala.

The correlation analysis of grain yield of rice varieties Jyothi and Kanchana, with various weather parameters was done by using last six-year (2013, 2014,2015,2016,2017 and 2018) crop data of rice. The crop weather pest relationship studies in rice variety Jyothi was studied for the years 2017 and 2018 and pooled correlations were worked out and the results showed that bright sunshine hours and maximum temperature have shown a negative influence on the incidence of stem borer.

2 National Innovations in Climate Resilient Agriculture (NICRA)

Dr. Ajith Kumar B
Asst. Professor and Head

The selected NICRA (National Innovations in Climate Resilient Agriculture) villages at Malappuram districts are Thavanur and Valavannur - Agromet Advisory Bulletins are preparing on every Tuesday and Friday based on the block level weather forecast from IMD and with the advice from the scientists of KVK, Malappuram and Kerala Agricultural University, Thrissur regarding the control measures for pest and diseases of crops. Validation of block level and district level weather forecast- shows that an improvement is needed in the weather forecast especially during SWM period. Case studies on economic impact of AAS- When AAS bulletin was followed for farm operations, farmer gained a net profit. Crop loss and extreme events in 2018-19- The various locations in the Malappuram district had faced severe flood and land slide during the month of August, 2018. The landslide occurred at locations such as Manjeri and Nilambur regions of Malappuram had caused severe crop damages, especially for vegetables and banana. Agroclimatic characterization of Malappuram district- The annual rainfall during 2018 is 3652.1 mm which is 5.36 % more than the normal rainfall. The highest daily rainfall noticed in the month of August was during 15th August(125.6mm).The Kerala flood (2018) occurred during this period.Farmers awareness programme- Farmer's awareness programmes have been conducted during the year 2018 at Valavannur and Niramaruthur villages in Malappuram District.

3 Gramin Krishi Mausam Sewa (GKMS) at Thrissur center

Dr. P. Lincy Davis,
Asst. Professor

AAS Bulletins on English and local languages are disseminated through e-mail to lead Farmers, PAO, Agricultural Officers, ATMA etc. Agromet advisory bulletins were being issued to the selected farmers of blocks of Thrissur District as Pananchery, Puthur, Madakathara, Ollukkara and Nadathara panchayath and their feedbacks were collected directly by skilled staffs. The weekly AAS bulletin is being published in Moon light. Dissemination of bulletin has been given to maximum number of farmers through M-Kissan Portal of Government of India. This is very helpful for the farmers to know about the local weather condition, it helps them for their cultivation practices.

4 Strengthening Agromet Advisory Services in Southern Kerala – Plan Project

Dr. Rajasree,G.

Station	Rainfall (No.of years) (daily data)	Max temp, Min temp, RH, Wind speed, Wind direction, Sunshine hours-daily data (No. of years)
Trivandrum district		
Vellayani	35	35
Trivandrum Airport	35	34
Trivandrum Observatory	35	30
Nedumangadu	35	
Neyyattinkara	27	
Varkala	35	
Kollam district		
Punalur observatory	30	34
Aryankavu	35	
Kollam (Hydro)	25	
Sadanandapuram		22
Pathanamthitta district		
Pathanamthitta (Konni)	35	
Thiruvalla	35	

Other data available

- Monthly mean of weather data – Sadanandapuram - 16years
- Monthly mean of weather data- Balaramapuram - 22years
- Weekly surface weather data of all stations in Kerala - IMD- 7years
- Weekly CWS data of all stations in Kerala –IMD- 5years
- Weekly surface data Tab 3- all stations in Kerala-IMD- 7years

30-year period Weather data collected from 9 stations in the zone, analysed to find out variability in rainfall, Max temp, Min temp, RH, Wind speed, Wind direction, Sunshine hours & trends recorded. Fine-tuned AEU wise agro advisory generation with the support of Kalavasta portal of C-DAC, Pune & 70 location specific bulletins prepared & issued through various media. Mobile based dissemination of advisories to contact farmers was developed. Water balance studies of the southern region conducted and period moisture adequacy was worked out

5 Strengthening Agromet Advisory Services in Central Kerala

Dr. Ajithkumar B

Collected and analysed the meteorological data base of Central Kerala.

Study of trends in rainfall, temperature and relative humidity across the zone indicate that annual rainfall, Relative Humidity and Minimum temperature were slightly increasing and that of Maximum temperature and the Mean temperature were found to be decreasing. 20 lead farmers were selected, trained for collecting crop-weather information. Location specific advisories are prepared &disseminated

6 Strengthening Agromet Advisory Services in Northern Kerala

Dr. P.K. Retheesh

Developed Agro Ecological Unit based meteorological data base for Northern Kerala. Collected meteorological data particularly rainfall and temperature from all the possible sources and a good data base has been maintained.

Data base of RARS, Pilicode–

1941- 1961 monthly rainfall data

1961-1986 weekly rainfall data

1986 onwards- daily data of all-weather parameters

Data base from IMD- 1992-2015

Studied water balance and rainfall trends of Northern Kerala. Components of water balance estimated using Thornthwaite book keeping method. AWS installed at RARS Pilicode, Nileswaram Farm.

7 Strengthening Agromet Advisory Services in High Range Zone

Dr. Sunil, K.M

Developed Agro Ecological Unit based meteorological data base for the entire Wayanad district.

Collected meteorological data particularly rainfall and temperature from all the possible sources and a good data base has been maintained.

Studied the water balance and rainfall trends of Wayanad district. Various components of water balance have been estimated using Thornthwaite's book keeping method.

The months showing highest PET are March April and May. The lowest PET was recorded during the month of December. Among the three AEUs Northern high hills recorded the lowest PET (1840 mm) and Wayanad Eastern Plateau recorded the maximum (2016). Water deficit is higher in Wayanad Eastern Plateau(1374mm)

Moisture availability index quite moisture availability begins from the month of May and the periods from the June to September is considered as the periods of excessive moisture. The duration of moisture availability periods varied between different AEUs. AEUs 21 shows lowest moisture availability periods of 3 months, followed by AEUs 20and AEUs 15(6months).

Dissemination of bulletin has been given to maximum number of farmers through M-Kissan Portal of Government of India

Developed a AEU wise crop-weather calendar of Wayanad district and started generating location specific bulletins.

8 Strengthening Agromet Advisory Services in Problem Zone

Dr.Ajith.K

An information support centre for data collection, analysis interpretation and preparation of bulletins was established. Collected weather data from all the available sources in Kottayam and Pathanamthitta districts and analysed.

Long term trends in climate variability across the zone were worked out. Water balance for the region was worked out. Trained 20 Climate managers for collection of real time crop situation, pest and disease information and dissemination of weekly Agromet Advisory bulletins

Dissemination of Agromet Bulletins were strengthened through, SMS so as to reach more than 50,000 farmers per week. Feed back from farmers are collected and the same was used for refining bulletins. Installed 20 Notice boards for displaying Agromet Advisory bulletins at different locations. Location specific bulletins were prepared and disseminated to farmers.

9 Pest and disease Surveillance and forewarning unit in Southern Zone Name of the

Dr. Faisal M.H

Recorded data from the selected farmers fields.(19 lead farmers)and IF, Vellayani

Details of pest incidence in the respective area were collected. Appropriate management measures were suggested for existing problems. The information was disseminated to the stakeholders through the lead farmers and Krishi Bhavans. The weather factors influencing incidence of important pests were identified and correlation coefficient worked out

Correlation of Epilachna beetle (*H. vigintioctopunctata*) population in brinjal with weather parameters showed significant positive correlation with maximum temperature + 0.84*, + 0.83*, + 0.91* for egg mass, grub and adult respectively, and with minimum temperature + 0.39* for adult. Significant negative correlation exists with relative humidity for egg mass andgrubs. Stem fly, *O. phaseoli*(Tr.) infestation in cowpea had correlation with minimum temperature (0.044), minimum humidity (0.108) and wind speed (0.395). Whereas, negative and significant correlation observed between feeding punctures and sunshine hours (r=-0.297). *In Spotted pod borer, M. vitrata of cowpea* a significant positive relationship between pod damage and wind speed (r = 0.778) and significant negative correlation coefficient with rainfall (r=-0.327)was noticed. The percent pod damage by *M vitrata*was negatively influenced by maximum temperature (-0.537), minimum temperature (-0.358), maximum relative humidity (0.282) and minimum relative humidity(-0.497)

10 Pest and disease Surveillance and forewarning unit in Central Zone

Dr. B. Ajithkumar

The pest such as pod borer in cowpea, pseudostem weevil in banana and leaf roller in rice were selected for surveillance. Observed diseases viz., mosaic in cowpea, sigatoka in banana and blight in rice. The observations were recorded weekly interval from the fixed plot. Roving survey also conducted on biweekly interval. Correlation of pest-disease incidence and weather parameters were worked out and recorded the trends. Established the relationship between weather variables and Pest and Disease incidence in Rice, Cowpea and Banana.

11 Pest and disease Surveillance and forewarning unit in High Range Zone

Dr. Dhanya, M.K

Studied the periodical resurgence and intensity of pest and diseases of cardamom andpepper.27 plots were randomly selected from 9 panchayats (located within an aerial radius of 25 kms from the agro meteorological observatory at CRS Pampadumpara). The observations on infestation/incidence of pests and disease of these crops were recorded in biweekly interval. Daily meteorological data on temperature, relative humidity, rainfall and bright sunshine hours were also recorded. Correlation and regression analysis were carried out between pest/disease incidence and weather parameters

12 Pest and disease Surveillance and forewarning unit in Northern Zone

Dr. B. Ramesha

Observation on pest & diseases noted from the surveillance plots and correlations with weather parameters was worked out. Relationship between Relative Humidity, Tmax and Tmin was worked out in case of BPH in rice, Pseudostem borer and Rhizome weevil in banana and Tea mosquito and *Colletotrichum* incidence in cashew.

13 Pest and disease Surveillance and forewarning unit in Problem Zone

Dr. AjithK

Collected pest and disease information from selected fields and analysis was done in relation to weather variables. Installed micro automated weather station at selected fields for monitoring hourly weather data. Time to time pests and disease forewarning were issued as Alert/warning based on the weather variability and crop stages. In rice thrips, stem borer, black bug and BPH were noticed as the major pests. The favourable weather condition is light or no rainfall with a temperature of 21to 32^0C. In case of banana the incidence of pseudo stem weevil was noticed during 150 to 300 DAP with light rainfall and a temperature between 23 to 34^0 C. Sigatoka disease was more prevalent during 100 to 200 DAP with a temperature of 21 to 34^0C. In cow pea light rain fall and temperature between 23 – 320 C favoured the incidence of thrips, bacterial leaf blight and powdery mildew

14 Identification of Lead farmers as Climate managers

Dr. Rajasree.G

Identified 80 lead farmers as climate managers. 20 farmers each were selected from four districts viz. Thiruvananthapuram, Kottayam, Thrissur and Kasaragod & trained to equip them as climate managers. The information collected by them was used in agro advisory generation

15 Indigenous Technical Knowledge in weather and Climate in relation with agriculture and forecasting in Central zone of Kerala –Thrissur

Dr. B. Ajithkumar

Fields survey was conducted in different parts of Thrissur, Palakkad and Ernakulam district. Many weather based ITK's were obtained from 247 farmers of Thrissur district, 225 farmers of Palakkad district and 210 farmers of Ernakulam district. Many of the ITKs were obtained on birds, animals, plants, insects, earthworms, ants, moon halos and number of stars, directions of wind, the colour of clouds etc. Three farmer awareness programmes were conducted in Thrissur, Palakkad and Ernakulam, districts

16 Indigenous Technical Knowledge in weather and Climate in relation with agriculture and forecasting in Southern zone of Kerala - Kollam

Dr. Bindu Podikunju

A document containing Indigenous knowledge of the people in the districts of Kollam, Pathanamthitta and Thiruvanthapuram districts for forecasting weather especially rainfall was prepared and published.

Indicators identified (ITKs) by interviewing 600 farmers in 3 districts

Animal- 19 Nos

Birds – 16 Nos

Fish – 5 Nos

Insects- 15 Nos

Plants – 18 Nos

Atmospheric- 25 Nos

Beliefs and Proverbs – 10 Nos

PG Projects

Concluded PG Projects

1. **To compare the accuracy of different weather-based models for forecasting rice yield. To validate the results with experimental data**

Athira Ravindran (2016-11-070)

Significant influence of date of planting on plant height was observed for both varieties up to 5 weeks after transplanting. After first five weeks, no significant influence of dates of planting was observed for both the varieties. During all weeks, significant difference was observed in plant height due to varieties. With delay in planting dates, dry matter accumulation was found to be decreasing in both Jyothi and Kanchana. Maximum dry matter accumulation was noted at 75 days after planting in both the varieties where June 5^{th} planting (15257.53 kg ha^{-1}) was found superior in Jyothi and June 20^{th} planting (15186.57 $kgha^{-1}$) was superior in Kanchana which was on par with June 5^{th} planting (15094.84 kg ha^{-1}).

The selected model for Jyothi is:

$$\mathbf{Y = 16.774 - 0.370X_{15} - 0.137X_{34} + 0.110X_{41} + 0.106X_{44} + 0.238X_{64} - 1.605X_{84}}$$

(Adjusted R^2 – 0.912 and MAPE – 4%)

Out of all the models fitted for Kanchana, the crop weather model using five fortnights' weather variables was selected which can give yield forecast at flowering stage of the crop. The selected model for Kanchana is:

$$\mathbf{Y = -6.143 + 0.053X_{42} + 0.134X_{45} - 0.952X_{81}}$$

(Adjusted R^2 – 0.657 and MAPE – 7.62%)

2. **Crop weather simulation model in Tomato (*Solanumlycopersicum*):**

Navya shree S (2016-11-119)

The study "Crop weather simulation model in tomato (*Solanumlycopersicum*L.)" was conducted at Department of Agricultural Meteorology, College of Horticulture, Vellanikkara, Thrissur during 2017–18. The study was carried out to calibrate the genetic coefficients for tomato using DSSAT CROPGRO-Tomato model and to evaluate the micrometeorological aspects of tomato under different growing environments. From the study on calibration of genetic coefficients of tomato using DSSAT CROPGRO model it can be concluded that, crop simulation models are

efficient in simulating the growth and yield of tomato. The calibrated genetic coefficients can be used to predict growth and yield of tomato of any location by using the standard input files for weather and soil condition as well as crop management.

Ongoing PG Projects

1. **Crop weather relationship of rice varieties under different growing environments-**Code No: FSCS-09-00-02-2018-VKA-(20)-KAU-PG

Haritharaj (2017-11-094)

Validation of different statistical models were carried out for Jyothi using the weather data collected at the time of field experiment. The models used were mainly based on weekly weather variables, fortnightly weather variables, crop stage wise weather variables and composite weather variables. Models based on weekly weather variables used eight week weather variables for better prediction of yield whereas models based on fortnightly weather variables performed well using five fortnightly weather variables. Weather variables during booting to heading stage was selected for the models that are using crop stage wise data for Jyothi and seven weeks data were used in those which uses composite weather variables. Yield prediction model was fitted for Jaya by performing principal component analysis and a best model with two components was selected for forecasting the yield.

2. **Crop weather relationship studies in finger millet in central zone of Kerala**

Anunayana T. John. (2017-11-135)

The present investigation on the crop weather relationship in finger millet suggested that the positive contribution of various weather and micrometeorological parameters like relative humidity, vapour pressure deficit, rainfall, forenoon and afternoon soil temperature etc. and the reduced maximum temperature and temperature range which increased the production of number of ear heads, finger number per ear head, increased finger length, straw yield etc. This ultimately leads to increased grain yield in May $15^{th}$and June 1^{st}date of planting. In case of the three planting methods, studies suggested that transplanting can be considered as best establishment method for finger millet cultivation in central zone of Kerala.

3. **Crop simulation in groundnut (*Arachishypogaea* L) using DSSAT- CROPGRO model:**

Vinu KS (2018-11-113)

4. **Analysis of potential yield and yield gap of rice (Oryza sativa L)using CERES rice model:**

Haritha lekshmi. (2018-11-067)

5. **Impact of climate change on production and nutritional qualities of rice.:**

Aswathi K P(2018-11-130)

6. **Agroclimatological analysis for crop planning in southern Kerala.:**

C A Hubaibhassan (2018-11-090)

7. **Assessment of impacts of selected extreme climatic events on the marine fisheries along Kerala & Tamil Nadu coast.**

Punya, P (2014-20-105)

8. **Valuation of ecosystem services of selected mangrove wetlands of Kozhikode district, Kerala**

Supriya Baburaj M (2014-20-108)

9. **Modelling climate change impact on surface runoff and sediment yield in a watershed of Shiwali region**

Anu. D. Raj (2014-20-112)

10. **Species richness and carbon sequestration potential of Sharngakavu sacred grove, Chengannur, Kerala**

KavyaJeevan (2014-20-114)

11. **Potential impact of Climate Change on surface runoff and sediment yield in a watershed of lesser Himalaya**

Sooryamol, K.R (2014-20-115)

12. **Study the impact of abiotic stress on photosynthetic potential of tropical tuber crops under elevated - CO2 - FSCS-09-00-04-2018-VKA (CC) (20)-KAU-PG**

Ancy, P (2014-20-117)

13. **Segregating the impact of climate change *vis-à-vis* effort on inter-annual variability of selected small pelagic fishes using numerical models - FSCS-11-00-032018- VKA (CC)(27)-KAU-PG**

Pooja, A.S (2014-20-118)

14. **Water budgeting studies for effective resource management in Chuvannamannu Watershed - FSCS-05-00-08-2018-VKA (CC) (22)-KAU-PG**

Varna G S (2014-20-119)

15. **Effect of salinity on growth, physiological and biochemical process of coconut seedlings (Cocosnucifera) - FSCS-09-00-05-2018-VKA (CC) (20)-KAU-PG**

Arya Santhosh (2014-20-120)

16. **Climate envelope modelling of hard corals - FSCS-11-00-04-2018-VKA (CC) (27)-KAU-PG**

Anakha Mohan (2014-20-123)

17. **Carbon sequestration potential of selected seaweeds of Thikkodi, Kerala-FSCS-11-00-05-2018-VKA (CC) (27)-KAU-PG**

Saranya, M.S. (2014-20-124)

18. **Seasonality of human-wildlife conflicts in Wayanad, Kerala - FSCS-11-00-06-2018-VKA (CC) (22)-KAU-PG**

Karthik Krishnan M.G. (2014-20-126)

19. **Growth dynamics and physiological response of forestry species to CO2 enriched atmosphere - FSCS-10-00-04-2018-VKA (CC)(20)-KAU-PG**

Anusha, R. M (2014-20-127)

20. **Quantify the temporal carbon, water and energy fluxes in selected land use system in Himalaya - FSCS-10-00-05-2018-VKA (CC) (20)-KAU-PG**

Arya. M. S (2014-20-128)

21. **Microbial remineralization of the Dissolved Organic Carbon (DOC) derived from the benthic producers of Gulf of Mannar (GoM) ecosystem -FSCS-11-00-07-2018-VKA (CC) (20)-KAU-PG**

Alen Mariyam Thomas (2014-20-129)

22. **Effect of high temperature on female flower receptivity and fertilization of coconut - FSCS-09-00-06-2018-VKA (CC)(20)-KAU-PG**

Neethu. P. (2014-20-130)

23. **Reconstruction of paleo climate data from tree rings using different techniques**

FSCS-10-00-06-2018-VKA (CC)(22)-KAU-PG

Jibin Rajan R Y (2014-20-131)

24. **Climate-forest fire linkages in selected protected areas in Kerala**

FSCS-10-00-07-2018-VKA (CC) (22)-KAU-PG

Sreedevi. K. (2014-20-132)

FACULTY OF AGRICULTURAL ENGINEERING

Dr. Santhi Mary Mathew

Professor (RC)

Name of P C Group (01)

Farm Power Machinery and Energy (FPME)

Compiled by:

Dr. P. K. Sureshkumar, Project Coordinator

Plan & External Aided Projects

Ongoing Projects:7 Nos.

Ongoing Projects

1. **Development of light weight climbers and Household extractors for coconut milk and oil -** FRC No. : FPME/01-03-01-18/TNR(01)/KAU/PLAN

Dr. Jayan P.R., Professor
Dept. of FMPE, KCAET, Tavanur
jayan.pr@kau.in

Analyzed the strength and stability aspects of two types of coconut climbers. The factor of safety of both KAU coconut palm climber and a Farmer's model were found out as 1.5 to 3.0 and hence these two sit and stand type coconut climbers are found safe w.r.to its strength and stability of its individual components. Draft test codes for coconut climbers were prepared and submitted to FMTC, Tavanur. A manually operated coconut milk extractor was developed and tested and is recommended to present the technology in the ZREAC meeting for technology transfer and including in the PoP, KAU.

2. **Sub-centre of Excellence in Agril. Mechanisation Extension Services and Research and Development-** FRC No. : FPME/01-03-01-18/TNR(01)/KAU/PLAN

Dr. Jayan P.R., Professor
Dept. of FMPE, KCAET, Tavanur
jayan.pr@kau.in

Design of scale down prototype of the Pokkali paddy harvester and the feasibility trials of tractor operated coleus harvester were conducted at different fields. Recommended to present the results of the trials conducted to uproot the turmeric at Seed Garden Complex, Munderi and RARS, Pattambi with the tractor operated coleus /ginger harvester to present in the next ZREAC meeting for its technology transfer and including in the PoP.

3. **Development and testing of tractor operated tuber/rhizome harvesters for homestead cultivation -** FRC No. :FPME/01-04-01-18/TNR(01)/KAU-PLAN

Dr. Jayan P.R., Professor
Dept. of FMPE, KCAET, Tavanur
jayan.pr@kau.in

4. **Cost effective mechanization for aquatic weed management in Kuttanad belt-** FRC No - FPME/01-06-01-18/TNR (01)/KAU-PLAN

Dr. Joby Bastian, Professor (FPME)
RARS, Kumarakom

5. **All India Coordinated Research Project Onfarm implements and machinery**

Dr. Shaji James P, Professor (FPME)
KCAET, Tavanur
shajijames.p@kau.in

6. **Development of an electrostatic spray charging system for attachment to electrically operated mist blower -** FRC No. : FPME/01-02-01/18/TNR(01)/KAU/ICAR

Dr. Shaji James P, Professor (FPME)
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A Line Output Transformer (LOPT) based high voltage generator system was developed. The output voltage was in the range of 10 to 15kV. Liquid atomisation was accomplished using high pressure diaphragm pump and hydraulic spray nozzle operating at 6 bar pressure. High velocity air assistance was provided using an Electronic Ducted Fan (EDF) having duct size of 70mm. Both EDF and diaphragm pump were powered by single 12V DC 9Ah lead acid battery. The preliminary field testing was done and the project will be concluded shortly.

7. **Development of a back-pack engine operated multipurpose tool carrier for homestead agriculture -** FRC No. : FPME/01-01-01/18/TNR(01)/KAU/ICAR

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A multipurpose tool carrier for a back-pack brush cutter engine for powering the rotary blades for light tillage and weeding in vegetable crops has been developed. A two row wet land paddy weeding attachment compatible with the brush cutter engine was also developed and field tested. Developments of an attachment for inter-cultivation and basin formation for the homestead coconut garden is being done.

Prototype Feasibility Testing: 6 Projects

1. **Micro-nutrient applicator attachment for four wheeled riding type rice transplanter.** The system was found suitable and could be used successfully in 4-wheel riding type transplanters. The farmers were happy that they need not spend labour for spraying micro nutrient in the nursery.
2. **Tractor operated power harrow**

   The tractor operated power harrow was found suitable for secondary tillage for dry seeded rice as well as vegetable crops. The field efficiency was found to be in the range 74-78 %. The vertical axis of tine rotation was expected to avoid the formation of any hard pan by repeated tillage with rotovator.

3. **Herbicide applicator attachment to 8 row riding type rice transplanter.**

Front mounted Herbicide applicator attachment to 8 row Yanmar rice transplanter was found to work satisfactorily and could reduce the cost of manual herbicide application.

4. **Wet land weeding attachment to mini garden tiller/ weeder**

The weeding attachment to mini tiller was found to work satisfactorily for machine transplanted paddy with a row spacing of 30 cm. The requirement to purchase a machine only for weeding in wet land can be avoided by this attachment which could be easily fitted to a garden tiller.

5. **Tractor operated spading machine**

The spading machine as a primary tillage implement had a depth of operation ranging from 22 to 30 cm. Field capacity was very low ie. 0.06 – 0.1 ha per hour with a field efficiency in the range 83 – 89 %. But farmers prefer it for tillage in coconut gardens as deep tillage will help to conserve moisture and better incorporation of organic matter.

6. **Tractor operated rake**

The tractor operated rake was capable of windrowing paddy straw at a fast rate. The operation of rake has also helped for complete straw recovery from the field. Even the spilled straw could be gathered resulting in overall improvement of paddy straw management.

Front Line Demonstrations (5 programmes)

1. **Tractor operated rake and straw baler combination**

Tractor operated straw baler when operated in conjunction with rake (windrower) was found to be advantageous in reducing the time for baling. The advantage with the combination was that entire straw could be collected including the left-over straw spilled in the field. Hence the total number of bales from unit area was found to be more.

2. **Combination implement for seeding and herbicide application for dry seeded rice.**

The combination implement could control the problem of weed growth in dry seeded rice to a great extend due to spraying of pre-emergent herbicides. The major advantage was that the herbicide application could be done without additional labour cost.

3. **Bio-fungicide applicator attachment to 4-wheel riding type rice transplanter**

Application of liquid pseudomonas on the mat nursery immediately before transplanting could be achieved without any additional labour cost and the farmers accepted the technology.

4. **Pre-germinated paddy seeder attachment to Chinese 8 row rice transplanter**
   This system was advantageous in situations where wet seeding of germinated seeds was preferred. The seeding attachment could be easily fitted to a Yanji transplanter by replacing the transplanting unit.

5. **Combi brush cutter for homestead**
   The combination brush cutter with pruning attachment could be used by the farmers for lopping the branches of green manure crops like glyricedia.

6. **Back pack brush cutter operated pineapple harvester**
   Even though there was no substantial time saving compared to manual operation, the convenience and drudgery were reduced by using the device.

7. **Straw baler**
   Straw baler (Round) could be successfully demonstrated in farmers fields. Farmers could collect straw without getting damaged by summer rains and could get an additional income of Rs. 10000 to 11000/- per ha.

Name of Project Coordination Group: (02)

Soil and Water Engineering

Compiled by:

Dr Rema K. P, Project Coordinator

Plan & External Aided Projects

Concluded Projects: 1 No.
Ongoing Projects: 5 Nos.

Post Graduate Projects

Concluded Projects:6 Nos.
Ongoing Projects:8 Nos.

Concluded Projects

1. **Studies on Augmenting Vegetable Production by Poly House Cultivation using Water and Energy Efficient Eco Friendly Technologies- State Plan**

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The project envisaged the installation of off grid Solar power system with UPS as an alternate energy source for the poly house constructed for the research purposes of the Department of IDE,KCAET and to install solar powered irrigation pumping system inside the poly house. Accordingly, 1 KW off grid solar power system for the poly house, panel GI structure, panel wiring, and output Ac generation system were installed. Solar powered irrigation system with 1 HP motor, motor connection with solar UPS and plumbing for output water connection were completed. The remaining fund was utilized for the procurement of research materials. The micro irrigation and fogging systems are operating using the supply from solar panel directly during day light hours and from the stored power in the UPS during night. The research activities inside the poly house are utilizing the solar power for operating the irrigation control systems. The excess power stored in the UPS is also utilized to light up the area near the poly house and the security cabin. The project is concluded and the total sanctioned amount was utilized.

Ongoing Projects

1. **Conjunctive water use planning for enhancing water availability in the command area of Chalakudy River Diversion Scheme – AICRP on Irrigation Water Management**

Dr. Kurien E K
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The survey work has been taken up initially at the Left bank canal system. Forty eight numbers of farm ponds have been located in this command. Geo referencing and capacity estimation has been completed. As suggested in the project these structures are a potential source for conjunctive irrigation use. The possibility of these structures to be fed by the canals and their suitability to serve as alternate irrigation source is under study. The work need to be extended to the right bank also. The project is in progress.

Ponds in the command area of Left Bank Main canal

2. **Development of suitable filtering technique for reusing household waste water for irrigation**

   Household kitchen waste water was tested and found that the same could be used for irrigation after filtration through suitable media. The different media identified include bio char, sand and baby metal. The filtered waste water was successfully tested for raising vegetables including okra. The waste water is also being tested for fish culture.

Fish harvest from kitchen waste fed tank

3. **Survey and intervention studies in Left Bank canal of Chalakudy River Diversion Scheme**

The work has been taken up to assess the water availability and demand in the LBC canal command. The total release for the entire irrigation season is about 13622.38 million litres. The seepage loss and losses through canal breaches accounts for the inadequate supply at the tail ends. Water supply at the branches is inadequate to meet the demand. Supply based on demand and proper management can improve the efficiency of the canal irrigation system.

Left Bank Main canal (Regulator at Palissery)

4. Study on Structural design and management of Hi-Tech Horticulture in Kerala- Dept. of Agriculture, Govt. of Kerala.

Dr.P.Suseela, Professor
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i) Modified poly kitchen garden

Poly kitchen garden developed at HTR&TU, IF, Vellanikkara of 10 m^2 and 20m^2 with multitier grow bag, multitier grow bag with composting facility , grow bags and troughs has been accepted by Govt. of Kerala and the same has been recommended for popularization among the public with 75% subsidy. Now the same unit was modified in such a way that we can raise not only vegetables, but also fish, egg and meat. In this system, poultry excreta after fermentation by adding some ingredients are fed into the fish tank in a particular proportion. This helped to reduce the daily fish feed rate by 40% and to increase the growth rate and yield of plants considerably. As the media used in the multitier grow bags, troughs and grow bags are 20mm gravel, there is no need to change the media. Provision was also given for cleaning the multitier grow bags without disturbing the system after raising 2 to 3 crops to remove the solid matter deposited. The operation of the system has been completely automated by utilizing a fish feeder cum operation regulation system developed at HTR&TU. This helped to feed fish and vegetables in time even in the absence of grower. As water from fish tank is re-circulating, the requirement of water could be reduced by 90% (requires only 10% water) than conventional soil cultivation. Growth & yield of plants was found better than the original poly kitchen garden and growth rate of fish was better than aquaponics system.

Modified poly kitchen garden with fish tank for raising >300 no. of fish, cage for raising 4 to 6 hen, 4 multitier grow bags (in one unit can grow >35 plants), 3 rows of troughs, 15 no. of grow bags, one microgreens cultivation

ii) Development of pollinator

In order to have a better solution for fruit setting of tomato, bitter guard and brinjal, two models of hand held pollinator, one model of wheel mounted pollinator and one automated pollinator (in which we can programme the time at which pollination has to be done and duration of pollination and it will work automatically as per the schedule) was developed and tested. It was found that the yield of tomato plants can be increased considerably (3 times) by giving provision to vibrate the flowers of tomato plants between 7.30 am to 9.30am by utilizing the pollinator. Inside the polyhouse, hand held pollinators and automatic pollinator were found to be more convenient and effective than wheel mounted pollinator. The automatic pollinator gives provision to feed the time at which plants are to be vibrated and duration of vibration. Once it is setup, the system will automatically operate daily as per the schedule of time fixed.

Automatic pollinator developed

Wheel mounted unit

iii) Influence of duration of light on growth of leafy vegetables

It was found that growth rate of palak can be increased by giving artificial light (with 75% red & 25% blue) during night from 8pm to 11 pm using LED light. A comparative evaluation of effect of light combination (75% red & 25% blue and 60% red & 40% blue) effect of light on other plants is progressing

iv) Influence of type of cooling system in polyhouse

The study was conducted to find out the influence of type of cooling systems (like exhaust fan, furnace fan, circulating system, foggers installed inside the polyhouse and foggers installed outside the polyhouse at gutter level) on growth and yield of plants revealed that yard long bean cultivated in the polyhouse fitted with circulating fan was found to give significantly higher yield than other cooling systems.

5. Standardization of Irrigation and Fertigation Requirement for Amaranthus under Polyhouse -Projects under Precision Farming Development Centre

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The objective of the study is to standardize irrigation and fertigation requirement for amaranthus under polyhouse and also to workout it's Benefit Cost (B: C) ratio. An existing polyhouse of size 292 m^2 located at the instructional farm of PFDC, Tavanur was selected for the study. The crop variety used for the study is Co1 and the crop spacing is 0.45 m × 0.30 m. There were three levels of irrigation viz. 100% of Etc, 80% of Etc and 60% of Etc and three levels of fertigation viz. 100% of RDF (N:P:K – 100:50: 50kg/ha), 125% of RDF (N:P:K - 125:62.5:62.5kg/ha) and 150% of RDF (N:P:K - 150:75:75 kg/ha). ETc with respect to different growth stages of crop were determined and fertigation was scheduled according to PoP recommendations of KAU. Growth and yield parameters are under observation. There were two harvests from the polyhouse until 01.04.2019. Weather parameters such as temperature (˚C) and Light intensity (lux) inside and outside polyhouse are also under observation. The trial is still continuing.

PG Projects

Concluded PG Projects

1. Evaluation and Refinement of Low Cost Automation System for Naturally Ventilated Greenhouse.

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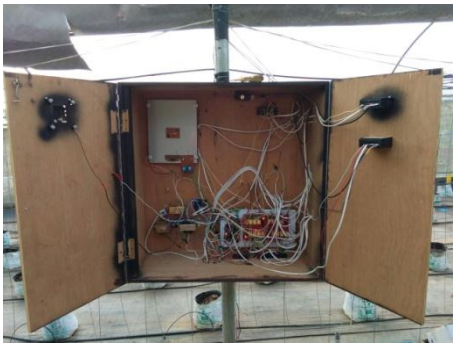
The study was conducted during the period July 2015 to February 2017 to modify the existing low cost automation system at ARS Anakkayam and also for its performance evaluation. Existing automation system has limitations such as it cannot manage temperature and relative humidity separately and also it cannot manage irrigation and fertigation. The refinement of the system was done by changing the microcontroller used in the automation system and also using a timer for the timely management of irrigation and fertigation. The refined system was capable of managing temperature and relative humidity separately and performing irrigation and fertigation operations inside the greenhouse. The refined automation system was tested without crop and with crop during three crop seasons with salad cucumber crop (variety *Saniya*) inside the greenhouse. For comparison, salad cucumber was cultivated inside another greenhouse which was manually controlled. Microclimate as well as crop data were collected from outside the greenhouse and both these greenhouses and compared. The temperature inside the automated greenhouse was less compared to non automated greenhouse and the relative humidity inside the automated greenhouse never exceeded above 70%. The yield and all other crop parameters were better in automated greenhouse compared to non automated greenhouse.



2. Water availability and Climatic Water Balance for a Selected Cropped area

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The rainfall data of Pattambi was analysed to study the variability, trends and probability of rainfall. A weekly climatic water balance was also assessed to determine the surplus/deficit of

rainwater. The trend analysis of annual, seasonal and monthly rainfall according to Mann-Kendall test and Sen's slope estimator revealed rising and falling trends. The rainfall probability at different levels of exceedance was found by fitting incomplete Gamma distribution. The weekly rainfall probability at 75% exceedance varied from 10.3 to 72.6mm during the weeks 21st to 46th. The annual rainfall at 75% level of exceedance was found to be 2051.6mm.Weibull distribution was identified as the best fit for weekly rainfall distribution in the region. The total ET_c demand of rice, banana and vegetable crops at 50 % probability levels of ET_o was estimated as 469.162 mm, 1124.81 mm and 267.92 mm whereas the rainwater availability at 75 % probability level was 933.85 mm, 1107.53 mm and 59.18 mm respectively. It was observed that there was a surplus of 464.688 mm for rice, deficit of 17.28 mm for banana and deficit of 208.74 mm for vegetable crops. The climatic water balance indicated that water surplus (SUR) and water deficit (DEF) components are significant. The total climatic water surplus and deficit in the region was estimated as 1985.54 mm and 155.08 mm. The determination of water availability period revealed that 1,4,5,8, 9, 11 and 50th SMWs were in water deficit whereas the remaining weeks were in water surplus.

3. Study of the Geo Morphological Influences on the Runoff Characteristics of a catchment

Er. Vishnu B
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The morphometric analysis using GIS gives platform for deriving the geomorphological parameters of the Thuthapuzha river basin. Thuthapuzha river basin has a dendritic type of drainage network with elongated shape. The runoff factor exhibits highest percentage of variance of about 37%. The high correlation coefficient was obtained between runoff and length of overland flow and constant of channel maintenance which are more significant. Factor analysis shows that form factor, elongation ratio, circulatory ratio, exhibits shape characteristics which are more important after the runoff factor. Length of overland flow, constant of channel maintenance, elongation ratio and rainfall are used as independent variables for estimating the runoff. R^2 obtained through regression analysis is 97.85%. Regression analysis reveals that constant of channel maintenance has a positive impact on runoff whereas elongation ratio reveals negative impact on runoff. From regression analysis, rainfall exhibits more contribution to runoff.

4. Soil Erosion Risk Assessment in Kunthippuzha Sub-wwatershed Using Remote Sensing and GIS

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This particular study mainly focused to identify the erosion prone areas in Kunthippuzha sub-watershed using RUSLE and MMF models and to analyse the effect of spatial and temporal variations of landuse on soil erosion rate with the support of NDVI values. The estimation was carried out for the years 2000 and 2013 and the mean value of soil erosion estimated for the year 2000 was 18.7 and 21.1 t/ha/y using MMF and RUSLE model respectively. Similarly for the year 2013, it was 33.7 and 42.6 t/ha/y respectively. To find the erosion prone areas in the sub-watershed factorial scoring method was chosen. From the analysis based on the RUSLE model, 1.47 % of the sub-watershed area experienced very slight erosion, 41.24 % area experienced slight erosion, 25.08 % area experienced moderate erosion, 26.02 % area experienced severe erosion and 6.19 % area experienced very severe erosion. Analysis using MMF model showed that the areal extent under slight, moderate, severe and very severe risk erosion categories were 40.70 %, 36.95 %, 15.07 % and 7.27 % respectively. NDVI values corresponding to land use were identified, in which negative NDVI values represent water pixels and thick vegetation is represented by higher NDVI values. The spatial variation of soil erosion varies from pixel to pixel according to the land use pattern. Highest soil erosion risk was observed under build-up plus barren land.

5. Swat Model Evaluation using Generated Data and Assessing the Impact of Land Use Changes

Dr Anu Varughese
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The Kunthipuzha river basin was selected as the study area for calibration and validation of the hydrologic model SWAT. In order to overcome the problem of data scarcity in ungauged areas, CFSR (Climate Forecast System Reanalysis) data which is a global, high resolution, coupled atmosphere-ocean-land surface-sea ice system is available. SWAT output comparison using CFSR and observed meteorological data as inputs was taken upland use change impact on the hydrology of the watershed was also studied. The most sensitive parameters for the study area are the CN2 (Initial SCS runoff curve number for moisture condition II) and ALPHA_BF (Base Flow alpha factor) which were evaluated using SWAT CUP (Calibration and Uncertainty Program). The model was simulated for the period 1991 to 2013 for calibration and 2014 to 2016 for validation. The NSE and R^2 before and after calibration were 0.81& 0.83 and 0.82 & 0.85 respectively. The NSE and R^2 for the validation were 0.7 & 0.87 respectively. The NSE, R^2 and RMSE for the observed meteorological data were 0.82, 0.85 and

29.25 respectively, where as for the predicted meteorological data (CFSR data) the values were 0.70, 0.72 and 37.18 respectively. From the graphical analysis, it was clear that the values of predicted meteorological data were highly correlated with the observed meteorological data except at the peaks. Hence, CFSR data can be used as a reliable data source in data scarce areas. Land use maps for the year 2000 and 2017 were prepared and on comparison, urban areas drastically increased from 3.01 to 20.01%, forest land reduced from 22.24 to 21.31% and percentage under paddy decreased from 17.57 to 6.12%. The model was simulated for the period from 1989 to 2016 for the comparison of simulated discharge for the year 2000 and 2016. There is no significant change in the stream flow when the land use alone is changed keeping all other factors same.

6. Regional Groundwater Resource Modelling Using Modflow – A Case study

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In this study, Visual MODFLOW was used to study the groundwater behaviour and predict groundwater heads at different scenarios in West Godavari district. The main objective of the study was to analyse the spatial and temporal variation of groundwater, identify the potential groundwater zones to collect the lithology and develop the groundwater flow model for the study are. Spatial and temporal variation of the groundwater heads was studied and it was observed that groundwater vary with respect to topography, climate and soil properties. Potential groundwater zones were identified by developing map using groundwater heads. Model was developed using data from 53 head observation wells from 2003 to 2017.A model was developed by assigning all boundaries, aquifer properties and head observation levels. After assigning all inputs, the model was calibrated with 2003 to 2005 year data in steady state condition and 2006 to 2011 data was added for transient state condition. Calibrated model was validated using groundwater heads up to 2017. Invalidation a new recharge layer is added considering the effect of lift irrigation canal. The effect of increasing the pumping rate by 5 per cent in every five year for the next fifteen years was also studied. The effect of 'Pattiseema lift irrigation project was also studied and it was observed that considering the lift irrigation project there was an increase in the net recharge from 50 mm/year to 100 mm/year. There was also a 3 m rise in groundwater level nearer to the canal. From this study, it was observed that West Godavari district is safe with increase in pumping rate and decrease in recharge up to 2032.

Ongoing PG Projects

1. **Assessment of Lateral Flow and Base Flow for Effective Interventions in Water Conservation**

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The objectives of the study includes estimation of lateral flow and base flow for the lateritic terrains, their modelling and suggesting interventions for better groundwater recharge and storage. Trenches of 2m deep have been taken at different locations and moisture movement studies at different depth of the trench face is undergoing. Data have been collected under natural rainfall condition and also under artificial rainfall using sprinklers. Bore holes have been made till the hard laterites to study the base flow movement. Study requires another 6 months time to collect all envisaged data.

2. **Conjunctive Water Management Model for a Multi Crop Irrigation Command**

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The main objective of the study is to develop a mathematical model for conjunctive water management in a multi crop irrigation command. The area selected for the study is the command area of Chalakudy River Diversion Scheme (CRDS) which lies in the Thrissur and Ernakulum districts of Kerala. Meteorological data for the study were collected from the Agronomic Research Station, Chalakudy. Rainfall data from two IMD rain gauge stations, near but outside the command area, were also collected in addition to data from ARS, Chalakudy to account the variation in rainfall over the vast command area. Base map of the command area was prepared by ArcGIS software using the CRDS boundary map obtained from the official web site INDIA-WRIS. A land use map of the command area was prepared using Google Earth and ArcGIS software to identify the crop intensity and pattern in the command area. The command area of CRDS is covered mainly by water demanding crops like paddy, coconut, nutmeg, banana and vegetables. Water requirement of crops in the command area was computed with the help of CROPWAT 8.0 software. Field measurement of canal flow is in progress. Study on groundwater status of the command area is in progress using the software MODFLOW.

3. **Development and Evaluation of an Automated Pulse Irrigation System**

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Pulsing irrigation refers to the practice of irrigating for a short period then switching off for another short period, and repeating this on-off cycle until the entire irrigation water is applied. By using sensors and applying automation in Pulse irrigation makes work easy for farmers. The study uses low cost sensors for automation. They were calibrated and validated to use in field. The sensors were attached to arduino UNO for controlling the system through moisture readings. The solenoid valves were attached to laterals and were connected with relay. The Pulse timing were calculated and fed into arduino. The results were obtained by measuring wetting front with pulse as well as continuous irrigation. The wetting pattern showed that pulse irrigation gives more horizontal spread than continuous, which reduces deep percolation losses. In addition, the air content in crop root zone through pulse irrigation was more with respect to continuous which helps for better growth of plant.

4. **Runoff estimation of KCAET campus by curve number method adopting Remote sensing and GIS techniques**

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The study area covers around 40 ha nourished by Bharathapuzha in the Northern side and the climate of the area is humid tropic. The runoff of the area is estimated using NRCS curve number method adopting remote sensing and GIS techniques. The land use map and soil map prepared were intersected in ARC GIS platform to get curve number map. The runoff of the study area was estimated for different rainfall events in ARC GIS. The calculated runoff was compared with observed runoff from the study area. The curve number method along with spatial techniques such as remote sensing and GIS showed better results in finding a correlation between rainfall-runoff events.

5. **Irrigation Planning and Management of a Canal Irrigated Command using Geospatial Tools.**

6. **Estimation of soil moisture indices using diffuse reflectance spectroscopy**

7. **Determination of sub surface storm flow using tracer method**

8. **Development of automated drip fertigation system for open field cultivation using GSM based controller**

Name of Project Coordination Group: (03)
Food & Agricultural Process Engineering

Compiled by:

Dr. K. P. Sudheer, Project Coordinator

Plan & External Aided Projects

Ongoing Projects:16 Nos.

Post Graduate Projects

Concluded Projects: 6 Nos.
Ongoing Project: 11 Nos.

Ongoing Projects

1. **Centre of Excellence in Postharvest Technology –** State Plan

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The center of excellence for post-harvest technology is a pioneering centre for agricultural research and development in post harvest technology. It aims in creating an effective system by enabling a start-up and growth of innovative research and for cost-attractive post-harvest technologies for agricultural commodities, particularly fruits and vegetables, spices and rice. The Center will ensure the adoption of research discoveries by end users to meet their needs in diverse areas of post-harvest technologies, including quality and nutritional value, value-added processing, and food safety aspects. The centre of excellence has five sub centers; an 'Agri Business Incubator' at KCAET Tavanur, a 'Quality control lab facility' at College of Horticulture, Vellanikkara, 'Food Pro-mall' at RARS Pilicode, "Agri-food Entrepreneurship Development Centre" at CGSAFED, Vellanikkara, and 'Centre for Post Harvest Management and Value addition for under exploited fruits and vegetables' at COA Vellayani. The research outcomes of Centre of excellence in post - harvest technology are briefed below:

2. **Establishment of Agri- Business Incubator Facility at CoH, Vellanikkara-** (FAPE/09-04-01-17/CoH/(03)/GoK Plan)

The main objective of Agri-business Incubator (ABI) facility at CoH Vellanikkara is to enhance the research and development in frontier areas of food processing, and encourage entrepreneurship development in food processing sector thus to improve the domestic as well as export potential of value added products. It also encompassing agri-market-oriented development plan that seeks to improve farmers' livelihoods through agri-business incubation. The centre has provided entrepreneur support to eleven processing industries (rice mills, banana based ethnic mix, dehydrated vegetables, spice powders, thermal processed tender jack fruit, Intermediate moisture fruits, vacuum fried jackfruit). In the current financial year 2018-'19, the centre has organized 19 training programmes to potential food processing entrepreneurs and various stake holders of food supply chain. Apart from training programme the centre also support in technology consultancy, business facilitation, and provide opportunity for agencies, institutes and individuals engaged in the food sector, to evaluate the quality of the food produced/manufactured and level of adulterants and contaminants present in various types of foods.

3. Development and Quality Evaluation of Thermally Processed Cassava in Retort Pouch-
(FRC No. FAPE/02-03-03-17/TNR(03)/KAU/GoK plan)

Dr. Rajesh G K

Cassava (*Manihot esculenta* Crantz), popularly known in India as tapioca is an excellent dietary source of energy and is one of the important food crops providing livelihoods and food security for millions of people in the tropical regions. High moisture content of cassava, leads to early deterioration due to microbial attack and also makes it susceptible to desiccation and mechanical injury. Therefore effort has to be put in so that cassava is made available to all the people year-round either in raw, preserved or processed manner. The study was conducted on two varieties of cassava namely, Sree Jaya and M-4. The physicochemical analysis of both the varieties were conducted and recorded. The blanching time at 100˚C was optimized and quality improvement with addition of 0.1% guar gum was conducted. The blanching time for M-4 was optimised as 5 minutes in 0.1% guar gum and for Sree Jaya the blanching time was optmised as 15 minutes in 0.1% guar gum. Calcium chloride brine with 0.4 per cent concentration was selected as the filler solution. Thermal processing was conducted at 100, 110, 121˚C in combinations with different F values. The retort pouch processing parameters were optimised and the shelf life studies of the microbiologically safe samples were conducted for six months at refrigerated condition and three months at ambient conditions. From the storage studies and the sensory analysis it was concluded that Sree Jaya thermally processed at 110˚C for 20 minutes with F_0 2.1 and M-4 thermally processed at 110˚C for 40 minutes with F_0 6.1 are the best thermal processing treatments. The quality parameters and the sensory attributes of the processed cassava were best throughout the storage period. The cost of one pouch was estimated to be Rs. 19.20. The optimised treatment resulted in a product which resembled the fresh sample, available to the consumers in a ready to eat form throughout the year.

Thermal Processed cassava after 5 months of storage under refrigerated condition

4. **Extraction of Anthocyanin from Jamun using Pulsed Electric Field Technology**-(FRC No. FAPE/05-01-05-17/TNR(03)/GoK Plan)

Dr. Prince M V

Anthocyanins have gained their importance not only because of its wide range of colour spectrum, but also because of its health benefits. They are generally extracted by conventional methods *viz.,* solid-solvent extraction, adsorption extraction etc. But these methods possess disadvantages such as low extraction efficiency and high extraction time. Pulsed Electric Field (PEF) technology is an emerging non thermal food processing technology. It involves application of short duration electric field pulses of high intensity to materials located between two electrodes. PEF induces extra membrane potential difference across the cell membrane. When the potential difference exceeds a critical value, called the breakdown potential, localised electrical breakdown of the membrane occurs resulting in pore formation on membrane and thus cell permeability increases. The permeability of plant cell membrane improves the mass transfer in subsequent process such as extraction. The developed extraction system consists of an outer protective chamber, inlet unit, pulse generating system, treatment chamber, display unit and cooling system. Pulse generating system forms the main component of PEF system in which a high boost circuit was made to generate pulses of voltage 5-20kV with an input supply of 230V, 12W power and a current of 5A. The pulses are transmitted through the pulp via electrodes resulting electroporation of the cells. The results showed that with increase in electric field strength from 5kV/cm to 10kV/cm, the anthocyanin yield was found to increase. Also, with increase in pulse frequency anthocyanin yield was found to decrease. Increase in treatment time up to 3 minutes, the yield increased. Further increase in treatment time the anthocyanin yield and other quality parameters were found to be reduced. Pulsed electric field assisted extraction of anthocyanin resulted in an anthocyanin yield of 11.584 mg/100g of sample, with an antioxidant activity of 93.188% where as the conventional extraction yielded an anthocyanin yield of 10mg/100g of sample, antioxidant activity of 82.3%. Thus it could be concluded that PEF assisted extraction of anthocyanin resulted in increase in anthocyanin yield and quality parameters. The optimized conditions of electric field strength, pulse frequency and treatment time for PEF assisted extraction of anthocyanin from Jamun were found to be 9.47 kV/cm, 60 pulses/s and 2.24 minutes. It is evident from the study that PEF assisted extraction of anthocyanin from Jamun resulted in increased extraction of high quality anthocyanin.

5. **Establishment of Technology Refinement and Marketing Programme** - (FRC No. FAPE/09-01-03-17/CoH/(03)/GoK Plan)

'***Technology Refinement and Marketing Programme*** - (TREMAP)' facility, at College of Horticulture Vellanikkara provide facilities for technology transfer, enterprise support services component and other agribusiness information resources. TREMAP work towards pushing the innovative technologies, up the commercialisation cycle, towards market through a network of technology commercialisation facilitators and establishing an enabling ecosystem for the same. The objective of the TREMAP programme is to facilitate linkages of the innovative technologies and developed products with market.

Under this project, two new fabrications were completed. These new machineries were developed to refine the existing protocol or to promote the food processing sector in our state. Vacuum impregnation is a recent development in the osmotic treatment of foods. It is useful to introduce dissolved or dispersed substances directly into the porous structure of the food matrix. Moreover, it can increase the mass transfer rate, as a result of shorter diffusive paths after the impregnation step, in processes in which solid-liquid operations are present, such as osmotic dehydration of fruits, oil extraction by liquid solvents and the incorporation of preservatives or additives to food items. Impregnated products can be commercialized as minimally processed fresh functional foods or can be dried osmotically or by air in order to obtain more stability. Keeping this in mind, a vacuum impregnation system was developed for minimally processed fruits and vegetables which could be used in large scale production. The current vacuum impregnation system consists of a syrup storage tank of 100 L capacity and an impregnation chamber of 5 kg capacity. Performance evaluation of developed vacuum impregnation system is in progress. A mini parboiling unit was also developed under this project to cater the needs of small scale rice farmers , SHG's, JLG's, and entrepreneurs to reduce the rice processing cost. Installation and performance evaluation of developed mini parboiling unit is in progress.

6. **Effect of High Hydrostatic Pressure Processing on Textural and Nutritional Behaviour of Minimally Processed fruits and vegetables - ICAR National Fellow project** (FRC No. FAPE/06-04-01-17/CoH/(03)/ICAR)

Optimisation of blanching treatment for tender jackfruit was carried out with different chemical preservatives. In the first stage the blanching time was optimized as three min based on minimum percentage reduction in firmness, toughness, colour value and inactivation of enzymes. Subsequently based on the optimum blanching time the best blanching preservative was identified as 0.3% citric acid based on textural properties and colour attributes. The blanched samples were subjected to a pasteurization temperature of 90°C. It was concluded that 0.3% citric acid blanching and 0.3% citric acid preservative as filling solution was best in terms of quality parameters of retort packed tender jackfruit.

Preliminary trails of High Pressure Processing of tender and ripe jackfruit , and pineapple were carried out during the current financial year. It was observed that with the increase in pressure and process time, an increase in total polyphenols, total flavonoids and ascorbic acid was noted. The initial observations showed that the HPP treatment at 300 MPa pressure for a duration of 15 min as the best, based on the quality attributes. However, there was a slight decrease in firmness of samples at elevated pressures. Therefore further experiments with higher pressure and time combination need to be carried out to optimize the process parameters. All the sample processed under high pressure were microbiologically safe even after 16^{th} day of refrigerated storage. Confirmatory trails for minimal processing of pineapple and jackfruit were carried out with various treatment combinations at ambient and refrigerated storage temperature. By considering quality parameters under the study, the best treatment combinations optimized for pineapple was combination of NaCl (1%), CA (1%) and SB (0.05%) followed by a combination of $CaCl_2$(1%)

and SB (0.05%). A treatment combination of NaCl (1%) and SB (0.05%) was the best suitable for minimally processed tender jackfruit, and that for matured jackfruit was a combination of $CaCl_2$ (1%) and SB(0.05%) at refrigerated condition. As per the microbial analysis, samples stored under refrigeration condition were safe and had good sensory quality.

7. Development and Quality Evaluation of Nutritionally Enriched RTE flakes from Speciality Rice (FRC No. FAPE/02-05-01-18/CoH/(03)/GoK Plan)

In this study efforts were made to develop a RTE product enriched with GABA content in flakes from specialty rice to ensure a food which is nutritious without consuming much time for preparation. The three paddy varieties germinated for different time period and all the flaked samples from this paddy were analyzed for GABA content. The results showed that GABA content was detected in all the germinated paddy varieties for different time period and also in the flaked samples. The results showed that GABA content increases with increase in germination period *i.e.*, 0.150 mg/g at 12 hr germination to 0.266 mg/g for 36 hr germination, in Raktasali paddy variety, 0.316 mg/g to 1.060 mg/g in Kakasali paddy variety and 0.100 mg/g to 0.650 mg/g in Kumkumasali. Effect of germination time on GABA content was studied and it was found that 36h germination resulted in higher GABA content. GABA enriched flakes was processed with standardised treatment and 3 different roasting temperatures were provided. Based on GABA content retained after roasting, effect of roasting temperature on various properties of flakes and sensorial attributes, Kumkumasali flakes roasted at a temperature of 120°C was selected as the best sample out of all 9 samples under concern.

36h Germination of Kumkumasali paddy and its flakes roasted at 120°C

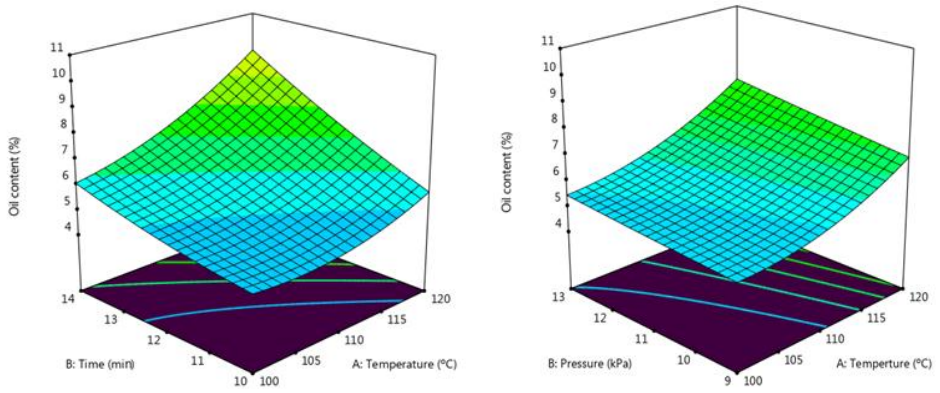
8. Establishment of Agri-Food Entrepreneurship Development Centre- (FRC No. FAPE/09-03-01-16/TNR(03)/GoKPlan)

Strengthened the activities of Agri-Food Entrepreneurship Development Centre (AfedC) established at CGSAFED to promote expanded opportunities for agri-food enterprises of major crops in the state through facilitation and capacity building of farm entrepreneurs. The field survey on crop produce surplus and value addition efforts of farmers in the Malappuram district of Central Zone was carried out during 2018.-19. The results from the survey indicated that micro enterprises dominated agriculture and allied sectors in the district. Unorganized farmers

and lack of proper storage and processing infrastructure also posed major challenges. Most of the farm entrepreneurs depended on markets for inputs and as such there existed a total disconnect between the farm producers and farm entrepreneurs which need to be bridged by integrating entrepreneurship into commercial farms so that the advantages of high yield can be properly utilized. A workshop was organized to provide an interface platform for resolving problems faced by agri-food entrepreneurs in the state. The programme was attended by 106 participants including farm entrepreneurs, representatives of local government. development agencies, Lead Bank Manager of Thrissur district, General Manager, District Industries Centre, Marketing experts and food technologists, . Twenty two cases from agri-food enterprises related to technology, credit, marketing and rules and procedures were resolved in the workshop.

9. Development and evaluation of process protocol for Vacuum fried bitter gourd chips - (FRC No. FAPE/02-09-02-17/TNR(03)/GoK Plan)

The vacuum frying is an excellent promising technology, in which food is fried under low pressure and temperature. Vacuum frying reduces the oil absorption, less formation of acrylamide content, and retains the colour and nutrients present in fried products. In vacuum frying, low pressure decreases the boiling point of water in foods and smoking point in oil. This technology was also used to preserve the colour, nutrients and in improving the textural properties of products. Considering the above facts, an attempt was made to develop vacuum fried bitter gourd chips using vacuum frying system. The blended oil (rice bran and palm oil at 80:20) was used as frying oil and de-oiling was done at a speed of 1000 rpm for 5 min. Different pre-treatments were done for vacuum fried bitter gourd chips. Control (Un-treated) sample had the best qualities with less oil content (4.43 %), moisture content (0.264 %), hardness (1.422 N), water activity (0.250) and green colour retention (a*(-4.13)). Quality parameters like moisture content, water activity, oil content, bulk density, true density, hardness, energy content, acrylamide content, thickness expansion, colour values and sensory evaluation of vacuum fried bitter gourd chips were analysed at different frying conditions. The treatment condition at 100ºC, and 9 kPa vacuum for a duration of 10 min produced good quality parameters with less oil content (4.011%), acrylamide content (56.52 ppb), hardness value (1.411 N), high retention of green colour (a*(-5.3)) and good organoleptic properties (Hedonic score of 8.7). The laminated aluminium flexible pouches with nitrogen flushing retained the quality of bitter gourd chips during the storage period. The TPC value of blended oil increased from an initial value of 9.4 to 24.21%, due to continuous usage of oil (70 times) under the vacuum frying process, and was within the safe limit. The FFA value of blended oil was within the acceptable limit upto 50 cycles of vacuum frying process.



Changes in oil content of vacuum fried bitter gourd chips with process parameters

10. Development of specialty rice based nutritionally enriched cold extruded pasta- (FRC No. FAPE/02-02-02-18/CoH(03)/GoKPlan)

Extrusion technology plays an important role in development of fast growing Ready-To-Cook (RTC) commodities. Such products are more acceptable to modern day consumers. So the present study was undertaken to develop ready-to-cook (RTC) pasta from specialty rice Raktasali in combination with other cereals wheat, corn and enriched with amaranths powder. Guar gum was also added as a binding agent. Ten combinations of pasta products with different proportions of flour, guar gum and amaranths powder were taken for the study. The quality parameters *viz.* cooking properties (cooking time (6.6 to 7.6 minutes), swelling power (1.66 g to 2.401 g), solid loss (3.626 % to 6.773%) and water absorption power (1.805 g/ml to 2.427 g/ml)), physical properties (expansion ratio (2.24 to 3.77) and bulk density) and other properties (colour, moisture content (4.6 to 13.1%) , total ash and water activity (0.424 to 0.583)) for various combinations of pasta were evaluated. Sensory evaluation was also conducted on a nine point hedonic scale by twelve panel of judges for appearance, aroma, texture, taste and overall acceptability of the developed pasta product. Overall acceptability of pasta varied from 5.500 to 8.773. Based on the results obtained, the sample with Rice flour (39%): Wheat flour (59%): Guar gum (2%) was selected as the best pasta from ten samples under concern.

11. Development of a user friendly tool for pulp/ seed separation from toddy palm fruit- (FRC No. FAPE/01-07-17/TNR (03)/ICAR)

The project resulted in the development of a user friendly tool to separate pulp/seed from toddy palm fruit. The cutting blade was developed based on various physical and mechanical properties of the toddy palm. It consists of "U" shaped blade which can easily remove the seed without any drudgery and damage. The tool was developed by attaching an additional knife to cut both top and bottom portion of the fruit. The field testing of the machine was conducted and compared with the existing methods. The performance evaluation of the tool was conducted in two locations with 10 nos. of nuts (both tender and mature) with the traditional knife and the developed tool. Machine was operated with the skilled labours at the same location for three times with three days interval. The time requirement with the knife for tender and mature fruit

was 7.27 and 7.85 minutes, respectively. Similarly the time requirement with the mechanical tool for tender and mature fruit was 8.41 and 9.02 minutes, respectively.

Toddy Palm fruit separator

12. Value chain of jackfruit- Microwave assisted extraction of pectin from jackfruit (*Artocarpus heterophyllus*. L) waste (rind and core) (FRC No. FAPE/05-01-06-18/TNR(03)/ICAR)

The rind and core from the two varieties of jackfruit were collected and dried at 55°C. The dried rinds were ground into powder. Preliminary studies were conducted for the optimization of conventional extraction of pectin using acidified water as solvent. Citric acid was used to optimize the pH and the extraction temperature was fixed at 90°C. For conventional extraction, the mixture was placed in water bath shaker with temperature set at 90°C for 1 h. The extracted solid was filtered and used for a second extraction with the same procedure while the filtrate was concentrated using rotary evaporator. Precipitation of pectin was carried out by adding 95% ethanol to the filtrate in ratio of 1:2 (filtrate: ethanol, v/v). The mixture was then stirred for 30 min at room temperature followed by keeping it under refrigeration at 4°C for 2 h. Then, coagulated pectin was separated by filtration and washed with 75 ml 70% ethanol two times and 75 ml 95% ethanol until the filtrate becomes colourless. The washed pectin was then dried at 40°C overnight then followed by grinding into powder. The quality analysis of the extracted pectin is progressing to check the purity.

13. Development and evaluation of a batch type rotary cocoa dryer - (FRC No. FAPE/01-03-02-17/TNR(03)/ICAR)

The traditional methods of cocoa drying such as drying under sun or by wood-fired dryers have many disadvantages such as damage by rodents, contamination by dust and dirt. Also, the beans are normally turned or raked to ensure uniformity of drying and the beans need to be covered when it rains. Therefore, an attempt was made to develop a batch type rotary dryer to dry cocoa beans. The various components of the dryer are drying chamber, blower, flow control valve, heating coil, rotating paddle type agitator and motor. Testing was done at different drying temperatures viz., 40, 45 and 50ºC at constant air velocity of 2 m/s. Quality parameters of the mechanically dried cocoa beans such as size, shape, pH, titrable acidity, free fatty acids, colour

and texture were determined and compared with that of sun dried cocoa beans. The process parameters were optimized based on the quality of the dried cocoa beans. Cocoa beans were dried up to a moisture content of 6-7% (w.b). The time required for drying to a moisture content of 6-7% (w.b) for temperatures 40, 45 and 50°C were 10, 7, 5.5 h respectively and for sun drying it was 4 days. The capacity of the developed batch type dryer was 10 kg. The efficiency of the developed dryer was 53.02, 48.47 and 36.80 per cent, for temperatures 40, 45 and 50°C, respectively. The average energy requirement to operate the dryer at different temperatures viz., 40, 45 and 50ºC was 10.12, 7.54 and 6 kWh, respectively. By considering the energy requirement of dryer, cocoa beans dried using cocoa dryer at 45ºC with air flow rate 2 m/s at an agitator speed of 50 rpm was selected as optimized parameter. The developed mechanical cocoa dryer will reduce fatigue of the farmers and the labours, and thereby encouraging people to be engaged in cocoa cultivation.

Cocoa bean dryer

14. Development of complete pilot plant for cocoa processing utilizing all byproducts with value addition either by adopting or development of new machineries- (FRC No: FAPE/01-07-07/19/ TNR(03)/ICAR)

Cocoa, (*Theobroma cacao L.*) is an important plantation crop in the world belongs to Malvaceae family. The primary post-harvest processing of cocoa on farm level comprises the steps of pod opening and beans removal from the pod, beans fermentation and drying. The dried seeds are roasted, shelled and ground to give a powdery mass from which fat is expressed. Cocoa beans are processed to obtain chocolate liquor, cocoa powder and cocoa butter which are the main ingredients of chocolate and a vast range of products like cocoa beverages, ice cream and bakery products and impart a characteristic and distinctive flavour to its derived products. Cocoa bean shells are used as fuel or mulch in gardens to add nutrients to soil. Dehusking/shelling of cocoa beans is the process of removing the outer shell from the cocoa beans. It is one of the primary processes and critical steps in the processing of cocoa. It depends on the quality of the cocoa nibs in terms of flavour and purity. The basic process involves an initial crack of the beans. During this step, it is important not to crack the bean too vigorously because it can lead to the formation

of fine particles. The aim of a good crack is to keep the nibs as large as possible while simultaneously separating the shells and removing the dirt. At present, small-scale food entrepreneurs cannot really compete with large scale confectionery manufacturers because of lack of available postharvest facilities that are appropriate to their level of operation. Hence a study will be conducted to provide a platform for cocoa farmers to promote value addition and to maximize the economic potential of cocoa. The availability of a complete protocol for cocoa processing will improve the current status of cocoa industry as well as the financial status of cocoa grower.

15. **Chemical characterization of essential oil from spices (nutmeg and mint) extracted using microwave assisted hydro distillation-** (FRC No: FAPE/05-01-07/19/ TNR(03)/ICAR)

Spices are heterogeneous collections of a wide variety of volatile and non-volatile basic dietary additives. The essential oil represents the essence or active elements of plants due to the presence of aroma compounds which are oily in nature. Demand and price of essential oils and herbal products are increasing constantly in national and international markets due to strong pro-consumer movement. Extent of usage of essential oils is 55-60% for flavours in food industry, 15-21% for fragrances in cosmetic/perfumery industry, 10-20 % as starting material for isolation of components, 5-10 % as active substances in pharmaceutical preparations and 2-5% for natural products. Estimated production of perfumery raw material is around 5000 t/annum valued at Rs. 400 crores in India (Skaria*et al.*, 2007). About 90 per cent of India's requirement of essential oils is met from indigenous production and remaining from import. Some recently published studies have utilized the microwave energy for extraction of essential oil from various spices. Since microwaves heating the biomaterial through kinetic effects and is a volumetric process, the plant materials respond differently to the action of microwaves. Considering the above facts a study was undertaken on "Development and optimization of microwave assisted process for extraction of nutmeg mace essential oil"in our centre and from the preliminary study it was observed that microwave power can increase that essential oil yield in less time and reduced energy consumption. The main advantage of using microwave energy is it significantly increases the speed of the processes and reduces the thermal gradients. But the quality of the oil is also important as the heating process is different. With this background, the present study envisages the chemical characterization of the microwave extracted oil leading to high extraction efficiency. Such a study could produce essential oil of high quality and quantity and also reduce operational costs.

16. **Establishment of RKVY-RAFTAAR- Agri Business Incubator**-(FRC No. FAPE/09-01-05-19/CoH/(03)/RKVY

The project 'RKVY – RAFTAAR – Remunerative Approaches for Agriculture and Allied sector Rejuvenation- Agri Business Incubator (RABI), launched in KAU on 25.02.2019. The key aim of this scheme is to make farming a remunerative economic activity through: (i) strengthening the farmers' efforts, risk mitigation and promoting agri-business entrepreneurship via creation of

agri-infrastructure, (ii). provide flexibility and autonomy to states to make plans and execute as per their local needs, (iii) to promote value chain addition linked production models that will help farmers increase their income as well as encourage productivity, (iv). to mitigate risk of farmers with focus on additional income generation activities – like integrated farming, mushroom cultivation, bee keeping aromatic plant cultivation, floriculture etc and (v) to empower youth through skill development, innovation and agri-entrepreneurship based agribusiness models that attract them to agriculture. Establishment of R-ABI in KAU as a central facility will enhance the attempts to facilitate and promote the educated and enterprising youth of the state to venture into innovative agri businesses. Above all, this facility would help devise models of agripreneurship to enhance the income of small and marginal farmers. Under this project, two awareness programmes were conducted on 25.02.2019 and 16.03.2019 to the potential stake holders. Based on the awareness programmes, women SHG has requested to fabricate a fruits and vegetable dryer which could retain the natural colour of the raw material. The RABI, KAU has decided to develop a dehumidified drier for drying fruits and vegetables. The fabrication work of dehumidified drying unit is in progress.

PG Projects

Concluded PG Projects

1. **Response surface optimisation of process variables for encapsulation of cumin oil by spray drying- FRC No, FAPE/05-05-02-16/TNR(03)/KAU/PG**

Spices are the main flavouring agents in food. Cumin (*Cuminumcyminum* Linn.) is one of the important commercial seed spices which belong to the umbellifereae family. Cumin is valued for its aroma, medicinal and therapeutic properties. The most important chemical component of cumin seed is essential oil content, ranging from 2.5 to 4.5%. The biological activity of the oil is lost due to the volatilisation or degradation of active compounds owing to direct exposure to heat, humidity, light, or oxygen. Encapsulation is the most suitable method which will protect the essential oil and flavour ingredients from the liquid form to solid form by coating agents. Microencapsulation and nanoen capsulation are the two encapsulating techniques commonly used. Spray drying is the most commonly used technique for encapsulation in the food industry as it is a rapid, continuous, cost-effective, reproducible and scalable process for the production of dry powders from a fluid material. The microencapsulation of cumin oil were carried out with a tall type spray dryer with twin fluid atomiser whereas the nano encapsulation was done in a laboratory spray dryer with ultrasonic atomiser. The wall materials selected for encapsulation were gum arabic and maltodextrin. The process variables used in the study were gum arabic: maltodextrin ratio (1:2, 1:3 and 1:4), core concentration (10, 20, and 30%) and spray dryer inlet temperature (150, 160 and 170℃). The pysico-chemical properties of cumin oil and wall materials were determined. The optimisation of the encapsulation process was done with RSM (Response Surface Methodology) from the quality characteristics of the encapsulatedpowders.

The optimised condition in microencapsulation were 1: 2.77 carrier blend ratio (gum arabic: maltodextrin), 10% core concentration and 162.50℃ spray dryer inlet temperature and that for nanoen capsulation were a carrier blend ratio of 1:2.92, core concentration of 10% and a spray dryer inlet temperature of 163.38℃. The total cost for the production of 1 kg of microen capsulted cuminn oil was Rs. 1577/kg and that for nano encapsulation were Rs. 13510.7/kg.

2. **Development and performance evaluation of a rubber tapping machine- FRC No.: FAPE/01-07-03-16/TNR(03)/KAU/PG**

Hevea brasiliensis, or commonly rubber tree is the only one species which is the commercial source of natural rubber. The Hevea latex obtained from the bark of rubber tree contains natural rubber particles that can be harvested and utilised for various industrial applications. The natural rubber is harvested in the form of latex, a sticky, milky colloid through a process called tapping. Tapping is the process of making a controlled wound in the bark of rubber tree to cut open the latex vessels which cause the flow of latex for capturing the latex and is traditionally done manually using knives. Scarcity of skilled labours in the field of rubber tapping is one of the main challenges in the rubber industry. Mechanization of the tapping process can reduce the effort of the labour and reduces the human drudgery. The present study was undertaken to develop a rubber tapping machine and to evaluate the performance of the machine. The developed rubber tapping machine consist of cutting blade, shaft, connecting rod, flywheel, gear assembly, bearing, coupling, frame, casing, motor and a battery. The field evaluation of the developed rubber tapping machine was conducted in the farmer's field at Kodanad and Malayattoor villages in Ernakulam district by three tappers. The performance of the developed rubber tapping machine was evaluated in terms of its capacity, depth of cut of bark, bark consumption or thickness of cut of bark, time for pre tapping operations, time for tapping operations and weight and compared with manual tapping. The developed rubber tapping machine taps the rubber tree with an average capacity of about 81 trees in 1 hour taking 44 seconds for a single tree. The machine cuts the bark with an average depth of cut of 7.2 mm and a thickness of cut of 1.8 mm. During the rubber tapping process the machine takes 23 s for tapping alone for a single tree and 21 s for pre tapping operations. The developed machine weighs 1.6 kg without the power source and 3.6 kg with power source. The cost of operation of rubber tapping machine was estimated as Rs.239/h.

3. **Development and quality evaluation of thermally processed cassava in retort pouch - FRC No.-FAPE/02-03-03-16/TNR(03)/KAU/PG**

Cassava (*Manihot esculenta Crantz*), popularly known in India as tapioca, is one of the important food crops providing livelihoods and food security for millions of people in the tropical regions. High moisture content of cassava, leads to early deterioration due to microbial attack and also makes it susceptible to desiccation and mechanical injury. Therefore effort has to be put in so that cassava is made available to all the people year-round either in raw, preserved or processed manner. Therefore, an investigation has been taken up to develop and optimise a process

protocol, which could contribute to cassava based industries. The study was conducted on two varieties of cassava namely, Sree Jaya and M-4. The physicochemical analysis of both the varieties were conducted and recorded. The blanching time at 100˚C was optimized and quality improvement with addition of 0.1 per cent guar gum was conducted. The blanching time for M-4 was optimised as 5 minutes in 0.1 per cent guar gum and for Sree Jaya the blanching time was optimised as 15 minutes in 0.1 per cent guar gum. Calcium chloride brine with 0.4 per cent concentration was selected as the filler solution. Thermal processing was conducted at 100, 110, 121˚C with different time combinations. The retort pouch processing parameters were optimised and the shelf life studies of the microbiologically safe samples were conducted for six months at refrigerated condition and three months at ambient conditions. From the storage studies and the sensory analysis it was concluded that Sree Jaya thermally processed at 110˚C for 20 minutes with F0 2.1 and M-4 thermally processed at 110˚C for 40 minutes with F0 6.1 are the best thermal processing treatments. The quality parameters and the sensory attributes of the processed cassava were best throughout the storage period. The cost of one pouch of 100 g was estimated to be Rs.19.20/- only. The optimised treatment resulted in a product which resembled the fresh sample, available to the consumers in a ready to eat form throughout the year.

4. Studies on pulsed electric field assisted extraction of anthocyanin from Jamun-FRC No.FAPE/05-01-03-16/TNR(03)/KAU/PG

Colour is considered as one of the major quality parameter of food. Anthocyanins are water soluble pigments after chlorophylls and impact red to blue colours to various fruits, vegetables and storage organs. Jamunis one of the under processed minor fruit found commonly in different parts of Indian continent. It is a rich source of anthocyanin. Conventional methods of extraction of anthocyanin are less productive and extracted product is inferior in quality. In this study pulsed electric field assisted extraction was carried out with an objective of increasing the yield and quality parameters. A pulsed electric field system was developed to carry out pre-treatment prior to extraction. The developed system consists of an outer protective chamber, inlet unit, pulse generating system, treatment chamber, display unit and cooling system. Pulse generating system consists of a Line Output Transformer, micro controller and filter unit. The treatment chamber consists of electrodes and isolated feedback circuit. In order to evaluate the developed system towards extraction of anthocyanin from Jamun, the process variables such as electric field strength of 5, 10, 15 kV/cm, pulse frequencies of 60, 80 and 100 pulses/s and treatment time of 2, 3 and 4 minutes were selected and the results were compared with conventional extraction. The results were analysed statistically for optimisation of the process parameters. The optimised conditions of electric field strength, pulse frequency, and treatment time were found to be 9.47 kV/cm, 60 pulses/s and 2.24 minutes. The quality parameters of PEF assisted extraction of anthocyanin such as anthocyanin yield, antioxidant activity, colour values and refractive index were 11.9 mg/100 g of sample, 97.2%, L value of 2.1, a* value of 2.36, b* value of -2.23 and 1.38 respectively whereas, the sample for conventional extraction process were 10 mg/ 100 mg of sample, 82.3%, L value of 3.1, a*value of 1.23, b* value of -1.35 and 1.37, it was concluded

from the study that PEF assisted extraction resulted in higher anthocyanin yield and increased quality characteristics compared to conventional extraction process.

5. **Development and evaluation of process protocol for vacuum fried bitter guard-FRC No: FAPE/02-09-01-16/TNR(03)/KAU/PG.**

Bitter gourd (*Momordica charantia*) is commonly known as bitter melon or Karela in India. The estimated post-harvest loss of bitter gourd was 25%. A realistic solution to reduce the post-harvest loss in bitter gourd is the adoption of the appropriate processing technologies. The vacuum frying is an excellent promising technology, in which food is fried under low pressure and temperature. Vacuum frying reduces the oil absorption, less formation of acrylamide content, and retains the colour and nutrients present in fried products. The vacuum frying system consists of two main chambers namely, frying chamber and oil storage chamber. A de-oiling system is attached to frying chamber to remove the oil content in the final vacuum fried product. This vacuum frying system used for the study was batch type and had a capacity of 3 kg/ batch with oil tank storage of 30 l. After every batch of vacuum frying, chips and oil were collected for analysing the quality. The blended oil (rice bran and palm oil at 80:20) was used as frying oil and de-oiling was done at a speed of 1000 rpm for 5 min. Different pre-treatments were done for vacuum fried bitter gourd chips. Control (Un-treated) sample had the best qualities with less oil content (4.43 %), moisture content (0.264 %), hardness (1.422 N), water activity (0.250) and green colour retention (a*(-4.13)). Quality parameters like moisture content, water activity, oil content, bulk density, true density, hardness, energy content, acrylamide content, thickness expansion, colour values and sensory evaluation of vacuum fried bitter gourd chips were analysed at different frying conditions. The treatment condition at 100ºC, and 9 kPa vacuum for a duration of 10 min produced good quality parameters with less oil content (4.011%), acrylamide content (56.52 ppb), hardness value (1.411 N), high retention of green colour (a*(-5.3)) and good organoleptic properties (Hedonic score of 8.7). The laminated aluminium flexible pouches with nitrogen flushing retained the quality of bitter gourd chips during the storage period. The TPC value of blended oil increased from an initial value of 9.4 to 24.21%, due to continuous usage of oil (70 times) under the vacuum frying process, and was within the safe limit. The FFA value of blended oil was within the acceptable limit up to 50 cycles of vacuum frying process.

6. **Development and Evaluation of Protein Enriched Ready to Eat Extruded Food Products -** (FAPE/02-01-02-17/TNR(03)/KAU/PG)

A majority of world population suffers from qualitative and quantitative insufficiency of dietary protein and calorie. In all such cases physiological maintenance and growth of human organs are impaired. In developing countries malnutrition accounts for half of the deaths of children under 5 years of age. Extrusion is one of the commonly adopted processing technique by food industries which employs mixing, forming, texturing and cooking to develop a novel food product. It is one of the contemporary food processing technologies applied for preparation of a variety of snacks,

specialty and supplementary foods. Extrusion cooking is preferable to other food-processing techniques in terms of continuous process with high productivity and significant nutrient retention, owing to the high temperature and short time required. Extrusion technology provides the opportunity to process a variety of food products by minute changes in ingredients and processing conditions on the same machine. A nutritionally secure Ready-to- Eat (RTE) food product has immense importance in this era. Hence

RTE extruded product enriched with raw materials *viz*. millet, rice, soybean, bengal gram and groundnut will ensure a food which is safe to consume, nutritious and convenient. Initial trials of RTE product is in progress.

Continuing Projects

1. Standardization and near infrared reflectance spectroscopy based quality evaluation of thermally processed tender jackfruit (*Artocarpus heterophyllus* L.)
2. Ohmic heat assisted - pulsed light treatment system for preservation of fruit juices
3. Technology refinement and Food Safety Management System assessment of food processing enterprises facilitated through Agri-Business Incubators
4. Combined treatment of Ultrasound and UV radiation for preservation of pineapple juice
5. Development of small scale parboiling cum drying unit for Paddy processing
6. Pneumatic extruder for production of fortified rice noodles (Noolappam)
7. Optimisation of process parameters for spray drying of passion fruit juice using response surface methodology
8. Development and evaluation of process protocol for vacuum fried carrot chips
9. Development and Evaluation of Protein Enriched RTE Extruded Foods
10. Development of Neera powder using spray drying process
11. Studies on combined technologies of pulsed electric field and microwave assisted process for extraction of pectin from Jack fruit rind and core

FACULTY OF FORESTRY

Dr. Nameer.P.O.

Professor (RC)

Name of Project Coordination Group: (01)
Natural Forests and Biodiversity (NFB)

Compiled by:
Dr. A.V. Santhoshkumar, Project Coordinator

Plan & External Aided Projects

Concluded Projects - 2 Nos.
Ongoing Projects - 5 Nos.

Post Graduate Projects

Concluded Projects- 6 Nos.
Ongoing Projects - 11 Nos.

Concluded Projects

1. Study on Human-Wildlife Conflict in Kerala

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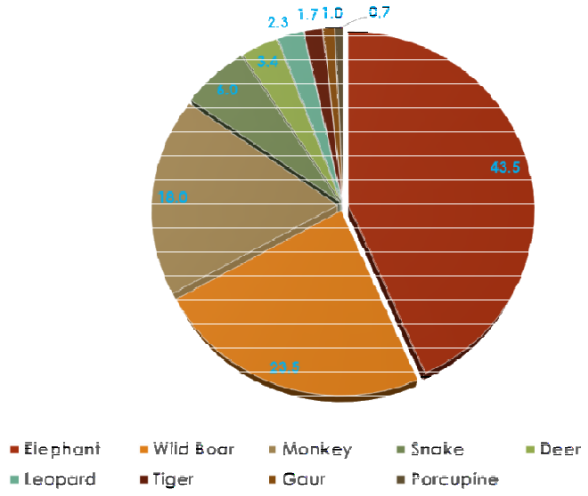
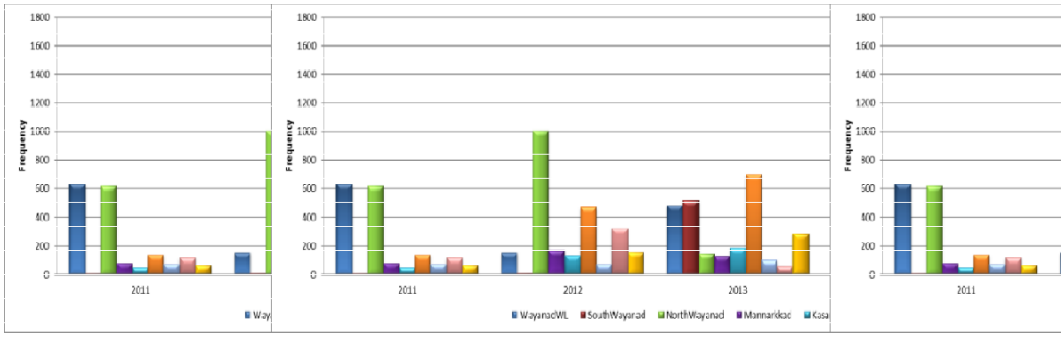
The objectives of the study were to find out the nature, extend sea sonality and causes of human – wildlife conflict (HWC) and to prepare geo-referenced maps of the conflict areas using modern tools like Geographical Information System. Study also aims to suggest location – specific measures to overcome human – wildlife conflict. Study was started in May 2017 and ended in August 2018. Data on human wildlife conflict for the last ten years (2006 to 2016) was collected from Forest Division Offices of Kerala Forest Department. Location details of each conflict incident was also collected. Maps were pre pared in GIS platform using the location data. Spatial and temporal pattern of conflicts were studied by analyzing these maps. More than 60 per cent of the conflict incidences are reported from the three Forest Divisions in Wayanad District. Identified the conflict causing animals and magnitude of conflict by each animal species. Identified the extent of occurrence of conflict incidences in Kerala. Elephant is the most conflict causing animal leading to maximum damage to crops due to conflicts, wild boar being the second. About 50 per cent of t he conflicts are due to elephants, 22 per cent du e to wild boar and 16 per cent due to monkeys. Studies reveal that most of the conflicts occur during rainy season. Identified the most conflict affected villages in Mannarkkad and Thrissur Forest Divisions. Changes in land use pattern during the last two decades in the conflict affected villages in Mannarkkad and Thrissur Forest Divisions was analysed using GIS soft ware. Socio-economic studies were carried out in the two Forest Divisions. Baseline data on the HWC for the various Forest Divisions of Kerala have been prepared.



Major wild animals that cause Human Wildlife Conflict in Kerala



The most conflict prone Forest Divisions in Kerala

2. Strengthening *ex situ* collections of endangered and endemic flora at College of Forestry, Vellanikkara for academic and outreach purposes

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The existing plant collections were strengthened by adding more plant species coming under the Endangered & Endemic category from the forest and non-forest areas in Kerala including sacred groves and agro-ecosystems. These species were planted and established in the appropriately designed plant conservation units in the campus. The existing Fern House was extended to house many new collections. An Andaman and Nicobar Arboretum were set up to create a grove of rare flora from the Andaman islands. Additionally, the trees in the campus were bar coded and linked to an in-house database.

Extended Fern House

List of newly added Andaman and Nicobar flora

Sl.No	Scientific Name	Family
1	*Rhopalo blasteaugusta*	Arecaceae
2	*Semecarpus prainii*	Anacardiaceae
3	*Dimocarpus longan*	Sapindaceae
4	*Mimusops andamanensis*	Sapotaceae
5	*Horsfieldia glabra*	Myristicaceae
6	*Knema andamanica*	Myristicaceae
7	*Mangifera griffithii*	Anacardiaceae
8	*Caryota mitis*	Arecaceae
9	*Sterculia parviflora*	Malvaceae
10	*Myristica andamanica*	Myristicaceae
11	*Pandanus tectorius*	Pandanaceae
12	*Artocarpus lakoocha*	Moraceae
13	*Ganophyllum f alcatum*	Sapindaceae

List of palms added to the collection

Sl.No	Scientific Name	Common Name
1	*Adonidia meririllii*	Manila Palm
2	*Caryota urens*	Fishtail Palm
3	*Areca concinna*	Squirrel Palm
4	*Elaeis guineensis*	African oilPalm
5	*Rhapis excelsa*	Lady Palm
6	*Carpentaria acuminate*	Carpentaria Palm
7	*Dypsis Lutescens*	Yellow Palm
8	*Areca triandra*	Wild Areca Palm
9	*Areca species*	Areca
10	*Licuala grandis*	Ruffled Fan Palm
11	*Calamus pseudotenuis*	Rattan cane

Ongoing Projects

1. Developing an Elephant Intrusion Detection and Early Warning System and its Networking

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The PI and collaborators had earlier developed a pilot device for the early detection and alert system for wild elephants which is being field tested. This pilot device can be further refined to develop a much more sophisticated, all weather electronic system with the help of a more efficient image processing algorithm for elephant detection. This developed device will be tested in the laboratory and multiple units of this device can be installed in the potential conflict zones in consultation with the farmers and other stakeholders. Based on inputs from Integrated Rural Technology Centre, Mundur, Palakkad district, field visits were conducted to identify a suitable location frequented by wild elephants. Accordingly we identified the farm of Mr Ravi, a local farmer in the Kaiyyara area of Mundur Panchayath which was frequented by wild elephants. After studying the geography of the terrain the design of an all weather electronic system was conceptualized. After that work began on developing the device. Basically the developed system consists of automatic detection of moving objects which is based on an array of sensors connected to onboard computer system which will trigger a camera module for a valid image. Camera module will take photo shots and will be transferred to image processing unit for the identification of the desired image. If the image is identified a warning message will be initiated to the concerned parties. Network connectivity part was implemented using GSM modem as there is enough mobile connectivity in the area selected for device installation. The above system was designed and implemented. Simultaneously the required fabrication work for the installation was also completed. Installation of the pilot system was completed on 28/12/2018. Also designed and implemented an algorithm for the image processing using Artificial Neural network for the pilot system. The efficiency of the algorithm is under verification based on the receiving data. The work of fine tuning detection algorithm and system optimization in terms power usage, system resources are also progressing. Optimization of overall equipment size reduction is also underway.

System Installation at Palakkad

2. Assessing and Developing Farm Tourism Models in Kerala

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The objectives of the study are to promote public awareness and learning experiences, provide diversity of experience to visitors through farm based activities promote family farming, organic farming and sustainable and integrated agricultural, livestock, fishery and forestry practices. Study also aims to promote farm tourism for ensuring the physical and psychological health in conjunction with ecotourism and also to revitalize the agriculture sector of Kerala and supplementing the farmers.

3. Development of KAU Botanical Garden (Itty Achuthan Memorial Botanical Garden) into Learning Resource Centre and Biodiversity Conservation repository- State Plan

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The objectives of the project are to develop the themes such as Arboretum, Orchidarium, Fernarium, Palmatum, Bamboosetum, Gymnodperm collection, Cacti and xerophytic plants, ornamental plants Medicinal plants, Wetland plant collections, water bodies, canopy walk-ways etc. and also to develop the KAU Botanical Garden into a learning centre for the students and the general public. A Master Plan of the Botanic Garden has been prepared. The whole area of Botanical garden is surveyed using Total Station (Leica Geosystems). Using data logger, the survey data has been processed digitally to generate contour lines in the format of AUTOCAD Version 13.0. For planning the different themes according to the elevation, a 3D model of the contour data is developed using Arc GIS 10.1. The location of different thematic areas, the local movement plan and locations of different structure are also planned based on the 3D DEM. Master Plan of the Botanic Garden has been prepared. Water harvesting ponds have been constructed. The trees in the Botanic Garden have been labelled. 200 plus wildlings have been planted in the Botanic Garden during last monsoon season and all the plants have been protected using tree guard and the success have been 100%. A Botanical Garden of International standards is in the making.

4. Processing and Value addition of wild edible fruits for enhancing livelihood opportunities of tribes in Kerala

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The present study focused on the utilization of products from the selected wild plants of Kerala. The project mainly envisaged to assess the current status, production and contribution of the selected Wild edible fruits to the livelihood of rural and forest dependent communities and also to develop post-harvest processing and value addition techniques of selected fruits. It is also aimed to impart training to the tribes and other stake holders on the processing and value addition techniques. A detailed survey on utilization of wild fruits was conducted in the tribal settlement at Vazhachal forest division. The survey revealed that tribals are mainly collecting the fruits of *Elaeocarpus serratus, Bacuurea courtelnesis* and *Artocarpus hirsutus* for their domestic consumption. They are also selling the above items in raw without going for value addition. *Elaeocarpus serratus* (Kara) fruits used for preparing Candies from mature fruits and young as well as mature fruits are used for pickling. *Artocarpus hirsutus* (Wild Jack fruit) used for the preparation of squash and jam. In *Baccaurea courtallensis* (Mootilpazham), entire fruits or its rinds used for pickling. Fruit rind could be used for wine preparation. The fruit pulp was found to be best for squash making. *Flacourtia* m*ontana* (Vayyamkaitha) is mainly used for the preparation of pickling.

5. Harvesting, Processing and Value Addition of Natural Dammars of Kerala

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Natural dammars are the important minor forest product of Kerala. In Kerala dammars obtained from two main species viz. *Canarium strictum* (Burseraceae) and *Vateria indica* (Dipterocarpaceae).They are locally known as black dammar and white dammar respectively. Dammars used mostly for the manufacture of varnish, lacquers, and paints. As part of the project we could able to document the various resources of *Canarium strictum* and *Vateria indica* in Kerala. We collected the data pertaining to the production of black dammar as well as white dammar in the natural forest of Kerala. Anatomical studies were conducted on the bark of Canarium and the sap wood of Vateria. The characteristics of resin oozing cells were identified and studied in detail by image analyser. Standardized the resin tapping technique in both *Canarium strictum* and *Vateria indica* trees. A new tapping method, namely ***"Strip cutmethod"*** was developed for the sustainable harvesting of black dammar. Value addition of black dammar were carried out and made incense sticks from black dammar. We conducted various training programmes on sustainable harvesting of black dammar and value addition, in various tribal settlements of Kerala. As a part of the above project, the project team had developed *Black dammar incense sticks* and it is officially released by Agricultural Minister Sri. V.S Sunilkumar on 2019 February 1st the Foundation Day of Kerala Agricultural University.

PG Projects

Concluded PG Projects

1. Spatio-temporal patterns in human-wildlife conflict in Kerala- (NFB-05-04-01-2016-FF-KAU-PG)

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The major objective of the study was to assess the spatial and temporal pattern of occurrence of human-wildlife conflict in Kerala, to evaluate the present preventive measures adopted against human-wildlife conflicts at Mannarkkad Forest Division and Thrissur Forest Division (FD) and to study the attitude, expectations and perceptions of the affected individuals/community towards human-wildlife conflict, in Mannarkkad and Thrissur FD. The study also aimed to suggest suitable location specific measures to reduce the incidence of human-wildlife conflict in Mannarkkad and Thrissur FD. Asian Elephant was found to be involved in 47.7 per cent of the HWC incidences in Kerala, followed by Wild Boar (23.3 %) and Bonnet Macaque (17.3 %). 81 per cent of the conflict incidences occur in the Forest Divisions towards north of Palakkad Gap in Western Ghats. 64 per cent of the HWC incidences were reported from the three FDs in Wayanad District alone. High level of fragmentation of forest ecosystems, changes in cropping pattern,

decreasing tolerance level of people towards wildlife, etc. may be contributing to high level of HWC incidences in North Kerala. HWC data of all the Forest Divisions (FD) were analyzed with geospatial tools and presented as heat maps, which depicts the spatial concentration of HWC incidences. Temporal variation of the HWC incidences was also analyzed and found that conflicts involving herbivores are higher during the months from June to December. In Mannarkkad FD, Padavayal, Pudur and Kottathara Villages together experience nearly 50 per cent of the HWC incidences. Asian Elephant contributes to 79.9 per cent of the HWC incidences in this Division, followed by 9.1 per cent of Wild Boar and 6.5 per cent of Leopard. In Thrissur Forest Division, villages like Peechi and Mannamangalam only are exposed to conflicts by Asian Elephant, which accounts for ten per cent of the HWC in this Division. However, Wild Boar is involved in 53.1 per cent of the conflicts in this Division. Conflicts involving Wild Boar are high in villages like Pilakkad, Thonnurkkara, Varavoor, etc.

Studies on decadal changes in land use land cover showed that there was a very high increase in the area under kharif crop in Mannarkkad FD. Within the villages with high intensity of conflict in this Division, a very high increase in the area under kharif crop is observed. In Thrissur FD also the area under kharif crop is increased in all the villages with high conflict intensity. The preventive measures adopted in Mannarkkad FD are elephant-proof trench and solar fencing. Elephant-proof trenches are dug at Pudur Village in Attappady Forest Range in less than a kilometer. Two to three year old solar fences only are maintained well and found to be functional. The solar fences installed during 2010 are completely damaged and not functional. The solar fences installed currently in this FD are not sufficient to contain the HWC incidences. No preventive measures were adopted in Thrissur Forest Division to prevent the HWC incidences. However, solar electric fences were installed in Peechi and Mannamangalam villages in Pattikkad Forest Range in 2016 along the boundary of the forests for a length of 20 km. More than 60 per cent of the respondents in Mannarkkad and Thrissur Forest Divisions, support the wildlife protection activities due to various reasons. The respondents had a low satisfaction level in Mannarkkad (57.8 per cent) and Thrissur (92.3 per cent) FD on the compensation pattern of Government. However, quick compensation was suggested by 39.7 per cent of the respondents in Mannarkkad FD and 43.8 per cent in Thrissur FD. 88.6 per cent of the respondents in Mannarkkad FD and 74.4 per cent of the respondents in Thrissur FD agree that among the government agencies, Kerala Forest Department is prompt in responding to the HWC related issues. A timely response from the Forest Department officials in reaching the conflict locations and quick release of compensation for the affected individuals will improve the tolerance level of people towards wildlife.

2. Status and habitat preferences of White-rumped Vulture (*Gyps bengalensis*) population of Wayanad Wildlife Sanctuary, Kerala - (NFB -02 -02 -03- 2017 -FF KAU- PG)

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The objective of the study was to understand the status, distribution and population of *Gyps bengalensis* of Wayanad Wildlife Sanctuary. It also proposed to study the breeding success of *Gyps bengalensis*. An estimated population of about 130-150 species of Vultures are present in the sanctuary. As their foraging range is very high, seasonal variation and availability of food are some of the factors that affect their population. 3 species of vultures were identified*; Gyps bengalensis, Gyps indicus*, and *Sarcogyps calvus.* Nests of vulture in Wayanad WLS is in adecreasing trend yearly. Only four active nests were identified in 2017-2018 nesting season of which three nests belongs to *Gyps bengalensis* and one nest is of *Sarcogyps calvus.* 30 species of trees were identified belonging to 17 different families from the 44 circular plots surveyed in the nesting colony of Wayanad Wildlife Sanctuary. *Terminalia alata* has the highest density of 23.29%, followed by *Tectonagrandis* (10.85%), *Anogeissus latifolia* (10.84%), *Haldinacordifolia* (8.21%) etc. The most common five species in the study area were *Terminalia alata, Tectona grandis, Haldina cordifolia, Cassia fistula* and *Lagerstroemia lanceolata*. Active andold nests were found in 6 tree species in the nesting colony. Out of the six, only *Haldinacordifolia* have active nests and the other tree species are; *Tectona grandis, Stereospermum chelonoides, Dalbergia latifolia, Lagerstroemia lanceolata* and *Terminalia alata*. 4 out of 4nestings were found in 2 different locations in Kurichiyad range. Kazukankolli is an important nesting area of *Gyps bengalensis.* 3 out of 4 active nests in this year is present in this area.

3. Habitat Characterisation of Asian Elephants (*Elephas maximus*) in Wayanad Wildlife Sanctuary, Kerala - (NFB -02 -02- 05- 2017 –FF- KAU- PG)

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The objective of the study was to understand the habitat preference of Asian Elephants in Wayanad Wildlife Sanctuary. The study also proposes to find out the correlation, if any, between habitat preferences of Elephant with the human-Elephant conflict. A total of 667 dung piles were recorded from 60 km of transect in season 1 (wet season) at an encounter rate of 11.12 per km. A total of 997 dung piles were recorded in season 2 (dry season) at an encounter rate of 24.75 per km. The population density also showed variation between vegetation types across the two seasons. The density of elephants in dry deciduous habitat was higher in both seasons, although it remained the same across seasons. The density of elephants in moist deciduous forests and plantations showed marked increase in the second season but they were still less than density in dry deciduous habitat. It was also observed that elephants prefer natural forests over plantations from the high elephant density in dry and moist deciduous habitats over low density in plantations. The population density also varied considerably among the four ranges across the seasons. The highest population density was recorded at Sulthan Bathery in the first season,

which decreased in the second season. In the second season, density in all three ranges other than Sulthan Bathery increased and highest was recorded in Muthanga.

4. Impact of invasive alien plants (IAP) on understorey vegetation in Wayanad Wildlife Sanctuary - (NFB -03 -03 -04- 2017 -FF KAU- PG)

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The study concluded that L. *camara* and *C. odorata* invaded all areas of the sanctuary except in the borders of Kurichiat and Sulthanbathery forest ranges. Lantana invasion was high in the Kurichiat RF (Reserve forest) and Rampur RF. Chromolaena invasion was found to be high in Mavinahalla and Kurichiat RF. In WS II part of the sanctuary, *S. spectabilis* was mainly distributed along the boundaries of Sulthanbathery and Muthanga ranges. In Muthanga, Senna invasion was extended up to "Kakkapadam" (2.5 km from Muthanga station). Among the IAPS, Chromolaena showed the highest density in all the three vegetation types, while the density of Senna was lowest in all the three vegetation types in WS II area. The density of Chromolaena in plantation and NF was 4943.52 ± 1079.07 and 4996.47 ± 1484.42 respectively. The density of Lantana in plantation and NF was 322.35 ± 88.18 and 85.42 ± 29.55 respectively. The density of Senna in plantation and NF was 63.5 ± 31.66 and 49.74 ± 23.93 respectively. Senna invasion was absent in vayal. Vayal showed highest density of Chromolaena (5810.59 ± 1262.43). Chromolaena had the highest percentage cover in both plantation and vayal. In NF, Lantana has (14.2 ± 2.8) the highest percentage cover. In all the three vegetation types, Chromolaena had the highest frequency and abundance. Among the seven weed category areas identified from the study area, highest MSR (Mean Species Richness) was seen in Control (weed free area), followed by L (Lantana invaded) and LC (Lantana and Chromolaena invaded) regions. The lowest MSR was obtained in S (Senna invaded) and CS (Chromolaena and Senna invaded) regions. All the three IAPS negatively influenced the native species richness. But no specific declining trend in species richness was observed during regression analysis. Results of regression analysis showed that, among the three IAPS, *C. odorata* had the biggest impact on the species richness of native species. It was followed by *L. camara* and *S. spectabilis.* Species richness of each growth form (herb & shrub) declined significantly with increasing Lantana, Chromolaena and Senna cover. In the current study, trees and climbers did not show any significant variation with increasing percentage covers of IAPS. For every 10% increase in percentage cover of *C. odorata*, two native herb species were observed being removed from the study area. At the same time only one shrub species was removed at every 10% increase in Chromolaena cover. For every 10% increase in Lantana cover, one native herb species was removed from the study area of the sanctuary. The species richness of shrubs also declined due to Lantana invasion. On plotting herb species richness against Senna percentage cover, only four herb species were obtained at 50% Senna cover. On further increase in percentage cover of Senna the herb species richness declined linearly and it was decreased to one at 100% Senna cover. It was also found during the study that, in plots where Senna and Chromolaena occured together, the species richness decreased from 86

to 4. Similarly in plots where Senna occured with Lantana and Chromolaena, species richness showed a decline. This probably indicates a dominating interference of Senna on the recruitment of native species and could be because of the impacts of its larger size, big and wider canopy, competitive reproductive ability, allelopathy and a broad, deeper root system. Out of the 125 plant species identified from the sanctuary, only thirteen were observed from Senna invaded region. But during regression analysis it was found that, among the three IAPS Senna has the least impact on native species richness. This may be due to the fact that compared with Lantana and Chromolaena, the invasion of Senna is restricted to only a small portion of Wayanad WLS. But left uncontrolled Senna will soon become a major threat in Wayanad WLS in the near future.

5. Impact of participatory forest management on livelihoods of indigenous communities-
(NFB -05 -06 -02- 2017 -FF KAU- PG)

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The study which was conducted in five randomly selected VSS was to understand the impact of participatory forest management on livelihoods of indigenous communities. A perception analysis to know the pre-PFM and post-PFM situations as perceived by the community was also conducted. PFM had a positive impact on the livelihood of the local communities in the selected five Vana Samrakshana Samithies namely Anapantham VSS, Karikadavu VSS, Kunchipara VSS, Poovanchira VSS and Vazhachal VSS. Impact analysis of Anapantham VSS showed that after the implementation of PFM activities, there were improvements in the financial capital, physical capital and social capital while a reduction was noticed in the natural capital and human capital compared to the pre-PFM situation. Impact analysis of Karikadavu VSS showed that after the implementation of PFM activities, there were improvements in the social capital, financial capital and physical capital. At the same time, a reduction was noticed in the natural capital and human capital compared to the pre-PFM situation. Impact analysis of Kunchipara VSS showed that after the implementation of PFM activities, there were improvements in the physical capital, financial capital and social capital. On the other hand, the human capital was unaffected. At the same time, a reduction was noticed in the natural capital compared to the pre-PFM situation. Impact analysis of Poovanchira VSS showed that after the implementation of PFM activities, there were improvements in the financial capital, physical capital, human capital and social capital. At the same time, a reduction was noticed in the natural capital compared to the pre-PFM situation. Impact analysis of Vazhachal VSS showed that after the implementation of PFM activities, there were improvements in the financial capital, physical capital and social capital. At the same time, a reduction was noticed in the natural capital and human capital compared to the pre-PFM situation. Perceptions of local people regarding the conditions before and after PFM were different in the VSS. The difference in perception was highest in Poovanchira VSS, while the lowest variation was observed in Kunchipara VSS and Karikadavu VSS. The highest variation in perception score was in Vazhachal VSS and the lowest variation in perception score was in Poovanchira VSS.PFM activities were not significantly different in the three pairs of VSS namely

Anapantham & Karikadavu, Vazhachal & Anapantham and Vazhachal & Karikadavu before implementation of PFM. PFM activities were not significantly different in four pairs of VSS namely Anapantham & Karikadavu, Anapantham & Kunchipara, Kunchipara & Karikadavu and Poovanchira & Kunchipara was observed.

6. Standardisation of gum-oleoresin extraction technique in Matti (*Ailanthus triphysa* (Dennst.) Alston.)

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Data analysed for different seasons revealed that the highest quantity of gum oleoresin was reported in Post-Monsoon season (195.45 gm/tree) followed by monsoon (117.93 gm/tree) and least in summer season (62.50 gm/tree). Analysis for whole study period indicated that there was significant difference in production due to different girth classes as highest amount of gum-oleoresin yield was registered from girth class >150 (59.34 gm) whereas in 75-150 cm girth class, the mean production was 50.33 gm and least in girth class <75cm (12.3 gm). Anatomical study unveiled the gum-oleoresin in vessels through the pits present on the walls of vessels and it was also observed that the ray parenchyma playing an important role in production of gum-oleoresin as the rays are mainly meant for radial conduction. The effect of bark thickness on production of gum-oleoresin was found to be significant with correlation coefficient 0.64. The relative humidity was found to be significantly related with gum-oleoresin production and it was found to be positively correlated with yield whereas the temperature, sunshine hours and wind speed found to be negatively correlated with the gum-oleoresin production and rainfall and number of rainy days was found no relation in gum-oleoresin production.

Ongoing PG Projects

1. Genetic diversity and domestication of *Pyrenacantha volubilis* Wight, an anti-cancer drug yielding plant

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This research work revolves around the specific objectives of exploring the genetic diversity in fragmented natural populations of *Pyrenacantha volubilis*, analyzing camptothecin and its major derivatives isolated from *P. volubilis* for druggability against major cancer proteins *in silico*, identifying elite lianas through a progeny trial and propagating the plant vegetatively. Literature reviewing, formation of the advisory committee, preparation and submission of the project proposal in the standard proforma and reconnaissance survey of the study area have been undertaken. Fruits (for progeny trial) was procured from FBTI Department, COF Sirsi, UAS Dharwad. All the fruits were labelled and sown in the COF nursery, KAU. The progeny trial has been established. Observations are being taken from the progeny trial. Leaf samples (for genetic diversity studies – stored in cold) has been procured from Department of Forest Biology and Tree

Improvement, College of Forestry, Sirsi, UAS Dharwad and analysis for genetic diversity has been initiated. Molecular docking has been initiated.

2. Modelling the impact of climate change on Net Primary Productivity (NPP) on selected ecosystems in Nilgiri Biosphere Reserve, India

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The main objective of the study is to assess the impact of present as well as projected climate change of the RCP scenarios on the Net Primary Productivity of forested ecosystems in the Nilgiri Biosphere Reserve. The present study will make an assessment of the impact of projected climate change on the selected forest ecosystems in Nilgiri Biosphere Reserve (NBR), India. This assessment will be done for the RCP 2.5, RCP 4.5, RCP 6.5 and RCP 8.5 climate projections, through the dynamic global vegetation modelling (DGVM). To assess the impact of climate change on the forests, changes that are expected to take place in location as well as towards the extent of the different forested ecosystems in NBR will be estimated. This estimation will be based on (i) data on the spatial distribution of forests across NBR (Satellite image derived data either from OLI or Sentinel) (ii) data on current climate consisting of the spatial distribution of climatic variables (rainfall, temperature, cloud cover) CRU data (Jones and Harris, 2013) and Indian Meteorological data (IMD) along with data available from the automated weather stations spread across the states including that of from KAU and other respective state agencies, (iii) similar data for future climate, as projected by relatively high-resolution global/regional climate models for four different climate change scenarios, at 2020s, 2040s, 2060s and 2080s (iv) data on water-holding capacity and depth of topsoil and subsoil at various locations of the study area (from ISRIC gridded data) and the data available with state agencies including department of soil survey and soil conservation, KFRI, other respective state agencies, and finally, (iv) the DGVM models including BIOME4, which uses these data as input and suggests the vegetation types most likely to occur at the corresponding locations. Water holding capacity for the soil will be derived through an empirical relationship. The project is in progress.

3. Small carnivores of selected protected areas of Kerala

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The objective is to study the status of small carnivores such as felids (lesser cats), herpestids (mongooses), viverrids (civets) and mustelids (otters and martens) in selected protected areas. It is also intended to study habitat preferences of small carnivores and their distribution in selected protected areas. It is proposed to study the temporal segregation between sympatric small carnivores. Feeding ecology of otters will also be studied. It is also proposed to study the feeding ecology of viverrids. In addition to the above, conservation challenges faced by the small carnivores in these selected study areas will also be studied. The project is in progress.

4. Comparison of feeding ecology of two endemic species of langurs, Tufted Grey Langur (*Semnopithecus priam*) and Himalayan Grey Langur (*Semnopithecus ajax*)

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The project is to study the food and feeding habits and habitat preference of *S. priam* and *S. ajax* and work is in progress.

5. Efficiency of intervention measures against crop raiding wild animals, in Wayanad Wildlife Sanctuary

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The project is to study the efficiency of intervention measures against crop raiding wild animals, in Wayanad Wildlife Sanctuary and work is in progress.

6. Utilisation of the waterholes by wild animals in Wayanad Wildlife Sanctuary

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The objective of the study is to document and map all the natural and artificial waterholes in Wayanad Wildlife Sanctuary. It is also proposed to assess the utilisation pattern of the waterholes by the wild animals. The project is in progress.

7. Floristic diversity and regeneration status of moist deciduous forests in Thrissur forest division, Kerala: Reassessment after three decades.

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The objectives of this Masters project are to assess the floristic diversity, structure and regeneration status of moist deciduous forests in the selected locations in Thrissur forest division, Kerala. The study also aims to investigating the vegetation changes and the drivers of change compared to a similar study carried out in the same locations three decades before. The analysis of the vegetation in the various experimental sites at Kuthiran and Kalluchal forests has been completed and the phyto sociological study in the Karadippara region of Peechi forests are in progress. Preliminary observations indicate that there is considerable change in the physiognomy, composition and structure of the forests in these regions after a period of 30 years. Studies on the diversity and other functional attributes of the vegetation are in progress.

8. Morphological and biochemical diversity assessment of *Garcinia indica* Choisy germplasm

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Development of phenotypic description (characterization) is the most significant and considered as the first step in assessing the extent of variability, for germplasm exchange and conservation. The study of variation in fruit and seed traits among different trees gives us an idea about the character which has more economic utilization for its domestication and help in identifying the superior genotypes based on the key feature of the particular species. Knowledge about the extent of variability in trees is an important aspect that decides the success of a plant breeding programme. Hence, exploration of crop variability is a pre-requisite for the commercial exploitation of the crop. The current study aims to throw light on the variability existing in different accessions of *Garcinia indica* trees that are maintained as germplasm in the orchard of National Bureau of Plant Genetic Resources, Regional Station at Vellanikkara which houses almost the entire assortment of this polygamo - dioecious tree in southern India. Observations are made from 15 accessions (single tree per accession) of *Garcinia indica*. Parameters studied includes variability in the general tree characters, leaf characters, flower characters, characters, Organic acids, primary metabolites (total carbohydrate, reducing sugar, total protein content, total fat content, total soluble solids), vitamin, minerals, (Phosphorus, Potassium, Sodium, Calcium, Magnesium), secondary metabolites (total phenols, total flavonoids) and variability in physical (colour, aroma, pour point, melting point) and chemical properties (acid value, saponification value, iodine value) of seed butter.

9. Impact of invasive alien plants on under-storey vegetation in Tholpetty Forest Range of Wayanad Wildlife Sanctuary

Dr. Gopakumar, S
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The major objective of this study is to assess the distribution characteristics of selected invasive alien species viz. *Lantana camara*L., *Senna spectabilis*(DC.) H.S. Irwin and R.C. Barneby and *Chromolaena odorata* (L.) R.M. King & H. Rob. in the selected ecosystems inside Tholpetty Forest Range of Wayanad Wildlife Sanctuary. This study also aims to investigate the effect of these invasive alien plant species on the regeneration of other plant communities. Vegetation studies were conducted in the deciduous forests, teak plantations and swamps (low lying grasslands) located in the northern region (Tholpetty forest range) of Wayanad WLS. Through reconnaissance surveys, eighty 10 m × 10 m sample plots were randomly selected in each of the three above mentioned vegetation types. The percentage of ground covered by the invasive alien plant species (IAPS) like *Lantana, Chromolaena, Senna* etc. in these 10 m x 10 m plots were estimated by measuring the crown area. The number of stems of these IAPS were counted and recorded to calculate density. Five plots with no IAPS were randomly selected in each of the vegetation types and treated as control plots for comparison. All the other tree species (> 10 cm

GBH) standing inside the 10 m x 10 m plot were identified and their GBH and height were recorded. Inside the 10 m x 10 m subplots, six 2 m × 2 m nested plots were randomly laid out to count the number of other plant forms (including regeneration). The field work has been completed and the data is being analysed.

10. Phytosociological and edaphic attributes of forest ecosystems of Shendurney Wildlife Sanctuary, Kerala.

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The main objectives of the study are to investigate the floristic diversity, structure and soil physico-chemical properties of various ecosystems in the Shendurney Wildlife Sanctuary and also to map the vegetation using geographical information system. We have started the field work and collected primary data on vegetation characteristics. The study is in progress.

11. Physico-chemical characterization of gum-oleores in from *Ailanthus triphysa* (Dennst) Alston and effect of ethephon on gum Oleoresin yield

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The main objective of the study is to assess the effect of ethephon on gum-oleoresin production from matti trees of different diameter classes and study will also attempt to know the physico-chemical characteristics of gum-oleoresin from *Ailanthus triphysa.* The study indicates the significant influence of ethephone on the gum Oleoresin production. The study is in the final stage of completion.

Name of Project Coordination Group: (02)
Planted Forest and Utilization

Compiled by:

Dr. E.V. Anoop, Project Coordinator

Plan & External Aided Projects

Ongoing Projects:7 Nos.

Post Graduate Projects

Concluded Projects: 2 Nos
Ongoing Projects: 15 Nos

Ongoing Projects

1. **Development of technologies for manufacture of value added products from coconut wood** - State Plan

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Freshly felled coconut wood is highly susceptible to wood boring insects, moulds and stain fungi as it has high levels of sugar, starch and moisture content throughout the trunk. The objectives of this study are (i) to develop appropriate preservative treatment methods to protect sawn coconut palm wood from insects and other pathogens under the prevailing eco-climatic conditions in Kerala; (ii) to evaluate the effect of different preservative factors on the treatability of coconut wood. Wood samples were treated with inorganic chemicals like Copper Chrome Boron - CCB and Borax Boric Acid – BBA by diffusion and pressure treatment, of which pressure treatment performed better. Diffusion treatment of inorganic preservatives in high and medium density wood showed no significant difference in retention whereas significant difference was observed for penetration percentage. For pressure treatment, retention and penetration were significantly higher in high density wood while medium density wood showed only better retention of preservatives. Solution concentrations and overall retention and penetration percentage were found to be significantly related. The study found that sawn coconut wood samples when effectively treated with preservatives complying with the prescribed retention and penetration percentages as per the optimized standards, could be used as a potential substitute for conventional timbers. The insect damage was almost absent for the treated samples and also minimal damage due to termites and pin hole borers were observed during the graveyard tests.

Seasoning of wood is drying of wood to a suitable moisture content warranting equilibrium with the prevailing atmospheric conditions in service with minimum of degrade. Coconut wood having a wide range of moisture range, seasoning is very crucial for the better utilization of wood. Freshly cut samples were collected from farmer's plot and converted into desirable sizes. Pilodyn standardisation was done to sort the coconut wood into different density classes. Fundamental physical properties were studied. Quick drying test was conducted in the laboratory in hot air oven to study the degree of defects during drying. Defects were graded according to Terasawa scale. Seasoning schedule treatments were determined for both high density and medium density wood. Samples were given different seasoning schedule treatments in convection kiln to determine the best treatment based on grading of defects.

2. **Short and long term strategies for income generation from the teak, matti and silver oak plantation areas at Panchavadi hills in KAU main campus- State Plan**

Dr. T. K. Kunhamu
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The objectives of the project include establishment of profitable short term and long term plantation forestry models at KAU campus and establishing demonstration facility for the promotion of tree farming for small and medium farmers of Kerala. The major physical

achievements as part of the project include purchase of mini tractor with trailor, cultivator, rotovator, tractor hood and bund former, establishment of implements and farm produce store, establishment of mist chamber of plant propagation, establishment of demonstration facility the promotion of tree farming, strengthening of laboratory facility for plant and soil analysis including procurement of chemicals and glassware and procurement of agricultural implements for field preparation and planting. The project includes income generation to the KAU by felling and disposing of old and over mature matti and silver oak trees in the KAU main campus. The trees were felled during august 2018 after prolonged delay in getting sanction from Kerala Forest Department. An amount of Rs. 23.43 lakhs has been generated through the sale of the trees. The second phase of the project involves planting commercially important trees in the felled areas at Panchavadi hills, KAU which will be completed during the next planting season (June 2019).

3. Development of Forestry Instructional Farm at KAU main campus – State Plan

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The objectives of the project include Development of model integrated multi-storeyed agroforestry production system, establishment of farm forestry/agroforestry interpretation centre establishment of animal rescue and rehabilitation facility and development of wood processing yard. The establishment of interpretation centre has been completed. Also as part of the development of multistoried agroforestry production system a fruit orchard involving 10 lesser known forestry tree species are in progress which will be completed shortly. The remaining components of the project are in the final phase of completion.

4. Germplasm collection and evaluation of species suitable for short rotation intensive forestry

Dr. A. V. Santhoshkumar
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Wood based industry in India has traditionally been developed with the subsidized and committed supplies of wood from public forests. As the timber harvest and its supply to the industry have dwindled since green felling has been curtailed from reserve forests, many industrial units which faced acute shortage of wood started their own forestry programs. WIMCO and other poplar based industry in the North India are already based on farm grown poplar. The attempt to establish such farm plantations have met with limited success in Kerala owing to several reasons. Further, in Kerala there is a need to diversify the farming due to economic and ecological reasons. In this context Short Rotation Forestry (SRF) in lands that were previously occupied by low productivity agriculture is a viable option. The economic returns on planted forests, especially high-yielding intensively managed forests have attracted the attention around the globe. In these systems, trees are grown either as single stems or as coppice systems, with a rotation period from 3 to 20 years and with an annual woody production of at least 10 tonnes of dry matter or 25 m^3 per hectare. Based on this an experiment was done to collect and evaluate fifteen indigenous species for short rotation intensive forestry. The species selected are *Acrocarpus fraxinifolius, Ailathus triphysa, Albizia procera, Anthocephalus cadamba, Chukrasia tabularis, Dalbergia sissoo, Gmelina arborea, Hardwickia binata, Lannea*

coromandelica, *Melia dubia*, *Mitragyna parvifolia*, *Paraserianthes falcataria*, *Pterocarpus marsupium*, *Toona ciliata*, *Thespesia populnea*. The study areas were selected after referring relevant literature from district floras, herbaria and other leading publications. Based on this information extensive field survey was conducted throughout the natural forests of Kerala. The trees available for all the fifteen species were identified from these locations. The growth parameters such as height, girth, length of clean bole, crown width etc. other parameters such as health of the trees, GPS locations of the tree were also recorded. From these twenty-five plus trees were selected based on Base-line method (Rudolf, 1956) and suggested by Bedell, 1980. Selection procedure for all the trees is progressing. In the case of *Melia dubia* twenty-five plus trees has been selected. Hundred ripe fruits from melia trees were collected from the selected plus trees and seedlings were raised to evaluate its performance. The experiment is done in CRD with 3 replication and 5 plants in each replication. The growth characters of the seedlings such as height, collar girth, no. of leaves etc. and the physiological parameters such as transpiration and photosynthesis rate, stomatal conductance, relative water content, chlorophyll content were observed. Another experiment is also done to evaluate the performance of the clonal progeny of plus trees for early growth and vigor. For this the root suckers shall be collected form the plus trees. To induce the root suckers the roots are injured. The collection of the root suckers from the forest is progressing. This experiment will be done in CRD with 3 replication and 5 plants in each replication. Based on the results the selected plus trees shall be ranked. This experiment shall be done for all the other selected species.

Field experiment:

A field experiment was also done in the College of Forestry to evaluate the performance of the 5 varieties of *Melia dubia* released from the Forest College and Research Institute, Mettupalayam as part of the multi locational trial. For this seedlings were planted in line with a spacing 3x3m. In total 50 plants are planted. Growth observation of the plants is being continued.

5. Agroforestry systems and practices suitable for humid tropics-AICRP on Agroforestry

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Objectives of this project include diagnosis and design survey of agroforestry systems of Kerala, MPTS Evaluation / Tree improvement programmes and management of Agroforestry systems in humid tropics of Kerala.

This project further divided into six small project focusing on different species and systems which includes provenance evaluation teak, Provenance evaluation of *Acacia mangium* Willd, Standardization of pruning and thinning regimes for *Acacia mangium* stands, Diagnosis and Design survey in the urban home gardens of Kerala, Multitier silvopastoral systems suitable for tropical homegardens, Development of an integrated and multitier agro-silvo-pastoral system suitable for the humid tropics. The results obtained from the project are given below

Among the ten provenances studied for *Acacia mangium***,** a consistently superlative performance was exhibited by the Papua New Guinean provenances after 16 years of establishment. Better performers include Kuranda, Upper Aramia and Arufi Village

In the teak provenance evaluation trial, best performance was observed from Nilambur provenances at the 17th year of establishment. Among the 30 different teak accessions from South India, the better ones were from Nedumkayam-1, Nedumkayam-2, Cherupuzha and Nellikutha-5.

In the multitier model farm, the coconut palms and MPTs are in their sixth year of growth. Nutmeg seedlings are planted in the centre of every four coconut trees and cocoa is planted within the coconut rows at 3m distance. This year some fruit trees were integrated at 3x3m spacing. Variety of vegetables and spices such as cowpea, brinjal, amaranthus, cucurbits, turmeric and ginger were planted as intercrop. Multitier silvopature systems including hybrid napier grass, mulberry and calliandra were also integrated in between the coconut trees.

The integration of protein rich mulberry hedgerows in coconut garden provides an excellent option to enhance quality forage production and carbon sequestration in humid tropics of Kerala. Mulberry fodder banks yielded maximum dry forage (32.85 Mg ha-1 coconut garden over three year period) at the highest tree density of 49,382 plants ha-1 and at 12 weeks harvest interval, when compared to other management options. In addition, the intercropped mulberry hedgerows has fixed more carbon to a maximum of 33 Mg ha^{-1} over three year period in the plant biomass and in soil up to 40 cm depth, when compared to coconut monoculture systems, thereby making considerable contribution for reducing atmospheric carbon dioxide levels.

In connection with the revitalization of homegardens, different fodder tree sp. were integrated in the understorey of 3 homesteads of Arimpoor Panchayath. Preliminary observations reveal that calliandra, glyricidia and mulberry showed better survival and yielded more forage than agathi and moringa in the initial year of establishment.

Research works are going on the topics like common experiment on bamboo based agroforestry practices for humid tropics and revitalization of homegarden based traditional agroforestry systems of Kerala.

6. **Development of Management Information System for Management of Kerala Forest Development Funded Projects -** Kerala Forest Development Fund

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The objectives of the Project are to develop a Research Management Information System (RMIS) and geo-spatial database on a suitable online platform for query and management of the research carried out in Forestry and Wildlife under the Kerala Forest Development Fund (KFDF) for the past twenty years of research related to ongoing and projects ended during the last 20 years. The RMIS will help management of the research and development works of the department in a more efficient manner and also help keep track of each and every project funded

under KFDF. It will also help in the audit trail and assist the forest authorities to offer timely and effective answers by the department to the queries raised by various agencies including the legislature. It will be very easy to add future projects, all reporting including sanctioning and progress to RMIS. Work Programme of this Project includes collection of secondary data of research carried out in Forestry and Wildlife under KFDF for the past twenty years and developing research management information, system. Currently it is decided to develop a research management information system using free operating system "Debian" and the software "DSpace". DSpace is the software of choice for academic, non-profit, and commercial organizations building open digital repositories. It is completely customizable to fit the needs of any organization. DSpace preserves and enables easy and open access to all types of digital content including text, images, moving images, mpegs and data sets.

7. Training and Technology Demonstration Project for Making Value Added Products from Coconut Wood - Coconut Development Board, Kochi

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The objectives of the Project are set up a modern Coconut Wood Technology Demonstration Centre (CWTDC), installing advanced machineries for sawing, seasoning and preservation and manufacture of utility items such as furniture, interior decorative items, building materials, handicraft items etc. based on coconut wood so as to popularize the use of cocowood for additional income to farmers. To develop a value chain model of cocowood extraction, conversion, design, manufacture and sale of cocowood furniture and other value added products in collaboration with Furniture Consortium Private Ltd. and the Kodungallur Coconut Producer Company Ltd. (KCPL). Making value added products from coconut wood and market the same in collaboration with the Kerala Furniture Consortium Private Ltd. (KFCPL) and Kodungallur Coconut Producer Company Ltd. (KCPCL). This will be achieved by providing training to selected trainees of the Kodungallur Coconut Producer Company Ltd., Perinjanam, Thrissur. A Coconut Wood Technology Demonstration Centre (CWTDC) was envisaged in the project. Training in bioconversion of coconut wood waste into potting media will be conducted for making potting mixture from the coconut wood waste. Under the project few prototypes of furniture from coconut wood were manufactured for the training programmes. Total 4 training programmes were conducted in collaboration with the Kodungallur Coconut Producer Company Ltd., Perinjanam.

PG Projects

Concluded PG Projects

1. Understorey productivity of selected fodder grasses in mature coconut and rubber plantations

Rose Mary Jose (2016-17-006)

A field experiment was conducted to assess the understorey productivity of four fodder grasses viz *Brachiaria ruziziensis* Germain & Everard (congosignal), *Panicum maximum* Jacq.(guinea), hybrid napier cultivar CO-3 and CO-5 under mature coconut (*Cocos nucifera* L.) and rubber (*Hevea brasiliensis* Muell. Arg,) plantations which are the two prominent land use systems in Kerala, from May 2017 to February 2018. The selected fodder grasses were planted in beds (10m× 1m× 0.3 m) in the under-storey of mature coconut and rubber plantations. Coconut grown fodder grasses showed the maximum plant height with a percentage increase of 3.73, 8.97 and 5.28 per cent respectively over control for the first three harvests. Under storey PAR transmittance ranged from 39.84 to 56.08 per cent in rubber and coconut respectively. Coconut grown fodder grasses showed an equally good performance in growth and yield attributes with the open whereas a substantial reduction in the yield was observed in fodder grasses grown in the under storey of rubber Under storey PAR availability plays a crucial role in determining the biomass production of the understorey vegetation. The results of the present study indicated that the growth and yield attributes of fodder grasses under coconut plantation were almost comparable with open plots. This practice of integrating fodder grasses in coconut plantations is gaining immense importance in Kerala, where mature coconut plantations forms one of the extensive and prominent land management system. Thus, judicious use of the vast area of interspaces under these matures coconut plantations for fodder production is very ideal especially in the state of Kerala. However, the rubber based fodder production system is not at all feasible and further conclusive studies may be done for affirming more reasons for such a substantial reduction of growth and yield of fodder grasses in rubber based silvi-pasture system.

2. Field evaluation of stump and root trainer grown teak (*Tectona grandis* l.f.) plantations

Eldhose George
Dept. Silviculture and Agroforestry

A field study entitled "*Field evaluation of stump and root trainer grown teak (Tectonagrandis* L.f.*) plantations*" was conducted on teak plantations established at Karakkad, Kalady range, Malayattoor forest division, Kerala during 2017-18, to evaluate the influence of planting material viz. stump and root trainer on growth aspects, soil physio-chemical properties and root distribution separately in five and seven year old teak plantations. The teak plantations selected for study included; five year old (2012 establishment) stump and root trainer grown stands at 3x3 m spacing, seven year old (2010 establishment) stump and root trainer based stands at 2x2 m initial spacing. Attempt were also made to study the effect of planting spacing on the growth of teak that was raised from root trainers and managed separately at 2x2 and 3x3m spacing. Nine random plots of size 20x20 m were demarcated for each of the treatments such that there were 45 experimental plots for observation. Altogether there were three treatment combinations for comparison viz. stump vs root trainer at 3x3m spacing and 5 year age; stump vs root trainer at 2x2 m spacing and 7 year age; five year old root trainer based teak stands at 3x3m vs at 2x2m spacing. Each treatment combinations were analyzed separately with independent t- test.

Biometric observations on teak growth showed considerable difference with variable planting material and spacing. Root trainer grown teak stands showed better performance in total tree height (6.68 m at seven years of age), DBH (9.04 cm at seven years of age), and mean tree volume (0.031 m^3 at seven years of age) as compared to stump origin stand both at five and seven years of stand ages. The basal area and bole height showed marginal improvement in root trainer grown stand at five years of age. Initial spacing showed only marginal influence on total height and bole height with an advantage for stands at 2x2 m spacing as compared to 3x3 m spaced stands. However, DBH, basal area and volume showed discernible improvement in the stands at 3x3 m spacing. Crown diameter showed a nominal increase in the root trainer grown stand than stump grown stand at both ages. However, spacing had great influence on the crown diameter with more spread (2.7 m) by widely spaced stands (3x3 m). Stand LAI also was better for root trainer stand while spacing had poor influence on LAI. Persistence of stem axis and straightness of stem showed limited advantage for stump grown teak origin stand. Also closely spaced teak stands (2x2 m) developed from root trainer stands showed slightly better performance than teak at wider spacing (3x3 m).

Attempts to analyze the influence of planting material and spacing on plant leaf nitrogen and soil physio-chemical properties suggested that plant leaf nitrogen concentration was modestly better for root trainer grown trees than stump grown trees. However effect of spacing indicated that widely spaced trees (3x3m) showing significantly higher nitrogen up take than narrow spaced trees. Soil physical and chemical properties were found to be less influenced by the planting material. However, all teak stands irrespective of planting material showed considerable improvement in soil organic carbon and nitrogen concentration and reduction in soil bulk density as compared with respective treeless open plots. Also there was consistent reduction in carbon content and nitrogen with increase in soil depth up to one meter soil depth. The average soil carbon concentration values were 1.15 % and 1.55 % for the root trainer and stump grown teak stands at 7 years of stand age. The corresponding soil carbon stocks were 24.60 Mg ha^{-1} and 32.85 Mg ha^{-1} for teak stands at 7 years of stand age. Investigations on root distribution among stump and root trainer grown teak trees revealed obvious advantage in root spread and root intensity for root trainer raised teak stands. Teak trees grown from stump had smaller roots confined to the base of the tree at shallow depths which drastically reduced with increase in lateral distance of soil depth. The presence of prominent multiple tap root systems could be the reason for the high root spread observed with root trainer based teak trees. The trends were the same for small, medium and larger root intensity. Yet another noteworthy observation was that teak trees at closer spacing showed reduction of root spread and restricted the root system at proximal lateral distance while widely spaced trees showed wider root distribution.

Ongoing PG Projects

1. Screening of jack trees (*Artocarpus heterophyllus* Lam.) for quality timber production.

Jobin Kuriakose(2017-17-003)
Dept. Forest product and Utilisation

This study is intended for the selection of plus trees of *Artocarpus heterophyllus* Lam. for seed collection, nursery raising and their evaluation from dry and wet regions of Thrissur and Palakkad districts. It is also aimed at assessing the farmers' perceptions towards growing Jack as a timber species in homesteads of Thrissur and Palakkad districts. Koozha and Varika varieties

were selected as plus trees and nursery was raised to evaluate the parameters. Detailed questionnaire was prepared to assess the farmers' perception towards growing Jack as a timber species. Survey is being conducted.

2. Standardization of tree injection procedures of azadirachtin in coconut (*Cocos nucifera* L.), mango (*Mangifera indica* L.) and neem (*Azadiracta indica* A Juss.).

Sarmishta V(2017-17-011)
Dept. Forest product and Utilisation

Tree injection, also known as trunk or stem injection, is a method of target precise application of pesticides, plant resistance activators and fertilizers into the xylem vascular tissue of a tree with the purpose of protecting the tree from pests or nutrition for correction of nutrient deficiencies. Trees belonging to three different size classes of coconut (*Cocos nucifera*), mango (*Mangifera indica*) and neem (*Azadiracta indica*) was selected randomly following stratified random sampling technique. One tree from each size class was selected. Wood samples in cross section were drawn from each selected tree and the collected wood samples were made into two discs of 1 inch thickness. Cubes of the size 3cm*3cm*3cm was made out of one disc so as to assess the specific gravity and basic density of the sample. Another replica of the disc was used to assess the factors like sapwood area, sapwood – heartwood ratio etc. Anatomical studies of wood Trees belonging to three different size classes were selected and treated by injecting azadirachtin at basal height. Tree injections were done on the sapwood at a specific depth so as to understand the sap flow which in turn is assessed by studying the transpirational rate. The effective time required for the azadirachtin to reach the leaves were assessed by timely collection of leaf sample and conducting HPLC (high performance liquid chromatography) separately for the collected leaves. The presence of azadirachtin and its amount were calculated using the high performance liquid chromatography. The data obtained is analyzed using CRD.

3. Wood property variation in jack trees (*Artocarpus heterophyllus* Lam.) grown in Thrissur district, Kerala.

Pavin Praize Sunny(2017-27-001)
Dept. Forest product and Utilisation

The objective is to study the variation in wood properties of jack trees (*Artocarpus heterophyllus* Lam.) grown in different regions of Thrissur district to understand the effect of different girth classes on wood physical, anatomical, chemical and mechanical properties. Jack tree wood samples were collected from different regions of Thrissur. Physical properties like wood basic density, moisture content, and specific gravity were studied. Chemical properties of jack tree wood from different regions were compared .Anatomical properties were studied in Central wood testing laboratory, Kottayam Analysis of anatomical properties are being done.

4. Standardisation of kiln seasoning schedule for coconut (*cocos nucifera* L.) wood.

Gayathri Mukundan(2017 – 17-001)
Dept.Forest Product and Utilisation

Seasoning of wood is drying of wood to a suitable moisture content warranting equilibrium with the prevailing atmospheric conditions in service with minimum of degrade. Coconut wood having a wide range of moisture range, seasoning is very crucial for the better utilisation of wood. Freshly cut samples were collected from farmer's plot and converted into desirable sizes. Pilodyn standardisation was done to sort the coconut wood into different density classes. Fundamental physical properties were studied. Quick drying test was conducted in the laboratory in hot air oven to study the degree of defects during drying. Defects were graded according to Terasawa scale. Seasoning schedule treatments were determined for both high density and medium density wood. Samples were given different seasoning schedule treatments in convection kiln to determine the best treatment based on grading of defects.

5. Integration of DNA barcoding and wood anatomy for the identification of selected timbers.

Azhar Ali. A
Dept. Forest Product and Utilisation

Timber has played a vital role in the daily lives of people from time immemorial. However, to put the right timber species to the right use remains a challenge especially when we consider its availability. The shortage of timber supply from domestic sources widens the demand-supply gap for timber which may lead to the adulteration practices in wood markets. To counteract such unwarranted instances we are in need of an unbiased system of identification. Although various keys for wood identification based on its physical and anatomical properties are available, they can't always serve as an authentic source as the conventional identification techniques need more expertise and understanding of the wood biology. Also, these properties show variations based on the conversion and end uses of timber. In such situations integration of DNA barcoding with the above said physical and anatomical features can serve as foolproof tool for reliable wood identification. Meanwhile, genetic identification techniques also require confirmed databases as reference. In this regard, this study aims at creation of a data base integrating DNA barcoding with physical and anatomical characters of some important timber species currently used in Kerala. To confirm the authenticity of the samples based on their physical and anatomical characters. The objectives of this study is to create DNA Barcoded database of 10 important timber species (*Dalbergia nigra, Shorea robusta, Ocotea rodiae, Nauclea diderrichii, Tsuga sp., Fagus sp., Koompasia malaccensis, Osyris lanceolata, Intsia palembanica, Hevea brasiliensis)* which are currently traded in Kerala.

6. Development of an anatomical key for the identification of selected timbers of Kerala.

Nimmy Sathish
Dept. Forest Product and Utilisation

Wood is one of the earth's most versatile and probably most familiar natural material and the role it plays in our daily lives is immense. However, to put the right timber species to the right use remains a challenge as hundreds of species with timber properties that are highly variable are available for one to choose from. In comparison with the other natural materials, the most striking feature of wood is its high degree of variability. Keys based on the anatomical features serve a pivotal role in the identification of an unknown sample of wood. Since anatomical features are relatively constant for each species they can be successfully employed in identification keys. The commonly used keys for wood identification are the dichotomous key, perforated card key and the computer aided identification key. Wood anatomy of a timber species is akin to fingerprints in humans. For preventing adulteration of superior species with inferior ones and for the efficient utilization of the timber concerned, accurate identification is of much relevance. The objectives of this study are to develop an anatomical key of commercially important timbers of Kerala and also to identify timbers using the anatomical key prepared.

7. Evaluation of growth and wood variation in *Ailanthus triphysa* (Dennst.) Alston, (Matti)

Prabhu. M
Dept. Forest Product and Utilisation

Ailanthus triphysa, a medium to tall tree belonging to the family Simaroubaceae. This species has high priority for match industry to produce match splints. The resin from the tree called as halmaddi; is used in the production of incense sticks. It is also used as a raw material for pulp and paper industry. A. triphysa is a prominent fast growing multipurpose tree, widely grown in the homegardens under the humid conditions of Kerala. It is recommended as an important plantation species in peninsular India. The utilizable size of the species about 35 cm girth, usually attained within 6–8 years and hence it is preferred as a short rotation plantation species. It fetches very good
price and is in huge demand in the match industry that makes it a suitable species for cultivation in the state. A. triphysa is also the most preferred raw material for match industry, obtained from the homegarden. This species has high yield (about 90 %) of match splints. There are over 313 matchwood industries in Kerala. Due to very high demand by the match industry, A. triphysa has become one of the most popular species for planting in recent years. The matchwood industry in Kerala and the neighbouring states will be greatly benefited through the development of varieties of A. triphysa with improved wood quality and growth traits. In this back drop, the objective of our work is to evaluate the growth attributes and wood property traits of A. triphysa trees grown in a tree improvement trial at the Kerala Agricultural University main campus, Vellanikkara for meeting the needs of the industry. The main objective is to evaluate the growth attributes and assess the wood property traits of *Ailanthus triphysa* grown in the main campus of Kerala Agricultural University, Vellanikkara under a tree improvement trial.

8. Impact of seed priming techniques on germination and seedling performance in Sandal (*Santalum album* L.)

Chitra P
Dept. silviculture and Agroforestry

The study is envisaged to evaluate the effect of different seed priming techniques on the germination and seedling growth of *Santalum album*. It focuses on the influence of biopriming, chemical priming, hydropriming and osmopriming on seed germination and seedling growth attributes.

9. Biopriming techniques for better germination and seedling growth of sandal (*Santalum album* L.)

Anjali KS
Dept. Silviculture and Agroforestry

The sandal seeds of Marayur will be obtained from the Seed Centre, Kerala Forest Research Institute, Peechi during March to April. The collected seeds will be cleaned and thoroughly mixed to improve the homogeneity. The seeds will be subjected to three bio priming agents (bio- inoculants) viz. *Pseudomonas fluorescens,* Plant Growth Promoting Rhizobacteria (PGPR 2 of KAU) and *Trichoderma viride.* The main objective is to evaluate the effect of three biopriming agents viz. *Pseudomonas fluorescens,* Plant Growth Promoting Rhizobacteria and *Trichoderma viride* on the germination and seedling growth of sandal (*Santalum album).*

10. Evaluation of fodder bank trees and grass-tree mixtures in a typical small holder farm of Central Kerala

Akash Ravindra Chichaghare
Dept. Silviculture and Agroforestry

The study focuses on the evaluation of the forage yield and quality of selected hedgerow grown fodder trees in farm boundaries of a typical small holder farm in Central Kerala. The study also assess the relative performance and interactions of grass-tree mixtures of hybrid napier/guinea grass with mulberry/calliandra tree sp. compared to sole crops under high density planting in small holder farm. Further, the study will probe into the biophysical parameters affecting forage productivity and quality; and the soil fertility changes associated with tree fodder integration in various systems.

11. Development of biodegradable containers as substitute for conventional polythene bag for seedling production in tree nurseries.

Subhasmita Parida
Dept. Silviculture and agroforestry

The objective include developing alternate eco-friendly plant container as substitute for conventional polythene bag based containers for the commercial production of quality planting materials of selected forest tree species. The study will be carried out in a phased manner with a

preliminary screening of locally available materials to serve as plant containers. The materials selected for the preliminary study include arecanut sheath, paper and cardboards, mud pots, coir pith, cow dung, jiffy pots, reinforced cloth bags, non-woven bags and bamboo splits. Biodegradable materials available in the market also will be tested for their effectiveness as plant containers. The plant containers based on the five selected materials from the preliminary study will be subjected to detailed nursery trial to test their suitability for growing prominent tree species demand. The trial will be carried out in the forest nursery facility at College of Forestry, Vellanikkara.

12. Evaluation of growth and biomass projection of selected fast growing tree species managed under varying planting densities

Sreejith M M
Dept. Silviculture and Agroforestry

This Doctoral project has just approved by the FRC and is in the process of establishment. The main objective of the study is to evaluate the performance of five selected indigenous fast growing tree species viz, *Acrocarpus fraxinifolius*, *Ailanthus triphysa*, *Gmelina arborea*, *Melia dubia* and *Neolamarckia cadamba* when grown under varying planting densities. The specific objectives of the study include, to compare the growth, biomass production, nutrient and carbon storage potential of selected five fast growing tree species under varying planting densities, to study the root distribution pattern of selected five fast growing trees species as a function of planting density and to assess the soil carbon stocks and nutrient status among selected five fast growing trees species under diverse density management regimes.

13. Genetic variability and plus tree selection in natural populations of *malaveppu* (*Melia dubia* Cav.)

Binu N Kamalolbhavan
Dept. Forest Biology and Tree Improvement

An estimate of the supply of timbers in Kerala, revealed that the total timber requirement of the state is met mainly by the rubber plantations (47%), homesteads (35.31%) and import (16%), while the contribution from the forest is only 1.6%. Thus, homesteads play a crucial role in meeting the wood demand of the state. There is always an escalating demand for a large and reliable supply of forest products of good quality in Kerala. Homestead tree cultivation is one of the major ways to reduce this pressure. *Melia dubia* is of high demand for plywood and paper industries. The wood is used for packing cases, cigar boxes, ceiling planks, agricultural implements, pencils, match boxes, splints and kattamarans. A study was done to assess the genetic diversity in *Melia dubia* and select plus trees in natural populations of this species. The study also analyzed the clonal and seed progeny of plus trees for early growth and vigor. Further, commercially viable clonal propagation protocol for the species was also attempted.

A recognizance survey was done in all the forest divisions of Kerala Forest Department having the natural population of the species. Based on the available population a proportional sampling was done. The study areas were selected after referring relevant literature from district floras, herbaria and other leading publications. The field experience of the staffs of the Kerala Forest

Department was also made use to locate the population of the selected species. The trees available in these areas were identified. In the field, the growth parameters such as height, girth, length of clean bole, crown width and other parameters such as health of the trees, GPS locations of the tree were recorded. In total 400 trees were enumerated, cluster analysis was done. The trees were selected from different locations such as Wayanad, Aryankavu, Kulathupuzha, Thrissur, Chinnar, Parambikulam. Hundred ripe fruits were collected from the selected plus trees and seedlings were raised to evaluate its performance. The experiment was done in CRD with 3 replication and 5 plants in each replication (fig. 2). The growth characters of the seedlings such as height, collar girth, no. of leaves etc. and the physiological parameters such as transpiration and photosynthesis rate, stomatal conductance, relative water content, chlorophyll content are observed. Another experiment is also done to evaluate the performance of the clonal progeny of plus trees for early growth and vigor. For this the root suckers shall be collected form the plus trees. To induce the root suckers the roots are injured. The collection of the root suckers from the forest is progressing. This experiment will be done in CRD with 3 replication and 5 plants in each replication. Based on the results the selected plus trees shall be ranked.

14. Physico-chemical characterization of gum oleoresin from *Ailanthus triphysa* (Dennst) Alston and effect of ethephon on gum oleoresin yield.

Latha, K. J. (2017-17-012)
Dept. Natural Resource and Management

Different diameter classes are considered to study the effect of different concentration of ethephon on gum-oleoresin production. Ethephon helps in the production of more yields. The basic information like physical and chemical properties of gum-oleoresin is essentially required for the industrial point of view and helps in value addition and product development including the industrial and pharmaceutical utilization. And also may go a long way in raising the socio-economical status of tribal communities. Hence, the present research work entitled "Physico-chemical characterization of gum-oleoresin from *Ailanthus triphysa* (Dennst) Alston and effect of ethephon on gum-oleoresin yield."The main objective is to assess the effect of ethephon on oleoresin production from *Ailanthus triphysa* trees of different diameter classes and Study will also attempt to know the physico-chemical characteristics of oleoresin from *Ailanthus triphysa*. Samples trees will be selected based on different
girth classes *viz*. 70-110cm and 111-150cm for studying yield and at standard cuttings height of 1.5 m. Twenty four (2×4×3) sample trees will be marked for analyzing the yield statistic for different girth classes. Bark thickness will be measured by using Swedish bark gauge and the treatment consisted of T1 (Control), T2 (Ethephon 2.34%), T3 (Ethephon 3.12%), T4 (Ethephon 3.9%).Physico-Chemical composition of oleoresin sample viz. solubility, pH , moisture level, color parameter, viscosity and ash content will be studied and the essential oil extracted from the gum-oleoresin analyzed by using Gas chromatography Mass spectrometry instrument The work was started in May 2018 and data collection will be over by the end of April 2019.All laboratory works are done except mineral test estimation.

15. Development and characterization of natural gum based nanocomposite

Meghna Joseph, (2017-17-006)
Dept. Natural Resource and Management

The main objective is to prepare and characterize the bamboo- natural resin based nanocomposite. The objective of this study is to develop and characterize a natural gum based nanocomposite and also to ascertain its selected mechanical and thermal properties. Nanocellulose was extracted following Abraham et al. (2013) with some modifications. The powdered bamboo will be soaked in 2% caustic soda and placed for six hours at a temperature of 25°C. The fiber characters like the length, thickness etc were studied with the help of SEM (Scanning electron microscope/microscopy). After extracting nanofibres, it was mixed with the resin in different ratios of fibre to resin using agitator so that both are mixed evenly and a good composite is formed. The characterization of composite film was done by using SEM by studying the change in the properties of the individual components in the composite. The mechanical properties like elasticity, tensile strength, shearing strength etc were tested using UTM (Universal testing machine) and thermal properties by using differential scanning calorimetry (Khalil et al., 2014) by obtaining temperature-mass curve and degradability rate. The development and characterization of nanocomposite using nanocellulose and babul gum is on the verge of completion.

Appendix : The list of research publications of KAU during 2018-19

	Authors	Year	Title of paper
1.	Naresh Babu P., Abida P. S., Beena R., Valsala P. A., Nazeem P. A	2018	Morpho-physiological and proteomic analysis to identify and characterise the traditional rice genotypes for drought tolerance. *Indian Journal of Plant Physiology*
2.	Manjesh S. and P. S. Abida	2018	In silico analysis of putative transcription factor binding sites in the promoter region of drought responsive bZIP1 gene in rice and its orthologue in Arabidopsis thaliana. *Journal of Tropical Agriculture*
3.	Vanaja, T., Neema, V.P., Mammootty, K.P., Balakrishnan, P.C., and Naik, J	2018	Saline and flood tolerant long duration organic rice variety (*Oryzasativa* L.), 'Ezhome -4'. *International Journal of Tropical Agriculture*
4.	Vanaja, T., Suresh, P.R. and Esakkimuthu, M	2018	Research efforts on coconut improvement at Regional Agricultural Research station, Pilicode. *Indian Coconut Journal*
5.	Pallavi, V., and Abida P. S	2018	Identification of differentially expressed mRNA in bleck pepper (*Piper nigrum*, L.) genotype for tolerance. *Journal of Pharmacognacy and Phyrochemistry*
6.	Radha, T., Priyanka James, Simi, S., Sangeetha P. Davis, Nazeem,P.A., Shylaja, M.R. and Deepu Mathew	2018	Mango DB: A Database of Mango Varieties and Landraces of Indian Subcontinent. *Current Science*
7.	Akshay, T. Sajitha Rani and Ammu Punnoose	2018	Effect different organic nutrient schedules on quality parameters of chilli (*Capsicum annuum). Agric.Res.J*
8.	Karthikeyan. K, Prasad, A. R., Jyothi, K. N., Prasuna, A. L and Narayanankutty, M. C	2018	Sex pheromone blends for rice caseworm, *Paraponyx stagnalis* Zeller. *Indian Journal of Entomology*
9.	Karthikeyan. K	2018	Efficacy of new insecticides against major pests of rice. *Journal of Rice research*
10.	Mini,V. and Mathew U	2018	Spatial variabililty of soil fertility in a coconut based agro ecological unit in the sandy plains of Kerala, India. *An Asian Journal of soil Science*
11.	Niranjan, H.P, G Suja and Shobha, V B.	2018	Evalulation of the efficacy of new generation granular insecticides against Rice Yellow stem borer, *Scirphophaga incertulus* (walker) in Thiruvananthapuram District, Kerala, India. *Int. J Curr. Microbiol. App. Sci*
12.	Thomas, C. G. and Indulekha, V.P	2018	Utilization of water hyacinth as mulch in turmeric. *Journal of Tropical Agriculture*
13.	Aparna K.K, Menon, M.V, Joseph, J. and Prameela, P.	2018	Diversity of *Echinochloa* spp. In Palakkad rice tracts of Kerala. *Indian J. Weed Sci.*
14.	Devaraj, A.G, Prameela, K.P, Menon, M.V. and Bridgit, T.K.	2018	Compatibility of herbicides and insecticides for tank mix application in wet seeded rice. *J. Trop. Agric*
15.	Sreepriya, S. and Girija, T	2018	Seed priming for improving the weed competitiveness

			in sesame. *J. Crop Weed.*
16.	Sreethu, M. J., Sindhu, P. V., Menon, M. V. and Thomas, C. G	2018	Performance of Kiriyath (Andrographis paniculata (Burm.f.) Wall. ex. Nees.) under different shade levels, dates of planting and mulching *J. Trop. Agric.*
17.	Antony, R., Joseph, J., Bastian, D. and Menon, M.V	2018	*In vitro* mutagenesis creates distinct morphological variants in cassava (*Manihot esculenta* Crantz): a characterization study. *Elec. J. Plant Breed.*
18.	Vithya, R.S., Gopal, K.S., Sujatha, V.S., Devi, K.M.D. and Girija, D	2018	Abiotic stress tolerant *Trichoderma harzianum* strain for growth promotion and foot rot management in black pepper. *J. Plant. Crops*
19.	Geethumol Thankappan and P.Anitha	2018	Effect of sources of coconut water and acidulants on physico-chemical properties of *nata-de-coco. Journal of Tropical Agriculture 56(2):206 -209,*
20.	Gracy Mathew, Abhimanue T.R., Ancy Joseph	2018	Standardisation of seedling production in Thaathiri (*Woodfordia fruticosa*) (L.) Kurz. *Indian Journal of Scientific Research. 19 (1): 23-27*
21.	Gracy Mathew & Ancy Joseph.	2018	A promising vetiver accession for coastal sandy tract of Kerala. *Indian Journal of Arecanut, Spices and Medicinal plants. 20 (1): 10-13*
22.	Gracy Mathew and Ancy Joseph	2018	A promising vetiver accession for coastal sandy tract of Kerala. *Indian Journal of Arecanut, Spices and Medicinal plants*
23.	C.Umesh, U. Sreelatha, P.SainamoleKurian andC.Naraynankutty	2018	Evaluation of African marigold (Targeteserecta L.) genotypes for yield and resistance to bacterial wilt pathogen, (*Ralstonia solanacearum). Journal of Tropical Agriculture*
24.	Rini, C.R., Ramya, J., Jayakumar, G. and Shajan V.R	2018	Low Cost Carrier Material for Mass Production of Trichoderma Inoculants. *J. of Trop. Agric.*
25.	Vijayakumar B. Narayanapur, B. Suma and J. S. Minimol.	2018	Self-incompatibility: a pollination control mechanism in plants. *Int. J. Plant Sci.*
26.	Minimol, J. S., Suma, B., Chithira, P. G., Shahanas, E. and Juby Baby.	2018	Genetic analysis for yield and contributing characters of new cocoa hybrids. *Res. J. Agric. Sci.*
27.	Pradeepkumar, T., Minimol, J. S., Deepu Mathew., Veni, K., Varun Roch, C., Chithira, P. G. and Rajeshwary Unni	2018	Development of CSMS system in ridge gourd (*Luffa acutangula* Roxb. L.) for production of F_1 hybrids. *Euphytica*
28.	Bini Sam, Hameeda Bindu Vahab and S. Regeena	2018	Assessment of ergonomic parameters of coconut climbing devices for women. *Current Science*
29.	Minimol, J. S., Suma, B., Juby Baby. and Simya, V. S.	2018	Drought mitigation in cocoa. *Cashew and Cocoa J.*
30.	Minimol, J. S., Suma, B., Jayasree, P. A., Chithira, P. G., Sunil, R., Deepu, M., and Midhuna, M. R.	2018	Phenotyping of vascular streak dieback disease (VSD) resistant gene in auspicious genotype by employing molecular marker systems. *Int. J. Microbiol. Res.*
31.	R. S Maheswari., B. Suma and K. T Presannakumari	2018	Morphological and biochemical characterization of long pepper (Piper longum L.) genotypes from Western Ghats regions of Kerala. *India. J. Trop. Agric.*

32.	Sobhana, A.	2018	Innovative Technologies for processing of cashew apple on commercial scale. *The Cashew and Cocoa Journal*
33.	Sheeja K Raj and Elizabeth K Syriac	2018	Bioassay for the detection of penoxsulam + cyhalofop butyl residue in soil. *Journal of Crop and Weed-14 (1): 188-194*
34.	Sheeja K Raj and Elizabeth K Syriac	2018	Herbicide mixtures effect on weed seed bank in direct seeded rice. *Indian Journal of Weed Science-50 (1):64-68*
35.	Arya S.R., Elizabeth K Syriac and Sheeja K Raj	2018	Bioassay for detecting flucetosulfuron residue in wet land rice soils. *Journal of Crop and Weed-14 (1): 212-219*
36.	Dally George, Girijadevi.L and Sheeja K Raj	2018	Magnesium fertilization for yield enhancement in directed seeded rice. *Journal of Crop and Weed-14 (2): 195-198*
37.	Suman.B.M, Sheeja K Raj and Prathapan.K	2018	Effect of nutrient levels and schedule of nutrient application on the grain quality of upland rice intercropped in coconut. *Journal of Applied and Natural Science-10 (3): 910-914*
38.	Suman.B.M, Sheeja K Raj , Prathapan.K, Elizabeth K Syriac and Radhakrishnan.N.V	2018	Effect of nutrient levels and nutrient schedules on physiological parameters and grain yield of upland rice intercropped in coconut garden. *Journal of Applied and Natural Science-10 (3): 964-970*
39.	Suman.B.M and Sheeja K Raj	2018	A review on Zinc and Boron nutrition in rice. *Journal of Applied and Natural Science-10 (4): 1180-1186*
40.	Dally George, Girijadevi.L and Sheeja K Raj	2018	Response of direct seeded rice to magnesium sulphate fertilization. *Trends in biosciences-11 (30): 3606-3611*
41.	Sathyan T, Aswathy K Mohanan, Dhanya M K, Aswathy T S, Preethy T T and Murugan M	2018	Impact of pink pigmented facultative methylotrophic bacteria and synthetic materials on small cardamom (*Elettaria cardamomum* Maton.) under drought. *The pharma innovation.*
42.	Aswathy T. S, Dhanya M K, Johny J, Sathyan T, Preethy T T, Murugan M	2018	Effect of biofertilizers and organic supplements on the growth of black pepper rooted cuttings (Piper nigrum L.). *Int. J. Chem. Stud.,*
43.	Preethy T T, Aswathy T S, Sathyan T, Dhanya M K, Murugan M	2018	Performance, diversity analysis and character association of black pepper (Piper nigrum L.) accessions in the high altitude of Idukki district, Kerala. *Journal of Spices and Aromatic Crops*
44.	Dhanya M K, Murugan M, Deepthy K B, Aswathy T S, Sathyan T	2018	Management of *Fusarium* rot in small cardamom. *Indian Journal of Plant Protection*
45.	Vishnu B.R., Kumar, V., Joseph, B., Rani, B., John, J. and Meera, M.	2018	Nutrient release pattern under long term permanent fertilizer application system in rice. *International Journal of Agricultural Sciences.10 (10): 6147-6149*
46.	Bashma, E. K., Sudha, B., Sajitharani, T., and Radhakrishnan, N. V.	2018	Growth, nutrient uptake, yield and quality parameters of *Nendran* banana (*Musa sp*.) as influenced by combined application of soil and foliar nutrition.

			Accepted for publication in Journal of Tropical Agriculture, KAU
47.	John, J. and Shirmila, G.J.	2018	Allelopathic effect of fresh leaf loppings of multipurpose trees. *Indian Forester.*
48.	R. Pandiselvam, M.R. Manikantan, Anjineyulu Kothakota, G.K. Rajesh, Shameena Beegum, S.V. Ramesh, V. Niral & K.B. Hebbar	2018	Engineering properties of five varieties of coconuts (*Cocos nucifera* L.) for efficient husk separation. *Journal of Natural Fibers*
49.	Nukasani Sagarika, M.V.Prince, Anjineyulu Kothakota, R. Pandiselvam, R.Sreeja & Santhi Mary Mathew	2018	Characterisation and optimization of microwave assisted process for extraction of Nutmeg mace essential oil. *Journal of Essential Oil Bearing Plants*
50.	K. Venkata Sai and Asha Joseph	2018	Trend Analysis of Rainfall of Pattambi Region, Kerala, India. *International Journal of Current Microbiology and Applied Sciences*
51.	B.J. Chethan and B. Vishnu	2018	Determination of the Geomorphologic Parameters of the Thuthapuzha River Basin in Central Kerala, India, Using GIS and Remote Sensing. *International Journal of Current Microbiology and Applied Sciences*
52.	Uday Bhanu Prakash and D. Sasikala	2018	Regional Groundwater Resource Modelling Using Modflow in West Godavari District. *International Journal of Current Microbiology and Applied Sciences*
53.	V. Tejaswini and K.K. Sathian	2018	Calibration and Validation of Swat Model for Kunthipuzha Basin Using SUFI-2 Algorithm. *International Journal of Current Micro Biology and Applied Sciences*
54.	V. Tejaswini and K. K. Sathian	2018	Assessment of hydrological processes in a small watershed using SWAT. *International Journal of Agricultural Engineering*
55.	Josephina Paul.	2018	Change Detection of Remote Sensing Images using Levy Flight PSO. *International Journal of Advanced Research in Computer Science*
56.	Josephina Paul.	2018	Change Detection using Undecimated Wavelet Transform Fusion and Genetic Algorithm. *International Journal of Emerging Technology and Advanced Engineering*
57.	Jinu A. and Abdul Hakkim V.M	2018	Performance of a low cost automation system for greenhouse cooling. *International Journal of Current Research*
58.	Rani R. Unnithan, N. Thammaiah, M. S. Kulkarni and p. M. Gangadharappa	2018	Physiological studies of colletotrichum musae the causal agent of anthracnose disease of banana. *International journal of plant protection*
59.	Suma Nair and Ramachandran, V.R	2018	How Mechanical Bund Formation Affects the Shear Strength of Bunds: A Study in Paddy Wetlands. *Int.J.Curr.Microbiol.App.Sci.*

60.	Suma Nair and Ramachandran, V.R.	2018	A Comparison of Engineering Properties of Soils in Two *Kolepadavus* of the *Kole* Lands of Kerala. *Int. J. Eng. Sc. Comp.*
61.	Beena, C., Kanakamany, M.T. and Sindhu, P.V	2018	Quality evaluation of important ayurvedic raw drug Brahmi (Bacopa monnieri). *International Journal of Tropical Agriculture-36(3): 649-652.*
62.	C.Beena	2018	Phenol content and total *in vitro* antioxidant capacity of the roots of different Plumbago species found in Kerala. *International journal of Tropical Agriculture-36(3).2018.653-655.*
63.	A.Suma, RM.Franceis,VV.Radhakrishnan , C Beena and IS Bisht	2018	Consumer preference: Crucialin determining the grain type richness in rice varieties grown across Kerala. *Ind.J.Plant Genetic Resources-31(2),178-184(2018).*
64.	Gayathri, P. and Kanakamany, M.T.	2018	Influence of storage environment and packing materials on seed germination and viability of *Desmodium gangeticum* (L.) DC. *Open access journal of medicinal and aromatic plants-vol 9(1):.23-33*
65.	Sindhu, P.V., Kanakamany, M.T. and Beena, C.	2018	Herbage yield and quality of Neel as influenced by shade level and planting dates. *Open access journal of medicinal and aromatic plants-vol 9(1):12-17.*
66.	C.Beena, M.T.Kanakamany and P.V.Sindhu	2018	Evaluation of Important Ayurvedic Raw Drug Brahmi (*Bacopa monnieri*). *Open access journal of medicinal and aromatic plants-Vol .9(1):18-22(2018).*
67.	Sindhu,PV, Kanakamany MT and Beena C	2018	Herbage yield and quality of Neel as influenced by shade level and planting dates. *Open access journal of medicinal and aromatic plants-vol 9(1):12-17(2018).*
68.	Binseena, S. R., Anitha, N., Paul, A., Amritha, V. S. and Anith, K. N	2018	Management of rice weevil, *Sitophilusoryzae*using essential volatile oils. *Entomon.*
69.	Anusree,S.S., Nisha,M.S and Sheela,M.S	2018	Evaluation of *Quisqualis indica* and *Samadera indica* as botanical pesticides against *Spodoptera litura* in Polyhouse. *Indian J. Entomol.*
70.	Anjali K., Ameena M. and Nimmy Jose.	2018	Morphological characterization of weedy rice morphotypes of Kerala. *Indian Journal of Weed Science*
71.	Jose, N., Abraham,C.T., Mathew,R. and Leenakumari S	2018	Novel weed wiper for the management of weedy rice. *Indian Journal of Weed Science*
72.	Isaac, S. R	2018	Nutrient management in elephant foot yam (*Amorphophallus paeniifolius* Dennst. Nicolson) with vermicomposted leaf litter. *J.Res. ANGRAU*
73.	Anjaly V. and Sheeba Rebecca Isaac	2018	Nodulation and nutrient uptake in grain cowpea (*Vigna unguiculata* L. Walp) under varying levels of Phosphorus, Potassium and Zinc. *Int. J. Agric. Sci.*
74.	Issac, S. R., Pushpakumari. R and Varghese Janova	2018	Structural diversity, leaf litter recycling and allelopathic influences of leaf litter in an agroforestry

			homefarden of southern Kerala. *Int. J. Farm Sci.*
75.	Renjan, B. and George, S.	2018	Effect of tillage, water regimes and weed management methods on weeds and transplanted rice. *Indian J. Weed Sci.*
76.	Arya, S.R., Syriac, E. K., and Raj, S. K.	2018	Bioassay for detecting flucetosulfuron residue in wetland rice soils. *J. Crop and Weed*
77.	Raj, S. K. and Syriac, E. K.	2018	Herbicide mixtures effect on weed seed bank in direct-seeded rice. *Indian J. Weed Sci.*
78.	Renjan, B. and George, S	2018	Management of blood grass (*Isachne miliacea* Roth ex Roemet Schult) in wetland rice. *J. Trop. Agric*
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