



ISAE 2020



International Symposium on Agriculture & Environment

Redefining agricultural & environmental policies:
Emerging challenges and new horizons

Proceedings



Faculty of Agriculture, University of Ruhuna, Sri Lanka



ISAE 2020
Faculty of Agriculture
University of Ruhuna
Sri Lanka

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Environment 2020
ISAE 2020**

***“Redefining Agricultural & Environmental Policies:
Emerging Challenges & New Horizons”***

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Preface

It is with immense pleasure and joy the Editorial Board unveils the Proceedings of the International Symposium on Agriculture and Environment (ISAE 2020). The theme of this year's symposium is "**Redefining agricultural & environmental policies: Emerging challenges and new horizons**" which is perfectly matching to the contemporary global interest of modern agriculture.

Agriculture has constantly been very closely connected with the environment, as it has a key influence on land use, soil, water, biodiversity, and the landscape. Conservative agricultural policies that support commodity prices and income support can insulate farmers from market signals. They may also have environmental implications, by boosting more rigorous land use, including heavy applications of agricultural chemicals. Intensive agriculture may unsettle the ecological balance and create numerous challenges to modern agriculture. Moreover, increased awareness of the environmental significance of agriculture has emerged over the last decade. It is based on growing concern over the consequences of agricultural policies that indirectly have a negative environmental impact. This may include the pollution of surface and groundwater resources, the acidification and erosion of soil, and the loss of biodiversity.

In the present context, environmental deliberations deliver motivation to the restructuring of agricultural policies. The relevant amalgamation of agricultural and environmental policies can bring multiple paybacks, by guaranteeing those policy goals are extended at least cost and that the burdens which agricultural policies can enforce on the environment are fully accounted for. To better comprehend policy integration, it is indispensable to advance our knowledge of the policy effects, in particular their environmental influence, and continue to develop analytical instruments to evaluate these. In this perspective restructuring or formulation of new agricultural policies that are connected with the environment are inevitable to face evolving challenges in the modern agriculture where it will be broadened new horizons for future generations to come.

The Editorial Board presumes that the Proceedings of the ISAE 2020 contributes as a wealthy cradle of knowledge compiled by renowned scientists, policymakers, planners, technologists, and thinkers on the main theme of ISAE 2020 "**Redefining agricultural & environmental policies: Emerging challenges and new horizons**". There will be 162 papers presented at 11 parallel technical sessions under 12 Sub-themes namely 1) Redefining agricultural and environmental policies 2) Plant resource management (3) Climate smart-agriculture (4) Soil, water and environment (5) Agricultural economics and social sciences (6) Innovative technologies for smart agriculture and environment (7) Food and nutrition (8) Networking for smart agriculture (9) Livestock and dairy production technologies (10) Oil palm industry (11) Fisheries and aquaculture, and (12) Agribusiness management and entrepreneurship. This proceeding is also enriched with the communications based on the keynote speech of the inaugural session by **Mr. Nishan Dissanayake**, *Senior Policy Advisor Agriculture, Embassy of the Kingdom of the Netherlands in Sri Lanka* and 14 keynote speeches presented at the 12 technical sessions.

On behalf of the Editorial Board and the Publication Committee, I would like to extend our inmost gratitude to the chief guest, keynote speakers and all authors for their scholarly contribution and praiseworthy collaboration in the process of compiling this proceeding. Proceedings of the ISAE 2020 are a substantial outcome of a much dedicated team effort of many including the coordinator of ISAE 2020 and, the members of the publication committee and the Editorial Board. Their persistent effort is extremely esteemed and acknowledged.

On behalf of the Editorial Board, I would like to extend my best wishes to all participants for a productive and satisfying experience in ISAE 2020 at the Faculty of Agriculture, University of Ruhuna, Sri Lanka.

Prof. Guttula Yugantha Jayasinghe

Editor-in-Chief

Proceedings-ISAE 2020

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Message from the Chief Guest

**Ambassador of France to Sri Lanka
His Excellency Mr. Eric Lavertu**



It is indeed a great privilege for me to have been invited as chief guest for this year's University of Ruhuna's Faculty of Agriculture's symposium.

The theme of this year's International Symposium on Agriculture and Environment is of utmost importance for dealing with the current challenges faced by Sri Lanka in finding a path to develop economically and socially in an environment-friendly way. This symposium will cover a range of areas in which French cooperation, and namely the French Agency for Development, has been active since the last decade. Present in Sri Lanka since 2005 as part of a post-tsunami intervention, the *Agence française de développement* is now promoting green growth while fostering social cohesion. Still in the process of being adopted, a new development project, financed through loans and grants from this agency, will be launched this year to improve the efficient use of water resources in the Mundeni Aru river basin, in the Eastern Province.

Another project, which will also be launched this year, will be undertaken by the Embassy in collaboration with the French Research Institute in Pondicherry and will cover, through the contribution of a range of researchers and a multi-disciplinary approach, the challenges pertaining to the management of Sri Lanka's South Eastern coast.

These few examples are proof of France's intimate collaboration with Sri Lanka in the field of agronomy, rural development and protection of the environment. And in this university, I would like to remind you about the French Sri Lanka project of Agricultural cooperation based in the region during the eighties and of course Dr. Paul Luu who, at that time was implementing this project!

Allow me to express my best wishes of success to ISAE 2020, its organizers and its participants.

**Message from the Vice Chancellor
University of Ruhuna**

It is with great pleasure I send this message to the ISAE 2020. Traditional agriculture has been challenged for some time and modern agriculture with a scientific basis had emerged during the last five decades. Key features of this were the use of technology and chemical fertilizer in a large scale to increase productivity. This was necessary to ensure food availability especially for the poor. Food safety and environment were compromised in this exercise. During the later half of the century this was recognized yet it was little too late to mitigate the risks. This has now emerged as a public health problem of serious magnitude and environmental change challenging the very survival of mankind. The UN has recognized this to be included in the sustainable development goals to be addressed by 2035.

Therefore, the need today is to “*Redefine Agriculture and Environment policies*” so that all identified risks and effective practices to reduce damages to the environment are implemented with haste and vigour. We need to see the results of this change within our lifetime. Otherwise as predicted, our younger generation will die before us with non -communicable diseases. Moral values in the teachings of Lord Buddha would be invaluable to change the lifestyles of populations to adapt and adjust to outcomes of such a change - be moderate in whatever we do and adopt a middle path.

Some challenges have already surfaced and other unknown are yet to arrive in the scene. These will not only test us but also will create new opportunities. We as global citizens in Sri Lanka must find solutions and disseminate this knowledge while encouraging the knowledge and better technology available globally are transferred, adopted and used for the resolution of these emerging challenges. Then we will be able to face new horizons well.

Organizing an international conference of this nature is always a challenge. I wish to congratulate the Dean, Chairperson and members of the organizing committee and wish ISAE all the success.

Snr. Prof Sujeewa Amarasena

Vice Chancellor

University of Ruhuna

Message from the Dean
Faculty of Agriculture, University of Ruhuna

It is a great pleasure and honor to send this message as the Dean on behalf of my colleagues who worked tirelessly to organize this symposium amidst many obstacles and challenges. The Faculty of Agriculture, University of Ruhuna has very successfully organized two national and nine international symposia during the past decade and we are committed to raise the standard of this event and live up to the expectations of contributors who selected our symposium to present their research findings.

Our vision is to make ISAE an annual meeting place for scientists and professionals in agricultural, environmental and allied sciences to share their research findings, innovative ideas and forge new collaborations. Agriculture is considered as one of the main polluters of environment and our biggest challenge is to raise the agricultural production to feed the ever increasing human population while protecting the environment.

The broad theme of this year's symposium is "*Redefining agricultural and environment policies: emerging challenges and new horizons*"; highlighting the need of formulating policies for agricultural and environmental management for enhanced productivity and to ensure prudent use of bioresources to sustain a healthy population on planet earth. Modern agriculture fulfils multiple roles and purposes, including producing more food for a growing population, supplying raw materials for expanding industrial and bioenergy sectors, conserving the natural resources, environment and biodiversity and, particularly in many agriculture-dependent developing countries like Sri Lanka, contributing to rural employment, livelihoods and economic development. The global demand for food is projected to increase several folds in the coming decades and there will be greater consumption of processed foods, animal proteins, fruits and vegetables with higher demand for food quality and safety. At the same time, there will be increasing efforts to address some of the negative impacts on environment caused by agriculture. Our country is in need of a solid policy framework in agriculture and environment to better position Sri Lanka's agriculture sector towards effective and efficient fulfillment of its multi-functional roles.

Networking in research is pivotal for the advancement of science and technology and hopefully, the presentations done and discussions followed at this symposium would lead to further research and development of technologies and collaborations towards national development. I take this opportunity to express my sincere gratitude to all my colleagues of the organizing committee who devoted their time and energy to make this event a success and I am also grateful to all our sponsors for their generous and valuable support. Finally, I sincerely wish all authors, invited speakers, special guests and participants a productive and pleasant stay at the ISAE 2020.

Prof. Sudas D. Wanniarachchi
Dean, Faculty of Agriculture
University of Ruhuna

Message from the Coordinator of the Symposium

It is a great honor and privilege to me to compile this message as the coordinator of the International Symposium on Agriculture and Environment 2020 (ISAE 2020) which builds a congregation platform for the professionals in the fields of agriculture and environment. The Faculty of Agriculture is now, for the 10th consecutive year, congregating ISAE 2020 under a timely important theme “Redefining agricultural & environmental policies: Emerging challenges and new horizons.” The main objective of ISAE 2020 is to bring together national and international academics, researchers and professionals in agricultural and environmental sciences, to redefine agricultural and environmental policies that help to face emerging challenges and promote new horizons that foster enhanced agricultural and environmental performance. Therefore, this year ISAE 2020 attempts to provide a productive platform to the national and international professionals in the agricultural and environmental sectors to gather and discuss about the avenues of working together to establish an effective and efficient pathway for the aforementioned policy sectors while recognizing challenges and new horizons. Being the green campus in the Southern hub, ISAE 2020 is conducting as an environmentally friendly green symposium while giving priority to minimize usage of polythene and plastic materials.

ISAE 2020 has received comparatively remarkable number of national and international research articles related to the 12 thematic areas this time reflecting national and international reputation towards the Faculty of Agriculture, University of Ruhuna. It further mirrors the official acknowledgment for the excellence of its teaching, research, and service to the national and international communities. Excellence in any work can be successfully achieved only through utmost dedication, hard work, and determination. I am very proud to state that with the commitment of highly qualified and efficient staff, the Faculty of Agriculture, University of Ruhuna endeavors dynamically to make a remarkable mark in the field of research and development related to the Agriculture and Environment this year through ISAE 2020.

I take this opportunity to express my heartfelt gratitude to all my colleagues of the organizing committee of ISAE 2020 who sacrificed their time and energy out of the clock to make this event a great success. I herewith welcome and thank all our sponsors of ISAE 2020, invited keynote speakers, special invitees, all authors, participants and all well-wishers, on behalf of the organizing committee. The organizing committee attempts to make your time at the symposium productive and comfortable as much as possible. I wish you all a very fruitful and pleasant stay at the ISAE 2020. Hope and wish the ISAE 2020 brings opportunities for all of us to gain new learnings, reach new heights and create a sustainable future of the agricultural and environmental sectors of the country in particular.

Prof. Ganganee Chandima Samaraweera
Coordinator, ISAE 2020.

Keynote Speech of the Inaugural Session

Redefining Agricultural and Environmental Policies: Emerging Challenges and New Horizons

Nishan Dissanayake

Senior Policy Advisor Agriculture, Embassy of the Kingdom of the Netherlands in Sri Lanka

The most pressing issues in the world today, which will also be huge challenges tomorrow, like climate change, water and food insecurity, instability and inequality have to be tackled through concerted effort. We have to work together, within nations and between nations.

We have to find common approaches based on common facts and common learnings. Publishing research findings, sharing successes and mistakes are key.

There will be an additional 2 billion people to feed in this planet by 2050. Population composition is changing as some nations are growing older and some are shrinking. Urbanization will continue at an accelerated pace. Food production will need to be increased by 70 percent and more resource-intensive, animal-based foods will need to be produced to cope with the diversifying food habits. Many countries in the world will continue depending on international trade to ensure their food security.

On the other hand, climate change so far has indicated that the impacts of current warming are much more severe than previously understood. The risks of reaching limits to adaptation have been increased making the existence of eco systems more vulnerable. The agricultural sectors in many countries have already been affected due to altered weather conditions in the form of declining yield. Further expansion in land use for agricultural production in developing countries, notably in Africa, will be needed as productivity will lag behind increase in food demand.

The issues faced by the Sri Lankan agricultural sector today are more or less an integral part of broader development objectives such as food security and poverty reduction. Current agricultural policy does not sufficiently address broader issues pertaining to the sector. Crop failures due to climate changes have been a challenge for the last few years and affected the agricultural sector significantly. Although the absolute agricultural contribution to total GDP has fairly increased, the relative contribution has declined over time. The yield levels of domestically grown food crops, except for rice, have stagnated for more than a decade. Some state regulations and ill-defined property rights have made the land market limited leading to continuation with small non-viable holdings. Lack of technical know-how on water management and lack of incentive to use water sparingly due to zero price of irrigation water have made the extent cultivated less than the maximum cultivable extent.

To respond to these emerging challenges efficiently and effectively, independent scientific research is tremendously important. Involvement of the private sector in R&D and collaborating with foreign institutions as well as with local universities are crucial. In the absence of adaptation, climate change will undoubtedly hamper the existence and sustainability of food systems and agricultural livelihoods. Holistic approach is needed with a better coordination of policy, technical and investment aspects. Business as usual is not going to work any longer.

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Redefining Agricultural and Environmental Policies



Keynote Speech

Lessons Learned from the Formulation of the Overarching Agricultural Policy (OAP) for Sri Lanka

Dr. Olaf Heidelberg

Programme Manager, Development Cooperate Section, Delegation of the European Union to Sri Lanka and the Maldives

The keynote describes the formulation process and the priorities of the overarching agricultural policy for Sri Lanka. The policy has been developed in a highly transparent and participatory manner and aims at shifting the sector's governance system towards market-facilitation and enablement of reform. The presentation outlines the necessary elements for the policy to be successful.

Keynote Speech

Multi-stakeholder Engagement for Sustainable and Inclusive Agriculture and Environmental Policies for the Sri Lankan Context

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Transforming food systems to deliver within earth's boundaries

The coming decade will be critical for global food systems to start delivering better outcomes for people, planet, and prosperity. This race for innovation and transformation requires unprecedented efforts by many different stakeholders, globally and in Sri Lanka. It will demand new ways of collaborating and coordinating.

Agriculture in Sri Lanka is under increasing pressure. Productivity and profitability is low, pollution of soil and water due to agriculture is high, and resilience to climate change needs to be improved. With increased priority for the agricultural sector to be economically more productive, the limits of what Sri Lanka's natural resources can carry are clearly in sight. This leads to a situation where many are calling for a transition towards sustainable agriculture, but nobody seems to take the lead. There are projects and pilots in place which deliver piecemeal solutions, but yet fail to bring transformative sector change at scale.

A similar concern is increasingly voiced at a global level. We live in a time when the disastrous impacts of human activity on nature and climate can no longer be denied in 2019 manifested in a growing climate protests led by school kids, more alarming reports on the emergency of climate and biodiversity representing a broad consensus of scientists, and a global systemic failure to take action on this threat as evidenced during the COP25 summit in Madrid. The industrial food system that we humans have designed and built is at the heart of biodiversity degradation, climate change, and more. But if redesigned and rebuilt, our food system can be turned on its head so that it's the source of the climate-resilient solutions we need, especially if we embrace nature- and people-based food and agriculture.

A key question therefore is: how can the food systems of Sri Lanka be transformed to become more sustainable and inclusive? What would it even look like? What is needed to get the right policies into place? Who should be involved to collaborate on this agenda?

Lessons from other countries suggest that concerted efforts from all stakeholders are required, based on a thorough understanding of the dynamics of the food systems in their context. Yet, the field of stakeholders in agriculture and environmental care is fragmented and uncoordinated, unable to maximize the use of resources (land, water, farmers, crops, technology, investment, public policy, entrepreneurship, academia) for better outcomes of these food systems. It is essential that these stakeholders are able to step over their own shadows and raise the collective ambition to transform food systems.

Incremental adaptation may be inadequate to deal with rapid shifts and tipping points for food production under climate change. It requires an unequivocal choice to prioritize investment in sustainable practices and technologies, both for commercial and smallholder farming systems. Success is not guaranteed, as there is little evidence yet about how such transformative

adaptation processes really work (Vermeulen et al, 2018). Yet, there do not seem to be other options to feed the world, uplift livelihoods of the poor, and put a halt to the depletion of natural resources.

This keynote will summarize recent global policy discussions around food systems, climate change and environment (eg. HLPE/CFS 2019; FAO/SOFI 2019; FOLU 2019; IPBES 2019) and will translate key insights to the Sri Lankan situation. Despite the size of the challenge, there are promising practices and technologies that may help Sri Lanka to make both agriculture and environment more resilient.

Farmers' Perception towards Government Intervention in Paddy Purchasing Process: Case Study in Ambalantota DS Division of Hambantota District, Sri Lanka

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Abstract

This study mainly focused to disclose the farmers' perception towards government intervention in paddy purchasing, exploring the present situation of paddy marketing and assessing benefits and challenges of Paddy Marketing Board (PMB). The primary data were collected by using a pre-tested questionnaire from randomly selected 150 paddy farmers in Ambalantota divisional secretariat (DS). Data were analysed by using parametric and non-parametric statistical methods and descriptive statistics. Key findings revealed that paddy farmers' perception was negative towards government intervention in paddy marketing ($z = -2.67$, $p < 0.05$). The choice of paddy selling agency was significantly influenced by farmer's experience in paddy farming and availability of transport facilities ($X^2 = 10.808$, $p < 0.05$ and $X^2 = 93.204$, $p < 0.05$, respectively). Majority of farmers (85%) have refused to sell their paddy to the paddy marketing board. Farmers have stated negative agreement with current ceiling price of paddy ($z = -9.962$, $p < 0.05$). Study further revealed that PMB is significantly more beneficial than private agencies due to higher guaranteed price for paddy ($t = 10.57$, $p < 0.05$), linkage with government ($t = 15.439$, $p < 0.05$) and restriction of the intervention by third parties ($t = 8.901$, $p < 0.05$). According to the respondents, main challenges faced by PMB were, (a) high quality maintaining cost ($t = -22.73$, $p < 0.05$), (b) limited purchasing ($t = -155.45$, $p < 0.05$), (c) documentary ($t = -22.98$, $p < 0.05$), (d) purchasing period ($t = -6.985$, $p < 0.05$), (e) high weight losses after drying ($t = -18.224$, $p < 0.05$), (f) time consumption ($t = -14.392$, $p < 0.05$), (g) inconvenience for cleaning and drying paddy ($t = -14.238$, $p < 0.05$), (h) quick cash accessibility ($t = -3.417$, $p < 0.05$) and (i) transport facilities ($t = -8.769$, $p < 0.05$). Key suggestions from farmers in order to improve the government intervention in paddy marketing were providing transport costs (75%), accepting higher moisture level of paddy at purchasing (72%) and increasing purchasing quantity (63%). It is recommended to launch awareness programmes on the importance of quality maintenance in paddy, establish drying beds in purchasing centres to maintain quality and provide moisture meter to farmer organization, establish local purchasing centres at village level to reduce the transport cost and utilize IT facilities to reduce unnecessary documentation and to enhance quick payment method.

Keywords: Farmers' perception, Government intervention, Paddy marketing

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Impact of Anthropogenic Activities on Rural Livelihoods in Bundala Ramsar Wetland

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Abstract

Bundala Ramsar Wetland is the first Ramsar site in Sri Lanka. It provides multiple economic activities including fishing, agriculture, livestock rearing, and tourism. Lunugamwehera irrigation scheme was introduced by the Government of Sri Lanka adjacent to the Bundala Ramsar Wetland. This study attempts to find out the long-term impact of this development project on the livelihood activities of the wetland dwellers at Malala lagoon in Bundala Ramsar Wetland. Snow ball sampling technique was employed to select 60 sample units. Mixed methods were employed including a questionnaire survey (n=60) and in-depth interviews (n=10) for primary data collection. The results show, fishing (55%), agriculture (17%), eco-tourism (12%), and livestock rearing (8%) as the main income generating activities in the area. Most of these are lagoon-based economic activities for the villagers with an average monthly income of 20,000 LKR. Thus, the productivity of the lagoon is crucial in attaining sustainable livelihood opportunities. However, 46 respondents (77%) have experienced an income reduction compared to the past 10 years. Water pollution, and anthropogenic activities with adverse impacts, have been reported by 53 % of the respondents as one of the main reasons for income reduction. Climate change (21%), government rules and regulations (18%), and reduced demand for tourism (12%) are the other factors. Based on the survey Lunugamwehera irrigation scheme has negatively affected on the lagoon ecosystem (p=0.00016). In depth interviews further affirmed that fishing, eco-tourism, and livestock rearing have been threatened in the area. This concludes, that the recent development activities have negatively affected on the ecosystem and sustainability of lagoon environment and the entire Bundala Ramsar Wetland. Hence, ecosystem based adjustments are needed to regain the productivity of the lagoon for the betterment of wetland dwellers.

Keywords: Anthropogenic Activities, Livelihoods, Water pollution, Wetland

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Farmers' Perception towards Direct Cash Transfer System for Paddy Fertilizer: A Case Study in Dimbulagala DS Division in Polonnaruwa District, Sri Lanka

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Abstract

The government of Sri Lanka has been subsidizing for fertilizer for four decades. While introducing a new system, it is important to go through farmers' perception towards it. However, existing studies have not yet focused on investigation of this grass root level perceptions. Therefore, the purpose of this paper is to analyze farmers' perception towards Direct Cash Transfer System (DCTS) for paddy fertilizer. The study has been conducted using 100 paddy farmers in Dimbulagala D.S. division in Polonnaruwa district, Sri Lanka, who have cultivated their paddy lands both in 2015 *yala* (material subsidy) season and 2016 *yala* (DCTS) seasons. The study includes two phases as "direct questioning" and "perception score" developing. Direct questioning was done by direct asking, whether DCTS is preferable or not, which was scored by seven-point Likert scale. Perception score was developed by ten positive statements scored with same seven-point Likert scale. The statements included areas such as economic, environmental effects and socio economic effects. One sample Z-test and the percentage evaluations were used for data analyzing. The result of Z-test for direct perception indicates no significant difference between the perception towards new and old subsidy schemes ($P=0.055$, $Z=1.92$) while perception score method indicates positive perception towards new DCTS as ($P=0.000$, $Z=3.8$), as the respondents gave higher scores for the statements with environmental and social benefits. The results indicate that though, the farmers do not have high direct perception on DCTS; there is a possibility to change their perception by the fulfillment of economic factors such as amount of subsidy for the fertilizer, timely requirement, the market price of fertilizer and the fertilizer availability. As an overall the study indicates this DCTS provides numerous economic, environmental and social benefits than material subsidy. The study concludes, based on respondents' view that the better involvement of government to make effective procedures to provide cash at the proper time with acceptable amount and conducting awareness programs and providing of specific places to produce their own organic fertilizers and developing new business ventures for organic fertilizer production can improve the direct perception towards DCTS and also increase the use of organic fertilizers instead of using inorganic fertilizers in paddy sector. This study is of great significance for the policy makers in particular.

Keywords: Direct cash transfer system, Farmers' perception, Paddy fertilizer subsidy, Polonnaruwa district

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Motive Factors of Adopting Organic and Conventional Farming among Spice Growers in Kandy District

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Abstract

Organic products are popular and experiencing a rapid growth over the past two decades. Although government efforts in promoting organic agriculture with favourable policy changes and promotions, a minority of farmers still involve in organic agriculture. Previous studies showed that, farmers have adopted different agricultural practices due to various reasons. But very few studies focused on understanding local farmer motivating factors related to organic agricultural practices. Therefore study focused on to identify different factors that affect the adoption of organic agriculture. The study was conducted as a cross-sectional study with a pre-tested interview schedule administered to organic and conventional spice farmers. A sample of sixty farmers (thirty for each category) was randomly selected from Udunuwara, Yatinuwara and Harispattuwa Divisional Secretariats in the Kandy District. In data analysis percentages, frequencies and means were used as descriptive statistics while T-tests, correlation and binomial logistic regression were used as inferential statistics. Results showed that most of the organic farmers were older part-time farmers who were having more interactions with local organizations compared to conventional farmers. Perceived health benefits of organic agriculture were the mostly stated motive factor of organic farmers while conventional farmers had strong economic motivations. Further, conventional and organic farmers had significantly different ($p < 0.05$) attitudes towards their respective agricultural practice. Policymakers should consider non-economic aspects of farmer motivation such as health and environmental concerns, explored in this study to formulate policies addressing key attributes of farmers when encouraging them to convert to organic farming. Furthermore, the results of this study can also be utilized by extension services to create better extension programs to promote organic farming effectively and efficiently.

Keywords: Adoption, Attitudes, Conventional, Motive factors, Organic

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Nature and Magnitude of Human Wildlife Conflict and Coping Strategies among Major Grain Farming Communities in Ampara and Moneragala Districts

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Abstract

In the recent past human wildlife conflict (HWC) have brought conversation in its entirety due to its wider prevalence, dominance and related consequences in the agrarian sector of the country. Evidences show that there is no doubt that it causes economic, social and environmental damages. This study focused on identification of economic, social and environmental impacts of HWC on paddy, maize, groundnut, green gram and cowpea farming families in Moneragala and Ampara Districts. This is a multi-method study and interviewed 243 farmer families who were selected by using stratified random sampling technique for questionnaire survey. In addition, focus group discussions (n=39) with 720 farmers, key person interviews (n=25), direct observations (n=39) and participatory observation (n=01) and transect walks were carried out in the selected villages (n=39). Villages were purposively selected based on the expertise knowledge where HWC was prevailing in the highest degree. Annual yield/crop damage due to wildlife was calculated by authors using the formula constructed through intensive literature review. However, calculations were mostly based on assumptions of the farmers. Accordingly, annual average yield loss is 30% and it extends as paddy 19%, maize 21%, groundnut 38%, green gram 35% and cowpea 36%. Composition of total damage is divided into three major groups such as wild elephants (38%), birds (36%) and other animals (26%). The average annual costs for protecting one acre of crop from wild animals were in between Rs.2,361.00 and Rs.33,830.00, respectively for materials and labor whilst the average crop protection duration is 34 days annually. The night protection is mostly conducted (89%) by male household heads. Less protection for family members, accidents for humans, travelling and sanitation concerns can be identified as social issues. Small or medium electric fences, thunder flyers, crackers and electric torches are the most prominent control measures. Sound pollution, mixing chemicals to environment and life risks for threatening animals are identified as significant environmental issues. Cost of production increases while decreasing the quantity of harvest. Consequently, farming communities are living under pressure and practice legal protection methods as well as illegal methods. Cultivating non-food crops such as medicinal, flower and foliage, some spices etc. and directing to off-farm occupations were identified as major coping strategies in dealing with those socioeconomic issues. Prompt actions such as improving the quality, food, water and habitat availability of forests while promoting electric fences and air rifles as protection measures.

Keywords: Coping strategies, Environmental issues, Farming community, Human wildlife conflict, Socioeconomic issues

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Recreational Value of the Pigeon Island National Park, Sri Lanka

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Abstract

The coastal ecosystem is essential to life on our planet. Pigeon Island National Park has one of the best remaining coral reefs with high live coral cover in Sri Lanka and is an ideal location for scuba diving and snorkeling. The objective of this research was to explore the recreational value of the Pigeon Island. Contingent valuation method was used in the study. The result indicated the use of Pigeon Island for diving was ranked by 74% of local visitors as the most preferred activity. Foreign visitors' mean willingness to pay for boating, swimming, scenic visit and whale watching were Rs.1454, Rs.375, Rs.365 and Rs.1510, respectively. But for local visitors' for diving and whale watching were Rs.1240 and Rs.919.00, respectively. Average willingness to pay of the foreign visitors for entrance fee was Rs.1560 and the average willingness to pay of the local visitors for the entrance fee was Rs. 644.00. Results of the T test showed that significant difference ($p < 0.01$) between foreign visitors and local visitors for entrance fee willing to pay, hours of spending, costs for boating, diving and whale watching. Chi square analysis showed that there was a high significant association between the total willingness to pay of the local visitors and their education level ($X^2=76.75$, $p < 0.01$). A significant association was observed between the total willingness to pay of the local visitors and the cost for boating in the Pigeon Island ($X^2=36.52$, $p < 0.01$). Also total willingness to pay was significantly ($p < 0.01$) affected by age, hours of spending, number of the group members and expenses for meals. The current entrance fees do not capture the economic value of the Pigeon Island. Hence it is recommended to increase the entrance fees and prices for different activities to improve the income of the Pigeon Island National Park and to place suitable management plan to maintain the quality of the services provided by Pigeon Island which are associated with the community that could result in increased revenue generation.

Keywords: Contingent valuation method, Pigeon Island, Recreational value, Willingness to pay

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Developing a Solid Waste Management Policy through Young Generation's View: A Case of School Children in Matara District, Sri Lanka

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Abstract

The acceleration of the accumulation of solid waste is a major national issue that needs a quick attention in Sri Lanka at present. The lack of policy framework triggers this situation. Exploration of attitude and perception at the grass-root level motivate to build a strong policy foundation to stand as a better and healthy nation in future. Therefore, this study explores young generation's view on solid waste management with the aim of developing a solid waste management policy. The study used two methodologies: questionnaire survey and Participatory Rural Appraisal (PRA) method. A sample survey of 1000 respondents from five randomly selected schools in Matara, Sri Lanka was conducted in late 2019. In PRA, students were grouped as 10-15 students per group. The data were analysed by using descriptive and inferential statistics. The study results related to survey indicated that: (1) majority (52.4%) of students were highly aware and already engaged in solid waste management practices; (2) gender significantly shapes ($\text{Mean}_{\text{male}} = 4.01$ $\text{Mean}_{\text{female}} = 4.82$; $t = 4.30$ $p = 0.000$) their perception on readiness of using solid waste management practices; stressing the importance of considering gender in solid waste management policies. Based on the results of PRA, study suggests that an effective solid waste management policy should mainly be focused on 3R concept.

Keywords: Management Policy, Solid Waste, Young Consumers

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Plant Resource Management



Keynote Speech

Fungi, an Overlooked Component of Sri Lanka's Biodiversity and Recent Advances in Mycology

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Abstract

Sri Lanka has a rich biodiversity but compare to other disciplines, understanding of fungi is less. Current studies on fungi mainly based on DNA sequences analyses thus it is important to revisit old species reported from Sri Lanka. And subject to morpho-molecular analyses. Missing species of fungi are predicted to be mainly in tropics, biodiversity hotspots and little-explored habitats. Hence, it is essential to implement collecting programs and carry out analyses. This type of studies will be helpful to establish correct generic boundaries, resolve species complexes and polyphyletic taxa, provide taxonomic placements. It is essential to update the existing checklists according to recent name changes (Art. 59.1). Taxonomists are encouraged to deposit putative cultures at culture collections and deposit herbarium specimens at least two well-known Fungaria. Establishing and maintaining a culture collection in Sri Lanka is also necessary while implement new collaborative programs with other leading scientific groups in other countries. Cultivation and domestication of wild edible mushrooms can be promoted after comprehensive survey.

Introduction

Fungi are one of the most diverse groups of eukaryotes and widely distributed worldwide. They occur as different life modes (*viz.* saprobes, pathogens (animal and plant), endophytes, lichenicolous, fungicolous, insectivorous etc.) and play important roles in different ecosystems such as mineral cycling, decomposing litter, causing diseases etc. Furthermore, some fungi are used in industries including bakery, pharmaceutical, and bioremediation. Approximately, 144,000 species of fungi have been identified (Willis 2018), but Hawksworth and Lücking (2017) estimated that it would be between 2.2 - 3.8 million species on earth. Therefore, only 3%-8% species are known to science (Hawksworth and Lücking 2017). Wijayawardene et al. (2020) accepted 19 phyla in kingdom fungi. This result was based on current knowledge comprising traditional, morphology based classification and modern DNA based classification. Recent studies by Tedersoo et al. (2018), Wijayawardene et al. (2018, 2020) accepted Rozellomycota (including Microsporidia) as a new lineage in fungi. Some groups which was treated as fungi in traditional taxonomy, have been excluded from kingdom fungi based on DNA based phylogenetic studies (e.g. Myxomycota).

Understanding of floral and faunal diversity in Sri Lanka is higher than of fungi and other microorganisms. 'Information available on Sri Lankan fungi is scattered. There are difficulties in estimating exact numbers due to synonyms used and duplicate entries' (Karunarathne et al. 2012) and lacking sequence data, proper protologue, herbarium deposits, cultures and collection details. There were not any significant surveys been carried out except for plant pathogenic fungi (Adikaram et al. 2001, 2013) and macro fungi (Karunarathna et al. 2011). However, still a large number of species has to be discovered based on both morpho-molecular analyses.

Identifying the species

In traditional taxonomy, species have been identified and described based on only morphological characters (Sutton 1980; Sivanesan 1984). Thus, morphological characters such

as ascomata, asci and ascospores in sexual fungi, conidiomata, conidiophores, conidiogenesis and conidia in asexual fungi have been mainly used to describe a species. However, since 1990, DNA based taxonomic studies play the vital role in mycology (White et al. 1990) along with morphological studies. Currently, mycologists widely use DNA sequences to establish new species, resolve species complexes and polyphyletic taxa, establish generic boundaries, provide classification and link sexual asexual morphs. Moreover, epitypification of old species is another hot topic which is popular among mycologists.

However, all the significant studies carried out in Sri Lanka are mainly based on morphological characters (Berkeley and Broome 1871, 1873, 1877; Petch 1906, 1909, 1910, 1912, b, 1916, 1917, 1918, 1919, 1920; Petch and Bisby 1950; Coomaraswamy 1979, 1981; Coomaraswamy and De Fonseka 1981; Coomaraswamy and Kumarasingham 1988). Almost all these taxa preserved as only herbarium materials and provided drawings (mainly for mushrooms). Thus, revisiting old species is a challenge as some herbarium materials are in poor condition or lost. Moreover, for the identification and classification of asexual fungi, taxonomists strongly suggest to use DNA sequences (Wijayawardene et al. 2019) as they show morphological plasticity. Thus, recollecting old species is important to determine whether those species were identified correctly.

Furthermore, some pathogenic species have been revealed as species complexes (i.e. morphologically similar but phylogenetically distinct) 'which means that species differentiation is problematic when relying only on morphological characters' (Phillips et al. 2008, 2012; Wijayawardene et al. 2017b) (e.g. *Colletotrichum acutatum* fide Damm et al. 2012; *Colletotrichum destructivum* fide Damm et al. 2014). Thus, it is important to recollect pathogenic species reported from Sri Lanka and carry out multi-gene phylogenetic analyses to determine the correct species. In quarantine, this type of study will be a critical step to update the checklists of pathogenic species.

DNA based classification

Since DNA sequences are the main source for phylogenetic and evolution studies, mycologists try to generate cultures from taxa they study. Single spore isolation is the most popular technique used by mycologists to isolate saprobes and pathogens (Chomnunti et al. 2014). Putative cultures are used to extract DNA. Different protocols are used to extract DNA from the mycelia (e.g. Kit). PCR technique is used to amplify the extracted DNA fragments and products are utilized for sequencing.

Generated sequences are widely used to determine the phylogenetic placements of the taxa. This is the best and most reliable method to clarify the classification of asexual genera. In traditional taxonomy, asexual fungi have been placed in subdivision Deuteromycotina (Ainsworth 1966). However, this classification is highly artificial thus DNA based studies are essential to reveal the correct taxonomic placements (Verkley et al. 2004; de Gruyter et al. 2009, 2013; Wijayawardene et al. 2016). Moreover, a large number of asexual genera are listed as 'orphan genera' (i.e. without family or higher ranks) in Wijayawardene et al. (2017a). Therefore, re-collecting old species is an important topic among mycologists.

As the known historic taxa from Sri Lanka lacking sequence data, it is highly recommended to recollect and subject to carryout DNA based phylogenetic studies. Some taxa are morphologically similar but polyphyletic in phylogeny (Wijayawardene et al. 2014b). Hence, without DNA sequence analyses, it is not a wise decision to determine the familial placements.

Nomenclature

Saccardo (1904) proposed the dual system of fungal nomenclature (i.e. asexual and sexual morphs with different names) 'as a solution to the confused situation of asexual and sexual

morphs faced by taxonomists at the time' (Wijayawardene et al. 2014a). However, mycologists link sexual-asexual morphs based on the culture studies, occurrence of taxa on same host. Nevertheless, DNA based taxonomic studies of pleomorphic genera, provide accurate and reliable links between two morphs (or three morphs when presence of synasexual morphs). Since, two taxa are linked, it was proposed to end the dual system of fungal nomenclature (Hawksworth 2012). Several studies with the involvement of mycologists, pathologists, proposed one name for pleomorphic genera (Rossman et al. 2013, 2015a, b, 2016; Wijayawardene et al. 2014; Réblová et al. 2016).

It is important to update the current lists of fungi in Sri Lanka after the name changes. Most of the taxa important in quarantine are subjected to name changes thus it is essential update (e.g. *Phomopsis* was suppressed under *Diaporthe*).

Importance of promoting mycological studies in SL

Sri Lanka has been listed as a biodiversity hotspot but compare to the studies in other disciplines, the number of researches in mycology are less in number. Hawksworth and Lucking (2017) suggested to carry out more research works in tropical regions and biodiversity hotspots to reveal missing species. Moreover, Hawksworth and Lucking (2017) concluded that plant: fungi ratio as 1: 8.1. Currently there are 3154 flowering plants and 366 ferns have been recorded (Wijesundara pers. com.) thus approximately 28,568 fungal species could be reported. However, only c. 2000 species are known (Karunarathe et al. 2012). Hence it is essential to carry out more studies to reveal missing taxa from different habitats. Some life modes such as fungicolous, lichenicolous have not been properly studied thus it is important to implement new researches to identify these species as well.

Domestication of wild mushrooms is one of the most popular topics among mycologists who are studying mushrooms in tropical regions. Gathering the knowledge of local people on wild edible mushrooms and experimenting to cultivate them in farms can be promoted in Sri Lanka. This type of projects need to be collaborated with experts in other countries.

Limitations and overcome them

Current mycological studies highly depend on DNA sequences analyses. Hence it is essential to get pure cultures from or extract DNA direct from the fruiting structures (i.e. ascomata or conidiomata). However, obtaining DNA from cultures is highly recommended for cultivable species and deposit the cultures at reputed culture collections. Moreover, depositing herbarium materials with the fungal species at well-known Fungaria is also mandatory. However, these practices (such as sending cultures abroad and sending specimens) are restricted from the legal background in Sri Lanka thus it is essential to establish culture collections in the island. And implementing a collaborative program with other scientific communities or institutes to exchange knowledge is also important.

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Molecular Confirmation of *Foc* race 1 is Crucial for Screening of Silk Banana for Fusarium Wilt (*Fusarium oxysporum* f. sp. *cubense*)

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Abstract

Panama disease or *Fusarium* wilt of banana caused by *Fusarium oxysporum* f. sp. *cubense* (*Foc*) is a wide spread disease in Sri Lanka. 'Kolikuttu' (AAB, silk banana) which fetches a high market price is highly susceptible for *Foc*. Banana improvement through conventional techniques is cumbersome due to its sterility and polyploidy nature. However, development of resistant or less susceptible varieties to *Foc* is indispensable for sustainable banana production. Therefore, the present study was aimed to develop *Foc* resistant or less susceptible 'kolikuttu' variety through *in-vitro* mutagenesis. Chemically (1% Ethyl methanesulfonate) treated shoot tips of kolikuttu variety 'Agra' were *in-vitro* multiplied for 3 subculture cycles and resulted buds and plantlets were screened for *Foc* under *in-vitro* and protected house conditions, respectively. During the period, 16 cultures were prepared using the vascular strands of infected pseudostems of kolikuttu banana collected from different locations. Variations in mycelial growth and morphology of the cultures were observed among the samples on Potato Dextrose Agar plates. Therefore, the pathogen was confirmed through PCR before employing in screening. Genomic DNA from fresh single conidia cultures was isolated from 16 samples using CTAB method. PCR was carried out with *Foc* race 1 specific primers (FP-GTTGAGTCTCGATAAACAGCAAT, RP-GACGAGGGGAGATATGGTC) with positive control (DNA from pure culture of *Foc*) and confirmation was made by the presence of 354bp amplicon. The molecular detection discriminated only 11 isolates to be *Foc*. The remaining isolates may be non-pathogenic forms of endophytic *Fusarium* present in the pseudostem of infected banana. The results suggested the necessity of molecular confirmation of *Foc* in screening of banana against *Fusarium* wilt.

Keywords: *Fusarium* wilt, Kolikuttu banana, Molecular confirmation

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Establishment of Callus Induction and Regeneration Protocol for Anthers of Selected Bell Pepper (*Capsicum annuum* L.) Varieties

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Abstract

Efficient breeding programs aid in the creation of new varieties with higher productivity and improved fruit quality. Plant breeders can improve the efficiency of breeding programs by the production of homozygous line. Anther culture is the most efficient method for obtaining haploid and diploid plant in bell pepper (*Capsicum annuum* L.). The present study was carried out with two distinct F1 hybrid genotypes of bell pepper, such as “Indra” and “Orobelle”, to find appropriate callus induction and regeneration media. The present study was carried out at the tissue culture laboratory of Horticultural Crops Research and Development Institute, Peradeniya, Sri Lanka. This was carried out in completely randomized design with ten replicates. Anthers were selected based on microscopic observation, where the nuclear stage is late uni-nucleate or early bi-nucleate. Two culture media, MS medium supplemented by T1 - 2,4-D (2 mg/L) + BA (3 mg/L) and T2 - BAP (1 mg/L) + NAA (0.5 mg/L) were compared in this experiment to test the efficacy of inducing anther derived callus structures in tested genotypes. Data were collected on number of calli produced by anthers and number of days taken for callus induction. After callus induction, selected calli were transferred into a regeneration medium, which include MS medium with T1 - BAP (1 mg/L) + Kinetin (0.1 mg/L), T2 - BAP (1mg/L) and T3 - Kinetin (0.2 mg/L). Observations were taken for calli growth, appearance and greening of calli. There was no significant difference between the two anthers induced callus media on growth of calli. However, there was a significant difference ($P \leq 0.05$) for the number of days taken for callus induction for two different treatments. The maximum greening percentage (54%) of callus was recorded in MS medium with BAP (1 mg/L) with “Indra”. Greening of callus was not recorded in “Orobelle”. In the regeneration medium, calli behaved in different ways. Light brown and cream colored calli were responded well to the regeneration medium, and observed calli enlargement and greening. Regeneration ability of the calli has to be studied further to produce double haploid plants.

Keywords: Anther culture, Bell pepper, Callus induction medium, Regeneration medium

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Influence of Some Latex Flow Dynamics Associated with Different Latex Harvesting Systems on Latex Yield of Different Clones of Rubber (*Hevea brasiliensis* Muell. Arg.)

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Abstract

A half spiral cut tapped downward is generally used by all over the rubber growing countries to harvest latex. However, the rate of bark consumption associated with different latex harvesting systems directly influence on anatomical and physiological status of the rubber bark, hence, sustainable yield. Therefore, study planned to determine the influence of some latex flow dynamics associated with different latex harvesting systems on individual tree yield. The experiment was conducted at Kuruwita substation, Rubber Research Institute of Sri Lanka from year 2014 to 2017. The five different harvesting systems *i.e.* T1 (S/2 d2 + rain guards (RG)), T2 (S/2 d2 + 3 RT per month), T3 (S/2 d2 + 5 RT per month), T4 (S/2 d3 + 2.5% Ethephone +RG) T5 (S/2 d1), with four major rubber clones, *i.e.* RRIC 100, RRIC 102, RRIC 121 and RRIC 133 were used in this study. Split-plot design was implemented with three replicates. Phloem turgor pressure (PTP), initial flow rates (IFR), plugging index (PI), cut length and thickness of shaved bark were monitored. Latex volume and dry rubber content were measured to determine the yield per tree per tapping (YTT). In addition, the incidences of tapping panel dryness (TPD) were recorded. The PTP were significantly different among the treatments and clones indicating clonal specific responses for the different tapping systems. IFR was not significantly different among the treatments but it was vice versa among the clones tested. Low frequency harvesting system, *i.e.*, once in three days recorded lower PI and resulted in higher latex volume and YTT. The treatments subjected to the maximum number of recovery tappings and daily tapping, resulted in lower DRC, YTT and higher number of TPD trees. Significant ($p < 0.05$) interactions among the treatments and clones were evident and the clone specific response on individual tree yield under different latex harvesting systems were discussed. Intensive tapping systems and the trees tapped daily have resulted in significant yield loss while affecting the physiological stability of trees.

Keywords: Latex harvesting, Low frequency, Rubber, Stimulation, Yield

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Effect of Gibberellic Acid, Thiourea, Dextrose and Foliar Nutrients on the Growth of Mangosteen Seedlings (*Garcinia mangostana* L.)

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Abstract

Mangosteen (*Garcinia mangostana* L.) is a tropical fruit with great economic potential. The major impediment to the development of the mangosteen industry is slow growth and the long pre-bearing stage that seedlings require to produce fruits. This study was conducted to determine the effect of gibberellic acid, thiourea, and foliar nutrients on enhancing the growth of young mangosteen seedlings at the Fruit Research and Development Institute, Horana, Sri Lanka in year 2015. Seven treatments; 500 ppm gibberellic acid- T1; 1000 ppm thiourea + 12000 ppm dextrose -T2; 2500 ppm foliar nutrients (250 mg N, 1300 mg P, 250 mg K, 0.5 mg B, 1.25 mg Cu, 2.5 mg I, 1.25 mg Zn, 1.25 mg Mn and 0.0125 mg Mo) -T3; 500 ppm gibberellic acid + 2500 ppm foliar nutrients -T4; 500 ppm gibberellic acid + 1000 ppm thiourea + 12000 ppm dextrose -T5; 500 ppm gibberellic acid + 1000 ppm thiourea + 12000 ppm dextrose + 2500 ppm foliar nutrients -T6; and control (water) -T7; were sprayed weekly and continued up to ten weeks. The experiment was conducted in a Randomized Complete Block Design with three replicates and a treatment unit consisted of ten (3 months old) seedlings. The observations on stem height (cm/week), internode length (cm/week), stem girth (cm/week), number of leaves (weekly interval), leaf area (cm²), and dry weight (g) were recorded as growth parameters. The data were analyzed using analysis of variance (ANOVA) in Statistical Analysis System (SAS) with windows 9.0 version. Application of 500 ppm gibberellic acid + 2500 ppm foliar nutrients significantly increased ($p \leq 0.05$) absolute stem elongation by 20.89cm through increasing internode length by 2.73 cm in 10 weeks. Minimum stem elongation was noted in control (1.43 cm) treatment and internode increment in control was recorded as 0.08 cm. Application of 500 ppm gibberellic acid + 2500 ppm foliar nutrients showed a significant increment ($p \leq 0.05$) of number of leaves (4.8) in 10 weeks, while control gave 1.6 mean numbers of leaves. At the end of the experiment, the seedlings treated with 500 ppm gibberellic acid + 2500 ppm foliar nutrients showed a significant increment of dry weight (0.76 g) at $p \leq 0.05$. It was three times over the control. However, stem girth and leaf area were not significantly affected ($p \leq 0.05$) by treatments. This study concluded that 500 ppm gibberellic acid + 2500 ppm foliar nutrients was effective out of the treatments tested to induce the growth of mangosteen seedlings.

Keywords: Dextrose, Foliar nutrients, *Garcinia mangostana*, Gibberellic acid, Thiourea

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Bio-efficacy of New Herbicide Molecules in Wet Seeded Rice Culture in Sri Lanka

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Abstract

A multi locational field experiment was conducted by adopting randomized complete block design with 03 replicates during maha 2018/2019 at 09 locations to evaluate the bio-efficacy of 12 new herbicide molecules which are selective and broad spectrum in wet seeded rice culture. Plot size was 18 m². Bg 360 rice variety was used as the test variety. Plots were separated by using a 30cm bund where there was a separate inlet and separate outlet maintained for each plot. Herbicides were applied using a 16L Knapsack sprayer with flat pan nozzle. At 6 weeks after sowing, using a 36×36cm quadrat, weed samples were collected at 3 different places of each plot. Dry weights of the samples were measured after categorizing into grasses, sedges and broadleaves. Visual phyto-toxicity was recorded at 07 days and 14 days after treatment and final grain yield was also measured. Weed controlling efficacy (WCE) for each treatment was calculated. All data were analyzed by using SAS statistical software. The herbicides; Penoxulam 10% + Cyhalopop butyle 50% OD at the rate of 1.5-2 L/ha within 7-15DAS, Triafamone 100 g/L + Tefuryltrione 200g /L SC at the rate of 250-300mL/ha within 7-12 DAS, Oxaziclomafone 1.2% + Tefuryltrione 6% SC at the rate of 500mL/ha within 3-6 DAS, and Pretilachlor 36% + Bensulfuron methyl 4% WP at the rate of 1200g/ha within 5-8 DAS were showed more than 80% of WCE values and no phyto-toxicity effect after 15days after treatment were recommended to be further tested in pilot scale experiments at the rates tested.

Keywords: Bio-efficacy, Broad spectrum, Herbicide molecules, Wet seeded rice culture

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***In Vitro* Establishment of *Cissampelos pareira* Linn (Diyamiththa)**

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Abstract

Cissampelos pareira Linn: a slender climber belongs to the family Menispermaceae, is a highly valued medicinal plant species known as Diyamiththa in Sri Lanka. It has been used as an ingredient in ayurvedic, unani and traditional Chinese medicine for centuries. *Cissampelos pareira* contains numerous secondary metabolites as berberine, hayatine, cissampeline, pareirubrine A and B which had been tested for their medicinal values and hence has great potential to produce drugs. The plant is conventionally propagated by seeds and root cuttings. But to extract the valuable secondary metabolites, a large collection of quality plants is required. Therefore, aim of this study was to develop a suitable *in vitro* establishment procedure for the mass production of this important medicinal herb. Nodal segment explants were collected from 10 weeks old mother plants maintained in shade house conditions. Best surface sterilization procedure was tested using combinations of three Clorox concentrations (10%, 15%, 20%) and two exposure time periods (10 min, 20 min). For shoot induction and multiplication, the established cultures were transferred to Murashige and Skoog medium supplemented with various combinations and concentrations of kinetin (1 mgL⁻¹, 1.5 mgL⁻¹, 2 mgL⁻¹) and 6-benzylaminopurine (1 mgL⁻¹, 2 mgL⁻¹) with constant level of 1-naphthalene acetic acid (1mgL⁻¹). The study was carried out in Completely Randomized Design (CRD) with 20 replicates. Growth data were recorded as the number of multiple shoot formation, shoot length, and survival percentage. Results revealed that 20% Clorox for 20 minutes showed least contaminations (12.5%) on nodal explants among tested Clorox levels. Highest shoot proliferation rate (7.8) was observed in Murashige and Skoog medium supplemented with 0.1mgL⁻¹ 1-naphthalene acetic acid, 2mgL⁻¹ 6-benzylaminopurine and 2mgL⁻¹ Kinetin. Highest shoot proliferation rate was observed after five weeks from culture initiation. Findings of the study can be used for future *in vitro* propagation studies of *Cissampelos pareira* Linn.

Keywords: *Cissampelos pareira* Linn, Establishment and proliferation, Micropropagation, Nodal explants

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Identification of Mahogany (*Swietenia macrophylla*) and Khaya (*Khaya senegalensis*) Timber Species using Anatomical Features

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Abstract

Timber is considered to be an ecologically friendly building material with less construction energy requirements. The Mahogany and Khaya species are economically valuable timber species belong to family Meliaceae. External appearance of both sawn wood is similar. Therefore, consumers and buyers tend to get mislead easily. Wood anatomy is considered to be a precise and rapid method for wood identification. Present practice of timber identification is mainly based on personnel skills as there is no proper systematic mechanism to identify them. In this research, both species were employed in identification of variations in wood anatomical features and distinguishing the species. Authentic timber samples were collected from the research division of the state timber corporation for this study. Mean fiber length of Mahogany is varying between 900 - 1600 μm and Mean fiber length of Khaya is $\geq 1600 \mu\text{m}$ and Mahogany shows heterogeneous cells in rays and Khaya mostly shows homogenous cells in rays. Up right cell shape of Mahogany is oval and Up right cell shape of Khaya is not oval. Mahogany and Khaya timber species could precisely be identified and distinguished using anatomical features.

Keywords: Anatomical features, Identification, Khaya, Mahogany

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Phytochemical Screening of Selected Medicinal Plants in Sri Lanka

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Abstract

Medicinal plants are used in Ayurvedic medicines for treating health problems in many countries including Sri Lanka. Secondary metabolites in these plants are responsible for different therapeutic properties such as anti-inflammatory, anti-tumor, anti-diabetic and anti-bacterial activities. Present study was carried out to identify phytoconstituents in the crude extracts of commonly used fifteen medicinal plants in Ayurvedic medicines in Sri Lanka. Ethanol, hexane and water extracts were prepared using powder of (1 g) fresh leaves, flowers, bark, stem or tubers of the selected plant species dissolved in 25 mL of 100% ethanol, hexane or distilled water, in triplicates. Leaves of *Aerva lanata* (Polpala), *Cassia auriculata* (Ranawara), *Centella Asiatica* (Gotukola), *Alysicarpus vaginalis* (Aswantha), *Justicia adhatoda* (Adhatoda), *Averrhoa bilimbi* (Bilin), *Hemidesmus indicus* (Iramusu), *Ipomoea aquatica* (Kankun), *Murraya koenigii* (Karapincha), *Asparagus gonocladus* (Hathavariya) and *Morus alba var. indica* (Ambilla), bark of *Salacia reticulata* (Kothalahimbutu), stem of *Tinospora cordifolia* (Rasakinda), flowers of *Averrhoa bilimbi* (Bilin), *Aegle marmelos* (Beli) and tubers of *Cyperus rotundus* (Kalanduru) were collected from the dry zone in Sri Lanka. Phytochemical analysis confirmed the presence of flavonoids, tannin, saponins, terpenoids, alkaloids, steroids, anthocyanins, coumarins, and leucoanthocyanins. Considering three different crude extracts of the tested plants, phytochemicals except saponins, anthocyanins and leucoanthocyanins were present in the water extract, however, only alkaloids and coumarins were found in the hexane extract. Coumarins, which has broad range of biological activities was strongly present in the water extracts of *H. indicus*, *T. cordifolia*, *A. lanata*, *A. bilimbi*, *I. aquatica*, *C. asiatica*, *S. reticulata* and *J. adhatoda*. Almost all tested plants indicated presence of alkaloids and tannin showing the possibility of anti-cancer, anti-diabetic and anti-microbial activities. However, saponins and leucoanthocyanins were not found. As many locals utilize the crude water extracts of these plants in Ayurvedic medication and to make beverages, it is reasonable to obtain the health benefits of these active compounds. Therefore, the medicinal plants with flavonoids (Bilin flowers, Kalanduru, Kothalahimbutu and Gotukola), coumarins (Rasakinda and Bilin leaves) and alkaloids (Hathavariya, Iramusu, Rasakinda, Beli, Gotukola and Kalanduru) are highly potential to be utilized in treating diabetes, obesity, rheumatoid arthritis, and cancers under Ayurvedic medications.

Keywords: Alkaloids, Coumarins, Medicinal plants tannins, Phytochemicals

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Optimizing a DNA Extraction Protocol for Date Palm (*Phoenix dactylifera*) using Liquid Nitrogen

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Abstract

Date palm (*Phoenix dactylifera*) is a dioecious fruit plant belongs to the family *Arecaceae*. These plants are grown in coastal areas in North-Eastern and South-Eastern regions of Sri Lanka. Date palm fruits have a high demand in globally as well as in local food industry. Date palm cultivators face a problem in identification of its sex because date palm has no distinguishable morphological features for sex determination until the sexual maturity is attained after 5-8 years of cultivation. In recent years, prior identification of gender specific DNA sequences have efficiently facilitated the sex identification of immature plants to avoid unnecessary management of male plants. Isolation of high-quality DNA is vital for these kinds of molecular biological applications. Therefore, this study was aimed at optimizing a widely used CTAB protocol (Doyle & Doyle) for date palm by introducing liquid nitrogen lysis step, increased volume of cell lysis buffer, increased concentration of Beta Mercaptaethanol, repeated chloroform-phenol extraction step and repeated ethanol washing steps at the end. The purity and concentration of isolated DNA were determined by using Nanodrop™ 2000 Spectrophotometer. Optical density at 230nm, 260nm and 280 nm were recorded and A260/280, A260/230 ratios were calculated. Further, DNA samples were checked in 0.8% agarose gels. 25 out of 33 samples gave acceptable values for A260/280 and A260/230, as ~1.8 and ~1.9, respectively which confirmed the absence of protein and other possible contaminants in the final elute. Clear bands of the gel electrogram confirmed the presence of genomic DNA with high purity.

Keywords: Date Palm, DNA extraction, Liquid nitrogen, Spectrophotometry

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Effect of NaCl Induced Salt Stress on the Physiological Parameters, Growth Attributes and Yield of Groundnut (*Arachis hypogaea*) Cultivars during the Vegetative Stage

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Abstract

Salinity is one of the most deleterious environmental dilemmas that severely limit plant growth and productivity in the dry zone of Sri Lanka. Groundnut is cultivated in the Batticaloa district to a limited extent; the yield is highly susceptible to salt stress especially in the water scarce areas. Therefore, an experiment was conducted in the sandy regosols to evaluate salt stress responses of selected groundnut cultivars; 'Tissa', 'Indi' and 'Lanka Jumbo' on the Relative Water Content (RWC), Leaf Area Index (LAI), Chlorophyll content and yield to determine the most salt tolerant groundnut cultivar which can resist salinity and produce a substantial yield. The salt stress was imposed during the vegetative stage. The experiment was laid out in the Randomized Complete Block Design with six treatments and four replications. Polyethylene bags (45 cm diameter and 42 cm height) filled with top soil, red soil and compost (1:1:1) were used for this experiment. Salt stress was imposed for the groundnut cultivars from 32 days after sowing. A quantity of 500mL NaCl of 100 mM solution was applied at 2 days interval as the salt stress treatment and the control plants were watered at 2 days interval to Field Capacity. Salt stress significantly ($p < 0.05$) reduced the RWC and LAI of all the tested groundnut cultivars. The highest RWC (69.6%) and LAI (0.73) were observed in 'Indi' cultivar and the lowest values (RWC-55.2%, LAI-0.42) were found in 'Tissa'. Significant ($p < 0.05$) differences were observed in the Chlorophyll a, b and total Chlorophyll contents between cultivars under salt stress. The highest amounts of Chlorophyll a (1.82 mg/g), b (0.65 mg/g) and total Chlorophyll (2.47 mg/g) contents were observed in cultivar 'Indi' and the lowest Chlorophyll a (0.74 mg/g), b (0.28 mg/g) and total Chlorophyll (1.02 mg/g) were recorded in 'Tissa'. Similarly, the highest yield (1.4 t/ha) was obtained in 'Indi' groundnut cultivar under salt stress. This would have been due to its inherent characteristic feature. Based on the measured physiological and growth attributes, 'Indi' was identified as the most salt tolerant groundnut cultivar among the tested ones, which could be suggested for cultivation in the salt prone areas of the Batticaloa district.

Keywords: Chlorophyll content, Groundnut, Leaf Area Index, Salt stress, Yield

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Yield Enhancement of Rain-fed Finger Millet by Adopting Simple Agronomic Practices: A Case Study in Southern Dry Zone

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Abstract

Finger millet is one of traditional favorites of Sri Lankans and considered as healthy food used for preventing diabetes and coronary diseases. The farmers in southern dry zone are cultivating finger millet mostly under rain fed condition. Majority of them practice random broadcasting for crop establishment. The yield obtained by the farmers is considerably lower than the researcher levels. Even though there already exist a number of low cost approaches to enhance the yield of finger millet cultivation in a sustainable manner such as Excellent scientific cultivation techniques and improved varieties giving positive yield effects that are not being taken by the rain fed farmers in the southern dry zone of Sri Lanka. The average yield of finger millet under rain fed farming in the dry zone is less than 1000kg/ha, but existing high yielding improved varieties have potential of more than 3000kg/ha under good management. This study was carried out to identify the possibility of enhance the finger millet yield by introducing some agronomic practices to the farmers. Introduced package of practices was consisted with a high yielding variety (Rawana) recommended by the Department of Agriculture, Sri Lanka (DoA), seed treatment (Imidacloprid) to prevent thrips damage at seedling stage, row seeding in 30cm apart rows for crop establishment, application of half of basal fertilizers recommended by DoA (Urea, Muriate of potash and triple super phosphate each at the rate of 25kg/ha) with compost at the rate of 2mt/ha and practicing 2 weed removals. Farmer field demonstrations were conducted in Thanamalwila and Angunakolapelessa in *Maha* 2016/2017 and *Maha* 2017/2018 seasons. Farmer trainings were carried out to educate farmers on yield benefits of introduced practices before establishment of demonstrations. Introduced package of practices was compared with traditional farmer practice during the demonstration to show yield benefits. Twelve demonstrations were carried out for analysis in both seasons. Results revealed that the yield increased by 36.4% to 102.3% in introduced practices. This study revealed the significance of farmer awareness on existing technology. Wild elephant damage was identified as a critical constraint faced by finger millet farmers in Thanamalwila area.

Keywords: Enhance yield, Finger millet, Package of practices, Rain-fed

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Impact of Stock - Scion Interaction on the Quality of Planting Materials of Rubber (*Hevea brasiliensis*)

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Abstract

Effect of stock on scion performances is a critical factor to produce quality planting materials, in bud grafting, for rubber industry. Selection suited stock- scion combinations should be done to have a clonal authenticity relevant to a clone for generations. This study was contributed to identify successful stock scion combination/s to produce vigorous plants. Research activities were conducted using 12 budded plant combinations, belonged to most popular seed bearers and clones, as treatments of four stock types *viz.* wild type, PB 86, RRIC 102, RRIC 121 and three scion types *viz.* PB 86, RRIC 102 and RRIC 121 at a site located in RRISL Substation Moneragala (IL1c). Treatments were arranged as four replicates according to the Randomized Complete Block Design (RCBD) and measurements were taken at monthly intervals up to two leaf whorl stage. Stock diameter and height, scion shoot diameter and height, time taken for bud breaking, leaf chlorophyll content, leaf area, specific leaf weight and leaf thickness were recorded before and after bud grafting. Data was analyzed using SAS (version 9.1) package. And significant means were separated using Duncan Multiple Range Test (DMRT) at the 5% probability level. Results revealed, that clone RRIC 102 is the most suitable stock to increase scion growth, leaf area and specific leaf weight whilst stock type not effect for chlorophyll content and leaf thickness. Although, clonal variations were recorded for leaf area, leaf thickness, specific leaf weight and chlorophyll content of leaves irrespective to the stock type. However, significant stock - scion interactions were identified and further studies are needed to recommend suitable stocks for higher yield and adaptability to the different agro-climatic regions.

Keywords: Bud grafting, Compatibility, *Hevea brasiliensis*, Planting materials, Stock scion combinations

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Abscisic Acid on Mitigation of Drought Stress in Groundnut (*Arachis hypogaea* L.)

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Abstract

Drought is one of the most important abiotic stresses which affect the crop growth and yield. Groundnut (*Arachis hypogaea* L.), a major leguminous oil crop cultivated in the world is significantly affected with drought, thus reduces fruit set percentage, filling percentage and pod yield. The occurrence of empty pods, half-filled pods, and wrinkled seeds reduces the seed quality, finally the marketable value of groundnut. Abscisic acid (ABA) plays an important role in abiotic stress including drought. Previous studies has shown that root-originated xylem sap ABA can move to reproductive structures and accumulate there to a high level under drought conditions in wheat crop. This elevated ABA content in the crop reproductive structures had been thought to be involved in controlling kernel pod abortion, presumably via inhibition of cell division in the young ovaries. Thus, a field experiment was conducted to evaluate application of ABA with induced drought stress conditions on the yield responses of groundnut variety, *Thissa*. A two factor factorial experiment with three replicates was designed under induced drought stress conditions in a rainout shelter at the grain legumes and oil crops research and development centre, Angunakolapelassa during 2016/17 *maha* and 2017 *yala*. The experimental site was located in DL_{1b} agroecological region and having reddish brown earth soil. The method of application of ABA *i.e.* application of 0.0001M solution at the onset of flowering (40 days after sowing) and seed priming were evaluated with the control (distilled water application) in different depletion levels (50%, 65% and 85%). Number of seeds, number of pods, seed weight, filled seed weight and shell weight were recorded. ANOVA was performed to evaluate the method of application of ABA by keeping the depletion level fixed using SAS 9.0 software. Filling percentage of groundnut was affected with the increasing depletion levels in all three treatments revealing the fact that filling percentage of groundnut reduces with the increasing water stress conditions. Filling percentage of groundnut was significantly higher in foliar application of ABA compared to seed priming with ABA and control in both seasons. In conclusion, the application of ABA at the onset of flowering can be suggested to mitigate the effect of drought in groundnut.

Keywords: Abscisic acid, Drought, Filling percentage, Ground nut, Seed quality

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Impact of Geographical and Host Variations on Physical and Chemical Properties of *Santalum album* Seed Oil

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Abstract

Santalum album L. of family Santalaceae grew in Sri Lanka, India, and Indonesia, are hemi parasitic in nature and high demand scented stem oil. According to the previous findings of *S. spicatum*, (Australian Sandalwood) seed oil is a rich source of natural and highly stable, Acetylenic fatty acid, and Ximenynic acid. It is useful as an anti-inflammatory agent to increase dermal micro-circulation. According to the literature, *Santalum* stem oil quality and quantity vary within local populations due to different host species. Therefore the present study was initiated to identify the variation of plantation grown *S. album* seed oil quality, and quantity due to the variations of host species and agro ecological conditions in Godigamuwa (WM3A), Moratuwawala (DL1A), Tangalle (IL1B) and Maho (IL3) of Sri Lanka. *S. album* seed samples were collected from the trees grown with different host species, viz., *Sesbania grandiflora*, *Leucaena leucocephala*, and *Gliricidia sepium* and oil of 5.000 g of kernels of each seed sample were extracted by Soxhlet extraction method. Gas chromatography was used to identify constituents present and their abundance in seed oil. One way ANOVA was used to analyse the statistical variant. In addition, fatty acid profile, physiochemical parameters, seed oil yield, kernel N% and the seed protein amount were analysed to find the impact from selected hosts and agro ecological variation. The recent study has identified statistically, there is a significant impact for seed oil yield, kernel N%, protein content, seed oil peroxide value, acid value, free fatty acid value, seed oil fatty acids profile from the selected host and agro ecological variation. However, there's no any significant variation in seed oil iodine value, saponification value, and specific gravity due to the impact of hosts and agro ecological conditions (F=0.03 p=0.998, F=0.09 p=0.992, and F=0.67 p=0.663), respectively.

Keyword: Host species, Impact, *Santalum album*, Seed oil quality, Ximenynic acid

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Impact of Foliar Application of Moringa Leaf Extract on Yield and Quality Attributes of Chili (*Capsicum Annuum* L.) Cv. MIPC-01

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Abstract

A pot experiment was carried out at the crop farm, Eastern University of Sri Lanka, from January to May 2019 to evaluate the impact of *Moringa oleifera* leaf extract (MLE) on yield and quality attributes of chilli (*Capsicum annuum* L.) var. MIPC-01. MLE is considered as a natural plant growth enhancer. Because it contains appreciable amounts of plant growth regulators such as cytokinin in the form of zeatin, antioxidants, proteins, β - carotene, vitamin C and phenols, and had a remarkable effect on yield in many plants such as onions, bell pepper, soybean, sorghum, coffee, tea, chilli, melon and maize. The experiment was laid out in a Completely Randomized Design with seven replicates and seven treatments. The treatments were (T0) control (Distilled water) and T1, T3 and T5 were treated with 10, 20 and 30% MLE once a week. Whereas, T2, T4 and T6 were treated with 10, 20 and 30% MLE once in two weeks interval. Young moringa leaves and the tender parts were shade dried for four days and made into powder. Then the powdered material was used for the preparation of MLE. Stock solution (100% MLE) was prepared and refrigerated and then, the different concentrations were prepared by adding distilled water on volume basis. Foliar application of MLE was commenced at 2 weeks after transplanting (WAT) and continued until pod formation. For once in a week and once in two weeks, the plants were sprayed with MLE eight and four times, respectively. At each time, the plant was sprayed with 25 ml of MLE. The results suggest that foliar application of MLE at 10% in one week interval had significant ($p < 0.05$) effects on the number of pods/ plant, number of seeds/pod, length of the pod, total yield/plant, leaf chlorophyll content, total soluble solid content over the control. Therefore, it was concluded that MLE is helpful in improving yield and quality attributes of chilli and MLE at 10% at one week interval is recommended for improving the yield and quality of chilli. Application of MLE is the cheapest, environmental friendly and low-cost technology for enhancing yield in chilli.

Keywords: Chilli, Foliar application, Moringa Leaf Extract, Yield

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Possibility of Pineapple (*Ananas comosus*) Crown Utilization as Alternative Propagule for Commercial Cultivation

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Abstract

Pineapple (*Ananas comosus*) crown is not used as a propagule for commercial cultivation as it takes long duration to fruiting. Large number of pineapple crowns is disposed at harvesting as waste material without any usage. Therefore, this research was undertaken to identify the possibility of using pineapple crown for commercial cultivation as an alternative propagule. The research was carried out at Fruit Research & Development Institute, Horana during 2016-2018. Three experiments were carried out to fulfill the specific objectives in RCBD with three replicates. First experiment was carried out to identify the performance of different suckers and crown with foliar fertilizer (0.24mL/100mL H₂O). While the second experiment was undertaken to identify the required foliar fertilizer levels for crown using three different levels of urea and ammonium sulfate (0.2g,0.5g,&0.3g in 100ml H₂O). Third experiment was carried out to identify the effect of crown size ie. small 100-150g, medium 150-250g, large 250-350g on fruit quality. Data were analyzed by SAS statistical software and mean separation was done by using Duncan Multiple Range Test. Finally the cost of cultivation was estimated in crown with foliar fertilizer and conventional propagation method using root/axil suckers. Based on the study there was no significant difference in fruit weight, crown weight, fruit weight without crown, brix value, titratable acidity and pH in both studies which crown used as propagule and conventional propagule methods. The highest root length was observed in ammonium sulfate treatment (19.633cm) and no significant differences were observed in length of leaves, wet weight of leaves, dry weight of leaves number of leaves. There was no significant difference in fruit weight, crown weight, brix value, titratable acidity, pH in study with different crown sizes. Cost reduction was observed in crown with foliar fertilizer method as planting material cost of crown is zero and it is considered as a waste material. Available pineapple crown could be grown as an alternative propagule for commercial cultivation with foliar fertilizer.

Keywords: Foliar fertilizer, Pineapple crown, Pineapple suckers, Yield

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Growth and Yield Responses of Cowpea (*Vigna unguiculata* L. Walp.) for Foliar Application of Banana Pseudostem Sap

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Abstract

Banana is the most important fruit crop widely cultivating in Sri Lanka mainly for fruit purpose. After the fruit harvest huge quantity of pseudostem is generated as a waste. Pseudostem sap contains essential macro and micro nutrients and growth promoting substances and it can be used as an organic nutritive supplier to the crops for increase their crop growth and yield. A field experiment was conducted to study the effect of foliar application of banana pseudostem sap on growth and yield of cowpea variety *Waruni* at the crop farm, Eastern University, Sri Lanka. The experiment was laid out in randomized complete block design with five treatments having four replicates. Treatments were; recommended dose of Urea, Triple super phosphate (TSP), Muriate of potash (MOP) as basal (T1), recommended dose of Urea, TSP, ½ MOP as basal with foliar spray of 1% Pseudostem sap solution (T2), 3% Pseudostem sap solution (T3), 5% Pseudostem sap solution (T4) and 7% Pseudostem sap solution (T5) at 3rd, 5th, 7th and 9th week after planting (WAP). Recommended urea was applied as topdressing in all treatment at onset of flowering. The results revealed that application of banana pseudostem sap showed significant differences ($P<0.05$) on plant height, leaf area, chlorophyll content, fresh weights of leaves, root and stem. Maximum values were noted in T2 while minimum in T1. Further significant difference ($P<0.05$) was noted on pod yield at each harvesting. Seed yield in T2 was approximately four times greater than the yield from cowpea in T1. Application of banana pseudostem sap leads to improve the growth and yield of cowpea compared to recommended inorganic fertilizer. Therefore, among the tested treatments, recommended dosage of Urea, TSP and ½ MOP as basal and recommended urea as topdressing with 1% banana pseudostem sap would be the most suitable combination among the tested treatments to get better growth and higher yield of cowpea.

Keywords: Cowpea, Growth, Peudostem sap, Recommended inorganic fertilizer, Yield

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Influence of Spacing and the Type of Planting Material on Selected Growth Parameters of *Cinnamomum verum* J. Presl (Cinnamon): at the Stage of First Harvest

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Abstract

Cinnamomum verum J. Presl is one of the most well-known spices in the world. Being the largest cinnamon exporter, Sri Lanka contributes largely to the international cinnamon trade. However, Sri Lankan cinnamon production is stagnated due to low productivity and lower grade cinnamon quills. To overcome this, quality and quantity of cinnamon quills need to be improved. Since cinnamon bark is the harvestable component, stem characteristics play an important role in quality and quantity of the product. Longer stems with medium girth are the most important characteristics in producing higher quantity of high-quality quills. Behaviour of cinnamon plants under different spacing need be studied from the initial stage due to the plant's perennial nature. Therefore, this study was aimed at identifying the type of planting material (seedlings and vegetative plants) and spacing on the main factors influencing the bark yield namely; height, top and bottom diameter of the main stem and leaf area of cinnamon plants at the stage of first harvest. Seedlings and vegetatively propagated plants of cinnamon variety Sri Gamunu were planted under three different spacing as 1.2×0.6 m with three plants per hill, 1.2×0.4 m with two plants per hill and 1.2×0.2 m with one plant per hill as two factor factorial RCBD for the study. The study was carried out at the Agriculture Faculty premises of University of Ruhuna. Seedlings established in spatial pattern 1.2×0.6 m with three plants per hill were used as the control. All trees were headed back at 10-12cm above ground after two years from establishment and the measurements were taken. According to the results, seedlings established in the spacing as 1.2×0.2 m with one plant per hill showed the highest mean height, highest bottom and top diameter of the main stem. But the values were not significantly different ($P=0.05$) from the control. Leaf area of seedlings were significantly higher ($P=0.05$) than the leaf area of vegetative propagated plants. Results of the study revealed, the seedlings developed their structure rapidly compared to vegetative propagated plants. Though vegetative propagated plants have a higher yield potential, it appears to require more time to develop a better structure which can give a higher yield. Experiment is continuing to validate the results.

Keywords: Bottom diameter, *Cinnamomum verum*, Leaf area, Plant height, Top diameter

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Climate Smart Agriculture



Keynote Speech

Oryza sativa* Responds to Inoculation with *Bradyrhizobium japonicum

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Some bacteria associated with the rhizosphere have the ability to promote plant growth. This group of bacteria, called plant growth promoting rhizobacteria (PGPR), establishes different interactions with plants that directly or indirectly facilitate their development. Indirect stimulation includes several mechanisms that inhibit the development of phytopathogens. Direct stimulation may include nitrogen fixation, phosphate solubilization, production of hormone-like molecules, enzymes and siderophores. *Bradyrhizobium* is a genus of soil PGPR that has been studied for several decades mainly for its ability of fixing diazotrophic nitrogen after having been established endosymbiotically inside root nodules of the legumes of Fabaceae. However, the presence of *Bradyrhizobium* as an endophyte in other crops such as rice was reported recently. Therefore, the aim of this work was to evaluate the capability of *Bradyrhizobium* to promote growth of crops belonging to other families, in this case rice (*Oryza sativa*). Laboratory and field tests were carried out to determine the effect of five isolates in the performances of rice. For laboratory test, surface sterilized rice seeds of the Italian rice variety Baldo were soaked with cultures of each strains and planted in pots. Plant length and dry weight were measured after 35 days, as well as the flowering time. Results showed that all inoculated plants had a better growth than uninoculated controls, according to the measured parameters. In addition, flowering was significantly anticipated in inoculated rice. Pigments production was also higher in plants inoculated with *B. japonicum*: Chlorophyl B was higher after 2 weeks of growth and at 5th leaf stage, and both Chlorophyl A and B were much higher at flowering stage. *Bradyrhizobium* was also re-isolated from inoculated rice: these results suggest that *Bradyrhizobium* locates predominantly in green parts, confirming previous reports of its endophytism in rice.

For field test, rice seeds of varieties Yeruá La Plata and Gurí INTA were inoculated with the three best strains observed in laboratory test and planted in plots. After 60 days of growth, plant length and dry weight were measured. At harvest time, we measured dry weight of the aerial part, yield and thousand grain weight. All three strains showed higher values than the control without inoculation for at least one of the parameters measured, both in the laboratory and field tests. One strain out of the three tested gave the best results in all measurements, resulting the most promising from the PGP point of view. In addition, it was the only one that had statistically significant difference in yield with non-inoculated rice control in the two varieties evaluated at field, with an increase of approximately 1 ton/ha on an average yield of approximately 4 tons/ha. The values of weight of thousand seeds showed that there were no important differences between inoculated rice and control, thus different yields could be explained by either variations in the number of grains or panicles. Data suggested that inoculated rice has a higher plant growth at the beginning of the crop compared to the uninoculated rice. This difference decreased as the crop progresses, until it is almost minimal at harvest.

In conclusion, we demonstrated that plant-associated bacteria such as *Bradyrhizobium japonicum* interacts with rice plants and is involved in the biological processes that leads rice to growth promotion and plant productivity. Further studies should be performed to identify the expression of the traits involved in growth promotion of rice in parallel with the identification of synthesis, activation and related physiological processes, and explore the specificity between rice varieties and *Bradyrhizobium* strains.

Evaluation of Korean Sesame germplasm under Sri Lankan Climatic Conditions for the Variety Improvement

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Abstract

Germplasm evaluation is a part of the methodology of the plant breeding programmes to select adaptive and high yielding genotypes. Evaluation of sesame germplasm is essential task as it is important to find out special plant characteristics for the variety improvement. Therefore, this study carried out to evaluate Korean sesame germplasm under Sri Lankan climatic conditions to improve varieties by enrich of available sesame gene pool. The 16 accessions were received from Korea were evaluated in research field at Grain Legume and Oil Crop Research and Development Centre, Angunakolapelessa during Maha season 2018/19. Accessions were evaluated in row method according to the randomized complete block design with 5 replicates. Each accession was planted in 5m length row with two borders. Random plant selection method was followed for the experiment. The data was analyzed using ANOVA and means were separated using DMRT. As agronomic characteristics, seed germination percentage, plant quality parameters with yield related other characteristics and yield were measured along with the check variety Uma. The evaluation revealed that seed germination was more than 80% in Korean genotypes under tested Sri Lankan condition as well as variety Uma. Days taken to 50% flowering were less than 30 days of every accession while Uma was taken 30-35 days. All accessions had number of 5 capsules per plant while Uma had 4 capsules per plant. Significantly, the highest 1000 seed weight was recorded from the accession Yu- Pung (Brown) as 3.4g, however the value was not significantly different from variety Uma. Recorded yield from all accessions were significantly lower than the check variety Uma. Desired agronomic characteristics such as not branching growth pattern, not dehiscent seed, early maturity and consumer preferred seed coat colours were recorded in contrast to those of the check variety. According to the statistical analysis, 5 accessions (Si-Ji, Ye- An, Yu- Pung (White), Geon- Baek, Baek- Soel) were selected to conduct yield trials.

Keywords: Agronomic characteristics, Evaluation, Exotic Germplasm, Seed germination, Sesame

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Study of Plant Species Composition, Stratification Structure, and Tree Species Diversity of Home Gardens in Belipola (Up Country Intermediate Zone), Sri Lanka

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Abstract

Home garden is a sustainable land management system that could be of great utility in ecosystem with both plant biodiversity and biomass. The present study was conducted in Belipola village situated in Welimada region (Intermediate Zone, Up-country) with the aims of identification of plant species, stratification structure and the tree plant diversity. The area was divided into three groups according to the topographic arrangement as steep (>30% slope), moderate (10%-30% slope) and flat land (>10% slope). Six home gardens were selected by simple random sampling method for each topography hence eighteen home gardens were evaluated. Plant species in the home garden were identified and classified into different categories such as uses, origin of species and growth habit. Stratification structure of home gardens was determined and schematic diagrams were drawn by using the physiognomic formula. Tree species were determined when the breast height diameter of a plant is greater than 5 cm. The diversity of tree species was calculated using the Shannon Weiner index. There are 297 plant species were identified in home gardens and out of them 69, 63, 108, 32, 20 and 5 species were determined as trees, shrubs, herbs, climbers, grasses, and ferns, respectively. When considering the origin, 213 species were identified as exotic species while 72 were identified as native species where 8 endemic plant species were also detected. Further, 107 species were identified as food sources while 10, 5, 31, and 25 species were mainly used as timber, firewood, medicinal plants, species for biodiversity improvement, Ornamental purposes, and miscellaneous uses, respectively. The Shannon wiener index of home gardens ranged from 1.53 to 3.10 and mean value was 2.35. However, it is not significantly different among the topographies of home gardens. Result of an architectural analysis of the canopy in the home gardens reveals that the good structure can be found in steep slope home gardens in the study area. High tree species diversity, layered canopy configurations and compatible species admixtures could be the most conspicuous characteristics of a home garden in the region. Hence, there is a large potential in the home gardens to enhance the forest cover of the Intermediate zone of up country, Sri Lanka.

Keywords: Home garden, Plant Biodiversity, Stratification structure, Tree species diversity

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Agronomic Traits and Grain Yield Performances of Traditional and Improved Varieties of Rice Cultivated during Yala and Maha Seasons

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Abstract

To investigate growth and yield performances of popular traditional (15) and improved (15) rice varieties, 14 day old seedlings were transplanted in experimental plots (8x3m) with 3 replicates to randomized complete block design during 2017 yala and 2017/18 maha seasons. Agronomic practices were done according to the recommendation of the Department of Agriculture. Tiller count, plant height (PH), leaf length (LL) and leaf width were measured before heading. Lodging and culm strength were monitored throughout the growth and recorded at visibility. Panicle length, total and filled grains per panicle (FGP), grain shattering, thousand grain mass (TGM) and plot grain yields were recorded after harvest. Most of the improved rice varieties recorded higher tiller numbers at 4, 6 and 8 weeks after transplanting (WAT). Prominent vegetative growth of traditional varieties was expressed through higher PH and LL or leaf area than improved during each season. When panicles bear more grains, FGP also tends to increase (positively significant correlation yala 0.903/maha 0.943). All 15 improved varieties had more than 75% of filled grains. More than 10% of shattering was observed in some of the traditional varieties such as Rathsuwandel, Suwanda samba, Pachchaperumal, Kalu heenati, Suwandel and Beheth heenati. Among traditional varieties TGM were significantly high in Wannidahanala (27.6g/27.3g) during both the seasons, Sulai (27.2 g) in yala, Hondarawala (27.4g) in maha and Masuran (27.9g) in maha. Significant lower grain yields were obtained in traditional varieties (3.83 t/ha-yala /4.4 t/ha - maha) than improved (6.41 t/ha-yala/ 5.6 t/ha - maha). In 2017 yala majority of the improved (10 out of 15) varieties yielded more than 6 t/ha where none of the traditional varieties could perform. More vegetative growth like PH and LL/leaf area and weak culm strength in traditional varieties have caused the plant to lodge at grain filling. Different agronomic traits have contributed to achieve significantly high grain yield in improved rice varieties favourably. Although some traditional varieties inherit desirable traits for high yields, plant height accompanied by lodging as well as grain shattering and more unfilled seeds per panicle had affected the poor yield. To maintain sustainable rice cultivation and to get optimum yield via traditional rice varieties will be a challenging target to the rice growers in future.

Keywords: Agronomic traits, Improved, Rice, Traditional

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Trend in Occurrences of Extreme Temperature Events of Anuradhapura District in Sri Lanka

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Abstract

Extreme climatic events are increasing because of climate change and thus likely to influence global agricultural production. Regional assessments on various abiotic factors and its influences on biological entities in diverse geographic locations are needed for understanding uncertainties. Most climate impact studies rely on changes in means of meteorological variables, such as temperature, to estimate potential climate impacts, including effects on agricultural production. However, extreme meteorological events such as a short period of abnormally high temperatures, can have a significant harmful effect on crop growth and final yield. The characteristics of daily temperature time series, specifically mean, variance and autocorrelation, are analyzed to determine possible ranges of probabilities of certain extreme temperature events with changes in mean temperature of the time series. The extreme temperature events considered are motivated primarily by agricultural concerns, particularly, the effects of high temperatures on rice production in Anuradhapura district in North Central Province of Sri Lanka. Trends in extreme daily temperature were analyzed for thirty years from 1975 to 2005 for Anuradhapura district for two major seasons for paddy production, *Yala* and *Maha*. Daily average temperatures were calculated using daily minimum and daily maximum temperatures and separated into two seasons. The 90th percentile was used as the reference value as an extreme temporal value. Number of occurrences above the 90th percentile was cumulated yearly and analyzed for a pattern from 1975 to 2005. These trends in extreme temperatures showed considerable consistency across the study area. The study reveals a positive correlation between the years and the occurrences of extreme temperature events for both *Yala* season and *Maha* seasons with *p* values of 0.03 and 0.04, respectively. From a statistical point of view, the occurrences have been increasing throughout the time series in Anuradhapura district and will detrimentally affect the crop production specially for rice production in the area.

Keywords: Climate, Extreme temperature, Paddy, *Maha*, *Yala*,

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Physiological and Growth Responses of Five Rice (*Oryza sativa* L.) Cultivars to Soil Moisture Stress

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Abstract

Scarcity of water for irrigation is an alarming issue limiting crop production worldwide and it is increasing severely in Sri Lanka. The rice yield is highly susceptible to moisture stress especially during the 'Yala' Season. This study therefore was made to evaluate moisture stress tolerance of selected rice cultivars viz; 'Bg300', 'Bg357', 'Bg366', 'Bw367' and 'Bg370'. Randomized complete block design with ten treatments and four replications were used in this study. The treatments were arranged in 5×2 factor factorial manner. Moisture stress was imposed for the selected rice cultivars for a period of fourteen days during the panicle initiation stage. The control plants were watered once in two days. Moisture stress significantly ($p < 0.05$) reduced the Relative Water Content (RWC) of all the tested rice cultivars. The highest RWC (59.2%) was observed in 'Bg370' rice cultivar and the lowest (48.2%) was found in 'Bw 367' under moisture stress condition. Moisture stress significantly ($p < 0.05$) reduced Chlorophylls a, b and total Chlorophyll contents of the tested rice cultivars. The highest amounts of Chlorophylls a (9.1 mgg^{-1}), b (9.8 mgg^{-1}) and total Chlorophyll (13.3 mgg^{-1}) were observed in 'Bg370' rice cultivar and the lowest amounts (Chlorophylls a- 4.5 mgg^{-1} , b- 4.5 mgg^{-1} and total Chlorophyll- 6.3 mgg^{-1}) were recorded in 'Bw367'. Moisture stress significantly ($p < 0.05$) reduced the Leaf Area Index (LAI) of all the tested rice cultivars. The highest LAI (0.9) was observed in 'Bg370' and the lowest was found in 'Bw367' under moisture stress. Moisture stress significantly ($p < 0.05$) reduced the yield of all the tested rice cultivars. The highest yield ($2.1 \text{ tonnesha}^{-1}$) was observed in 'Bg370' rice cultivar and the lowest ($0.5 \text{ tonnesha}^{-1}$) was found in 'Bw367' under moisture stress. Hence, Cultivar 'Bg370' exhibited comparatively more tolerance to moisture stress with less reduction in various physiological and growth attributes and could be suggested for cultivation in the drought prone areas of the Batticaloa district.

Keywords: Leaf Area Index (LAI), Moisture stress, Panicle initiation, Relative Water Content (RWC), Yield

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Climate Challenge on Australian Rice Production – A Comparison in Two Climatic Zones

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Abstract

More than half of the world's population consumes rice as the staple food and Australia produces 1.2 million tons of rice per year feeding around 40 million people daily. Future climate change predicts increase temperatures and reduction in water availability due to reduced rainfall. Rice production heavily relies on climatic changes especially atmospheric temperature and rain fall. This study evaluated the responses of different rice varieties to change in temperature (associated with elevated atmospheric CO₂ concentration) and rainfall using APSIM–Oryza model at two sites, Griffith/ Riverina in New South Wales and Kununurra in Western Australia. Varieties used at Riverina were Amaroo, Langi, and Quest, representing late, mid and early maturity types, respectively. Variety (IR72) was used for Kununurra region. Five different changes of temperature were 0 (base temperature 30°C), +1, +2, +3, +4°C with a combination of five rainfall changes (+10, 0, -10, -20, and -30%) used in the simulation to represent the series of projected climatic changes predicted for Australia over the next 60 years. The corresponding CO₂ concentrations allied with above temperature levels were 380, 435, 535, 640 and 750 ppm. All three rice varieties in two Riverina climatic zones showed a yield increase of 0.36 tons/ha (up to 10%) with increase in temperature by 2° C at Griffith, which could be due to CO₂ fertilization effect. Further increase in temperature caused a steady decline in yield, with short season variety 'Quest' affected least. Grain yields at Kununurra steadily declined by 37% with 4°C increase in temperature. These results indicated that warmer temperatures would increase spikelet sterility. Adaptations could be included, use of shorter season varieties and changing planting dates. In the above two different climatic zones, higher temperature is expected to limit rice production in future.

Keywords: Climate change, CO₂ elevation, Rice, Yield components

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Life Cycle Assessment on Climate Change Impacts from Sugarcane Cultivation in Sri Lanka and their Mitigation Potentials through Effective Utilization of Crop Residues

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Abstract

Sugarcane is the feedstock for raw sugar manufacturing in Sri Lanka where the existing cultivation occupies 30,000 hectares that is around 35% of the arable land area for sugarcane. Future improvements in the local cane sugar industry require expansion of cultivation in the full capacity. The conventional rain-fed sugarcane cultivation method in Sri Lanka utilizes diesel-operated tractors/equipment and manual agricultural operations in land preparation, crop establishment, crop maintenance and harvesting activities with open burning of crop residues. Since these agricultural operations contribute many airborne emissions (CO₂, SO₂, NO_x, CH₄, NH₃, N₂O, particulates, etc.), a quantitative assessment of life cycle climate change impacts is required for future policy decision making towards sustainable expansion of sugarcane cultivation. A published life cycle impact assessment on cradle-to-gate life cycle of sugarcane cultivation in Sri Lanka has not been reported. Hence, the novelty of this study is the evaluation of four major climate change impacts (global warming potential, terrestrial acidification, photochemical oxidant formation, and particulate matter formation) and associated airborne emissions. Inventory data on materials/resources utilization and energy consumption are collected from a data survey through interviewing sugarcane farmers and industry statistics, which are applied to estimate emissions from individual operations: agrochemical manufacturing/transportation/application, agricultural machinery operations, seed cane transportation, crop residues burning, etc. The corresponding climate change impacts were quantified using the ReCiPe midpoint (H) V1.12 impact assessment method in SimaPro Life Cycle Assessment (LCA) software. The results indicate the contributions from agricultural operations in the conventional cultivation practice for all climate change impacts. Global warming potential impact result is 3,120 CO₂ eq where the major contributors are chemical fertilizers application (45%) and open burning of crop residues (40%). More than 50% of terrestrial acidification and particulate matter formation impact results are also represented by chemical fertilizers application while open burning of crop residues is responsible for almost 95% of the photochemical oxidant formation impact result. Therefore, the study compares impact results with a scenario for effective crop residues utilization (zero crop residues burning with 50% utilized as organic manure in the same cultivation field) and the respective climate change impact mitigation potentials are quantified.

Keywords: Airborne emissions, Climate change impacts, Crop residues burning, Sugarcane cultivation

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Evaluation of Global Warming and Toxicity Potentials from Chemical Fertilizer Application for Maize (*Zea mays*) Cultivation in Sri Lanka

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Abstract

Maize is cultivated in Sri Lanka with an average yield of 3.52 tonne/ha which is adequate for 40% of the local demand. Cultivation yield improvement is essential to reduce future maize imports where chemical fertilizer application is a key factor at recommended rates, i.e., Urea: 350 kg/ha, Triple Super Phosphate: 100 kg/ha, and Muriate of Potash: 50 kg/ha. Chemical fertilizer application is associated with many environmental impacts due to direct/indirect emissions. A published study has not yet been reported in Sri Lanka with a proper evaluation of environmental emissions/associated impacts from fertilizer application for maize. Therefore, this study focused to evaluate the environmental emissions/associated impacts from fertilizer application for maize cultivation in Sri Lanka. The evaluation of emissions/impact potentials follows the life cycle approach which considered three main phases in the chemical fertilizer application process, such as chemical fertilizer production, fertilizer transportation, and fertilizer application. Emission calculations in fertilizer production and transportation phases were performed by obtaining emission factors from the Ecoinvent 3.0 database and necessary considerations. Airborne emissions (CO₂, N₂O, and NH₃), groundwater leaching (heavy metals and nitrates), and soil deposition (heavy metals and phosphorous) due to the fertilizer application phase were calculated by using the standard Agri-footprint 4.0 methodology. Five impact potentials: climate change, human toxicity, terrestrial ecotoxicity, freshwater ecotoxicity, and marine ecotoxicity were evaluated and compared. Impact potentials were evaluated by using the ReCiPe world (H) V1.12 impact assessment method in the SimaPro Life Cycle Assessment software. Emission results showed that fertilizer production and transportation phases released lower pollutant levels, compared to the application phase. Impact results revealed that 92% of the climate change impact is contributed by the fertilizer application phase. Soil deposition from fertilizer application devotes the highest influences (above 98%) in human eco-toxicity and terrestrial eco-toxicity impacts. Freshwater eco-toxicity and marine eco-toxicity impact results were 0.26 kg 1,4-dichlorobenzene eq and 0.22 kg 1,4-dichlorobenzene eq, respectively where groundwater leaching of heavy metals from fertilizer application contribute more than 80%. The findings from this study quantify the current levels of environmental impacts that support future decision making for environmentally-benign fertilizer application for maize cultivation in Sri Lanka.

Keywords: Chemical fertilizer, Global warming, Maize cultivation, Sri Lanka, Toxicity potentials

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Soil, Water and Environment



Keynote Speech

Nitrogen Management in Soil and Water for Our Future Earth

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Abstract

Although nitrogen (N) is an essential element for plants, it is one of the main contributor to eutrophication in closed water bodies such as lakes and inland sea. Beside, nitrous oxide gas (N_2O) derived from fertilizer and manure is one of the greenhouse gases. Humans can take in just 14% of fertilizer-N as protein for vegetation diets and 4% for carnivorous ones. Other remaining N is lost by N leaching or denitrification (N_2 and N_2O), or may be stored in soil as organic N. We emphasized excess application of manure compost caused N contamination of water by using natural abundances of ^{15}N . Nitrous oxide emissions can be reduced by controlling pH and decomposability of organic matter. Organic waste management should be well studied to establish sustainable agricultural systems in the future.

Keywords: Groundwater, Leaching, Nitrate, Nitrous oxide, Organic waste, Upland fields

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Introduction

Nitrogen, an essential element for plants, is one of the main contributor to eutrophication in closed water bodies such as lakes and inland sea. Nitrate that is the most oxidized form of N contaminates groundwater when excess N was applied to farmland. NO_3^- is easily leached out of the root zone because soil is usually negatively charged and cannot adsorb anions like NO_3^- . In Japan, the percentage of groundwater containing nitrate exceeding a Japanese standard, 10 mg N L⁻¹ peaked at 6.5% in 2003 and has decreased to 2.9% in 2013 (Ministry of the Environment, 2014) due to less application of N fertilizer and proper management of livestock manure after 2000. Many management practices have been proposed so far to reduce NO_3^- leaching losses in upland fields, based on scientific outcomes.

Nitrous oxide gas (N_2O), one of the greenhouse gases is derived from fertilizer and manure that were inputted to agricultural land. N_2O is of great importance because it can stand in the atmosphere for more than 114 years and has a global warming potential 298 times higher than CO_2 (Smith et al., 2007).

In this report, the author points out how N inputted to farmland affects soil and water environments and what we need for our future earth.

Nitrogen use efficiency

Crop production has increased greatly after the establishment of the Haber-Bosch process in 1911. N used as fertilizer will reach to 120 Mt all over the world by 2030, which is nearly equivalent to that of the N cycle on Earth prior to 1930 (Vance, 2001).

In addition to chemical fertilizer, we need to consider N from organic wastes. For example, a large amount of compost is produced from livestock wastes in Japan (7.7 Mt from cattle manure, 2.1 Mt from pig manure, and 2.1 Mt from chicken manure, Mishima et al., 2009). Livestock compost application to the farmland is very effective to increase soil organic matter and adjust soil pH as soil amendment. On the other hand, livestock compost contains lots of nutrients,

which is slowly released to the soil over many months or sometimes years. This nutrient release, which cannot be controlled or predicted, would lead to unintended N leaching or N₂O emissions.

Figure 1 shows N use efficiencies of chemical fertilizer. Humans can take in just 14% of N as protein for vegetation diets and 4% for carnivorous ones. Other remaining N is lost by N leaching or denitrification (N₂ and N₂O), or may be stored in soil as organic N. The greatest loss occurs in crop production, where only 50% of N is absorbed by crops. Average Japanese requires 4 kg of N per year, and therefore ten times larger N, 40 kg of N must be applied to the farmland to produce foods for a Japanese (Maeda, 2007). Namely, 5.2 Mt of N is necessary for all Japanese people. However, the total use of fertilizer-N in Japan is only 1 Mt. This indicates that the remaining 4 Mt of N is used in other countries, where environmental problems may occur to foster Japanese people. This is a reason why Japanese should be responsible for N management in other countries as well as in Japan.

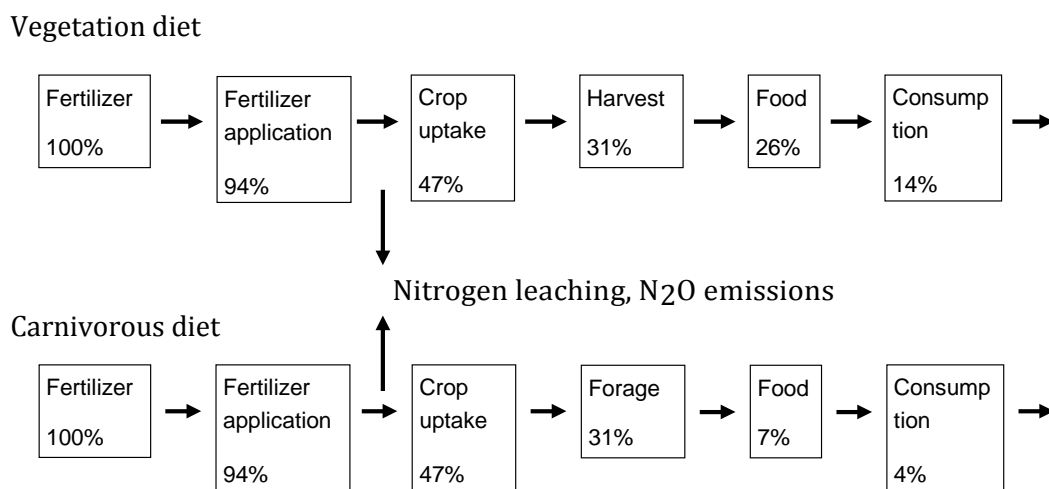


Fig. 1. Fates of chemical-fertilizer nitrogen for vegetarian and carnivorous diets.

Water pollution in agricultural areas

N and phosphorus concentrations have been reported to be high in the main drainage canals in the reclaimed areas of Kasaoka Bay, Japan, where livestock farming is the most common form of agriculture. Maeda et al. (2011) monitored water quality bimonthly from May 2009 to February 2010 and monthly from March to October 2010 at four or five sites in each of three branch canals running through farmland areas with different uses: (i) grassland, (ii) livestock and forage crops, and (iii) livestock, forage crops and horticulture. Concentrations of total N and P in water were higher for land use in the order of (ii) livestock and forage crops > (iii) livestock, forage crops and horticulture > (i) grassland. We also investigated the mechanism of N contamination by analyzing stable isotopes in drainage water, soil plots in all areas, and forage crops in area (ii). Abundances of natural fractions of ¹⁵N (δ¹⁵N) and ¹⁸O in nitrate-N indicated that N contamination in canals could be attributed to the high rate of manure compost application on fields of forage crops owned by livestock farmers in areas (ii) and (iii) and the fact that ammonia volatilization and/or denitrification occurred in the fields and/or in the canals. Further, ammonia volatilization from a cowshed was inferred based on significantly lower δ¹⁵N values in orchard grass and soil in plots closer to the cowshed. In concluding, excess application of manure compost causes N contamination of water and ammonia volatilization from livestock affects soil N in reclaimed land.

Nitrogen leaching in upland fields with different fertilizer management

Fertilizer types affect NO_3 leaching in upland fields. Maeda et al. (2003) tested four N fertilizers (swine compost, coated urea, ammonium N, or no fertilizer) in a volcanic ash soil (Andisol) fields for 7 years. Sweet corn was grown in summer, followed by Chinese cabbage or cabbage in autumn each year. In chemical fertilizer plots (coated urea, ammonium N), NO_3 concentrations in soil water at 1-m depth increased markedly in the summer of the second year and fluctuated between 30 and 60 mg N L^{-1} . In the compost plot, NO_3 concentration started increasing in the fourth year, reaching the same level as in the chemical fertilizer plots in the late period of the experiment. The potential NO_3 concentrations by an N and water balance equation satisfactorily predicted NO_3 concentration in the chemical fertilizer plots, but substantially overestimated that in the compost plot, presumably because a large portion of N from compost first accumulated in soil in the organic form. Our results indicate that excessive N from chemical fertilizers can cause substantial NO_3 leaching, while compost application is promising to establish high yields and low N leaching during a few years but would cause the same level of NO_3 leaching as in chemically fertilized plots over longer periods.

Nitrous oxide emissions from Asian soils

Denitrification is an important process to remove NO_3 from water, but the process may produce N_2O when soil is not enough reductive. Ha et al. (2015) compared three flooded soils (paddy soil from Vietnam, mangrove soil from Vietnam, and paddy soil from Japan). In Japanese paddy soil, N_2O and N_2 emissions were increased significantly by the addition of greater NO_3 concentrations. However, N_2O and N_2 emissions from Vietnamese paddy and mangrove soils were increased by the addition of 0 to 5 mg N L^{-1} , but not by 5 to 10 mg N L^{-1} . At 10 mg N L^{-1} , N_2 emissions were greater in Japanese paddy soil (pH 7.0) than in Vietnamese paddy (pH 5.8) or mangrove (pH 4.3) soils, while N_2O emissions were higher in Vietnamese paddy and mangrove soils than in Japanese paddy soil. In Vietnamese mangrove soil, N_2O was the main product throughout the experiment. In conclusion, NO_3 concentration and soil pH affected N_2O and N_2 emissions from three flooded soils.

Nitrous oxide emissions in disinfestation, a good agricultural practice

Biological soil disinfestations are developed as alternatives to chemical fumigations. Reductive soil conditions produced by the application of easily decomposable organic matter, water irrigation and covering of soil with plastic mulch films suppress soil-borne pathogens during biological soil disinfestation at high temperature in the greenhouse. This method became popular as a good agricultural practice. However, N_2O may be more emitted as an intermediate product of denitrification during biological soil disinfestation. Maeda et al. (2015) determined the effects of different organic matter (rice bran, rice husk and dent corn) and mulch films on N_2O emissions during biological soil disinfestation. Incorporation of organic matter increased N_2O emissions compared with no organic matter addition at 50°C. Incorporation of rice bran and dent corn with easily decomposable C and low C:N ratios increased N_2O emissions for the first 12 h, but thereafter, available C supply from these amendments suppressed N_2O emissions. Permeability of mulch films increased at a higher temperature and was larger for polyvinyl chloride than for triple-layer polyolefin films. Our study indicated that rice husk should not be used for soil disinfestation and that application rates of organic matter must be determined based on their decomposability. Moreover, mulch film covering would not suppress N_2O emission in biological soil disinfestation because of high temperature.

Conclusion

The author showed how N management affect soil and water environments. Organic wastes are increasing in recent years. The management of organic wastes is a key to creating sustainable systems in agricultural and other sectors. All of us are important players responsible for our future earth.

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Keynote Speech

For Achieving Eco-friendly and Sustainable Rice Farming with Less Environmental Impact

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Abstract

Agriculture is one of the important activities for us to produce foods. Rice production is considered as a sustainable farming activity due to its thousands of years of history. As of 2018, rice was produced more than 700 million tons in the world. By region, Asia produces the most rice and accounts for about 90 % of world production. In Japan, around 100 years ago, modernization of agriculture (rice farming) such as mechanization and chemical fertilizer application started, and then, around 70 years ago, large-scale field integration and application of herbicide started. As a result, rice production was stabilized and increased. However, on the other hand, rice farming started to show negative impact for the Environment, especially water quality. Thus, it is a keen issue to evaluate the relationship between rice farming and drainage water quality influencing downstream water environment, and reduce nutrient loadings from the fields by managing drainage gate and water depth in the critical periods for water quality conservation. In addition, it is necessary to remember rice fields are not only the place for producing food, but also the place for nurturing life by other animals. Thus, it would be great if we could share the value of rice fields with wildlife, and obtain benefit for rice production from them, such as organic nutrient inputs. For achieving eco-friendly and sustainable rice farming with less environmental impact, it is very important to understand their activities in the fields and evaluate the benefit such as nutrient inputs to the fields and use it in next season. In this presentation, as examples, research findings for reducing adverse effects from paddy fields to the Environment are introduced.

Keywords: Farming activity, Nitrogen, Paddy fields, Phosphorus, Water environment

1. Introduction

Agriculture is one of the important activities for us to produce foods. Rice production is considered as a sustainable farming activity due to its thousands of years of history. However, agricultural lands are considered as non-point sources of pollution, and the loads from the sources have recently been found to contribute a larger amount of the load flowing into many closed water areas than point sources of pollution (Takeda and Fukushima, 2006). Therefore, it is essential that their impact be considered when attempting to improve the quality of nearby water environments. It is very difficult to evaluate the overall environmental impact of agricultural farming activities such as irrigation and fertilizer application in a drainage basin. This is especially true in paddy fields, which use a large amount of water and result in a high volume of drainage into surrounding water bodies.

Paddy fields typically lie between upland and lower-elevation water bodies; therefore, they can have a major impact on water quality. The growing season of rice extends from May to October and corresponds with the hydrologically active period. Paddy fields are surrounded by earthen levees 10-30 cm height and are usually shallowly ponded (3-10 cm) during most of the growing season. Therefore, these fields resemble wetlands; however, chemical fertilizers are applied and the fields are irrigated and drained.

It is widely recognized that the presence of paddy fields leads to soil conservation, ground water recharge and denitrification, and that paddy fields play a substantial role in food production (Mizutani, 1999). On the other hand, rice farming started to show negative impact for the Environment, especially water quality, because of modernization of farming activities. Thus, it is very important to re-establish eco-friendly and sustainable rice farming with less environmental impact manner.

In this report, two examples are selected to consider a way of reducing negative impact from paddy fields to the Environment: 1) relationship between farming activities and drainage water quality, 2) possibility of introducing eco-friendly agricultural practices to paddy fields.

2. Example 1: Relationship between farming activities and drainage water quality (Somura et al., 2009)

In this study, the relationship between puddling procedures and changes in the quality of drainage water from paddy fields was evaluated to determine the impact of paddy drainage water on the quality of aquatic systems located downstream.

2.1 Variation in the concentrations of water quality parameters in drainage water

Relatively high concentrations were observed in drainage water during the non-irrigation period, with averages of 2.56 mg L⁻¹ TN, 0.13 mg L⁻¹ TP, 4.55 mg L⁻¹ TOC, and 21.2 mg L⁻¹ SS in 2005 and 2006. During the non-irrigation period, no agricultural activities were conducted in the target paddy fields. Therefore, it is believed that residual nutrients in the soil are leached by rain water and subsequently flow to the drainage ditch. Conversely, the concentrations of several water quality factors decreased during the irrigation period, especially during the growing season. Specifically, average concentrations of 1.79 mg L⁻¹, 0.15 mg L⁻¹, 3.45 mg L⁻¹, and 26.8 mg L⁻¹ of TN, TP, TOC and SS, respectively, were observed during the irrigation periods in 2005 and 2006. In addition, the concentrations of the parameters evaluated in this study tended to be lower during the irrigation periods in July and August than at the beginning and end of the growing season. This decreased concentration may be due to the retention time of the water in the paddy fields during irrigation periods inducing purification via a mechanism like those present in natural and artificial wetlands such as denitrification, plant uptake or sedimentation (Thomas et al., 2003; Braskerud, 2002). Alternatively, the decreased concentrations may also have occurred due to a dilution effect induced by irrigation water that drained directly into the drainage channel before flowing into the paddy fields. However, the water concentrations of these contaminants increased significantly during the puddling processes in 2005 and 2006, as indicated by average concentrations of 6.27 mg L⁻¹ TN, 1.13 mg L⁻¹ TP, 10.79 mg L⁻¹ TOC, and 296.2 mg L⁻¹ SS during this period. This finding is like the results of several studies conducted to evaluate the concentrations of water quality factors in drainage water from paddy fields in Japan (Kondoh et al. 1992).

2.2 Farming activities and water quality during puddling in 2006

The results of the water quality investigation conducted in 2005 revealed that a large quantity of irrigation water is used for the puddling and transplanting processes. Large amount of drainage water released during this period was believed to have a high impact on the downstream water quality; therefore, we evaluated the water quality extensively during this period to determine if a relationship existed between farming activities and variations in water quality. In 2006, the puddling and transplanting processes lasted for 6 days. During that period, the average concentrations of TN, TP, TOC and SS in the drainage water were 7.9 mg L⁻¹, 1.6 mg L⁻¹, 15.3 mg L⁻¹, and 372 mg L⁻¹, respectively. In addition, the maximum concentrations of TN, TP, TOC and SS during this period were 36.2 mg L⁻¹, 12.3 mg L⁻¹, 83.2 mg L⁻¹, and 3020 mg L⁻¹, respectively. The correlation coefficients between SS and TN, TP, and TOC in the drainage water were 0.91, 0.90 and 0.92, respectively, which indicates that these factors were closely related. The changes in water quality in response to farming activities by a tractor and drainage gate operation on each

paddy field were also observed. The results of this study clarified that the concentrations of drainage water increased rapidly when the puddling processes began and that high concentrations were maintained during the farming activities. Moreover, the high concentrations did not decrease after finishing the daily activities, and kept discharging until next day.

In the composition ratios of TN and TP in the drainage water during the puddling, the discharge of particle nitrogen (PN) was found to increase as the puddling processes progressed. In addition, the concentration of particle phosphorus (PP) also tended to increase during the period. It has been reported that the concentrations of N and P in drainage water increase during puddling and transplanting, as well as at the time that fertilizer is applied (Takeda et al. 1991; Feng et al. 2004). Therefore, it is likely that a portion of the fertilizer is discharged via surface water drainage because chemical fertilizer was applied simultaneously during rice transplanting.

A review of the history of farming activities and drainage water at paddy field No.12 revealed that no water was released from that paddy field via the surface drain during the puddling processes. According to the farmer in charge of that field, there is an optimal water depth for puddling at which it is not necessary to drain the water during the puddling process, but that depth is uncertain. Thus, if the optimal water depth were found for puddling and the amount of water drained during that time were decreased (such as in paddy field No.12), contaminant load discharges would decrease greatly. Additionally, determining the optimal depth for puddling would allow the amount of nutrient salts applied by chemical fertilizer to be decreased because the nutrient salt runoff via surface drainage would decrease. Taken together, these findings indicate that developing methods to optimize the water depth in paddy fields during the puddling process can reduce costs while improving and protecting the downstream environment of nearby bodies of water.

3. Example 2: Possibility of introducing eco-friendly agricultural practices by winter-flooded paddy fields (Somura et al., 2015)

In this study, the changes in the water qualities of winter-flooded paddy fields and the influence of bird excrement on water quality in the paddy fields during winter were evaluated, and then the amounts of nitrogen and phosphorus provided by bird droppings to the winter-flooded paddy fields were estimated.

3.1 Changes in water qualities in winter-flooded paddy fields during the overwintering season

During the birds' stay, water in the paddy fields gradually turned dark green and emitted a foul smell. The mean water concentrations in the paddy fields were thought to be extremely higher in winter than in summer. For reference, surface water from paddy field No. 1 was collected between 11 June and 11 September in 2006 (n: 11) to determine the water qualities during the irrigation season, and the mean concentrations were found to be 13.8 mg·L⁻¹ in SS, 1.76 mg·L⁻¹ in TN, 0.75 mg·L⁻¹ in NH₄-N, 0.53 mg·L⁻¹ in TP, 0.20 mg·L⁻¹ in PO₄-P, and 5.82 mg·L⁻¹ in TOC (no data were available for NO₂-N and NO₃-N). Although each mean value of the water qualities in winter were different across the target paddy fields in both the seasons, the simple mean concentration of the observed water qualities from November 2006 to March 2008 was 288 mg·L⁻¹ in SS, 7.45 mg·L⁻¹ in TN, 4.59 mg·L⁻¹ in NH₄-N, 0.09 mg·L⁻¹ in NO₃-N, 0.02 mg·L⁻¹ in NO₂-N, 1.20 mg·L⁻¹ in TP, 0.37 mg·L⁻¹ in PO₄-P, and 28.1 mg·L⁻¹ in TOC. Unlike other water qualities, the average concentrations of NO₃-N and NO₂-N were not high. Especially, NO₃-N was not detected by the equipment in some water samples. On the other hand, the concentrations of TN and NH₄-N were remarkably higher in the seasons other than the irrigation season. The water quality analysis results for November to March revealed that the percentages of NH₄-N in TN concentration varied from 40% to 80% in the first season and from 75% to 79% in the second season. This

result indicated that most of the nitrogen consisted of ammonium nitrogen. TP, PO₄-P, SS, and TOC values were also high and similar between the first and second seasons. Especially, SS concentration was high during the overwintering season, since the water in the paddy fields was extremely disturbed by the Tundra Swans.

Water qualities immediately after puddling could not be measured in the first season; in the second season, they were measured in Paddy field No. 3 on November 5, 2007. The concentrations were 5 mg·L⁻¹ in SS, 0.47 mg·L⁻¹ in TN, 0.053 mg·L⁻¹ in NH₄-N, 0.006 mg·L⁻¹ in NO₂-N, 0.22 mg·L⁻¹ in TP, 0.21 mg·L⁻¹ in PO₄-P, and 2.6 mg·L⁻¹ in TOC. These values were considered as initial values in the overwintering season. The concentrations at each paddy field varied remarkably, but the concentrations gradually increased toward January or February and decreased after March. Since the concentrations were analyzed until May in the first season, the trend was clearly observed. However, the SS concentration did not show any remarkable changes like the other components. Further, the changes in TP concentration in the beginning of the first season changed markedly and might have been affected by the disturbance caused by Tundra Swans.

3.2 Observation of Tundra Swans

In the second season, Tundra Swans landed in the study area at the end of October 2007, but paddy fields were not flooded at that time. Puddling was executed in the paddy fields between October 30 and November 4, and water was stored in the paddy fields. Therefore, on November 5, the color of the water was brown. The number of the birds peaked from December to January, and then the birds returned to their original habitat between the end of February and mid-March in 2008.

The number of Tundra Swans in the flooded paddy fields was counted every hour from sunup to sundown. Around thousands of birds remained in the target paddy fields at 7:00 am, and their activities gradually increased with an increase in air temperature. They began to vacate the flooded paddy fields between 9:00 am and 10:00 am. Some of the birds just changed their location from one paddy field to another, whereas the others flew to the surrounding paddy fields for foraging. They also foraged within the flooded paddy fields and stood on the earthen levees for resting. They moved in a group. They repeatedly left and returned to the flooded paddy fields during the day. Most birds returned to the flooded paddy fields by 5:00 pm. The activity of returning to the paddy fields continued even after sundown.

3.3 Nutrient inputs by Tundra Swan excrements to the winter-flooded paddy fields

N and P inputs to the paddy fields were estimated by conducting excrement analysis and comparing with the values published in literatures. In paddy field Nos. 3 to 5, the maximum and minimum values for N varied from 40 to 70 kg·ha⁻¹ and from 25 to 43 kg·ha⁻¹, respectively, and the mean value was 46 kg·ha⁻¹. In those fields, the maximum and minimum P values varied from 9 to 12 kg·ha⁻¹ and from 6 to 8 kg·ha⁻¹, respectively, and the mean value was 9 kg·ha⁻¹. The N input from chemical fertilizers during the irrigation period was almost the same as that present in the Tundra Swan excrements. Further, the amount of P in the excrements was one-third of that present in the fertilizers.

These findings suggest that farmers need to reduce the amount of fertilizers applied if birds overwinter in the paddy fields. The levels of dissolved N and P should be monitored to determine if enough quantity of these nutrients is present to warrant a reduction in the amount of fertilizer applied. Further, the N and P concentrations need to be monitored because excessive of these nutrients might have adverse effects such as lodging (Peng et al., 2010). Hence, expanding the area of winter-flooded paddy fields and managing the distribution of birds across the fields would be a good strategy. Managing the surplus nutrient inputs by controlling the use of chemical fertilizers might substantially reduce the farming cost for producing rice as well as

the environmental impact potentially inherent in agricultural lands (Hodgkinson et al., 2002; Smith et al., 2001a; Smith et al., 2001b; Somura et al., 2012; Zebarth et al., 1999).

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Effect of Different Potting Media on Rhizome Bud Multiplication of Turmeric (*Curcuma longa* L.) under *Ex Vitro* Conditions

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Abstract

Turmeric (*Curcuma longa* L.) is a rhizomatous herb and belongs to the family of Zingiberaceae. The experiment was conducted to study the effect of different potting media on rhizome bud multiplication of turmeric for vegetative propagation in a net house. The potting media such as sand alone (T1- control), sand: compost at a ratio (v/v) of 1:1 (T2), sand: paddy husk at a ratio of 1:1 (T3) and sand: compost: coir dust at a ratio of 1:1:1 (T4) were used for the study. Uniform size rhizomes of turmeric (variety local) with two buds were planted in different media at 5 cm depth and arranged according to a completely randomized design with three replicates. Length of aerial stem and number of leaves per plant were recorded at two weeks intervals. At the time of harvesting, number of shoot buds per rhizome, chlorophyll content, rhizome length, fresh and dry weights of aerial stem and rhizome were measured and data were statistically analyzed. The results indicated that different potting media had significant ($p < 0.05$) effect on shoot bud multiplication, chlorophyll content and also fresh weights of aerial stem and rhizome of turmeric grown under *ex vitro* conditions. Among the tested treatments, maximum number of shoot buds (5.7) was recorded in T3 and there was no significant difference between T1 and T3. It may be due to the high amount of potassium content in T3 potting medium than other treatments. It was noted that T2 showed the highest fresh weights of aerial stem (8.2 g) and rhizome (9.7 g) followed by T3 and T4 whereas the control (T1) had significantly ($p < 0.05$) the lowest values than other treatments. T2, T3 and T4 treatments showed significantly greater values than the control for all measured parameters except the number of shoot buds. For the most of the parameters tested, there were no significant differences among T2, T3 and T4 treatments. However, usage of paddy husk with sand as an ingredient in potting medium preparation would improve the bud multiplication of turmeric by rhizomes.

Keywords: Coir dust, Compost, Paddy husk, Rhizome bud, Sand, Turmeric

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Possibility of using *Mucuna bracteata* as a Cover Crop in Coconut Plantations in Low Country Intermediate Zone of Sri Lanka

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Abstract

Mucuna bracteata is a legume with high biomass production and ability to cover the land rapidly. It also identified as a potential cover crop for rubber plantations. However, its potential of growing under coconut cultivation has not been investigated. Therefore, this study aimed to assess the possibility of using *Mucuna bracteata* as a cover crop for coconut plantation in the low country Intermediate Zone of Sri Lanka. A field experiment was carried out under 25 years old adult coconut plantation on red yellow podzolic soil. Four treatments in this experiment were, *Mucuna bracteata* planted in two rows in center of square {T1}, *Mucuna bracteata* planted in three rows in center of square {T2}, *Mucuna bracteata* planted in four rows in center of square {T3} and coconut without cover crop (control) {T4} and they were arranged in a Randomized Complete Block design with four replicates. Soil properties were analyzed before and 75 days after and ground cover were assessed 75 days after establishment. The highest ground coverage of (81 %) and the lowest weed density were observed in coconut with *Mucuna bracteata* in three rows. *Mucuna bracteata* planted plots had significantly ($p < 0.05$) lower bulk density (1.1 - 1.3 Mg / m³) than the control (1.5 Mg / m³) plots. Soil total nitrogen content of those treatments (0.20 - 0.27 %) was also higher than the control (0.16 %) and there were no significant difference between T2 and T3. According to the results of this study, it can be concluded that *Mucuna bracteata* could be used as a cover crop under coconut in low country Intermediate Zone of Sri Lanka. It also suggested that coconut with *Mucuna bracteata* planted in three rows was the most suitable planting method for coconut cultivation which gave better ground cover, lower soil bulk density and high soil nitrogen content than other treatments.

Keywords: Coconut plantation, Cover crop, Ground cover, *Mucuna bracteata*

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Efficiency of Natural Geo-Sorbents in Remediating Lead (Pb)

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Abstract

Forest dieback in Horton Plains, Sri Lanka, has become a disastrous environmental problem in the country. More than a natural forest, Horton Plains may also be the most important water catchment and a biodiversity hotspot. Although there are dozens of factors identified as reasons for the forest dieback in Horton Plains, soil pollution by Pb has been identified as one of the key factors behind the problem. This study focused on finding a cost-effective solution to remediate the contaminated soils in Horton Plains. The efficacy of three (3) geo-sorbents made from plant materials were used to assess their capacity for the immobilization of soil Pb. Soil samples collected from the worst affected area with 100% forest dieback, Thotupolakanda in Horton Plains were used for the laboratory experiment. Three types of biochar materials which have been tested negative for Pb, (a) Rubber Nut Shell (RNB) (b) Rice Husk (RHB) (c) Naturally developed Biochar (HPB) in Horton Plains, were used to study their immobilization capacity in relation to the Pb in contaminated soils. Soil samples were spiked with 500ppm standard Pb at a rate of 10 mL per sample and treated with biochar at a rate of 5% in each sample. The soil samples were then left for incubation at room temperature for 14 weeks. The efficiency of biochar in immobilizing soil Pb was assessed by using Pb-spiked soil samples. Soil pH was 5.4 and the cation exchange capacity (CEC) was 210 cmolc/Kg soil. Soil organic matter (SOM) content was high (13.4%). It was evident that the Pb immobilization capacity of RHB is the highest – followed by RNB ($P < 0.0001$). HPB was proven to be ineffective in immobilizing soil Pb. Thus, RHB appears to be a cost-effective sorbent to remediate Pb contaminated soils in Horton Plains. Starting from the worst affected, soils in all the dieback affected areas in Horton Plains should be treated by RHB at a rate of 5% in the top soil.

Keywords: Biochar, Forest Die back, Immobilization, Lead

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Comparative Evaluation of the Treated Municipal Wastewater and Water in Boo Ela in Kurunegala Town on Paddy Productivity: A Case Study

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Abstract

Kurunegala Sewage Treatment Plant (STP) is treating both grey and black water from the houses, hospitals and the commercial buildings around the city. The treated effluent is releasing to the nearby Boo Ela, after meeting the quality standards of the Central Environmental Authority (CEA). Objectives of this study were (a) to determine the irrigation water quality of treated municipal wastewater and Boo Ela water and (b) the effect of water quality of these water sources on the growth and yield of paddy. Selected irrigation water quality parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Chloride, Sodium Adsorption Ratio (SAR) and Nitrate-nitrogen in treated wastewater, Boo Ela (before adding treated wastewater), and mixed water (Boo Ela water + treated wastewater) were determined. Three sources of water namely Boo Ela (BW), treated wastewater (TW) and mixed water (MW) were used for determine of effect on growth and yield of paddy (BG 305) as treatments. The rice experiment was laid out according to the Complete Randomized Block Design (CRBD). Seed germination percentage (%), plant survival percentage (%) (first week), paddy plant height (cm) (5 day intervals), number of leaves in a one plant (5 day intervals), number of tillers per plant (5 day intervals), tiller panicle length (cm) (last week), number of seeds given by each plant (per pot) (at the end of three months), weight of the seeds (g) (at the end of the three months) were measured. Irrigation water quality parameters of pH (5.5-9.0), EC (2250 μ S/cm), TDS (2100 mg/L), chloride ion (600 mg/L) and SAR were within the recommended limits and Nitrate-nitrogen was in suitable range according to the standards provided by the Food and Agricultural Organization (FAO). The highest and lowest seed germination percentages were obtained in BW water and TW, respectively. The seed germination percentages are significantly affected by sources of water ($p < 0.05$). The survival percentage, the plant height, number of leaves, number of tillers, panicle length, number of seeds and seeds weight were not significantly different under three different types of irrigation water. Based on this study, the irrigation water quality of three sources of irrigation water were suitable for irrigation of paddy and it can be concluded that the growth and development of paddy were not affected by the prevailing water quality of three sources of water.

Keywords: Growth parameters, Irrigation water quality, Paddy, Treated wastewater

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Quality Evaluation of the Compost Produced From Water Hyacinth and Cow Dung at Different Mixing Ratios

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Abstract

Eichhornia crassipes (water hyacinth) is a noxious aquatic weed which can cause series of problems in aquatic eco-systems. In Sri Lanka there is an island wide distribution of water hyacinth and currently 45% of the water bodies have infested by water hyacinth. However, if they are properly managed, it will help to community in numerous ways such as improving the water quality, producing alternatives for fertilizer animal feed, etc. The objective of this study were to produce compost from water hyacinth in combination with cow dung as the co-composting material and saw dust as the bulking agent, and to evaluate the compost quality at different mixing ratios of raw materials. The experiment was conducted with 5 treatments and 3 replicates and the treatments were allocated based on the C:N ratios (within the accepted range) and the percentage of bulking agent. Five treatments were, T1-C:N ratio of 20:1 with 10% sawdust, T2-30:1 with 10% sawdust, T3-40:1 with 10% sawdust, T4-30:1 with 5% saw dust and T5-30:1 with no sawdust. Compost piles were tested for temperature, moisture, EC and bulk density throughout the composting process at weekly intervals and the quality of the composts was analysed (after 12 weeks) and compared with the Sri Lankan standards. Maximum temperature at the beginning of the second week was recorded as 54.2 °C in treatment 1. Compared to the final compost quality standards C, N, K, Ca and Cr all the treatments were within the recommended levels. However, C:N ratio was low (high N) in all treatments except treatment T3 (~25:1) and EC was in the recommended level in all the treatment except treatment T3 (~4.8 dS/m). The moisture was higher than that of the recommended range (20-40%). Maintaining the moisture during the composting is essential since it affects the final compost quality. Based on the results of the study, all mixing ratios of raw material can be used for the production of compost since all treatments matched the greater than 6 important quality parameters out of 10. However, phyto-toxicity test should also be performed before application to ensure the safety of compost.

Keywords: Compost, Compost quality, Cow dung, Water hyacinth

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Comparison of Water Use by Mango Nursery Plants under Sprinkler and Manual Irrigation: A Case Study at Seed and Planting Material Production Farm in Polonnaruwa

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Abstract

The better management of irrigation technologies can be used to enhance the crop yield significantly. Water saving and conservation is considerably important in agriculture all over the world. Sri Lanka suffers from critical water shortages during dry season specifically in dry zone, basically due to mismanagement of water. Micro irrigation can play a major role in reducing the wastage of water during irrigation. It is not popular in plant nurseries in Polonnaruwa District due to the lack of knowledge and unaware of benefits. This study was conducted in the government seed and planting material production farm in Polonnaruwa (Thamankaduwa), Sri Lanka to highlight the importance of micro irrigation in relation to reduction of water wastage. The objectives of this study were to determine the water consumption under manual and sprinkler irrigations for selected varieties of mango plants (potted) and to compare seedling quality under two irrigation systems. The potted plants (three months old) of three mango varieties, Tom JC, Karuthakolumban and Villard was laid out in the field according to split plot design. The size of main (520 m²) and sub plots (173.3 m²) were similar in size and the numbers of plants. Manual and sprinkler irrigation methods were taken to the main plots, while the sub plots were mango varieties. The numbers of plants in sub plots were 460. The quantity of water used for manual and sprinkler irrigation was determined during the potting stages of the plants (3 months). Villard mango variety consumed significantly higher amount of water than other two varieties. Water used by the mango plants (three varieties) in manual irrigation was comparatively higher than sprinkler irrigation. All irrigated nursery potted plants were met the crop water requirement throughout the study period according to the ET_{crop} of mango. However, water wastage in two irrigation systems, according to the crop water requirement, was high and the highest amount of water wastage was identified in manual irrigation than sprinkler irrigation. Types of irrigation influenced to the selection of pots to market at the end nursery period. The marketable numbers of potted plants were significantly higher in plants produced from sprinkler irrigation. According to the results of the study, it can be concluded that if sprinkler irrigation is practiced, the water saving as well as numbers of marketable potted plants can be significantly increased than when practicing manual irrigation.

Keywords: Mango variety, Manual irrigation, Potting stage, Sprinkler irrigation, Water use

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Effect of Biofilm Biofertilizer Application on Soil Parameters and Grain Yield of Rice (*Oryza sativa* L.)

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Abstract

To increase agricultural harvest, growers have been using chemical fertilizers (CF), the amount of which has increased over time. The declined soil quality, fertility, microbial diversity and many health hazards have been reported as negative impacts of CF. Thus, there is an urgent need to find out alternative methods to reduce the CF usage. As a novel improvement in biotechnology, useful microbial communities in biofilm mode have been developed *in vitro* to be applied as biofertilizers, which are called as Biofilm Biofertilizer (BFBF). The usage of BFBF can reduce CF usage in rice. It has been shown in small scale that BFBFs can cut down CF use by farmers in rice up to 50% or more without affecting grain yield. Therefore, this study was conducted to evaluate the effect of BFBF on soil parameters and grain yield of rice. Field experiments were conducted in 12 farmer fields in Polonnaruwa district in yala season in 2018. The experiment was arranged in a randomized block design for paired comparison with two consecutive, uniform paddy fields applied with the BFBF practice (1 L BFBF with 90 kg NPK per acre) and the farmers' CF practice (195 kg NPK per acre) as treatments. There were 12 replicates for each treatment. Means of rhizosphere soil moisture (%), pH, total N (%), total P (%), organic C (%), exchangeable K (cmol/kg) and final yield (kg/acre) of the two practices were calculated. T-test was done for mean comparison. Results showed that there is a significant increase ($P < 0.05$) in grain yield (21%) in the BFBF with reduced dose of CF practice, compared to the CF practice. Furthermore, BFBF with reduced dose of CF practice showed significant increases ($P < 0.05$) in soil moisture (26%), total N (555%) and organic C (22%). Thus, it can be concluded that BFBF helps in cutting down CF while improving grain yield and soil conditions in farmers' fields.

Keywords: Biofilm Biofertilizer, Chemical fertilizer, Microbial biofilms, Rice

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Hydrophobic Effects on Organic Matter Retention in Potting Media

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Abstract

Growing plants under controlled environments able to provide optimum status for their development. Potting media is a key factor which governs the root environment of potted plants. It provides the physical support, water and nutrients to the plant grown in the pot. Soil organic matter plays a significant role in the nutrient balance in the potting media. Organic matter retention is very much important throughout the growing period. The objective of this study is to improve the organic matter retention of the potting media by intermixing hydrophobic plant materials. *Pinus* spp. and *Casuarina* spp. leaf litters were used as hydrophobic plant materials intermixed into selected two potting mixtures at the rates of 20% and 30% according to complete randomized block design. During the study period organic matter content of three replicates from each potting mixture was measured in regular intervals by using loss on ignition technique. Powdered Pine leaf litter had 83% initial organic matter content and around 4000s of water drop penetration time (WDPT) value, where Casuarina had 74% organic matter content and more than 10000s WDPT value. Potting media one and two had 67-68% organic matter decomposition rates at the end of study period (after 52days) in their control samples. Although powdered Pine leaf litter showed higher organic matter content, it showed relatively low persistency of water repellency compared to Casuarina. This reveals that the proportion of hydrophilic organic matter contributes to total organic matter content in Pine can be higher than in Casuarina. Casuarina treated samples showed higher retention (55-57%) of organic matter compared with those treated with Pine (48-50%). Although the organic matter retention was higher at 30% rate compared with the 20% rate, increment in retention was not comparatively high (less than 4%) to justify the use of higher rate. Further studies are required to find the hydrophobic effects on hydrological properties in real field studies.

Keywords: Hydrophobic organic matter, Organic matter retention, Potting media

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Challenges in Adoption of Integrated Pest Management Practices in Vegetable Cultivation in Hambantota District, Sri Lanka

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Abstract

Farmers extremely rely on usage of synthetic pesticide in high yielding cropping systems in developing countries. Therefore, there is an urgent need to adopt integrated pest management (IPM) practices in crops cultivation as a safe and sound technique for human health, household economy and environment worldwide. Empirical background evidences show that influencing farmers to adopt IPM practices does not have effect on its adoption. Several studies reported that adoption rate is affected by different reasons. Therefore, this study aimed to identify factors affecting on adoption of IPM practices in vegetable cultivation, pesticides usage pattern and opportunities to influence farmers for adoption of IPM practices in Hambantota district, Sri Lanka. Primary data were collected through a questionnaire survey. Based on the Raosoft web based sampling calculator, sample size was decided as 194 vegetable farmers. Cluster sampling procedure was assigned to select the most suitable areas for the study. Respondents from each cluster were randomly drawn to the sample and face to face interviewed. Adoption level was measured by developing adoption score and socio economic factors were tested through stepwise regression to identify factors affecting adoption level. Results indicated that factors of knowledge on IPM and awareness on negative impact of use of heavy synthetic pesticides positively affected IPM adoption level. Further, income through farming and farmers' attitudes negatively affected IPM adoption level. However cultivated extent and interaction with extension officer were also about to significant (p- value = 0.051 and 0.053, respectively) although they did not considered in the equation. In terms of pesticides usage pattern, 56% of the farmers applied synthetic pesticide even at the pest population is minimum and frequency of application was ranged from 3 to 18 in average and 10 to 40 in maximum with disparities among different crops. Only 5% of farmers were well aware about IPM, though adoption level was moderate. Opportunities are still there to increase adoption level by long-term mechanism that linked extension officers and farmers through different approaches. Continuing demonstration cultivation for every isolated areas, providing quick access for updated knowledge, facilitate extension officers for continuous field supervision were priorities among those approaches as supplements for the available programs.

Key words: IPM adoption, Synthetic pesticides, Vegetable cultivation

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Effect of Urbanization on Water Quality of Selected Canals in Colombo and its Suburbs; with Special Reference to Diatoms

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Abstract

Diatoms are widely used in monitoring environmental contamination and serve as bio-indicator for water quality and pollution status and they are more sensitive to the small variations in the environment as compared to other macrophytes and benthic algae. Objectives of this study were (a) to identify diatom species found in canals of Colombo with varying water quality and (b) to identify the species variations within rural, suburban and urban canals. Variations in water quality parameters, nutrient content and organic matter content were expected between canals due to different degrees of urbanization. Three canals were selected in Colombo area according to the varying degree of urbanization and four sites in each canal were selected. Diatom, water and sediment samples were collected, whereas, diatoms were analysed and abundance values were taken. Dissolved oxygen (DO %), DO (mg/L), pH, conductivity and salinity values were determined as the water quality parameters. Weight ignition method was used to measure organic carbon content of canal bottom sediment. There was no significant difference observed in mean values of the trophic diatom index (TDI) between the three canals. Furthermore, water quality parameters between canals except for salinity and conductivity were observed with no significant difference between the canals. A significant difference in nutrient content and the organic matter content was identified between canals. Furthermore, nine diatoms were identified up to genus level according to their morphology. Even though it was expected to have species distribution differences between three canals credited to varying water quality parameters, there was no significant difference in species distribution was observed between the canals. Identification of diatom species up to their species level might help to have more accurate diatom diversity and environmental evaluation within and between canals. Furthermore, it is recommended to continue this study in both monsoon and inter-monsoon with more environmental parameters to have a better understanding about the variation on environmental parameters with species diversity and to determine more parameter changes according to the degree of urbanization.

Keywords: Benthic algae, Bio-indicators, Diatoms, Urban canals, Urbanization

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Bio-control Potentiality of Forty Soil Actinomycetes against *Sclerotium rolfsii*. Sacc.

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Abstract

Sclerotium rolfsii. Sacc. [Teleomorph: *Athelia rolfsii* (Curzi) C.C. Tu & Kimbr.] is a necrotrophic soil borne facultative plant pathogen. This cosmopolitan fungus has a very wide host range, affecting more than 500 plant species. Actinomycetes, a group of prokaryotic filamentous organisms, are mainly soil inhabitant. They are well-known for the production of bactericidal and fungicidal metabolites to control plant diseases. Hence, forty Actinomycetes were isolated following crowded-plate technique on starch casein agar medium supplemented with Naligram and Nystatin (each of 0.050 mg/mL) from thirty four soil samples, collected from different habitats of five districts of Bangladesh. After being characterization they were tested *in vitro* for their biocontrol potentiality against *S. rolfsii* following cross strike method on Trypticase Soy Agar medium with 0.6% yeast extract. Out of forty Actinomycetes isolates 14 showed suppression of growth of the test fungi. Actinomycetes isolate no. 26Pa showed maximum inhibition (27 mm) followed by 25Sa (26 mm) and 19Ta (25 mm). These three Actinomycetes isolates were belong to the genus *Streptomyces* sp. can be used as biocontrol agent against *S. rolfsii*.

Keywords: Actinomycetes, Biocontrol Potentiality, *Sclerotium rolfsii*

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Effect of Biofilm Biofertilizer on the Performances of Native Plant Species in Degraded Grasslands at Knuckles Forest Reserve, Sri Lanka

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Abstract

Lower montane forest in “Knuckles Forest Reserve” is important due to harbouring of high biodiversity and provision of watershed services to Sri Lanka. In the British colonial era, these forests were cleared for coffee and tea plantations. However, some of these lands were abandoned due to low yield. Presently, these abandoned lands are dominated with *Cymbopogon nardus* and they act as a barrier for reconnecting the fragmented forest patches. Therefore, this study aims (a) to restore lower montane forests on these grasslands by planting native plants in islands and with the application of biofilm biofertilizer (BFBF), (b) to indicate the potential use of BFBF in degraded grasslands for ecological restoration programs. Rhizosphere microorganisms were isolated from the seedlings of *Macaranga indica*, *Bhesa ceylanica*, *Symplocos cochinchinensis* and *Eugenia bracteata*. Among the isolates three different combinations of fungal and bacterial mixtures were selected as BFBF. A field study was conducted in four grassland blocks of three plot sizes (small 4 m², medium 16 m² and large 64 m²). Seedlings of above four species were planted randomly at 1 m interval in the plots. Half of each plot was treated with BFBF and the other half was kept as a control. Number of survived species and their heights were recorded every month. Significantly higher Relative Growth Rate (RGR) of the four species was recorded in the plots applied with BFBF. *M. indica* and *S. cochinchinensis* showed the highest RGR and the survival in all the plots. *Eugenia bracteata* observed the lowest survival.

Keywords: Lower montane forest, Native tree species, Restoration

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Determinants of Drinking Water Sources among Farmer Community in Anuradhapura District: Evidence from *Kekirawa* DS Division

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Abstract

Chronic kidney disease of unknown etiology (CKDu) is a tragedy in North Central Province especially among farmer community. Since there was a belief that drinking water in affected areas is the main reason for the disease, reverse osmosis (RO) plants were established to purify water and reduce the exposure to possible nephrotoxins through drinking water. Moreover, many campaigns were organized by the government and other parties, to inform people on the importance of consuming purified water either by avoiding contaminated well water or by using purification methods. Even though there have been many efforts taken to increase the consumption of purified water, not 100% of the farmers were doing as same. The overall objective of this study was to find out farmers' usage of purified water for both drinking and cooking purposes. The specific objective of the study was to examine the factors affecting on farmers drinking water choices. The theoretical approach to the study is expected utility theory which explains the nature of decision making under the risk. The analysis of factors affecting for water choice was performed using Logistic Regression (logit) method. 48 farmers were randomly selected from Kekirawa DS Division in Anuradhapura district. The results indicated that only 40% of the farm families were consuming RO purified water. Majority of them were consuming purified water only for drinking purposes. Those who were consuming RO purified water were having kids in their home, having some knowledge on CKDu, educated or willing to pay for purified water. According to the study more than 60% of the respondents believed that chemicals used for agricultural activities are leached to ground water sources and that is affecting on kidney diseases. This study concludes that, not all the farmers in Kekirawa DS Division are consuming RO purified water yet. Even though RO purified water is available in CKDu affected areas, not all the people can afford it since they have to pay for it or do not know the importance of consuming it.

Keywords: CKDu, Contamination, Drinking water, Purification, Reverse Osmosis

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Organic Farm Habitats as a Wildlife Refuge for Increasingly Endangered Amphibians in the Piduruthalagala Lower Mountain Range, Sri Lanka

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Abstract

Permanent changes caused due to agriculture have resulted in wide-ranging impacts on amphibian diversity and abundance. Altered environmental conditions such as using chemical fertilizer, insecticides, antibiotics, growth hormones, and soil erosion have pushed amphibians to the end of their range of tolerance. Therefore, this study was designed to ascertain the amphibian species diversity of an urban ecosystem: Nuwara Eliya, with the objective of assessing the contribution of organic farming for the conservation of amphibian species. Two different habitat types viz. a terrestrial habitat with an organic farm garden (OFG) and a habitat with a non-organic farm garden (NOFG), were studied. Amphibian species inside the square were recorded during the night (19:00 – 21:00) using 5m² quadratic plots. For each new species recorded within the plot, a new square was plotted adjacently, and observations were repeated once a month for a period of 09 months from January - September 2019. As per the observations, 206 amphibians belonging to 06 species and 04 families were recorded within the area representing critically endangered, endangered and least concern amphibian species. The Simpson's index and Shannon diversity index for OFG & NOFG were 0.34/0.36 and 0.53/0.07, respectively. The most dominant species recorded were the common house toad (*Duttaphrynus melanostictus*), small eared shrub frog (*Pseudophilautus microtypanum*), Mountane hour-glass tree frog (*Taruga eques*), with relative abundances of 44.66%, 36.40% and 14.07%, respectively. The globally critically endangered and endemic schmarda's shrub frog (*Pseudophilautus schmarda*) was the least recorded species with a relative abundance of 0.48%, recorded when heavy rains began in the area (September). The least diversity was recorded in NOFG with a Shannon diversity index (0.53) and the highest (0.34) was recorded in OFG representing all six recorded amphibian species including one critically endangered species, leaf nesting shrub frog (*Pseudophilautus femoralis*) which was not recorded in NOFG. Therefore, it is evident that these organic farm habitats act as wildlife refuges and neutralize the negative effects of non-organic farming on amphibians to a certain extent. Thus, proper conservation plans should be implemented through research to manage and improve the existing local habitats and thereby protect the amphibians.

Keywords: Amphibians, Conservation, Nuwara Eliya, Organic farming, Jetwing St. Andrew's

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Evaluation of Filter Media Prepared From Natural Materials to Improve the Water Quality of Drinking Water

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Abstract

Water quality is a vital factor for the human health and well-being. Even though in most of the areas in Sri Lanka have less impurity of water, people in dry zone are suffering from poor quality of water mainly due to hardness. The objectives of the study were (a) to produce filter media from natural materials such as moringa bark, rice husk, and natural sea sand, (b) to evaluate its filter media properties, and (c) to evaluate them as a filter media for the removal of hardness and turbidity in water. The filtration media were produced from natural sea sand (NSS), carbonized moringa bark (CMB) and carbonized rice husk (CRH) and they were used for the preparation of filter cartridges. Three replicates of filters were used to evaluate the filter materials. Thirty liter of water was filtered through the filter as 2L batches. The drinking water quality parameters; hardness, pH, Electrical Conductivity (EC) and turbidity were measured in raw water and filtered water. Raw water hardness (270 mg/L), EC (1130 $\mu\text{s}/\text{cm}$), Turbidity (12.0 NTU) and pH (6.2) of water were recorded and the same parameters of filtered water were also measured during the filter evaluation process. Reasonable reduction of hardness was not observed when these materials are used as filter media after converting into char. The changes of hardness in three different filter media were significantly different. However, hardness changes among moringa bark and rice husk were not significantly different. It was found that reduction of hardness in natural soil was low compared with other filter materials. However, pH and turbidity in filtered water were within the recommended limit of drinking water. Based on the results of this study, the filter materials used to reduce hardness cannot be recommended for the preparation of drinking water filter. However, further studies using the mixtures of these materials in different ratios for the removal of hardness is suggested.

Keywords: Charred Moringa Bark, Charred Rice Husk, Hardness, Natural Sea Sand

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Genetic Diversity of Selected Sri Lankan Traditional Rice (*Oryza sativa* L.) Varieties

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Abstract

A large number of traditional rice accessions belong to Sri Lanka, which may serve as a valuable genetic resource for the improvement of rice mainly in terms of biotic and abiotic stress resistance and nutritional upgrades. However, these varieties are rapidly being disappeared due to replacement of agronomically improved inbred varieties. The utilization of traditional rice germplasm in rice quality improvement is currently being practiced upon morphological features. A detailed understanding of the genetic structure and diversity of traditional rice accessions is vital for efficient utilization of rice genetic resources and identify potential parents. In the present study, 33 SSR markers were used to assess genetic diversity and relatedness among 31 rice accessions including 151 individuals from plant genetic resource centre, Sri Lanka. All 33 loci displayed polymorphism (66.7-96.9 %) among the 31 accessions, 387 alleles identified with an average of 11.72 alleles per accession. Moderately high genetic diversity was found for accession 4770 ($H_E = 0.561$), while the accession 3947 recorded the lowest ($H_E = 0.344$) diversity. The AMOVA results indicated that 34% of the variation distributed among accessions, 59% among individuals and 7% within individuals, indicating a comparatively high level of genetic differentiation among individuals of selected rice accessions. Structure analysis results illustrated that all 31 accessions were genetically structured into fifteen well-separated groups, high ΔK peaks were recorded at $K=15$, $K=5$, $K=19$ and $K=2$, respectively. Accessions viz. 12818, 2504, 2340 and 3470 showed low admixture while 2087, 4236, 3440 showed a moderately high rate of admixture. UPGMA results indicated accessions: 4236, 4595, 2119 were differentiated from all other accessions. This genetic diversity assessment at the molecular level provides reliable information to avoid duplication of traditional rice accessions/varieties in the gene bank at plant genetic resource centre and selection of germplasms to develop new rice varieties. Therefore conservation of traditional rice genetic resources for future breeding programs is vital important.

Keywords: Genetic diversity, Indigenous rice, Rice landraces, Rice genetic resources, SSR markers

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Morphological Diversity in Twenty *Capsicum Chinense* Accessions

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Abstract

Chili is a major spice crop in Sri Lanka with a per capita consumption of 2.84 kg. According to the field crop and development Institute in Sri Lanka, 49,928 Mt of Chili is imported annually to fill the gap between the demand and the production. The genus *Capsicum* consists of more than 25 species and out of them, five species are domesticated. In Sri Lanka, there are locally available *Capsicum chinense* accessions within a broad morphological spectrum. The *Capsicum chinense* accessions are not properly characterized yet because the greatest attention has been directed to *Capsicum annum*. In the present study, twenty *Capsicum chinense* accessions were collected from PGRC, Gannoruwa & Agricultural Research Station, Telijjawila and explored the morphological diversity of *Capsicum chinense* accessions. Twelve quantitative morphological traits and eighteen qualitative traits were considered to evaluate *Capsicum chinense* accessions in a protected house. Data were analyzed using IBM SPSS 22 statistical software. Two principle components (PC) exhibited more than 1 Eigen values. PC 1 and PC 2 explained 52.65%, 18.37% variability, respectively and cluster analysis showed that there were five major clusters at cluster distance 8 among the collected accessions. In 2D scatter plot diagram, tested chili accessions were dispersed in 3 quadrants suggesting that genetic variation among them was fairly wide. According to the frequency distribution of 18 qualitative traits, anther colour, corolla colour, and pod shape largely contributed to the variability within the accessions. The clustering pattern can be used for the selection of parental materials with diverse characteristics as this gives a picture of similarities and dissimilarities of individual *Capsicum chinense* accessions which are not familiar to the local farmers and researchers.

Keywords: *Capsicum chinense*, Cluster analysis, Genetic diversity, Morphological traits, Principal component analysis

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Agricultural Economics and Social Sciences



Keynote speech

Agriculture in the Contemporary World: The Economic and Environmental Issues

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Abstract

This paper seeks to highlight the economic and environmental issues concerning the agricultural sector in the contemporary world. It emphasizes the role of agriculture in the process of overall economic growth and poverty reduction. The recent developments in the rental markets of agricultural capital goods have been tapped quite successfully by the small and marginal farmers which are a healthy sign when the average size of agricultural land holding is shrinking. On the other hand, the global climate change is expected to not only adversely affect agricultural yields, labour productivity, and insurance coverage but also increase the gap between rich and poor countries as far as the fate of their farmers is concerned. The role of innovations in agricultural technology in dealing with the dual challenges of degradation of natural resource base and global climatic change is also discussed in this paper.

Keywords: Agriculture and economic growth, Agricultural factor markets, Climate change, Agricultural technology.

Introduction

Agriculture has gone through several phases of transition thereby giving way to development of other sectors. In the process of structural transformation the shares of agriculture in gross domestic product (GDP) and employment have declined in all the economies around the world. However, the rate of decline in employment share of agricultural sector has lagged behind that in GDP in the developing countries mainly due to their low labour productivity. Consequently agriculture has still been the main source of livelihoods for the majority of their population. Notwithstanding this, because of lesser and lesser percentage contribution to the economy and a falling share of expenditure on agricultural products agriculture is often seen as a declining sector and one which should receive less policy priority than others in efforts to promote growth (Carlson 2018; Colman, 2009; Timmer, 1988). Such a perception is not only wrong but also unfounded. The world produces more agricultural output and feeds more people than ever before, and this role would be much bigger in the decades to come. Moreover, the role of agriculture in the economy does not end with only its percentage contributions to GDP and employment. Even in the developed countries where these shares are low agriculture has been and will continue to be the main driving force as the source of food and energy, and sustenance for the entire population irrespective of their sector specific employment. Because of this and the growing challenges of food and nutrition security that the policy makers need to refocus on agriculture to fight the challenges of 21st century including those emanating from beyond the national boundaries.

Agriculture's role in economic development

The general economic growth in any economy is to be preceded by a rapid agricultural growth (Timmer, 1988). Even the industrial revolution in England in the eighteenth century that paved the way for rapid technological progress and industrialization around the world was supported by agricultural revolution that preceded it. A rapid growth in agriculture provides cheap food and raw materials for the industrial sector. As productivity in agriculture improves with growth it releases manpower for industrial sector. Moreover, a progressing agriculture sector helps industrialization as the rural population constitutes the major chunk of demand for their

products. Because of this role it is often found that the economies which are stagnant in agriculture are those which are also lack industrial development (Timmer, 1988).

No country has been able to sustain a rapid transition out of poverty without raising productivity of its agricultural sector (Timmer, 2007). A rapid growth in the productivity of agricultural sector has an important role in poverty reduction in rural as well as urban areas. This is because of a lower food prices resulting from higher production and an increase in rural wages (Ravallion and Datt, 1996). For example, Thirtle et al (2002) find that a 1% increase in crop productivity reduces the number of poor people by 0.48% in Asia. Such a poverty reducing role of agriculture sector is much higher than other sectors of the economies of not only low income but also middle income countries (Pingali, 2010). Therefore, any anti-poverty policy should focus on uplifting the conditions of the agricultural sectors because it is the sector where most of the poor are dependent for livelihoods.

It may be noted that the process of structural transformation in most of the developing countries with relatively a higher poverty has remained slow because of bottlenecks like poor infrastructure, low technology, low labour productivity, higher transaction cost, and lack of integration between urban and rural economies.

What makes agriculture distinct from other sectors?

Agriculture is basically a land based activity which is critically dependent on natural factors like land, water, rainfall, temperature etc. The production system is itself biological which is critically dependent on the sustainable use of land and water, and also the climatic factors which are beyond the control of the farmers. This gives rise to the issue of sustainability of agricultural production which makes agricultural sector quite distinct from other sectors of the economy. Unlike the industrial and service sector the output of agricultural commodities is highly vulnerable to supply and price shocks. Moreover, compared to others the people engaged in agricultural sector find it more difficult to protect themselves from risk with insurance because of the fact that the risk faced by them are not independent and hence the private insurers are usually not interested to come into the picture as a result of which the insurance coverage for the farm sector very low in the developing countries. Further, the terms of trade of agricultural products are historically low and they have declined over the years.

Agricultural factor markets: Recent trends and their implications

Agricultural activities are mainly land based. The inelastic supply of land and conversion of agricultural land into non-agricultural activities have limited the scope of area expansion under agriculture is limited. On the other hand, the average size of farm land holding is declining. Historically the land reform measures that focused on distribution of land among marginal farmers are not only unfeasible but also may be counter-productive. There may not be enough land to redistribute and doing so may result in pulling down all rather than pulling up the marginal ones (Goswami, 2017). Therefore, what is more important in today's context is improving landless and needy farmers' access to land to operate on through appropriate tenancy reforms.

Contrary to the conventional wisdom small farm size need not be a hindrance to agricultural mechanization and development. For example, despite consolidation of land holdings remaining unimplemented in many parts of India and the average size of individual holding going down over the years mechanization of farms is on the rise even among the small and marginal farms in recent times (Das and Tamuli, 2017). The experience of many parts of India shows that the rental markets for water and agricultural capital goods have emerged which has been successfully tapped by many small and marginal farmers who cannot afford to buy these capital goods (Dutta 2017, Das and Tamuli, 2017). Moreover, the owners of such goods like shallow tube wells, power tiller, tractor etc. have also been benefitted by renting them out after using

them in their own field. Thus the markets have helped optimal use of the otherwise indivisible agricultural capital goods.

Trade in agriculture

In this era of globalization the importance of trade in agricultural commodities can be visualized from the facts that the average annual volume growth in agricultural trade between 1950 and 2010 was about 4 per cent compared to the annual growth in global agricultural production of about 2 per cent (Cheong et al, 2013). This increasing volume of trade has played a huge role in reducing global hunger and food insecurity. However, agriculture is one of the most distorted sectors in international trade with relatively a high tariff and subsidies compared to other sectors (Cheong et al, 2013).

The well-being of farmers in the developing countries who are mostly poor has been a major socio-economic issue. The special contribution of the farmers in providing food and energy, and therefore the need of taking care of their well-being has implications for economics of cultivation in general and trade in particular of agricultural products. Agricultural subsidies and protection to farming has been a controversial issue in trade negotiations. While a relatively smaller number of people engaged in agriculture sector has been supported by a huge amount of subsidies by the rich countries the developing countries cannot afford to do the same out of their relatively smaller public exchequer for a huge population engaged in farming. Moreover, the provision and continuation of large amount of subsidies to their farmers may turn out to be counter-productive by hampering agricultural investment and thereby its growth. There still exist high tariff and non-tariff barriers which are detrimental to exports from the developing countries. Ironically the rich countries spend a huge amount in subsidizing and protecting their farmers which is detrimental for not only the farmers of developing countries but also their own taxpayers and consumers (Timmer, 2007). Besides, the agony of the developing countries in trade negotiations is compounded by the fact that while the developed countries promote production of 'dirty-industry' manufactured goods and buy them at lower prices from the former they discourage imports of agricultural produce by setting a higher standard of safety which the developing countries often fail to comply with.

Climate change and agriculture

Perhaps the most serious challenge confronting the agricultural sector is climate change. Since agriculture is critically dependent on climatic factors like rainfall and temperature it is highly susceptible to the adverse effects of global warming and extreme weather events. Climate change which is predicted to be worse in coming decades threatens the sustainability of agriculture through its effects on biotic (such as pest, pathogens etc.) and abiotic factors (such as variations in solar radiation, water, temperature etc.) (Aryal et al, 2019).

The predicted future impact of climate change on agriculture, however, is going to be heterogeneous. The regions, especially in the developed countries where temperature is relatively low may be benefitted from the increased temperature as it may help cultivation of some crops which is otherwise not feasible because of low temperature. However, the available empirical evidence from around the world show that the net impact of climate change on agricultural yield is going to be negative in most of the regions. These adverse impacts are going to be exacerbated in the developing countries because of excessive dependence on rainfall, a relatively higher existing average temperature and limited adaptive capacity of their farmers who are mostly poor. In fact the developing countries are predicted to suffer an average 10 to 25% decline in agricultural productivity by 2080s (Mahato, 2014). The loss in crop yield may be even larger in some regions of the developing countries due to their existing relatively higher temperature, lack of adequate infrastructure like irrigation, farm loan, farm insurance etc.

Climate change has the potential to affect agriculture by changing labour productivity as well. It can increase the incidence of vector and water borne diseases thereby raising morbidity and illness. The extreme weather events like flood and drought may aggravate the problem of safe drinking water and mental illness. All this will affect health of the farmers who have very limited capacity to fight them which will ultimately adversely affect their productivity.

The amount of risk and uncertainties associated with the agricultural sector is going to be exacerbated owing to climate change. This will increase the insurance premium for the agricultural activities and thereby jeopardize their insurance coverage. Ironically the farmers would be unable to have access to insurance because of higher premium when they would require it more urgently than ever before. There is a need for modifications in the design of the crop insurance schemes with a much more important role of both the private and public sectors. The public sector may address catastrophic risk and provide multi-peril insurance where subsidy requirement is high, but allow private sector to provide insurance products for less severe events and for individual independent idiosyncratic and localized risk (Swain, 2014).

The above discussion points to the fact that climate change is going to further widen the gap between the developed and developing countries as far as the fate of their farmers are concerned. To reduce the adverse impacts a combination of adaptive measures may be adopted. The measures that can be helpful in this regard include cropping pattern changes, crop diversification, water harvesting and water management, preponing and postponing sowing dates, integrated pest management, water harvesting, real-time weather forecast, extension services, and technological development.

Future of agriculture and the role of technology

The increase in agricultural production in the 19th century was facilitated by area expansion scope of which gradually declined. Thus there was an urgent need of intensive cultivation and technology in the form of high yielding variety of seeds, chemical fertilizers and irrigation played an important role since the 1960s in increasing global food production and reducing global hunger. During 1960 and 1990, global cereal production doubled, per capita food availability increased 37 percent, per capita calories available per day increased 35 percent and real food prices declined 50 percent (McCalla, 2001). However, there are significant regional variations with respect to the impact of this new agricultural technology. Moreover, the intensive agricultural practices of the new agricultural technology have resulted in significant land and water problems such as soil degradation, and over-exploitation of ground water thereby threatening the sustainability of agriculture sector.

Despite the adverse consequences of the agricultural technologies in the recent past if anything can feed the growing population in the face of degrading natural resources like soil and water, shrinking cultivable land, and climate change it is the technology. Taking lessons from the past and to meet the new challenges technology is to be impoverished accordingly. The agricultural research and development have gone a long way with developments in the field of genetic engineering and biotechnology which has been facilitated by support of private sector. To make agriculture sustainable there is a need of development of seed varieties which are more resilient to climate extremes, and increased temperature, insects and pests attacks. Moreover, vertical farming and hydroponics can help produce more in the face of land and water scarcity particularly in case of fruits and vegetables. It is worth mentioning that many progressive farmers in rural and even urban areas are coming up who use a combination of traditional and modern farming techniques that can help sustainable agriculture. Many agricultural start-ups have come up which act as a link between farmers, input dealers, and wholesalers etc. who assist them in providing timely inputs along with useful information.

The forthcoming technology that can help the agriculture in the face of challenges include conventional breeding, genetically modified food, information revolution, GPS, vertical farming, high-tech urban start-up, nanotechnology etc. It may be noted that there has been a shift in the agricultural research and development (R&D) from public sector to multinational corporations which has been facilitated by a new set of incentives such as protection of intellectual property rights, growing importance of molecular biology and genetic engineering and more open agricultural input and output trade (Pingali, 2010). Though such developments in private agricultural R&D are welcome but they may be not accessible to poor farmers. Hence government should come forward and some philanthropists may also step in to help them in this regard.

Conclusion

No country can progress by ignoring its agricultural sector. The role of agriculture in an economy is far bigger than just its contribution to GDP and employment in that it is the source of sustenance for the entire population. One of the biggest issues confronting the world today is to ensure food and nutrition security for a growing population in the face of dual challenges of degradation of natural resource base and global climatic change. In the developing countries where average size of agricultural land holdings is shrinking recent developments in the rental markets of agricultural capital goods along with some tenancy reforms can be very helpful for the growth of their agricultural sector. On the other hand, to cope with the adverse impacts of climate change on agricultural yields innovations in technology along with ex-ante coping strategies like changing cropping patterns, preponing and postponing sowing dates etc. may be helpful.

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Plant Quarantine in Sri Lanka; Past, Present, Weaknesses and Opportunities

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Abstract

The National Plant Quarantine Service (NPQS) aims to prevent the introduction of alien pests into Sri Lanka, which may harm the flora and the environment of the country. The institute is located in Katunayake and headed by an Additional Director. There are four plant quarantine stations (PQS) at the entry points under NPQS. It has seven technical divisions and two supportive divisions where each division has a specific role. The objective of this exercise was to identify weaknesses of the present system and recommend future requirements and possible mitigation methods. This study was performed based on the SWOT analysis carried out where information obtained from NPQS publications, annual reports, formal discussions and group sessions with senior officers, officers in charge of plant quarantine stations (PQS), and other stake holders such as coconut research institute, export development board, etc. who has a knowledge on legislations and operational procedures. The main weaknesses identified were that there was no legal coverage for most of the activities carried out in compliance with international plant protection convention (IPPC) such as pest risk assessment and pest surveillance, stake holder role, responsibilities and rights. The Institute continuing its activities with limited skilled training staff as well as experiencing; limited fund allocations and lack of awareness programs are also among identified weaknesses. In order to mitigate these weaknesses, the amendment of quarantine act is necessary. A qualified staff recruitment procedure and scheduled staff training is a requirement to carry out efficient pest diagnosis, pest risk assessments, and other operational activities. The funds could be raised from the government and private sector partnerships for repairing and maintenance of laboratory equipment for high efficiency. Stake holder discussions and awareness programs are necessary to emphasis the importance of plant quarantine in Sri Lanka. Moreover, research need to be focused on pest diagnosis and surveillance to find out changes in pest biology, development of treatment standards, identifying alternatives for methyl bromide, and explore the efficient biological control strategies. Mitigation of these shortcomings may enhance the pest-free quality international agriculture trade and also minimize noncompliance rate. As a result, this provides opportunity to access new international markets and thereby increase our foreign revenue.

Keywords: Plant Quarantine, SWOT analysis

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Impact of Individual Characteristics of Agriculture Inspectors on Knowledge Acquisition Process: A Study in *Hambantota* District in Sri Lanka

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Abstract

Agriculture extension services are designed to enable the diffusion of knowledge about farm technology. Agriculture Instructors (AIs) act as bridges implying that their capacity to absorb and diffuse knowledge is crucial for the effectiveness of the entire knowledge dissemination system. Despite the vast amount of research done on organizational dimensions on knowledge acquisition by agriculture extension officers, few studies address individual dimension in general and the role of knowledge acquisition in particular. In this study, we examined the extent to which individuals' capability to identify and acquisition new knowledge from external environment is shaped by their motivation, ability and opportunities drawing on MAO (Motivation, Ability and Opportunity) framework. To explore this, 72 AI officers in the Hambantota District in Sri Lanka were surveyed using a semi-structured questionnaire. Multiple regression model was used for our analysis and tested basic four assumptions before data use for regression analysis. This study found a positive and insignificant effect of individual ability on knowledge acquisition process ($\beta=0.008$, $p>0.05$). Further, we found that individual motivation has a negative and statistically insignificant impact on knowledge acquisition ($\beta=-0.001$, $p>0.05$). Moreover, opportunities show positive and significant impact on knowledge acquisition process ($\beta=0.324$, $p<0.05$). Based on these research findings, we conclude that opportunities and individual abilities of AIs for the access of new knowledge is much more important in Sri Lankan context and individual motivation to accesses new knowledge does not equally important for knowledge acquisition. Therefore, government of Sri Lanka should improve individual ability of AI officers as the primary mechanism to improve their performances and should stimulate their interest by developing and sustaining opportunities through social interaction. Moreover, we can propose different groups of activities to HR managers of the organization such as increasing individual ability (through staffing, training, performance appraisal) and providing opportunities (by improving communication, team building, and creating the right corporate culture to acquire knowledge).

Keywords: Ability, Agriculture instructors, Knowledge acquisition, Motivation, Opportunity

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Efficiency and Imperfections of Rental Markets of Tilling Machinery: A Study in the Brahmaputra Valley in Eastern India

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Abstract

Rental markets of tilling machinery have emerged as important factor markets in rural India enabling even small and marginal farmers to mechanize their tilling operations. It is, however, pertinent to examine if outcomes of these markets are vitiated by imperfections. Apart from the usual sources of inefficiency, one specific form of imperfection in these markets can arise from the fact that the suppliers are mostly user-suppliers rather than independent suppliers. Since tilling machinery are leased out only when these are not required in the owners' farms, the hiring-users may not have access to such capital goods at the most opportune times. To examine if this apprehended market imperfection has manifested in reality, a sample survey of farms was carried out in 2013-14 covering the Brahmaputra Valley, an agriculturally important area in Northeast India. The sample of 232 farm households surveyed was drawn through a three stage sampling design. First, three districts from upper, central and lower Brahmaputra Valley were selected to make the survey geographically representative. In the next stage three villages from each of the selected districts were selected. In the Final stage 12% of farm households from each selected village were selected at random as ultimate sampling units. Analytical tools used include Fisher's t-test, Tobit model and Log-linear regression. Analysis of survey inputs revealed little impact of market power distorting the rental rates. The owner-users on the average achieved somewhat better farming outcome than the hiring-users, but the observed difference is statistically not significant (p values are in excess of 0.177 for each indicator of farming outcome). It is hence concluded that the rental markets of tilling machinery in the Brahmaputra Valley are functioning without serious imperfections.

Keywords: Farm capital goods, Imperfection, Rental market

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Are Young Women Abandoning Agriculture in Sri Lanka? Livelihood Choices of Rural Women

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Abstract

Livelihood diversification among rural youth reflects potential impacts on agricultural sector of Sri Lanka. Due to the uneven gender distribution of youths in the population, gender-based assessment of livelihood choice & migration decision is an urging requirement. Therefore, this study was designed to assess the household and individual factors affecting rural female youths' choice of livelihood and their choice of migration. A national representative sample of rural youth was isolated from the secondary data compiled under the Household Income and Expenditure Survey (HIES) – 2016 by the Department of Census and Statistics (DCS) and a multinomial logit model under random utility framework was estimated to assess the livelihood diversification. A probit model of migration outcome was estimated to assess the rural youth's choice of migration. Results revealed that being a female youth makes the choice of livelihood less likely to be agriculture instead favours livelihoods apart from agriculture. Education act as an upward driver in choosing urban salaried employment while educated youth tend not to choose agriculture. However, age and education levels of the household heads do not influence the young women's livelihood decisions. Livestock holdings of the household exhibits a direct relationship with the young women's probable livelihood choice to be agriculture. The tendency to migrate reduces with increased access to agricultural land. Female youths are less likely to be migrated however married female youth exhibits significant propensity to be migrated. Majority (49%) of rural young women are students of any kind. High unemployment prevails among young women and 22% of young women were engaged in household activities while only 14% being employed. Thus, the study suggests policy reformations to promote domestic level entrepreneurship for economic empowerment of young rural women.

Keywords: Gender inclusivity, Livelihood choices, Rural youth, Sustainable agriculture, Women empowerment

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An Analysis of the Relationship between Advanced Level Z-Score and Academic Performance of Graduates of the Faculty of Agriculture, University of Ruhuna

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Abstract

Scientific analyses on the factors that influence the undergraduates' academic performance are essential in revising curricula and assessment strategies. The objective of this study was to determine the relationship between University entrance Advanced Level (A/L) Z-score and undergraduates' academic performance indicators including semester grade point average (SGPA) and overall grade point average (OGPA). Z-score, SGPA and OGPA of 402 Agricultural Resource Management and Technology (AT), 136 Agribusiness Management (AB) and 123 Green Technology (GT) graduates of the Faculty of Agriculture, University of Ruhuna (FAUR), who completed their programmes in 2016, 2017 and 2018 were considered for the study. Pearson correlation was used to determine the relationships between Z-score with SGPA and OGPA. The Mean Z-score of the students enrolled at FAUR was 0.9418 and ranged from -0.6458 to 1.5444. Female students had significantly higher Z-score than males. Z-scores of the students of AT, AB and GT were not significantly different. The dropout rate was 6.5%. Dropouts had lower Z-scores at entry and SGPA levels in the exams they sat than those who completed. GT graduates reported a significantly higher OGPA than AT graduates. AB students' OGPA value was not significantly different from those of other two programmes. Female students of all three programs reported higher OGPA value than male students. Those who passed the English Level I examination and who submitted the thesis of the final year research on time had secured higher OGPA than those who had not. The percentages of AT, AB and GT graduates with a class were 50.7%, 69% and 83.5%, respectively. All the first class holders and 77% of the second upper class holders were female. Compared to 34% among males, 75% of the female students had completed the programme with a class. Z score had stronger relationships with the SGPA of 5th (R=0.962), 4th (R=0.954 and 3rd (0.918) semesters. Significant, but weak relationships between Z score and OGPA were reported for AT (R=0.32), AB (R=0.32) and GT programmes (R=0.42). OGPA gave its strongest relationship with first semester GPA (R=0.59; p=000). Z-score is concluded to be a weak predictor of the final performance. Academically, females outperformed male. Need of more effective orientation programmes and, considerations on the high degree of variation in entry-level academic background in revising the curricula and selecting teaching and assessment strategies of the FAUR is highlighted.

Keywords: Academic, OGPA, Performance, Undergraduates, Z-Score

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Prospects and Challenges of Vegetable Exporters in Sri Lanka during Year 2000 to 2015

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Abstract

The vegetable sector is one of the leading subsectors which significantly contribute to commercialize the non-plantation agriculture in Sri Lanka. This sector has a potential for diversifying the peasant farming while generating foreign income to the country. This study is a situation analysis in terms of the competitiveness, potentials and the limitations in vegetable export sector during 2000-2015. Primary data was collected using a pre-tested questionnaire. Sample size was 28 exporters out of 40 registered vegetable exporters. Secondary data was collected from the annual reports of Export Development Board. Revealed Comparative Advantage (RCA) and Comparative Export Performance (CEP) indices were used to analyze the competitiveness. Potential vegetables for the major importing countries were identified calculating the Indicative Trade Potential (ITP). Results reveal that the contribution of the vegetable export sector to total export was 0.25% in 2015 and the world market share was less than 0.1% from 2006 to 2015. SAARC, Middle East, Europe and countries with NAFTA are the main export destinations. Dried leguminous vegetables are exported in the highest quantity. Sri Lanka has occupied the 81st position among vegetable exporting countries to the world in 2015. RCA index described that Sri Lanka has the comparative advantage over Malaysia and comparative disadvantage over Egypt. However, the CEP index reveals that, Sri Lanka is losing its vegetable export performances. HS: 071340-Dried and shelled lentils have recorded the highest trade potential in the SAARC, Europe, NAFTA countries and Middle East. Results show that vegetable export industry is still underdeveloped in agribusiness infrastructures. Further, high air freight charges, inability to offer satisfactory prices, lack of advanced technology, irregularity and insufficiency of quality vegetable supply and lack of incentive programs are identified as main limitations of the sector. This research recommends that competitive countries for particular markets should be identified and need to analyze the factors to compete with them. Government should give subsidies and incentives to the exporters to increase the production of potential vegetables. Sri Lanka should use the latest technology to the continuous quality vegetable production.

Keywords: Comparative export performance, Export, Foreign exchange Vegetable, Revealed comparative advantage

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Adoption of Good Agricultural Practices by Vegetable Farmers in Galle District in Sri Lanka

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Abstract

The main challenges involved in vegetable production are price fluctuation, low level of income for farmers, and lack of quality fresh products in local and export markets. The adoption of Good Agricultural Practices (GAP) in vegetable production systems will be a sound solution to overcome these problems as it helps farmers to reduce the cost of agrochemicals, chemical contamination of the farmers, and environmental pollution. Also, it leads to produce better quality vegetables by preventing on-farm contamination of vegetables. Thus, the present study aimed to find out the adoption of GAP by vegetable farmers and their attitude towards the GAP, using 100 randomly selected vegetable farmers in the Galle District. The sample was obtained by applying a multi-stage simple random sampling technique and data were collected from March to July 2018 using a self-administered questionnaire survey. Garrett's ranking test and Chi-square test were employed in data analysis. The findings revealed that most vegetable farmers in the Galle district have a general level of awareness on GAP, and a positive attitude towards the GAP programme. However, most farmers do not adopt the GAP, and some farmers lack the required amount of information, technical know-how, inputs, capital, labour, and required field conditions to practice GAP, even though they wish to practice it. According to the results, awareness of GAP, GAP certification, and the awareness of the importance and benefits of GAP were the significant factors affecting the adoption of GAP by vegetable farmers. Therefore, farmers need the correct guidance to make them aware of the GAP programme. An association was noted in gender (male) (P-value = 0.019) and land ownership (P-value = 0.000) towards the positive attitude on GAP. Identifying the many potentials and constraints of implementing GAP in the district is crucial. However, by making farmers aware and providing the main requirements, it would be possible to motivate farmers towards the adaptation of GAP in vegetable production systems.

Keywords: Adoption, Attitude, Galle district, Good Agricultural Practices (GAP), Vegetable farmers

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Evaluation of Farmer Perception on Biofertilizer for Rice in Anuradhapura District

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Abstract

Farmers' acceptance of a biofertilizer is mainly determined by the crop response to it and the socio-economic aspects such as the economic feasibility, awareness of the farmers and government policies. Although biofertilizer is an alternative to inorganic fertilizer, it is still underutilized in Sri Lanka. Lack of knowledge on biofertilizer would be a constraint to popularize biofertilizer application to overcome the alleged hazardous effects of inorganic fertilizers. Therefore, the objective of this study was to assess the perception of farmers on utilizing biofertilizer for rice cultivation and, farmer friendliness and economic viability of introduced novel inoculation method, developed through our previous research work and was introduced to the farmers through a handout. One hundred farmers were randomly selected from Medawachchiya Divisional Secretariat (DS) division in Anuradhapura district. Data was collected through pre-structured questionnaires and, focus group discussions and analyzed through one sample Wilcoxon sign rank test and Pearson's correlation coefficient. None of the farmers had been using biofertilizer in the test group up to the time of study in Medawachchiya DS division. Forty four percent (44%) of farmers were unaware of the importance and constraints related to the biofertilizer application in rice cultivation while, 46% farmers were not aware about commercially available biofertilizer. According to the results of one sample Wilcoxon sign rank test, 82% of the farmers were not ready to adopt biofertilizer application for rice cultivation directly without an assurance on unreduced yield with the biofertilizer in comparison with inorganic fertilizer ($p= 0.447$). Sixty three percent (63%) of farmers were willing to apply biofertilizer after observing results of pre-users and 45% farmers were willing to apply biofertilizer in a small land area before applying it in large scale. A strong correlation was detected between agreement levels for user friendliness and economic profitability of the suggested method ($r=0.828$ at 0.01 probability level). Moreover, income level of the farmers and the cumulative impact of production factors elicited a significantly positive correlation with the agreement level on economic profitability of the suggested method ($r=0.230$, $r= 0.240$ respectively at 0.05 significance level). In conclusion, introduced novel inoculation method was highly perceived by all farmers of the test group due to its potential user-friendliness and economic viability. However, pre-trials and government intervention were preferred by farmers indicating their expectation for assurance on yield to accept the novel method.

Keywords: Biofertilizer, Farmer perception, Novel inoculation method

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Factors Effect on Consumers' Buying Decision of Fresh Vegetables at Retail Level

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Abstract

Commercially cultivated vegetables reach to consumers via numerous marketing channels. Several marketing levels are existed in them such as wholesale marketing and retail marketing. The problem that was going to explore by this study is the effect of different factors on consumers' buying decision of fresh vegetables at retail level. The selected district for the study was Ratnapura. It has a good representation of various socio economical levels. The population of the district was 1,140,000 in 2017. According to Yamane formula, under 95% confidence level the sample size calculated as 400. Convenient sampling technique occupied to select the respondents. The evaluating method was a Likert scale. The scale was from 5 -1 with responses ranged from 5="extremely important" to 1="not at all important". Respondents had to select one response for every statement. The mean values and standard deviations of statements were calculated by SPSS 19 software. The mean values are ranged from 4.38 to 1.90. The highest mean values were belonged to the most effective factors to decide consumers' buying decision. They were freshness (4.38), free from chemical residuals (4.32), free from pest disease attacks and physical damages (4.05) and good sanitary level of the market (4.08) Arrangements to attract children (1.9) was the least effected Availability of minimally processed and pre packed vegetables (2.11), presence of additional services (2.44), facilities to use credit cards (2.48), personal attention to consumers (2.72) were belonged to least important factors. By these results concluded freshness and other factors supportive to keep a better sanitary level of vegetables were highly affected for buying decision of fresh vegetables at retail level while some modern techniques are not much affected. These results are considerably noteworthy for marketers in vegetable marketing channels. They can invest their money in an additionally effective way to maximize their profits while providing better service for the consumers.

Keywords: Buying decision, Fresh vegetables

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Effectiveness of Partnership Extension Models Implemented in Tea Smallholding Sector in Sri Lanka

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Abstract

Tea smallholding sector provides the highest contribution to Sri Lankan tea industry. In recent years the productivity of tea smallholding lands has shown a declining trend. One of the most significant lacuna in the tea sector has been the low level of adoption of proven technologies due to limitations of providing an optimum extension service. The Public-Private Partnership (PPP) extension models have been introduced in tea smallholdings densely located areas of Ratnapura, Kalutara and Galle districts during the last decade as an alternative to provide optimum extension service and develop tea smallholding sector. This study was carried out to assess the performance of three such well-established partnership extension models and to identify the factors affecting their success. Three partnership extension models representing a factory-based model (FBM), an input supplier-based model (ISBM) and, a development agency-based model (DABM) were selected. Six key components of a successful partnership i.e. trust and cohesiveness, motivation to participate, resource sharing, support to achieve long-term expectations, sharing technical information and, satisfaction about the model were used to assess the success of PPP. The primary data was collected using pretested questionnaire schedule followed by key informant interviews with randomly selected 90 smallholders (30 from each model) and extension partners. The findings were revealed that productivity of tea smallholder lands in FBM is highest when compared with other two models due to frequent contacts with smallholders and supplement of needful services by the extension partner. The ISBM provide sponsorships for TSHDA extension programs and level of resource sharing with TSHDA officials is significantly higher than other two partnership model ($p=0.001$). DABM was highly focus on poorer tea smallholders, whilst extension partners of other models more concern to strengthen the relationship with smallholders who having higher land extent. Level of support to achieve long term perspective and the level of satisfaction of tea smallholders about partnership model is significantly higher in the FBM than other models ($p=0.001$). This study proves that trust and cohesiveness, resource sharing, technical information sharing and motivation to work are the success factors for straightening of the partnership and land productivity of tea smallholding.

Keywords: Extension partners, Partnership components, Partnership extension models, Public-Private, Partnership, Tea smallholders

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Consumer Buying Behavior of Aloe Vera and Papaya Natural Anti-ageing Face Creams in Batticaloa District

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Abstract

The present study relates to consumer preference on natural anti-ageing face creams in Sri Lankan cosmetic industry. It is one of the current trends that natural anti-ageing products are being converted to value added forms due to high customer orientation. Among the value added products, Aloe Vera and Papaya natural anti-ageing face creams are two of the excellent products which have emerged in modern cosmetic industry. Importantly, the industry needs to determine the values of their existing products and requirements of potential customers. This will be important to develop and validate a diverse array of metrics to comprehensively capture the attitudes and feelings of modern cosmetics consumers in Sri Lanka. This study aimed to explore the product attributes considered by consumers when purchasing Aloe Vera and Papaya natural anti-ageing face creams through online shopping channels in Batticaloa district. This was done using a conjoint analysis of consumer preferences based on data collected from 130 online consumers along with purposive sampling technique. Socio-cultural factors affecting purchasing behavior of Aloe Vera and Papaya natural anti-ageing face cream were determined using descriptive and Multinomial Regression analysis. Results revealed that volume and ingredients are the most important attributes of natural anti-ageing face cream. Further, if a new anti-ageing cream will be introduced to customers, the best product attribute combination is a tub container Papaya day cream with 100 mL pack. In addition, working location, health consciousness, skin allergic interactions, skin allergic symptoms, skin type of consumer and the usage duration of one face cream tube or tub were the most important determinants of purchasing behavior of Aloe Vera and Papaya natural anti-ageing face creams.

Keywords: Conjoint analysis, Consumer preference, Multinomial regression analysis, Natural anti-ageing face creams

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Study on the Impact of Consumer Awareness of Organic Food on Green Purchase Intention with the Mediation Effect of Premium Price

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Abstract

Continuous degradation of earth is turning the land into a concrete jungle and this led to emergence of the concept of “going green” which creates a tremendous opportunity for food manufacturers as lead for organic food. The two key reasons behind the purchase intention of organic food have been identified as the environmental concern and health consciousness. Further premium price of organic food has been deemed the main reason for not to develop positive purchase intention. The Study was conducted in order to assess the impact of consumer awareness of organic food on green purchase intention with the mediation effect of premium price. The data were collected from a sample of 300 individuals who have purchased organic food from Western Province using multistage and judgmental sampling methods. The mixed research design has been adopted and data was analyzed by using descriptive statistics such as Karl Pearson’s correlation analysis, regression analysis, Baron and Kenny model and Sobel test analysis and thematic analysis. Thus, the results of the analysis concluded that there was a strong positive relationship between consumer awareness and green purchase intention. Further, the relationship between consumer awareness and green purchase intention is partially mediated by premium price. As recommendations, social media promotions, local and international organic certification bodies, outlets within highly complex cities to attract the market segment, environmental concern and health consciousness in marketing organic foods and introduce differentiated and innovative organic food products can be suggested.

Keywords: Environmental concern, Green purchase intention, Health consciousness, Organic food, Premium price

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Visitors' Preferences and Willingness to Pay for Conserving a Forest Reserve in an Urban Area: A Case of Udawattakele Forest Reserve, Sri Lanka

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Abstract

Udawattakele is a historic forest, spread in 104ha, located in the city of Kandy, Sri Lanka. It is rich in floral and faunal diversity and provides diverse benefits to the urban society. Increasing atmospheric temperature is one of the main climate variability at present and an urban society has become one of the main victims. Hence it is important to find out the public awareness and their preferences on conserving the forest reserves and their willingness to pay for future improvements. Therefore, this study mainly focuses to estimate visitors' willingness to pay as an entrance fee on existing and improved situations of conservation of Udawattakelle forest reserve. Contingent valuation method was the theoretical concept applied. Iterative bidding method was used to elicit the local and foreign tourists' willingness to pay. 60 locals and 60 foreign visitors were selected using simple random sampling method. Results revealed that both foreign and local tourists have moderate awareness on the forest reserve and they have positive perception regarding valuation and conservation. Sixty five percent foreign tourists and 79 % local tourists prefer to pay more on improved situation of the forest reserve. They have suggested implementing several activities of forest replanting, conserve wildlife, and removal of invasive plants. The estimated entrance fee values of the existing and improved situations of the local tourists are 51.50LKR and 74.50LKR, respectively. Similarly, foreign tourists are willing to pay 898.20LKR and 1279.16LKR, respectively. Respondents' income is the only significant factor which influenced to the willingness to pay. The study concludes that there is a potential to increase the entrance fee and earn additional income which can be invested to implement the conservation plans of the forest.

Keywords: Conservation, Contingent valuation method, Udawattakele forest reserve, Urban forest, Willingness to pay

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Household Knowledge, Attitudes, Awareness and Behaviour towards Solid Waste Management: A Case Study in Kamburupitiya Divisional Secretariat

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Abstract

Increasing solid waste generation has caused unprecedented damage to Sri Lanka. Present study was conducted as a case study in Magamure Grama Niladari division (GN 330B) and Mapalana Ihala Grama Niladari division (GN 331 D) of Kamburupitiya divisional secretariat. The main aim of this study was to assess the knowledge, attitudes, awareness status and behavior concerning solid waste management (SWM) among the households. Further, as a secondary objective it was targeted to compare the two GN divisions on waste segregation as Mapalana GN division has provided facilities for waste segregation by the local authority. To achieve these aims, a questionnaire based survey was conducted for 100 households in these selected GN divisions. The descriptive statistics were used to interpret the household's knowledge, attitudes, awareness and behavior and the SPSS software was used to compare these two divisions on waste segregation. The results revealed that most of the households (83 %) do not have proper knowledge on SWM. However, most of them strongly believe (98 %) that the improper SWM causes severe environmental pollution. Further, 80% of the households were not exposed to any awareness program on SWM. Seventy six percent and 58% of households do not aware of 3 R concept and recycle number, respectively. Considering the behavior on waste management, most of the households (72 %) used to burn solid waste. Despite the low status of awareness expressed by the households concerning SWM, their behavior and practice to segregate waste were high (80 %). It revealed that there was no significant difference ($p=0.128$) between two GN divisions on waste segregation, though the facilities were provided only to households in Mapalana GN division for waste segregation. Eighty eight percent households were willing to participate to a proper SWM awareness program as many of them (80 %) were not exposed to such an awareness program. Seventy five percent of the households were willing to pay a tax on waste. Further, by considering the findings of this study, it suggests that considerable changes in knowledge, attitudes and behavior can be addressed by awareness programs towards SWM.

Keywords: Attitude, Awareness, Household, Segregate, Solid waste management

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Innovative Technologies for Smart Agriculture and Environment



Keynote Speech

Nepal's Agriculture in the 21st Century: Traditional to Climate Smart Approaches

Anup Pradhan

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Abstract

Nepal is an agrarian country where majority of people rely on farming for their livelihood. Due to small farm sizes and lack of capital, most farmers in high hills and mountains still use traditional approaches and follow subsistence farming. The level of mechanization has increased which is characterised by increasing number of tractors. The use of tractors is mostly limited to Terai region (plain land), whereas low hilly region has adopted two-wheeler tractors. The total GHG emissions of Nepal accounts for 0.09% of the world emissions, however agriculture sector contributes more than half of the nation's GHG emissions. Most of agricultural plans and policies promote sustainable agricultural development through commercial and market oriented economic growth, however the implementation has been unsatisfactory. Climate smart agriculture (CSA) and sustainable agricultural practices have been identified and implemented to improve agriculture production considering climate change and emissions.

Keywords: Agricultural policies, Climate smart agriculture, Emissions, Mechanization, Nepal

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1. Introduction

Nepal is one of the least developed countries in the world, which is located in South Asia between India and China. The country occupies about 0.3% and 0.03% land area of Asia and the world, respectively (CBS, 2019a). Total population in 2018 was estimated to be 28.1 million, of which 80.3% resided in rural areas (World Bank, 2019). The annual population growth rate is estimated at 1.65%. The per capita income in 2018 was reported as USD 1034 per annum.

Land covers about 97.4% of the total area, which is divided into three agro-ecological zones: Hills (rugged terrain), mountains and Terai (flat lowland). Two-third of the land is covered by hills (42%) and mountains (35%), and only 23% is occupied by Terai (Knerr, 2017). Figure 1 shows the nation's land use, of which 28.7% is classified as agricultural area. About 51.3% of agricultural area is classified as arable land, 43.6% as permanent meadows and pastures, and remaining 5.1% is covered by permanent crops.

2. Agricultural practices in Nepal

Agriculture is one of the major means of people's livelihood in Nepal. In 2018, the agricultural sector contributed to 25.3% of total GDP and provided employment to 70.1% of the population (World Bank, 2019). Agriculture is mostly characterized by small scale farms as 76.5% of farm holdings are smaller than two hectares (CBS, 2019b). The average farm size has continued to decrease over the decades (Table 1). Small farm holdings and lack of capital and market have compelled most farmers to adopt subsistence agriculture using traditional tools (Shrestha, 2012).

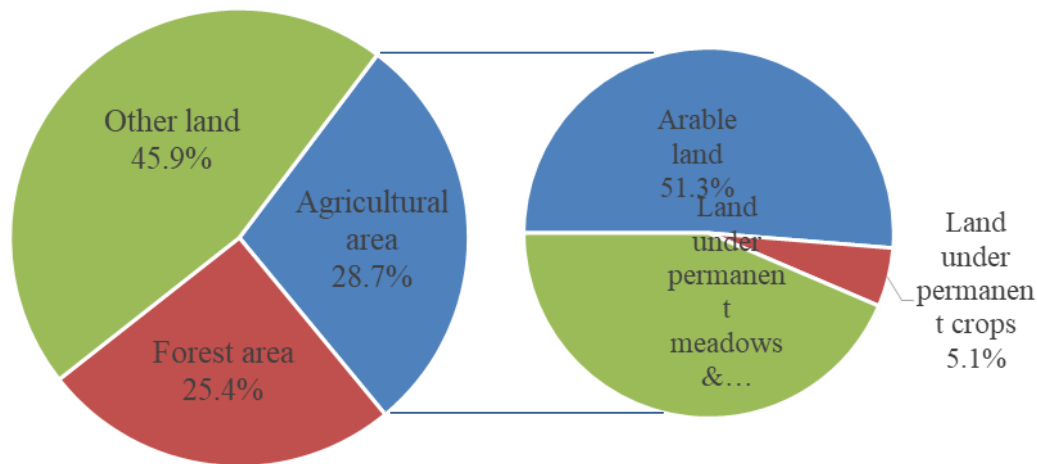


Figure 1. Land use classification of Nepal (FAOSTAT, 2019)

Table 1. Average farm size by agro-ecological zones (CBS, 2006; CBS, 2019b)

Agro-ecological zones	Average farm size (ha)			
	1981/82	1991/92	2001/02	2011/12
Mountain	0.62	0.68	0.74	0.65
Hill	0.90	0.77	0.66	0.57
Terai	1.48	1.26	0.96	0.75
National	1.13	0.96	0.80	0.66

The major cereal crops are rice, wheat and maize, and major cash crops are sugarcane, oilseed and potato. Other agriculture products include pulses, fruits and vegetables. Rice is mostly cultivated in Terai and lower part of mid hills, while maize is mostly cultivated in mid hill to lower mountain regions (Gauchan and Shrestha, 2017). Figure 2 presents area harvested and yields of these agricultural products for last five years. Both area and yields have slightly changed over the years. In 2017/18, the yields of rice, maize, wheat, oilseed, pulses, vegetables and potato observed annual increase of 4%, 5%, 6%, 9%, 2%, 2%, and 22%, respectively. However, the yields of sugarcane and fruits declined by 0.4% and 22%, respectively.

Figure 3 presents the annual fertilizers inputs; green line indicates total fertilizer input per hectare of arable land, which shows an increasing trend, however it remained same in 2015 and 2016. Different sources of irrigation are available for the farmers including dam/ reservoir, tube wells/ boring, gravity fed/ pumping through canals/ rivers. About 66.8% of the cultivable area is irrigable, however only 47.5% was irrigated in 2010/11 which increased to 52.7% in 2016/17 (MoAD, 2012; MoALD, 2018).

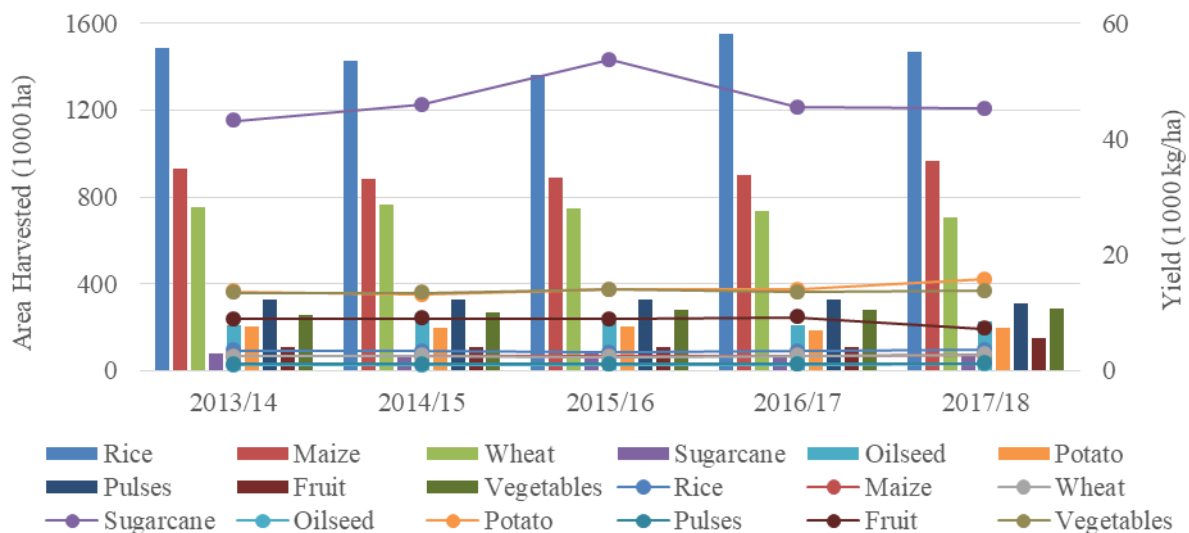


Figure 2. Area harvested and yield of major crops in Nepal (CBS, 2016; CBS, 2018; MoALD, 2018; CBS, 2019c)

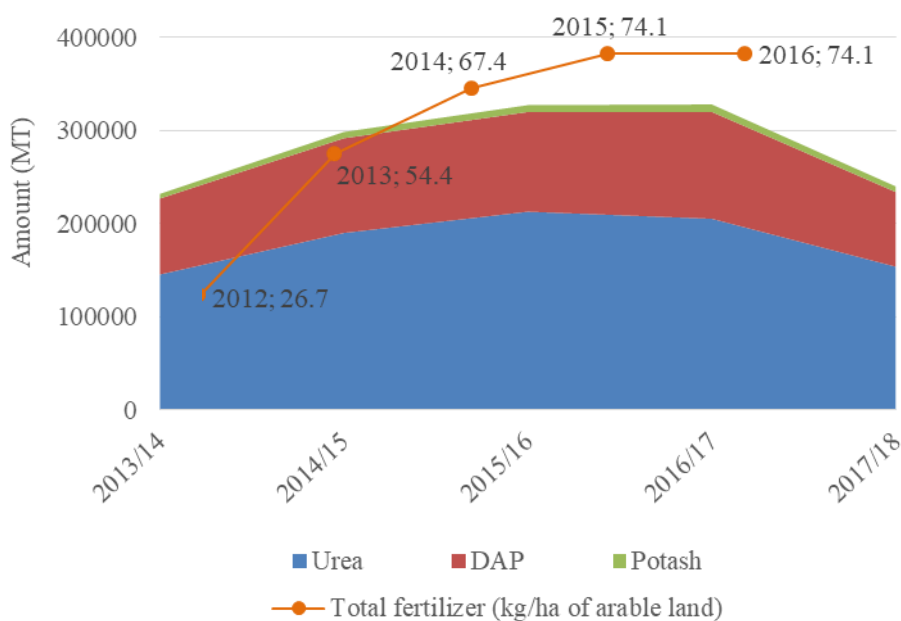


Figure 3. Annual usage of fertilizers (CBS, 2016; CBS, 2018; MoALD, 2018; CBS, 2019c; World Bank, 2019)

Farm mechanization level in the country was used to be low with majority (77%) of farm power needs being fulfilled by human and animal power and only 23% power was being provided by mechanical power. Most of this mechanical power (92%) was concentrated in Terai region (Shrestha, 2012), while most farmers in remote hills and mountain regions relied upon traditional tools. Since 1990, the country has been observing annual growth of number of tractors. Between 1990 to 2000, the number increased significantly from 5000 to 26300, an increase of 462% (World Bank, 2019). In the next decade, the number reached 37425 in the

fiscal year 2011/12 (CBS, 2013), an increase of 42.3%. In 2016, the numbers of tractors were reported to be 47000 (Takeshima, 2017), another increase of 25.6%.

In recent years, Terai region has observed widespread growth of tractors and motorized pumps, and hilly region has started adopting power tillers and mini tillers. Tractors have enabled farmers to intensify production per unit of land and expand cultivated area, reduce labor utilization and increase family income through off-farm activities (Pradhan et al., 2016). The growth of tractors, mainly in Terai region, is due to increase in agricultural production, labor wages, and emigration (Takeshima, 2017), as well as development of market oriented farming. Most of the cultivated area in Terai region can utilize tractors, and growing demand of tractors has played a major role in agricultural transformation in the region. Private sectors and owners are providing custom hiring of tractors, power tillers, combine harvesters, pump sets and other implements. This has benefitted farmers who cannot afford to purchase these implements, and also enabled owners to make additional off-farm income.

Table 2 presents mechanization level of the county, which indicates that there is one tractor and one power tiller (two-wheeler tractor) for every 56 ha and 200 ha of arable land, respectively, compared to one iron plough for every 2.5 ha of arable land. It was reported that about 150 farmers in the Western Terai own combine harvesters (Paudel et al., 2015). These combine harvesters cover 8% of rice and 21% of wheat area, with an average coverage of 200 ha per year.

Table 2. Agricultural implements available in Nepal: 2011/12 (CBS, 2013)

Implements	Total	No. of implements per ha of arable land
Iron ploughs	856283	0,405
Power tillers	10430	0,005
Deep tube well	82009	0,039
Shallow tube well	261975	0,124
Rower pump	36183	0,017
Tractors	37425	0,018
Threshers	51928	0,025
Pumping set/ motor	150304	0,071
Animal drawn cart	159934	0,076
Sprayer	282315	0,134

*Arable land = 2113700 ha

Some farm activities (sowing, weeding, and fertilizer application) are done manually, while some are done using combination of power sources. For instance, during land preparation farmers use tractors for ploughing and animals for levelling. Similarly, both manual and mechanical methods are used in threshing; transportation of harvest is done either manually or using animal-driven carts or tractors.

2.1 Agricultural Emissions

In 2014, greenhouse gas (GHG) emissions including land use change and forestry was estimated to be 44.1 Mt CO₂e, which is 1.13% and 0.09% of South Asia and the world's total, respectively (WRI, 2019). Agriculture sector contributes highest to this emission (Figure 4) adding 52% to the total. About 54% of agricultural emissions is attributed to enteric fermentation, followed by

the emissions from rice cultivation (17%). Emissions from fuel combustion in tractors and pumps, fertilizer production, and waste management contributed to agricultural emissions.

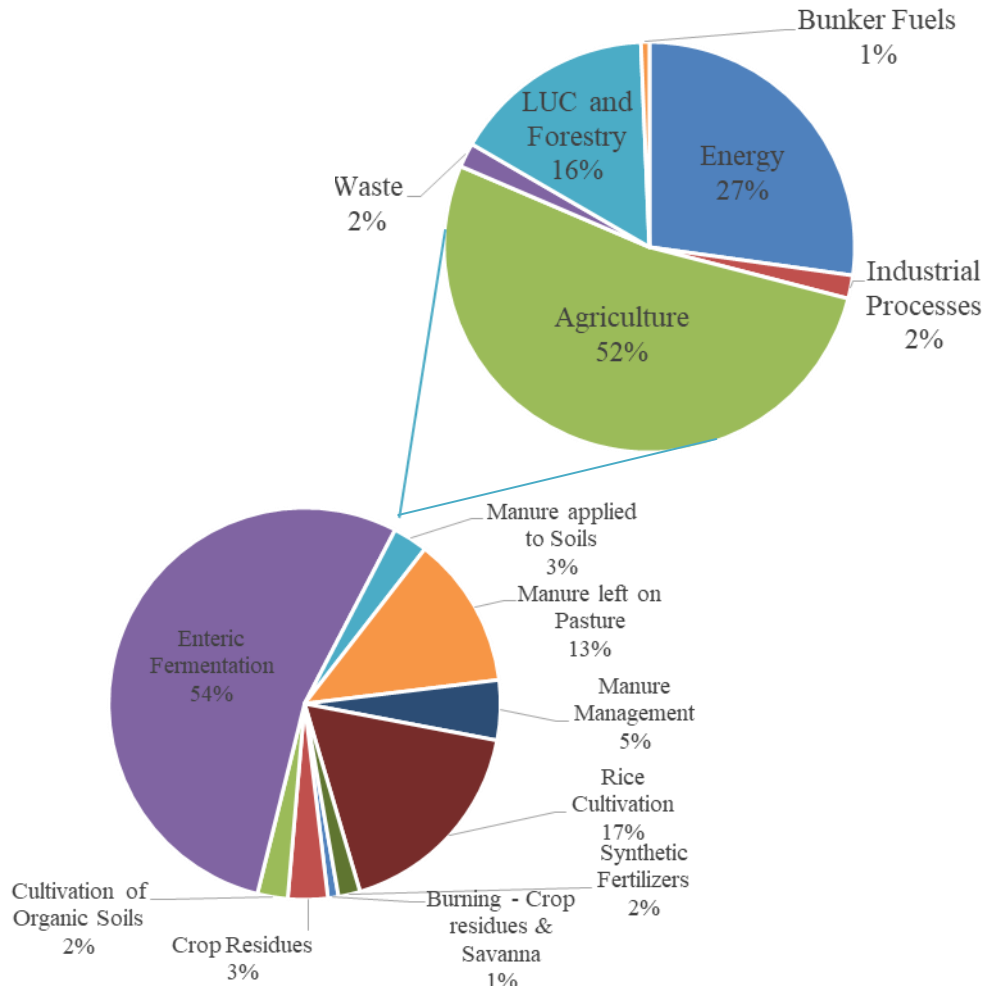


Figure 4. Contribution of Nepalese agriculture on GHG emissions (FAOSTAT, 2019; WRI, 2019)

2.2 Agricultural Policies

Several national policies on agriculture have been adopted, which mostly aim towards sustainable agriculture development, food security, poverty reduction, and promotion of market oriented economic growth in Nepal. Some of the prominent agricultural plans and policies include Agriculture Perspective Plan (APP), 1995/96 – 2014/15; National Seed Policy, 2000; National Fertilizer Policy, 2002; Irrigation Policy, 2003; National Agriculture Policy, 2004; Agribusiness Promotion Policy (AgPP), 2006; Agriculture Bio-diversity Policy, 2007; Trade Policy, 2009; Agriculture Mechanization Policy (AMPP), 2014; Agriculture Development Strategy (ADS), 2015-2035. Most of earlier plans and policies overlooked agricultural mechanization which affected the investment, research and proper implementation of mechanization throughout the country. To address this gap, AMPP was introduced to promote mechanization which is friendly to different agro-ecological regions, climate, and gender (GC et al., 2019).

ADS is the latest long term plan, which was adopted in 2014 with a vision of “A self-reliant, sustainable, competitive, and inclusive agricultural sector that drives economic growth, and

contributes to improved livelihoods and food and nutrition security” (MoAD, 2014). ADS included agricultural mechanization as one of thirteen core priority areas, which promotes agricultural mechanization through creation of awareness and financial arrangements, tax regulations, public-private coordination, and institutional mechanism (Takeshima et al., 2016).

Agricultural plans and policies aim to transform farming from subsistence to commercial level through public-private coordination. Majority of policies, however, has not performed satisfactorily as there is a gap between contents and their implementation. Other policy gaps include: (i) lack of policy to regulate or control conversion of productive lands into housing and other infrastructure; (ii) lack of consideration of land consolidation issues; (iii) lack of agricultural legislation to implement NAP; and (iv) lack of information dissemination about agricultural services and cooperative supports to farmers (JICA, 2013).

Ministry of Agricultural Development (MoAD) provides 50% subsidy on imported power trailers and tax exemption for tractors (Takeshima, 2016). The cost of registering these machineries with the Zonal Transportation Division is relatively high, which may have resulted in owners not officially registering their machines (Takeshima, 2017).

2.3 Climate Smart Agriculture

According to the Department of Hydrology and Meteorology (DHM, 2015), annual mean maximum temperature, minimum temperature and precipitation are reported to be 22°C, 10.8°C and 1859 mm, respectively. Analysis of historical data presented an increasing trend of temperatures and precipitation, with an annual increase of 0.037°C in maximum temperature, 0.012°C in minimum temperature and 0.7 mm of precipitation.

Majority of farming is still climate-sensitive, hence climate change poses a huge challenge to Nepalese agriculture. The climate change may result in droughts/ floods, which may affect crop yield of rain-fed agriculture. In order to respond to climate change through agriculture, climate smart agriculture (CSA) was initiated in collaboration with multiple stakeholders. CSA aims to develop and implement agricultural technologies and practices to achieve food security and economic growth under a changing climate (CIAT, World Bank, CCAFS and LI-BIRD, 2017; Paudel et al., 2017). CSA has three pillars: productivity (yield), adaptation (income, water, soil, risks) and mitigation (energy, carbon and nitrogen). Multiple institutions (local agencies, ministries, NGOs and INGOs) are involved in carrying out activities related to these pillars.

Some of CSA technologies and activities include precision nutrient management, improved water and irrigation management, soil conservation techniques, crop intensification technique, improved planting and management of crops, use of modern technologies, and use of ICT to disseminate climate information. Figure 4 and Table 3 provide CSA options and activities based on their suitability to different agro-ecological zones of Nepal.

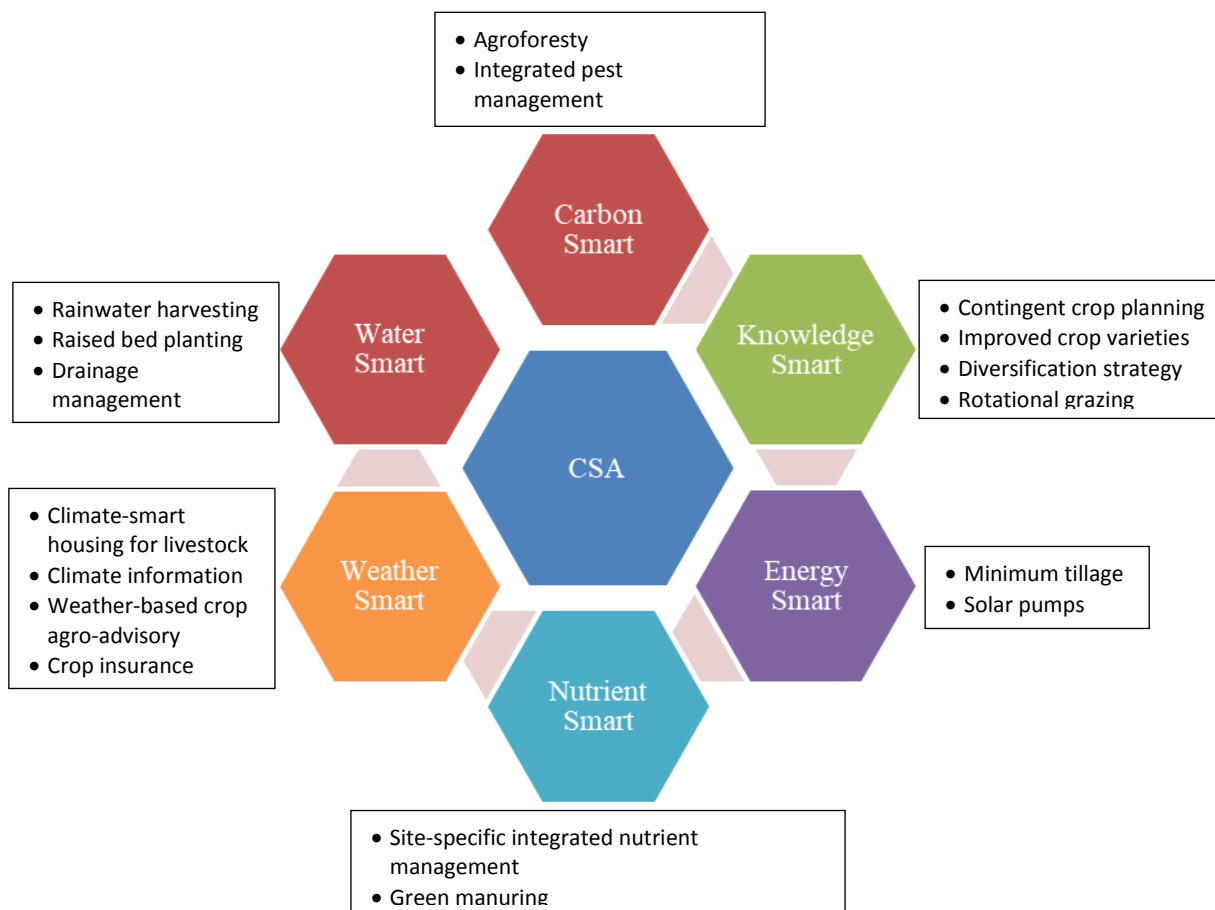


Figure 4. CSA categories applicable to Nepal (adapted from Paudel et al., 2017)

Table 4. CSA techniques for different agro-ecological zones of Nepal (adapted from Paudel et al., 2017)

CSA Techniques	Smartness	Agro-ecological Zone
New crops, seed varieties, etc.	Weather and knowledge smart	High and mid hills; Terai
Home garden	Weather and knowledge smart	High and mid hills; Terai
Mixed farming (legume integration)	Nutrient and weather smart	High and mid hills; Terai
Community seed banks	Knowledge smart	High and mid hills; Terai
Small hand-tools/ machines	Energy smart	High and mid hills; Terai
Agriculture insurance	Weather smart	High and mid hills; Terai
ICT based agro-advisory	Weather and knowledge smart	High and mid hills; Terai
Cattle-shed improvement	Nutrient and carbon smart	High and mid hills
Plantation and agroforestry	Carbon smart	High and mid hills

Plastic house	Weather and water smart	Mid hills
Plastic pond	Water smart	Mid hills
Water harvesting ponds, water source protection	Water smart	Mid hills
Drip irrigation	Water smart	Terai
Solar based irrigation	Water and energy smart	Terai
Conservation agriculture (zero tillage)	Carbon, water and weather smart	Terai
Rice intensification system	Water smart	Terai

2.4 Challenges and Opportunities

Numerous challenges exist with the development of agriculture in the country, for instance population growth (1.65%), poverty (25.2%) and inequality (GINI index of 32.8), literacy rate (60%), low investment, subsistence farming, slow pace of research and technology development, lack of subsidy on farm equipment, lack of trained human resources, and lack of implementation of agricultural policies. However, agriculture sector can benefit from the adoption of sustainable agricultural practices. Technologies can be modified to suit agro-ecological zones of Nepal, for instance, improved water mills for hills and mountains, wind mills, solar powered pumps, hand power tillers, etc.

3. Conclusion

Agriculture is one of major livelihood of Nepal, which contributes towards one-fourth of the nation's GDP. In last decades, agriculture sector has progressed as indicated by increased production and adoption of tractors, however it is slow and not satisfactory. Agriculture contributes highest to GHG emissions, but it is still low compared to South Asia and the World. Government has adopted several agricultural plans and policies, but the implementation is unsatisfactory. Investment on infrastructure, implements, public-private partnership, technologies for varying topography, and transformation of subsistence farming to commercial farming are important for agricultural development in the country. Climate smart agriculture (CSA) initiatives has identified several practices and techniques suitable for different agro-ecological zones to address food security and economic growth under a changing climate. Renewable energy based technologies and practices are needed to be explored to lower GHG emissions due to agriculture sector.

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Screening of Potential Laccase Producing White Rot Fungi by Using Solid and Liquid Culture and Zymogram Technique

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Abstract

White rot fungi are important source of lignocellulytic enzymes. It has capability to produce both extracellular and intracellular laccases, which fungi are available and successfully cultivated in Bangladesh. This experiment was conducted to identify the laccase producing white rot fungi and a screening program has been designed for the selection of potential laccase bearing fungi. Mycelial culture of six different white rot fungi viz. *Pleurotus ostreatus*, *Pleurotus sajor-caju*, *Pleurotus djamor* and *Calocybe indica*, *Phaenerochaete chrysosporium* JBH 01 and *Phanerochaete chrysosporium* JBH 02 were used for screening program. All the fungi grown on Poly-R solid media were identified as potential white rot fungi but *Pleurotus ostreatus* was found as the highly potential and which had the ability to change rapidly the red colour of Poly-R to yellow, indicating their ligninolytic capability and laccase production ability. This was confirmed by the oxidation of Guaiacol which was seen as the reddish brown coloured zone around the colony indicating the laccase producing capability. Poly-R decolourization in liquid media was also quantified by reading the spectrum of computer-controlled UV- spectrophotometer. Maximum Poly-R degradation rate was found for *Pleurotus ostreatus*. Laccase enzyme was further confirmed by performing the Zymogram technique where green coloured bands were visualized in ABTS treated gel and reddish-brown bands were developed in Guaiacol treated gel. Results suggested that the maximum laccase activity was found in *Pleurotus ostreatus* which was 180.55 IU/ml followed by 160.56 IU/ml for *Pleurotus sajor-caju*. This result is also compatible with that of the screening program. Therefore, *Pleurotus ostreatus* was selected for further experiments of laccase purification.

Keywords: Laccase, Poly R, Screening, White rot fungi, Zymogram

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Vegetative Growth and Genetic Diversity in Different Strains of Pink Oyster Mushroom Based on PCR Polymorphism

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Abstract

Pink oyster mushroom is known as *Pleurotus salmoneostramineus*. This experiment was undertaken to depict the favourable condition for mycelial growth, molecular identification and phylogenetic relationship of the selected strains of pink oyster mushroom. Suitable temperature and pH were obtained at 25°C and 6, respectively for the mycelial growth of pink oyster mushroom. Mushroom complete, glucose peptone and yeast malt extract culture media were the favorable, while Hennerberg and Hoppkins were unfavorable. Dextrin was the best and xylose was less effective carbon sources. Inorganic nitrogen sources were less effective for the mycelial growth of *P. salmoneostramineus*. The sequences of internal transcribed spacer (ITS) region of selected strains revealed that the total length ranged from 614 to 663 bp. The size of the ITS1 and ITS2 regions varied among the strains. Sequence analysis showed that 5.8S of rDNA sequences were identical. Phylogenetic tree of the ITS region sequences indicated that strains of *P. salmoneostramineus* belongs to a same cluster. The reciprocal homologies of the ITS region sequences ranged from 98 to 100%. The strains of *P. salmoneostramineus* were also analyzed by random amplification of polymorphic DNA (RAPD) with 20 arbitrary primers. RAPD results suggested that tested strains of *P. salmoneostramineus* were genetically similar with some variations.

Keywords: ITS sequence, Molecular identification, *Pleurotus salmoneostramineus*, RAPD, Vegetative growth

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Synthesis of Silver Nanoparticles using *Pavetta indica* Leaf Extract and its Toxicity on *Spodoptera litura* and Dengue Vector, *Aedes aegypti*

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Abstract

Spodoptera litura is a significant polyphagous pest in many countries, causing substantial failure to numerous vegetable and field crops. The yellow fever mosquito, *Aedes aegypti*, is accountable for dengue fever. It is there in more than 100 countries and threatens the health of just about 2.5 billion people. The application of synthetic insecticides in agricultural pest and mosquito control plan has resulted huge damage to the ecosystem, insect pest resistance and adverse effects on non-target organisms. Therefore, eco-friendly management tools against lepidopteran pest and mosquito vectors are a primary concern. In this study, silver nanoparticles (AgNPs) were synthesized by the leaf extracts of *Pavetta indica*. The AgNPs were illustrated by UV-vis spectrophotometry, X-ray diffraction (XRD), Fourier transform infrared spectrum (FTIR), and transmission electron microscopy (TEM) analysis. *P. indica* - aqueous extract and AgNPs were tested for their potential larvicidal activity against *S. litura* and *A. aegypti*. In addition, we estimated the biological toxicity of aqueous extract of *P. indica* and green synthesized AgNPs on non-target aquatic organisms, *Gambusia affinis*. The AgNPs was confirmed by the color of the leaf extract which was altered from light yellow to light-brown within 3 h after the *P. indica* extract was added to the AgNO₃ solution. The pattern of AgNPs was confirmed through the presence of an absorption peak at 466.5 nm. XRD patterns of AgNPs showed a high crystalline nature. TEM analysis exhibited most of the AgNPs were roughly circular and spherical in shapes. The leaf extract of *P.indica* exhibited a moderate toxic effect on *S. litura* after 24hr of exposure (99.5 and 100% mortality was observed at 750 and 100 µg/mL of leaf extract and AgNPs, respectively); Nevertheless, the utmost larval mortality was established in the AgNPs (LC₅₀ =38.22 µg/mL). Under laboratory conditions, the AgNPs were greatly toxic against *A. aegypti* with the LC₅₀ value was 11.11 µg/mL and the negligible toxicity against *G. affinis*. On the whole, the green synthesized AgNPs have potential to be employed as a promising candidate for the control of agricultural pests and mosquitoes through eco-friendly and cost-effective approaches.

Keywords: Green-synthesis, Innovative nanotechnology, Insect pest, Mosquitoes, Smart agriculture and environment

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Chemical Composition of Essential Oil Seed of *Hydnocarpus pentandra* and its Nanoemulsion Synthesis for Insecticidal Activities against *Sitophilus oryzae*

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Abstract

Synthetic pesticides are widely used to control pests in stored grains. In recent years, consumer awareness of the health hazard from residual toxicity and the growing problem of insect resistance to these conventional insecticides have led the researchers to look for alternative strategies for stored grains protection. Nanoemulsions are now widely using for enhancing delivery and biological functions of pesticides. Therefore, in the present investigation, the oil extracted from *Hydnocarpus pentandra* (Garudphal / Maravattai) seed were first tested for its physical, chemical properties and active compounds like free fatty acids through TLC and HPLC methods. Then it has been utilized to produce a nanoemulsion as an alternative and efficient tool to control rice weevil (*Sitophilus oryzae*) population. After 72 hrs of exposure time nanoemulsion oil possess phytotoxic effect against *Sitophilus oryzae* (adult mortality) which caused 94% mortality at the low doses of 1, 2, 3 and 4 mL/mg when compared to oil alone treatment. This toxic effect might be due to the aromatic flavonoids and free fattyacid contents present in the essential oil of *H. pentandra*. Hence, it can be concluded that nanoemulsion produced from *Hydnocarpus pentandra* seed oil can be used as a biopesticide to control *Sitophilus oryzae*. However, further investigations on its mode of action, side effects, effects on other pests and effects on grain quality are important.

Keywords: Stored pest; *Hydnocarpus pentandra*; Fumigants; Nanoemulsion; *Sitophilus oryzae*.

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Comparison of Properties of Biodiesel Produced from Different Mixing Ratios of Used Coconut Oil, Sunflower Oil and Palm Olein

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Abstract

Waste vegetable oil is considered as one of the renewable energy sources and can be used as a feedstock for biodiesel production. Biodiesel is sustainable, non-toxic and biodegradable fuel which can be considered as an alternative fuel for petroleum diesel and solution for the energy crisis. For that, trans-esterification, pyrolysis, micro-emulsion, and direct use and blending are the biodiesel production methods. Nevertheless, trans-esterification is the most common method in the world. It consists of such steps; preheating the oil sample, free fatty acid calculation, trans-esterification, separation, washing and drying processes. Furthermore, reusing used oil can cause several health hazards to human beings; especially cancers. In Sri Lanka, reusing used cooking oil is a very common situation due to the lack of knowledge and to gain more profit. Besides, dumping the waste vegetable oil into the river or land can create negative environmental impacts. Therefore using waste vegetable oil as a feedstock for biodiesel production helps to be economically feasible, healthful and environmentally friendly. In Sri Lanka, coconut oil, sunflower oil, and palm oil/olein are mostly utilised for edible purposes. It is essential to investigate the chemical and physical properties of biodiesel before using it as a fuel. In this research, the main objective is investigating biodiesel properties such as viscosity, flash point, density and yield produced from used coconut oil, sunflower oil and palm olein mixture with various percentages. It's observed that the majority of the results are within the expected range as a fuel. Here, all properties were compared with the EN14214 standard. The viscosity of every sample lied between 6-7 mm²/s at 40 °C. Furthermore, all samples had a density range of 0.86-0.9 g/ml and at the preferable range. But the flashpoint of the samples with 100% sunflower oil and palm olein deviated from the standard (flash point < 136 °C). The rest of the samples were following the standard. The maximum yield 83% could be gained in the sample with 75% coconut oil and 25% palm olein and others were between 70-80%. Finally, compare with all observed results, the properties of produced biodiesel are comparable with the fossil diesel for different ratios of used cooking oil and 80-83% yield can be achieved.

Keywords: Biodiesel, Biodegradable, Environmental-friendly, Trans-esterification, Waste vegetable oil

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Fabrication of Low Cost Hydroponic Device for Sustainable Fodder Production

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Abstract

Availability of green fodder is the basis for any livestock enterprise and with the decline in area under pasture and non-availability of land for fodder cultivation, alternate techniques such as hydroponic fodder production is gaining importance. Objective of the study was to design a low cost hydroponic device with a production capacity of 20 kg / day that is suitable for small scale farmers having 2 - 4 dairy cattle. The materials required for the fabrication of the device like mild steel pipe, mild steel angle and agro shade net were procured from the local market. An exhaust fan was fitted at the rear end, to maintain optimal humidity and to remove the unwanted gas produced during germination. The machine was fabricated with 2 columns and 8 rows, holding 3 trays each. Each row was designed with 3 foggers on either side at the rate of one mister / tray for misting water over the fodder. The hydroponic tray was planned with buds for root grip and holes at the sides for draining excess water sprinkled over the fodder. The device was provided with a water tank of 120 liters capacity and a ½ HP motor to pump water from the water tank into the machine. Different seeds such as yellow maize, horse gram, sun hemp, jowar, ragi, cowpea, foxtail millet and bajra were selected to test the efficiency of the fabricated device. The device requires only 12 sq. ft. of land to produce 20 kg of hydroponic maize green fodder. With one kg of un-sprouted maize seeds, 4 - 6 kg of green forage was obtained in 7-8 days. The total cost for fabrication of low cost hydroponic device was 17,000 Indian Rupees (\$235). Hence, it is concluded that this hydroponic fodder device can be used as alleviate fodder shortage problem of small scale farmers during forage scarcity period at a low cost.

Keywords: Biomass Yield, Economics, Growth Rate, Hydroponic fodder

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Moisture Removal of Katuwelbatu Fruit (*Solanum virginianum L.*) by Heat Pump Drying with Different Temperature Treatments

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Abstract

Katuwelbatu (Solanum virginianum L.), is a commonly found prickly herb in most of the Asia and used as a valuable indigenous medicine. In Sri Lankan condition, *Katuwelbatu (Solanum virginianum L.)*, a medicinal plant mainly used for colic fever, loss of appetite and in the treat itching, fever, cough and cold etc. Different pre-treatment methods are used to increase the drying rate of *Katuwelbatu* fruits when drying using heat pumps. This research study was focused to identify the most suitable pre-treatment condition for heat pump drying of *Katuwelbatu* fruit in different temperature treatments. Hot air drying and Hot water blanching pre-treatment method were conducted at 40°C, 60°C and 80°C (3minutes) temperature, respectively. The experiment was conducted in completely randomized design with three replicates. Pre-treated *Katuwelbatu* samples (30g) were dried in a heat pump dryer for 142.6 hours. The drying characteristics and colour variation (ΔL , Δa , Δb , and ΔE) of the *katuwelbatu* fruits were analysed. Dehumidify room conditions were monitored by recording relative humidity and temperature data by a data logger during research time period. The initial moisture content of fresh and pre-treated fruit samples was 80 % \pm 1 (wb). The 80°C hot water treated sample had the lowest final moisture content of 50 % \pm 1 (wb) while other sample had final moisture content of 70%-75% (wb). The values of the drying constant of control, 40°C hot water and hot air treated, 60°C hot water and hot air treated and 80°C hot water and hot air treated were -0.0015,-0.0016,-0.0014,-0.0018,-0.0016, -0.007 and -0.0017, respectively. The colour changes of 80°C hot water treated sample obtained more closer to the reference colour (golden brown) value ($\Delta L=12.86$, $\Delta a=-2.87$, $\Delta b=10.67$, $\Delta E=16.95$) for *Katuwelbatu* fruit. The statistical analyses indicated that 80°C hot water treated sample moisture content was significantly different ($P < 0.05$) than that of pre-treated samples. The results suggest that the 80°C hot water treatment increases the drying rate of *Katuwelbatu* fruits in heat pump drying.

Keywords: Drying, Heat pump, *Katuwelbatu (Solanum virginianum)*, Pre-treatment

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Marasmius oreades Mediated Silver Nanoparticles Synthesis: An Ecofriendly Tool against Anopheles stephensi and its Effect on Predatory Copepods

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Abstract

Malaria remains a decisive problem for public health due to the emergence and spread of *Plasmodium falciparum* strains resistant to chemical drug all over the world. There is an insistent to investigate new and valuable sources of antimalarial drugs. This research fabricated a novel method of mushroom-mediated synthesis of silver nanoparticles (AgNP) using a cheap mushroom extract of *Marasmius oreades*, acting as a reducing and capping agent. AgNP were characterized by UV-vis spectrophotometry, Fourier transform infrared (FTIR) spectroscopy, energy-dispersive X-ray spectroscopy (EDX), and X-ray diffraction (XRD). In mosquitocidal assays, LC₅₀ of *M.oreades* mushroom extract against *Anopheles stephensi* ranged from 50.0 (larva I) to 110.1 ppm (pupa). LC₅₀ of *M.oreades* -synthesized AgNP ranged from 3.917 (larva I) to 9.704 ppm (pupa). LC₅₀ of *M.oreades* -synthesized nanoencapsulated AgNP ranged from 3.055 (larva I) to 8.934 ppm (pupa). Furthermore, the antiplasmodial activity of *M.oreades* mushroom extract and green-synthesized AgNP was evaluated against CQ-resistant (CQ-r) and CQ-sensitive (CQ-s) strains of *P. falciparum*. IC₅₀ of *M.oreades* was 65.78 µg/mL (CQ-s) and 69.67 µg/mL (CQ-r); *M.oreades* -synthesized AgNP achieved IC₅₀ of 43.54 µg/mL (CQ-s) and 48.13 µg/ml (CQ-r). The AgNP did not show evidence of any noticeable toxicity on *Cyclops bicuspidatus* after 5 days of exposure. Overall, the outcome highlighted that mushroom-synthesized AgNP could be candidated as a new tool against *P. falciparum* and diverse developmental instars of its primary vector *An. stephensi*.

Keywords: *Marasmius oreades*, Malaria, Nano-encapsulation

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Agro-waste Mediated Silver Nanoparticles and its Effect against *Helicoverpa Armigera*

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Abstract

Helicoverpa armiger is the common pest of maize. Every year, around, 20–40% of crops are lost due to plant pests and pathogens. Recent advances in nanotechnology have provided promising tools for management of insect pest of essential commodities. In the present study, the effects of green synthesized silver nano particles (AgNPs) produced by *Zea mays* silk on corn pest *H. armiger* were investigated. The green synthesized AgNPs were bio-physically characterized by UV–vis spectroscopy, scanning electron microscopy and energy dispersive X-ray analysis. AgNP was highly effective against the larvicidal and pupicidal on *H. armigera* with LC50 values ranging from 16.134 ppm to 62.110 ppm. Consumption index, relative growth rate, the efficiency of ingested and digested food values were highly reduced in silver nanoparticles treatment. Further the *Z.mays silk* synthesized AgNPs negatively affected on adult longevity and fecundity of *Harmigera*. This study concludes that the effects of AgNPs are significant against *H. armiger* hence could be used as an alternative pest control agent in the management of crop pests.

Keywords: *Helicoverpa armigera*, Nanotechnology, Silver nanoparticles, *Zea mays*

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Effect of Monometallic Nanoparticles Produced from *Lawsonia inermis* on Sustainable Control of *Anopheles stephensi* and *Callosobruchus maculatus*

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Abstract

Mosquito-borne illnesses are caused by bacteria, viruses or parasites transmitted by mosquitoes which include malaria, dengue, west Nile virus, chikungunya, yellow fever, filariasis, Japanese encephalitis and Zika virus. Newer and safer tools are urgently needed for mosquito control. Stored-product insect pests are responsible for considerable quantitative and qualitative losses of agricultural stored products like peas, cowpea etc. The cowpea weevil *Callosobruchus maculatus* is considered as the most destructive pest in stored grains and grain-derived products. Therefore in this study the effect of monometallic nanoparticles synthesized from *Lawsonia inermis* for the sustainable control of *Anopheles stephensi* and *Callosobruchus maculatus* was examined in laboratory condition. Copper nanoparticles were produced by using the leaf extract of *Lawsonia inermis* which was characterized by using UV-vis, FTIR spectroscopy, scanning electron microscopy (SEM), energy-dispersive X-ray (EDAX), and X-ray diffraction analyses (XRD). After biophysical characterization, the Li-Cu NP at various concentrations was tested for its toxicity against young instar of *A. stephensi* and *C. maculatus*. From these results it is evident that the toxicity was higher as the concentration increases. Even though *Lawsonia inermis* has its own toxicity against this vector at the concentration of 20, 40, 60, 80 and 100ppm, Li-NP dominated in the larval mortality when treated with 2, 4, 6, 8 and 10ppm. In the case of stored pest the toxicity was at 0-97% when exposed with the concentrations of 1, 1.5, 2, 2.5, and 3ppm after 72 h exposure time. Overall, the laboratory studies have shown that the formulated Li-copper nanoparticle could be a good alternative for the control of the *A. stephensi* and stored pest *C. maculatus*. However, the present research demonstrated simultaneous of the bionano formulations against vector and stored pests.

Keywords: *Anopheles stephensi*, *Callosobruchus maculatus*, Copper nanoparticles, *Lawsonia inermis*

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Study on Vessel Characteristics and their Relationships with Wood Density and Texture of Selected Uncommon Timber Species in Sri Lanka

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Abstract

There are many uncommon local timber species available in Sri Lanka with potential to use as high quality timber which has high density ($>500 \text{ kgm}^{-3}$) with fine or moderate texture. Therefore, it is important to identify these species and classify according to their timber properties to popularize among consumers and people engaged in timber industry and forest management. Determination of the relation between wood anatomical structures specially vessel properties with related to wood physical properties such as texture and density are important for the wood identification process. In this investigation, approximately same age 86 uncommon timber species were selected. (Eg: Masmoru, Walipanna, Gonna, Aridda, Dickwenna, etc.) The samples were selected from the center part of the heartwood as 5 samples from each plant in each species. Timber density was calculated by Archimedes method. To study the anatomical features, slides were prepared with small wood sections and observed through the microscope using anatomical photos and Micrometrics SE Premium 4 software. Texture was determined using vessel diameter (vessel diameter (μm) 0 -100: fine texture, 100 – 200: moderate texture, $> 200 \mu\text{m}$: coarse texture). There is a significant association between wood texture and density. Further, a significant negative relationship was observed between wood density and vessel diameter ($r = -0.866, p < 0.05$), wood density and vessel perimeter ($r = -0.610, p < 0.05$) as well as wood density and vessel area ($r = -0.546, p < 0.05$). The wood density and vessel number had a very poor positive relationship ($r = 0.458, p < 0.05$). There is no significant relationship between wood density with vessel arrangement and shape. Vessel number showed significant negative relationship with vessel diameter ($r = -0.582, p < 0.05$). Wood texture can be mainly categorized into coarse texture with rough surface and fine to moderate texture with smooth surface of wood. The classification according to texture explains that most selected uncommon species has fine to moderate texture when compare to coarse texture. Finally, these fine & moderate texture species with high density can be suggested to popularize within the fields of lumber industry, silviculture, forestry and also among consumers because those spp. have high timber quality and thereby high economic value.

Keywords: Wood density, Wood texture, Wood vessel properties

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Physiological Response of Aged Rice Seeds to Flooding During Germination and Crop Establishment

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Abstract

The Key component of weed management in direct seeded rice is early flooding, Therefore, this study was conducted to understand the response of seed storage duration and storage conditions on germination under flooding. The present study was carried out using 4 rice genotypes such as KhaoHlanOn (KHO), Khaiyan, IR64 and IR42 with three different storage durations: 5, 10 and 15 months and two storage conditions; controlled storage (Seal Jar) at 25 °C and relative humidity of 60-70 % and ambient storage (uncontrol storage -27-35 °C). Dry seeds were sown in dry soil in 1 cm soil depth and flooded to 5 cm water depth and 0 cm (saturated soil) maintained as control. Germination %, seedling vigor, growth and seedling survival were assessed at 21 d after sowing. Lipid peroxidation and total phenolic content were assayed in dry seeds before sowing and amylase activity was assayed in germinating seeds at 4 d after sowing. Flooding decreased germination, seedling vigor and survival in 15 months old seeds; greater decrease was associated with the seeds stored at ambient conditions than controlled storage conditions. Higher malondialdehyde (MDA) content, lower phenolic content and lower amylase activity of age seeds were associated with their lower germination and seedling survival. The prolong seed storage at ambient condition resulted in increased MDA content and decreased amylase activity. MDA content of dry seeds which were stored at controlled conditions before sowing negatively correlated with seedling survival ($r = -0.75^{***}$) under flooding condition at 21 d after sowing. Controlled storage seeds showed higher phenolic content and which was positively correlated with seedling survival ($r = 0.56^{**}$) under flooded condition. Five months stored tolerant rice genotypes ((KHO) and Khaiyan) had lower MDA and phenolic content, dry seeds before sowing and higher germination, seedling vigor, survival, and higher amylase activity under flooding conditions. Seed storage time and ambient storage condition negatively affects the seedling survival and amylase activity under flooding conditions. Combination with flooding tolerant rice genotypes and pre- seed management are important to achieve improved crop establishment, especially areas prone to early flooding condition.

Keywords: Amylase activity, MDA content, Seed age, Storage durations, Total phenolic content

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Factors Affecting the Adoption of Beekeeping and Associated Technologies in Matara District, Sri Lanka

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Abstract

In Sri Lankan prospect, limited research and development in beekeeping has been conducted. Efforts to increase production would require proper assessment of the factors affecting the adoption of beekeeping and associated technologies. This study was undertaken to assess the factors affecting the adoption of beekeeping and associated technologies in Matara district. A total of 21 beekeepers were purposively selected to respond to a standard questionnaire. Results revealed that majority of the farmers (61.9%) were in the age group of above 50 years, predominantly males (85.71%), and have passed A/L examination (76.19%). The bee farming shows a new entrepreneurship paradigm accounting that the most of the farmers are having experience for 11-15 years (57.14%). Unfortunately no farmers were engaged in apiculture in commercial level or as a full time employment. Though constrained by lack of equipment, bad weather, pests, lack of credit facilities, and poor extension services, the farmers do generate income, from selling honey. All the participants (100%) owned Langstroth hives and produce an average 2.5 L of honey is produced from three fully functioning hives. All the farmers are expecting to expand their apiary due to the demand for pure honey by an average of 2.5% within next five years. The major factors affecting the adoption of beekeeping enterprise include the fear for bee stings, lack of awareness, inability to meet the starting capital, inadequate knowledge and skills, inadequate information about the technology and value addition. The multiple regression model revealed that adoption index is affected by the age of the farmer (years), education level (primary, secondary or tertiary), experience in beekeeping (years), size of the apiary (number of hives), extension services (number of sources of information), training received (Yes/No) and access to credit. Among these factors, age of the farmer, education level, experience in beekeeping and extension services were significant ($P\text{-value} \leq 0.05$). It is concluded that, the following key actions must be taken to address the constraints on adopting beekeeping and associated technologies: (i) increase awareness programmes and trainings (ii) strengthen small-scale systems by diversifying product assortment and value addition (iii) improve market and credit.

Keywords: Adoption index, Beekeeping, Matara district, Modern technologies

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Effect of Innovation on Agri-Technology Adoption in the Presence of a Moderator

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Abstract

Technology adoption phenomenon is contextual and same is widely recognized as a research notion across the agriculture, industry and service sectors alike. In the present research study, the relationship of innovation characteristics on adoption of agri-tech is being examined in the context of Sri Lanka. Quantitative methods including correlation, ANOVA, ANCOVA, regression, mediation analyses were used for the research. The empirical evidence supported positive relationship of Perceived Ease of Use (PEOU), Perceived Usefulness (PU) variables and Innovation (INO) variable towards Adoption of Agri-Tech (AAT) by correlation analysis and hierarchical regression analysis. Presence of differences in AAT between low income category agriculturalists and higher income categories were also supported by contrast test of ANOVA. ANCOVA revealed that the covariate; age was not significantly related to the AAT while the moderation analysis has confirmed relationship between INO and AAT is being moderated by the age. Due to the time and resource constraints, sample has been restricted while the research is limited only to the quantitative method. Originality of the research could be recognized as there is only limited number of researches executed by integrating technology adoption model (TAM) along with additional variables such as innovation in agricultural sector, specifically in Sri Lankan context.

Keywords: Adoption, Agri-tech, Innovation, Sri Lanka, TAM

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Mechanization as a Potential Alternative for Skilled Labor Shortage of Paddy Farming Sector in Wet Zone, Sri Lanka

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Abstract

Due to the limitation of productivity in dry zone paddy fields, it is necessary to increase the productivity of paddy cultivation in the wet zone by increasing the degree of mechanization as a labour solution strategy. However, according to the literature review, the degree of mechanization in the paddy sector in Sri Lanka is lower than compare to other developing countries. Therefore, this research study tried to find out the potentials for using new agricultural machinery rather than using traditional ways of paddy cultivation in the wet zone. Main objectives of the study were (a) to identify paddy farmers' degree of mechanization in each stage of the paddy farming process, (b) to identify the significant barriers and influencing factors that paddy farmers faced while using agricultural machinery, (c) to workout farmers' costs and benefits associated with agricultural machinery usage, and (d) to suggest recommendations to uplift the mechanization in wet zone as a solution for skilled labour shortage. The data were collected from 100 paddy farmers in the Dodangoda Divisional Secretariat division using a pre-tested questionnaire. Collected data were analysed by using the one-way ANOVA test, cost-benefit analysis, and descriptive methods. The cost-benefit analysis indicated the lowest feasibility score of hiring machinery of both land preparation stage and harvesting and threshing stage and those scores were 0.11 and 0.13, respectively. Accordingly, hiring machinery seems beneficial to farmers. This study revealed that younger age of farmers, high education level, cultivating in hired lands, farmers' experience level, and better land conditions, low availability to cheaper alternatives than machinery act as influencing factors while muddy field condition, availability of cheaper alternatives, cultivating in own land, low education level and increasing age act as barriers for mechanization. The degree of mechanization can be increased if machinery developers can build machines that are compatible with the field condition of local paddy fields. Besides, purchases own mini combine harvester (MCH) is not beneficial to an individual farmer. Therefore, the study suggests purchasing MCH for farmer organizations would be more beneficial for them.

Keywords: Agricultural Machinery, Cost-Benefit Analysis, Degree of Mechanization, Labour Solution Strategy, Wet Zone Paddy Farming

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Food and Nutrition



A Comparative Study on the Nutritional and Sensory Qualities of Biscuits Supplemented with Brown Rice and White Rice Flour from Selected Rice Varieties

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Abstract

Rice (*Oryza sativa*) is the staple food of Sri Lankans and more than 60% of the global population which directly supply more than 42% of calories consumed by the entire human population. As staple foods, rice provides a greater proportion of carbohydrate, dietary fiber and protein. In addition, rice is a rich source of vitamin B, vitamin E and minerals, such as calcium, magnesium, iron, zinc and phosphorus. Rice and rice products provide a large number of phytochemicals and antioxidants, which exert protection against gastrointestinal cancers and cardiovascular diseases. Therefore, a research was conducted to assess the nutritional and sensory qualities of biscuits supplemented with brown and white rice flour of selected varieties namely Suwandel, At 309 and Bg 94-1. Rice bran has better nutritional value therefore the biscuits were prepared using whole grain rice flour with 1:2 proportion of brown rice and white rice flour. For the preparation of biscuits, sugar and margarine were mixed to produce a creamy mixture. Then, the rice flour, baking powder, corn flour, margarine, sunflower oil, brown sugar, salt, and vanilla essence were added and thoroughly mixed to form a consistent hard dough. The dough was spread, cut into circular shapes of 4cm diameter and baked in an oven at 180°C for 25 minutes. The baked products were stored in metallized laminated pouches under ambient conditions of 30°C and 70-80% RH for 2 months. During the storage period, the biscuits were subjected to nutritional and sensory analysis at 2 weeks intervals. The sensory evaluation was carried out by 30 experienced panelists using a 7-point hedonic scale. Results revealed that the biscuits which were prepared with Suwandel obtained the highest overall acceptability value of 6.88±0.21 compared to other varieties. Nutritional analysis proved that the biscuits made with Suwandel rice variety had the highest fiber, protein and ash contents of 1.83%, 6.28% and 1.41%, respectively and Bg 94-1 variety poses the highest fat content of 12.3%. Based on the nutritional and sensory evaluation, biscuits prepared from Suwandel rice variety was considered as the best among the tested rice varieties.

Keywords: Biscuits, Nutritional quality, Rice flour, Sensory analysis, Staple food

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Development and Quality Evaluation of Instant Green Smoothie Powder

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Abstract

Fruits and vegetables are rich in more nutrients and phytochemicals that can be given enormous healthy and nutritional benefits. The world health organization recommends to consume ≥ 5 portions of fruits and vegetables per day. But, only 17.5% of Sri Lankan adults consume suggested value. Therefore, the production of a healthy and convenient product may increase the consumption of fruits and vegetables. The aim of this study was to develop an instant green smoothie powder as a more convenient product using locally available fruits and green leafy vegetables and to evaluate the quality parameters of the powder. Four fruits and three green leafy vegetables were selected to develop fresh green smoothie. The best formulation of the green smoothie was selected by conducting a sensory evaluation using 30 semi-trained panelists. The selected formulation was freeze-dried to obtain instant green smoothie powder. The resulted powder was analyzed for proximate composition; protein ($2.67 \pm 0.02\%$), fat ($1.96 \pm 0.01\%$), moisture ($4.82 \pm 0.01\%$), ash ($1.22 \pm 0.02\%$), and fiber ($28.57 \pm 0.01\%$) using AOAC 2000 method. Reconstituted green smoothie showed physicochemical properties such as pH of 4.21 ± 0.04 , titratable acidity of 0.213 ± 0.04 g/100ml, total soluble solid of $12.330 \pm 0.01\%$, and water activity of 0.17 ± 0.01 . The powder properties revealed that the powder has very good (based on Carr Index) flow ability (6.665 ± 2.35) and it has low (based on Hausner ratio) cohesiveness (1.0713 ± 0.03). The solubility (94.71 ± 2.43) of the powder complied with the SLS Standards (668: 1984). The instant green smoothie contained 129.5 ppm of vitamin C content and 107.25 ± 3.32 Ascorbic Acid Equivalent mg/g of total antioxidant capacity. The powder was microbiologically stable (only 1log CFU/mL of total plate counts). The water activity of the powder was significantly ($p < 0.05$) increased, but the pH and total plate count were not significantly ($p > 0.05$) increased during the five weeks of storage at room temperature in vacuum package. This instant powder can be introduced as the more convenient and healthy choice for the consumers, which has higher crude fiber content, better microbiological stability and very good powder properties.

Key words: Green smoothie, Instant powder, Fruits, Green leafy vegetables

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Effect of Wax Coating, LDPE Packaging and Storage Conditions on Prolonging the Shelf Life of Fresh Lime (*Citrus aurantifolia* L.)

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Abstract

The study was conducted to assess the effect of wax coating and LDPE packaging on shelf life, physical appearance and internal quality parameters of lime fruits under cold storage and ambient conditions. Mature green lime fruits were harvested from commercial orchards at Anuradhapura and brought to laboratory within 30 minutes. 1200 fresh lime fruits were divided into 8 lots and each lot contains 150 Lime fruits. Four lots of fruits were dipped in bio-wax formulation for about one minute. Other four lots were remaining without application of bio-wax. Four lots, representing two lots each from with and without bio-wax application were packed using LDPE packaging. The remaining four lots were kept without LDPE packaging. Four lots (with LDPE and without LDPE packaging under the each of bio-wax coating and without bio-wax coating) were kept under cold storage (13°C ±2°C, RH 95%) and other four samples kept under ambient conditions (32°C ±2°C, RH 70%) in medium size plastic crates. Each treatment was replicated in 3 times. Percentage weight loss, percentage decay incidence, fruit quality characteristics (titratable acidity, total soluble solids, fruit firmness and pH), visual quality and peel colour were recorded in weekly interval. Combination of wax coating, LDPE packaging and cold storage was the most effective treatment in maintaining the quality of lime fruits. This effect was significant ($p < 0.05$) as indicated by the lowest percentage weight loss (14.56%) during 8 weeks of storage period than the other treatment combinations. Although weight, firmness, pH, total soluble solids of this treatment remained within average values during storage period while 73% of fruits in marketable condition after 60 days of storage, the peel colour change from green to yellow after 30 days. Quality attributes such as firmness, pH, titratable acidity and total soluble solids had significant difference with other treatments ($p \leq 0.05$). Limes can be stored only 7 days without applying any preservation method in ambient condition while combination of wax coating, LDPE packaging and cold storage method extend the shelf-life of lime fruits up to 60 days.

Keywords: Cold storage, Edible coating, LDPE, Lime fruit, Shelf life

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Role of Grain Flour Packaging on Consumer Buying Behavior – Study in Ratnapura Divisional Secretariat Division

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Abstract

Due to increasing self-service, changing consumers' lifestyles and increasing the complexity of the markets, the interest on package as a tool of sales promotion and stimulator of impulsive buying behavior is rising gradually. In such a context, seeking to maximize the effectiveness of package in a buying place, the researches of package, its elements and their impact on consumer's buying behavior became a relevant issue. Aim of present research was to study the role of grain flour packaging on consumer buying behavior based on consumers that deal with markets in Ratnapura Divisional Secretariat Division. A sample of 125 consumers were selected from the target population using purposive sampling. Primary data were collected using self-administrated structured questionnaires and used the SPSS version 23 software to analyze the research findings. Descriptive statistics, factor analysis, linear regressions were used for data analysis. Of the sample, all respondents were aware about packed grain flour products. In store presentations were the main source of awareness on packed grain flour products. Quality of the product, product brand, packaging and price were given priority consequently, while purchasing packed grain flour products. Protectiveness of the product was given the priority of the product packaging in buying decision. According to results of regression analyses, quality of packaging and innovations significantly affect buying behavior of consumers. According to the factor analysis under the objective to study consumer perception towards packed grain flour product quality and brand image, safety and trust, attractiveness and printed information, environment, nutrition and price were the main factors that influence on purchase of packed grain flour products. Majority of the respondents intended to buy packed grain flour products even if non packed grain flour products are available. Research findings support the stakeholders to design an informative product packaging of high value.

Keywords: Consumer buying behavior, Grain flour, Packaging, Perception

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Whey Protein Based Edible Film Coating on the Quality and Shelf life of Fresh-cut Pineapples (*Ananas comosus* L.) during Cold Storage

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Abstract

Edible film coating is an environmentally friendly technology that offers considerable advantages owing to its non-toxic, biodegradable and biocompatible properties. The edible coatings can act as a barrier for moisture and gas, control microbial spoilage and can effectively extend the shelf life of the fruits. Pineapple (*Ananas comosus* L.) fruit is highly appreciated fruit for its aroma, flavor, and juiciness, however its immediate consumption is difficult. The present study was conducted to investigate the effect of whey protein as an edible film coating on the shelf life and quality of freshly cut pineapple (*var. Smooth Cayenne*) during refrigerated storage at 10°C for 20 days. The pineapples were washed, cleaned with 300 mg/kg chlorine and cut into slices of 6 mm thickness. The slices were dipped into anti-browning solution of 1% of citric acid and coated with 1, 2, 3 and 4% (w/v) whey protein suspensions. Fruits only treated with anti-browning agents were used as control. The physico-chemical parameters such as ascorbic acid, total sugar, titrable acidity, weight loss and firmness were measured during storage and compared with control fruits. Ascorbic acid and total sugar content decreased during storage; however this decrease was slower in coated slices compared to uncoated fruits. Pineapples coated with 3% of whey protein showed greater retention of ascorbic acid, titrable acidity and texture of 86.9 mg%, 82.7% and 89.7%, respectively, following 20 days of storage. The storage life fruits coated with 3% whey protein were lasted longer for 20 days with an internal atmosphere of 2% O₂ and 10% CO₂ whereas the control fruits had the shelf life of 7 days. Coating had a significant potential for reducing the microbial spoilage. Sensory evaluation proved the efficacy of 3% whey protein coating in maintaining the colour, texture, flavour and overall quality of the pineapples during the storage. The results of this study revealed that using 3% whey protein as an edible film coating, the fresh cut pineapple could be stored for 20 days at 10°C with modified environmental conditions. Thus, this study is useful for consumers and fresh-cut industry interested in knowing factors affecting shelf life and quality of fresh-cut pineapples.

Keywords: Edible film coating, Fresh-cut pineapples, Quality characteristics, Whey protein

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Consumers' Knowledge, Understanding and Use of Food Label Information for Purchasing Decision: A Case Study at Matara Urban Area

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Abstract

Food labels influence the healthy food purchasing behaviour of consumer by presenting a set of vital information to them. Price, brand name, date of expiry, nutritional information, ingredients, health claims are the main determinants for their purchasing decision. This study was conducted to assess the awareness, understanding and use of information on food label by the consumer. The study aims to reveal the type of information used by consumers while purchasing the food products, to assess the knowledge, awareness and understanding of food label information and thereby to develop strategies to fill the food label information knowledge gap for the consumers' benefit. A structured questionnaire was used to collect information from a systematic sample of 100 consumers purchasing pre-packaged foods at supermarkets in Matara urban area. The questionnaire was filled from questioning customers. The Wilcoxon Sign Ranked Test was used to analyse the data in the Likert scale and regression analysis was used to find out the relationship between the consumer awareness and their demographic factors. Awareness of food label information was significantly associated with the age of the respondent and the number of family members under 12 years. It was found that 84% of the selected consumers always read the food label when purchasing food items. The most influencing factor that determines their purchasing is the expiry date printed on the food label followed by the nutritional information. Moreover, they considered the ingredients list, size either in weight or volume, price, brand name and quality certificates. It is noteworthy that the consumers assigned high importance of learning Nutritional Reference Value (NRV), serving size, calorie, fat types and sugar types. None of the respondents have ranked health claims, packaging methods and processing methods under first ten parameters they are focusing when purchasing food. Eighty eight percent of the consumers stated that they face inconveniences in understanding the scientific or technical terms used in the food labels. They revealed that it is important to uplift their knowledge through audio, visual and printed advertisements via mass media. The outcomes of the study help the policymakers in formulating policies for the benefit of both food producers in their marketing strategies and consumers to make rational food choices.

Keywords: Consumer choice, Food information gap, Food label, Purchasing behaviour, Food policy

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Assessment of Food Hygiene, Safety and Sanitation Practices amongst Households in Weeraketiya Secretariat Division, Sri Lanka

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Abstract

Food is a basic human need that plays a vital role in life. Its safety, however, has become a major concern in the food industry. Consumption of contaminated food and water contributes to a myriad of health problems in the world. Experts agree that the home is the primary location where foodborne outbreaks occur; however, many consumers do not believe that the home to be a risky place. The home has become a multifunctional setting comprising of many activities that influences the need for and practice of food safety. This study aimed at evaluating consumers' food hygiene, safety and sanitation practices (FHSS) in the household in Weeraketiya area. The study determined the consumers' behaviour and knowledge on FHSS practices in the home environment, and the socio-demographic factors that influence FHSS practices in the households. This study utilized a cross-sectional study design targeting consumer who had the sole responsibility of food preparations in the households. A multistage sampling approach was used. Data was obtained from a total of 385 respondents. Data was analysed using SPSS version 20 and presented using tables and pie charts, while association between variables was assessed using Chi-square statistics and Odds Ratio. Findings show that consumer has practiced good FHSS practices at 43% in the sample. Educational level ($\chi^2=8.144$; $df=3$; $p=0.043$), type of house ($\chi^2=15.002$; $df=2$; $p=0.001$), total number of family members ($\chi^2=10.467$; $df=3$; $p=0.015$) and monthly income ($\chi^2=8.954$; $df=2$; $p=0.011$) were statistically significant in relation to FHSS practices by consumers. Sixty four percent (64%) of the consumers had good knowledge on FHSS practices but the overall consumers' knowledge was not effective on FHSS practices in the home environment. While 80% of consumers had positive attitude towards good food hygiene, safety and sanitation practices. The findings of this study show the need of developing and implementing more effective household health educational programs in sub urban areas and address through mass media, household campaign, workshops etc.

Keywords: Food borne diseases, Food safety, Household health, Hygiene, Sanitation

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Formation of Mono-species Biofilms by *Escherichia coli*, *Klebsiella spp.*, *Salmonella spp.* and *Staphylococcus spp.*

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Abstract

Biofilms are complex, sessile consortiums of microbes found either attached to a surface or embedded within an extracellular matrix. In food industries, persistent organisms are capable of colonizing surfaces compromising food safety and quality. Biofilms are getting more attention due to the antibiotic-resistant nature of biofilm cells; hence, the treatment efficacy has become questionable in human and veterinary medicine. In present work, mono-species biofilms of 20 bacterial isolates; *Staphylococcus spp.*, *Escherichia coli spp.*, *Klebsiella spp.* and *Salmonella spp.* isolated from mastitic bovine milk and quail eggs were characterized. Quantification of biofilms was conducted by using the microtiter plate assay at two different incubation temperatures (37 °C and 28 °C) under two different nutritional conditions; undiluted Tryptic Soy broth-TSB and 1:100 diluted TSB, for 24, 48 and 72 hours. Phenotypical characterization of biofilms was done by investigating the colony morphology on different media; Congo red agar, Coomassie brilliant green agar and staining with fluorescence dye. Sensitivity pattern of the biofilm cells and their planktonic counterpart against commonly used antibiotics was studied by disc diffusion method. The effect of chemical (Tween 20 and Tween 80, hydrogen peroxide) and natural (ethanol extract of cinnamon) compounds on biofilm were studied further on tested isolates representing weak, moderate and strong biofilm formers. It was found that the nutritionally diluted media (1:100) was inductive of biofilm formation and beta polysaccharides were predominant in their biofilm exopolymeric substance mixture. Moreover, 28°C was the best temperature and maximum biofilm formation was reached after 48 hours. There was a variation among isolates to form biofilms resulting strong, moderate and weak biofilm. Further, antibiotic susceptibility test revealed that differential results of resistance among species, between biofilm and planktonic cells of the same species having a general trend in lower susceptibility in biofilm cells. The effect of analysis study revealed that the hydrogen peroxide was the best in reducing biofilms at both 48 and 72 hrs whereas Tween 20/80 and *Cinnamomum verum* were only effective against on two bacterial species in each treatment for 72 hrs. In conclusion, the dependency of biofilm quantity on incubation temperature, duration and nutritional status of media were evident and these biofilms were controllable through Tween 20, 80, hydrogen peroxide and *Cinnamomum verum* extract treatments. Further, it was found that the different organisms have varying capabilities of forming biofilms.

Keywords: Antibiotic susceptibility, Biofilms, Composition, Exopolymeric

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Agriculture, Nutrition and Unemployment: An Analysis of Scholarly Literature (1974-2018)

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Abstract

Malnutrition remains as a key development challenge in many developing countries. A diversified agriculture practice can play an important role in dealing with this challenge. This paper is an attempt to review the research done on Agriculture and nutrition and analyse its outcome on employment generation through a systematic review of literature. The paper concludes that the first paper on this aspect was published in 1974 but very few papers were published in this area mainly from India and United States. Post the year 2000, there was an increase in number of papers published in this area but still, the number of publications in this area is quite low. This calls for a focus on the research in this area. Several patterns of the research have evolved from issues like mortality, mother, breastfeeding, child population, and education and have turned to recent issues like sustainability, livelihood, food insecurity, and urban agriculture. This paper provides insights on the gaps in the field of agriculture relating nutrition and employment aspect and analysis of new frontiers for the development of Agriculture, Employment and Nutrition, enabling recommendations for policy makers to encourage work in this untouched area of research. The analysis of the literature shows that the linkage between agriculture, nutrition, and employment is a less explored area, and there is a need for further research in this area.

Keywords: Agriculture, Employment, Linkages, Literature review, Nutrition, Systematic review

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Diversity of Zooplankton Revealed by DNA Barcoding with Special Reference to Rotifera, Cladocera and Copepoda

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Abstract

Zooplankton is a part of secondary food web in the aquatic ecosystem. The habitat loss and increasing pollution have caused a change in the diversity of zooplankton. Species identification of these organisms would be difficult even in adult stages and is not possible for immature stages. The current taxonomic keys rely on adult morphological characters such as matured reproductive structures. DNA barcoding has the potential of overcoming these limitations while providing faster and more accurate taxonomic identification. In the present study, zooplankton was collected from Ukkadam Lake, a perennial lake in Coimbatore, South India at different intervals. Totally 42 species were identified and they were mass cultured using phytoplankton as their feed. Among them, nine dominant species (Rotifers: *Brachionus calyciflorus*, *Brachionus caudatus personatus* and *Brachionus rubens*; Cladoceran: *Ceriodaphnia cornuta*; Copepods: *Macrocyclus albidus*, *Eucyclops speratus*, *Mesocyclops Pehpeiensis*, *Theromocyclops inversus* and *Theromocyclops crassus*) which attained 1000 and above individuals per litre during mass culture for 45-days were taken for molecular identification using DNA bar-coding with specific universal primers, LCO1490 and HCO2198. The DNA amplification yield was >600bp. The sequences showed 98-100% similarity with BLAST Database. The nucleotide compositions showed >60% AT bias, which indicates the occurrence of less numbers of NUMTS genes. The phylogenetic tree topology revealed that *C. cornuta* alone sat in a clade, and the remaining species aligned in another clade with two clusters. Thus these species are genetically distinct but closely related to each other.

Keywords: AT-GC biases, Divergence, mt-COI gene, Phylogenetic tree, Zooplankton

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Expression of Antiradical Power of Pigmented and Non-pigmented Rice (*Oryza sativa* L.) Varieties in Relation to their Colour Strengths Before and After Polishing

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Abstract

Natural antioxidants have potential to counterbalance the effect of anti-oxidative stress and the deleterious effect on human health caused due to the synthetic antioxidants. Rice is one of the rich sources for antioxidants. Therefore to explore the total natural antioxidants in de-husked (un-polished rice), polished and cooked rice of forty which included 20 pigmented (red) and 20 non-pigmented (white) rice varieties were selected. These varieties were represented by new improved, traditional and exotic rice. Eighty percent Methanolic extract of these varieties were analyzed for total antioxidant activity which was expressed as anti-radical power (ARP) the reciprocal of EC₅₀ value. The reducing power of 2,2-diphenyl-1-picrylhydrazyl (DPPH) was used to identify the efficient concentration (EC₅₀) required to decrease the initial DPPH concentration by 50%. Brown rice and milled rice pericarp colour were measured by CR-20 spectrophotometric method to determine lightness, redness, and yellowness. Antiradical power of forty rice varieties was found to be highly diverse. Pigmented rice of un-polished, polished and cooked contained more antioxidants than that of non-pigmented rice. Mean ARP values for pigmented un-polished, non-pigmented un-polished, pigmented polished, non-pigmented polished, pigmented cooked and non-pigmented cooked rice were 20.7±1.77, 1.8±0.10, 10.3±0.92, 1.4±0.08, 1.4±0.07 and 0.2±0.02 mL/mg, respectively. Due to presence of colour pigments in red rice varieties, they have shown comparatively higher ARP values. Two of the traditional and improved rice varieties namely *Masuran* and *Nonabokra* and *Ld 368* and *Ld 408* recorded the highest antioxidant contents with an ARP value more than 27 mL/mg. A drastic decline (average 35 and 88 %) of antioxidant contents were observed after milling and cooking irrespective of the presence of colour pigments in the outermost layer of the rice grain. Milling followed by cooking reduces the antioxidant content to minimum of 24 % and maximum of 96 %. However, on the average, pigmented cooked rice contain 6 times more antioxidants than non-pigmented rice. Colour values (lightness, redness and yellowness) of these varieties were significantly different among un-polished as well as polished rice. There was a significant decline in redness of pigmented varieties after polishing process. The mean redness values ranged from 3.5 to 15.2 and from 2.1 to 11.6 in un-polished and polished rice, respectively. Mean redness values of pigmented rice varieties varied between 9.0 and 14.3. Therefore, comparatively higher antioxidant capacity was observed with red pigmentation of rice grain which is reduced by polishing and further reduced by cooking.

Keywords: Antioxidants, Antiradical power, Colour, Pigment, Rice

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Food Insecurity in Sri Lanka: Nature and Determinants

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Abstract

This study examined incidence of food insecurity in Sri Lanka along with its household determinants. The current study recognized food insecure households based on the minimum dietary energy requirement (MDER) and hence a household was considered as food insecure when at least one member of the household had not met 2030 Kcal per day. Moreover, the study used household income and expenditure survey (HIES) Data (2012/13) which was collected by the Department of Census & Statistics of Sri Lanka. The study found that 41.9% of Sri Lankan households are food insecure while 59% of households in Colombo district where the highest food insecurity is reported. Food insecurity in urban sector is significantly higher than the rest of the country, as urban people mainly consume prepared and instant foods. The deep classification of food insecurity observed that 1.9% of households are extremely food insecure while 42.2% are vulnerable to food insecure. Furthermore, the impact of growth on reduction in food insecurity is significantly low, despite growth remarkably reduces poverty. The econometric analysis which based on Ordered Probit Model estimation confirms that higher assets level, being a male-headed household, higher level of education, employed in government, semi-government sectors and being a self –employer and having agricultural lands significantly reduce the probabilities of falling into extremely and moderately food insecure. Therefore, the study recommends ensuring better employment opportunities, higher educational attainments along with safety nets for vulnerable groups such as female-headed households in order to achieve food security. Furthermore, urban-based food insecurity should be addressed by encouraging urban people to have energy rich staples rather than rely on prepared foods.

Keywords: Calorie intake, Economic growth, Food insecurity, Poverty

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Personal Hygiene of Food Handling Workers; A Case of Food Exporting Company in Sri Lanka

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Abstract

Food safety issues have emerged in recent decades as a major aspect of the problem of insurance of general wellbeing. In this sense, food safety and individual cleanliness are interdependent and their relationships are both complex and dynamic. This paper investigates empirically the present situation of personal hygiene of food handling workers in a reputed food exporting organization in Sri Lanka. Fifty five food handling workers and fifteen laboratory workers were selected for the sample by random sampling method. The study was consisted of a self-structured questionnaire, direct observations to evaluate the attitudes of the workers. Moreover, a microbiological analysis was carried out to assess the personal hygiene of the workers. The study revealed that workers maintain a satisfactory personal hygiene relative to the personal hygiene score (PHS), while 9% of workers were reported with less personal hygiene relative to the microbiological analysis conducted to detect the presence of coliform and E.coli in their hand. These findings were shared with the responsible authorities of the food exporting organization together with proposals to develop effective strategies in achieving competitive advantage.

Keywords: Food handlers, Personal hygiene, Safety

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The Prevalence of Under-nourishment of Sri Lanka: An Overview

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Abstract

Sri Lanka is focusing its development agenda on hastening economic growth. The country is attributable with hefty advancement in many development areas. At present furnish more attention on food policy formulation targeted on nutritional issues. Undernourishment is the fore most nutritional health issues and consider as undernourished who are not consumption enough food to meet minimum dietary energy requirement to maintain a healthy and active life. This research studied the prevalence of undernourishment of the population in general and sectors in particular, of Sri Lanka. The food energy deprivation was estimated based on the recommended food energy intake. The method was applied to secondary data available on 25,000 household units collected from the national household income and expenditure surveys conducted by Department of Census and Statistics in 2016. The study revealed that the estimated proportion of the population whose per capita dietary energy intake per day fell below a recommended minimum dietary energy requirement at national and sector levels. The recommended daily per capita minimum energy requirement in Sri Lanka is considered as 2095 Kcal. 25.36% of the national population fell below the recommended minimum food calorie level. Urban, rural and estate sectors population fell in 18.5%, 26.62% and 27.19%, respectively below the recommended minimum food calorie level. Pearson correlation test was applied to determine the relationship between derived prevalence of under nutrition and monetary poverty. Head Count Index (HCI) and energy intake were used as variables. There was no significant relationship between HCI and energy intake ($r=-0.009$, $p=0.966$). The test was also used to determine the affecting factors on food energy intake. Mainly food expenditure ($r=0.350$, $p=0.000$) and household size ($r=-0.138$, $p=0.000$) are directly affecting the food energy gained.

Keywords: Dietary energy, Head Count Index, Minimum dietary energy requirement, Prevalence of undernourishment

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Consumer Awareness, Brand Preference and Determinants of Purchasing Decision of Ultra High Temperature Treated Milk: A Study in Galle District, Sri Lanka

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Abstract

Demand for fluid milk products including ultra-high temperature (UHT) treated milk among Sri Lankan consumers has been increased dramatically over the past. In response, the leading dairy companies in the country started processing more and more UHT milk in state-of-the-art factories and marketed adopting different marketing strategies to attract consumers. Nevertheless, those companies have experienced returns of their products, might be due to various reasons which needs corrective measures to be successful in the competitive market. Therefore, a study was conducted in Galle District of Sri Lanka, to find out the consumer awareness, brand preference and factors affecting on purchasing decision of UHT milk marketed by leading dairy manufactures. Three hundred consumers were selected from each of two Grama Niladhari divisions (to represent the rural and urban areas) from two Divisional Secretariats in Galle District of Sri Lanka, based on the presence of highest population. A pre-tested questionnaire was used to collect the information from the consumers. Data were analysed using SPSS. It was found that the majority (89%) of the consumers were aware of the UHT milk even though the age, monthly income, area of living and occupation affected significantly ($p < 0.05$) on the awareness. Consumer preference for the type of UHT milk in descending order was full fat-flavoured > full fat-unflavoured > low fat flavoured > low fat-unflavoured. Around 41% of the consumers got awareness of UHT milk through television advertisements irrespective of the area of living. Kendall's W test results indicated that there was a significant ($p < 0.01$) difference on consumer preference for the UHT milk brands available in the market and Highland brand was ranked the first followed by Kothmale and Ambewela. Further, supermarket channel was ranked the first among the preferred market for the purchasing of UHT milk. Quality of the product was ranked first by the consumers for the reason for purchasing of UHT milk, followed by the available quantity, reasonable price, availability of the product, packaging material and advertisement. Significant ($p < 0.05$) positive relationship was found between money spend on milk and milk products vs. money spend on UHT milk by the consumers. Findings of the current study could effectively be utilized by the leading manufacturers to successfully intervene the problems associated with UHT milk industry.

Keywords: Awareness, Brand preference, Determinants, Purchasing, UHT milk

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Networking for Smart Agriculture



Keynote Speech

Rethink: Digitally Connected Smart Agriculture – A Systems Approach

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Abstract

Though World's food production has increased throughout the past decades due to advancement in technology, machinery, chemicals, etc. based on FAO data the world's food insecurity has also increased. Also overall farmer livelihoods have not significantly improved as evident from a large number of people still living below the poverty line, in predominantly agricultural countries in developing world. Furthermore, some of the technologies, processes and policies used to optimize the food production, mainly agrochemicals such as pesticides and fertilizers and some of the Government subsidy schemes, have been negatively impacted the economic and environmental sustainability and, health and safety of humans.

Thus, it has become necessary to rethink how agriculture is practised and managed at scale to address the above mentioned challenges. The past outcomes have taught us that we need a systems approach rather than individual solutions to achieve economically and environmentally sustainable food production system that also uplift farmer livelihoods and empower societies. We found the root cause for above long term unsatisfactory outcomes is a multi-level coordination failure. The base level being not having a coordinated approach to provide timely access to information for all stakeholders in the agriculture domain for optimal decision making followed by poor market linkages, uncoordinated input supply and logistics and availability of effective credit facilities. We have developed Digital Knowledge Agribusiness Ecosystem (DKAE) platform to address these challenges. It provides an effective approach to provide actionable cultivation and market information to farmers, through farmer actions to generate situational knowledge, which then can be used to effectively coordinate input and output supply chains as well as better mitigate risks in agri-lending.

This platform is now being trialled at scale in India and Sri Lanka in partnership with many agriculture and technology universities, government agencies and research institutions as well as private sector organisations.

Keywords: Smart Agriculture, Digital Knowledge Agribusiness Ecosystem, Precision Agriculture, Systems Thinking

Introduction

Food production has increased over the past decades due to advancements in technologies, mechanization, increased chemical use, specialization, and government policies. These advancements have allowed to produce more food by fewer farmers at low prices (Brodt, 2011) However according to FAO data (Food et al., 2019) more than 820 million people do not have enough to eat. Overall the Food insecurity in the World is increasing. Even though Modern agronomy, plant breeding, agrochemicals such as pesticides and fertilizers, and technological developments have sharply increased yields, these are also causing widespread ecological and environmental damage.

Agriculture forms a major part of a country's food production effort. It is estimated that across the developing world, a total of 1.2 billion people live in rural areas, depend on agriculture for

their livelihoods, and live in poverty (Dixon et al., 2001). Roughly one-third of the food produced in the world for human consumption every year (approximately 1.3 billion tonnes) get lost or wasted throughout the supply chain, from initial agricultural production down to final household consumption (Gustavsson et al., 2011). This inevitably also means that vast amounts of the resources used in food production and associated greenhouse gas emissions are also wasted.

Above indicates that we need to rethink how we practise Agriculture in the future. New practise should enable us to meet the triple bottom line, economic sustainability, individual and societal empowerment leading to enhanced livelihoods for farmers as well as others in the society and environmental sustainability. The word “Smart” implies intelligent way to achieve better outcomes. Thus “Smart Agriculture” should enable us to practise agriculture in way to achieve the triple bottom line.

To be Smart we need timely access to data and effective ways to make optimal decisions. Advances in computing approaches such as Smart Computing, Social Computing Machine learning, Artificial Intelligence and rapid growth of mobile phone usage are providing new ways to become “Smart” (Ginige, 2018). Based on our research since 2011 we have developed a Digital Knowledge Agribusiness Ecosystem (DKAE) to enhance data, information and knowledge flow in the agriculture domain to optimise crop selection, cultivation practises, market linkages, input supplies, logistics and financial services (Ginige and Sivagnanasundaram, 2019, Ginige et al., 2016).

Digitally Connected Society and New Possibilities

We are increasingly becoming a digitally connected society. In year 2019 the world mobile phone penetration surpassed 108% (ITU, 2019). Most of the earlier feature phones are now getting replaced by Smartphones. The Smartphone in addition to the basic voice communication provides exchange of rich multimedia as well as equipped with range of sensors to capture the location, altitude, acceleration, images, sounds, heart beat etc. This rapidly growing mobile connectivity together with advances in sensor networks and other areas of computing provides us new possibilities to tackle challenges in the agriculture domain in a Smart way.

We can consider the agriculture domain as a system that consists of many processes and each process consist of many activities. Digital Technologies have enabled the automation of some of the activities and processes giving rise to the concepts of Smart farming and Precision farming. The driving force of smart farming is Internet of things (IoT); connecting smart machines and sensors integrated on farms to make farming processes data-driven and data-enabled to achieve an increased quantity and quality of agricultural produce. Precision farming, or precision agriculture is an umbrella notion for IoT-based approaches that make farming more controlled and accurate (plants and cattle get precisely the treatment they need, determined with great accuracy). The biggest difference from the classical approach is that precision farming allows decisions to be made per square meter or even per plant/animal rather than for a field.

Even with all these advances the World Food insecurity is increasing. The challenge is to integrate all these advances to work in harmony to decrease the world food insecurity. We need to take a Systems approach to tackle this problem while achieving the triple bottom line.

Digital Knowledge Agribusiness Ecosystem (DKAE)

In the developing world often, farmers not being able to sell their harvest, and forcing them to throw it away is a commonly reported problem. This reflects the absence of a mechanism to coordinate supply and demand side of the agriculture production. Previous research has revealed that the primary cause for the problem was farmers and related stakeholders such as government, agriculture authorities, and agro-chemical companies in the domain not receiving

the right information when they need it most (Giovanni et al., 2012). This inability to access right information when needed has resulted in multilevel coordination failure in the agriculture domain giving rise to inefficient productivity and food waste (Ginige et al., 2014).

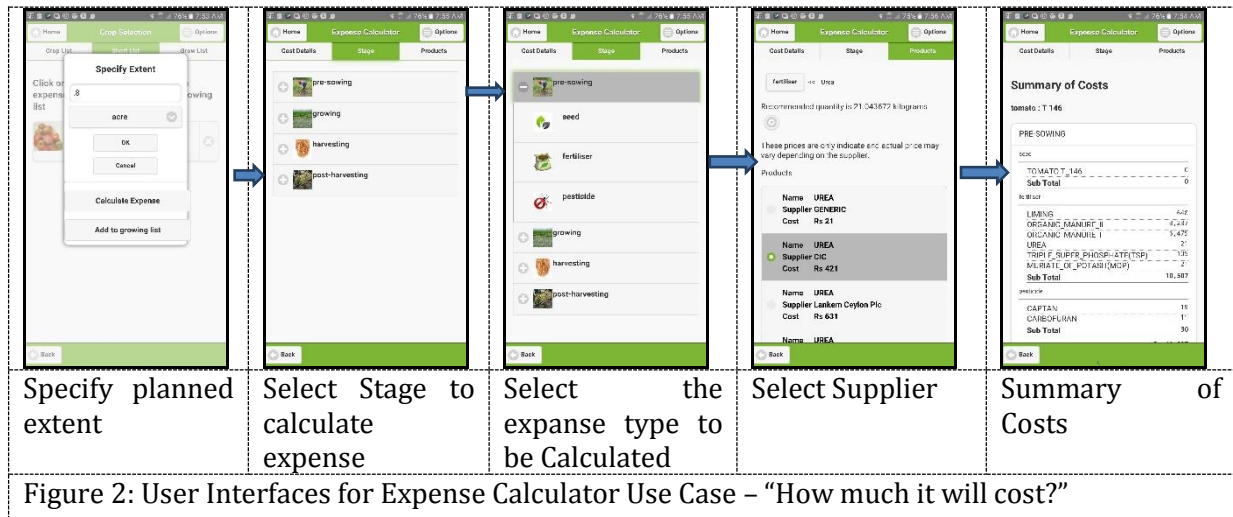
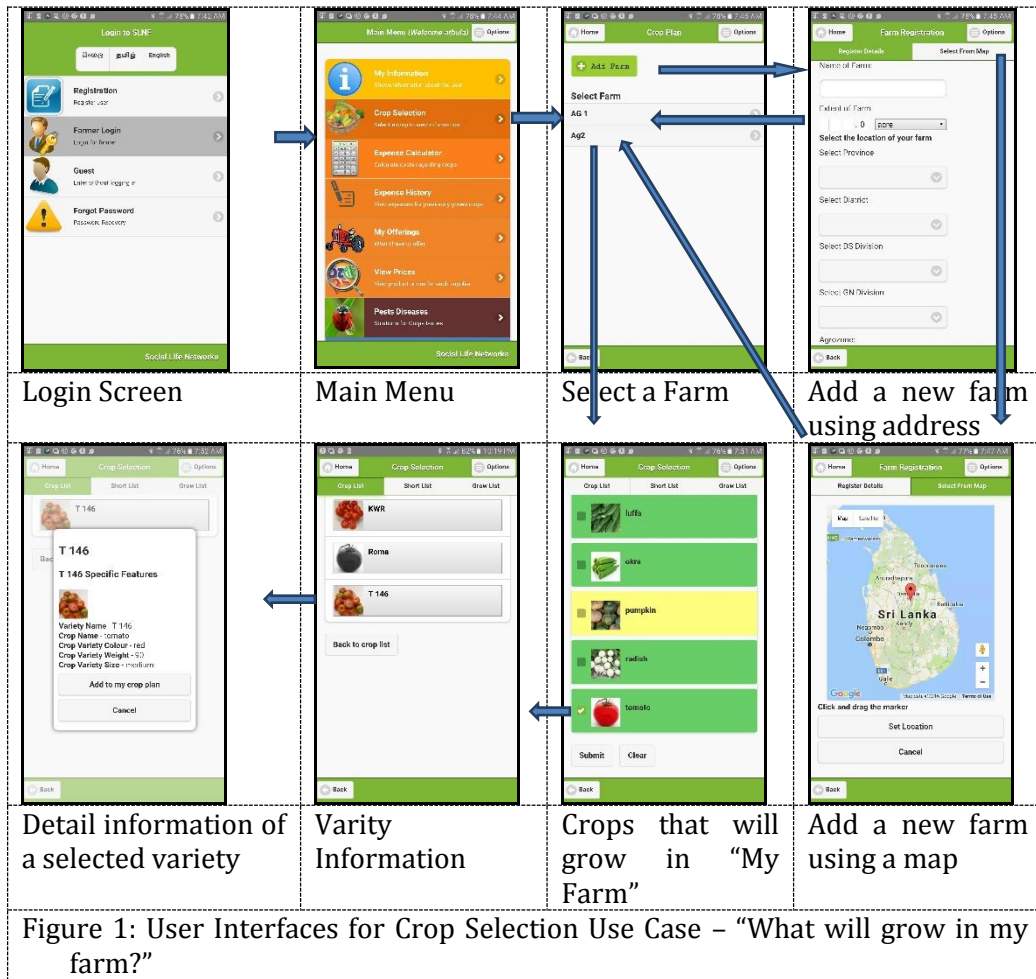
Developing a solution to balance the supply and demand in food production is a complex problem with many challenges. Through a 7 years long research project (2011 – 2018) we developed an artefact based on Smart Agriculture concepts that can provide a solution (Ginige, 2018, Ginige et al., 2016). Due to the complexity of factors that affect supply and demand in the agriculture domain, it was very difficult to identify the deeper requirements that an artifact should address to achieve good coordination between the two. To overcome this difficulty an iterative participatory design approach was used (Silva et al., 2016, Ginige et al., 2018). It was found farmers would like to get answers to the following questions to better select and cultivate the crops.

- 1) What crops and varieties will grow in my farm?
- 2) How much it will cost to grow specific number of acres?
- 3) How much of a selected crop variety is grown by other farmers?
- 4) What is the best way to grow a selected crop variety?

An ontological knowledgebase was developed to answer the question “What will grow on my farm?” (Walisadeera et al., 2014). When a farmer asks the question, what will grow on their farm using a mobile application, the system captures the user’s geo-coordinates to obtain the farm location and map the location to a corresponding agro-ecological zone using a GIS. Based on the agro-ecological zone, the system finds the climatic and soil parameters for the farm. Using this information, the ontological knowledgebase is queried to obtain a list of suitable crops that will grow on that farm. This is presented to the farmer on his/her mobile as shown in Fig. 1. The next question to address was: “How much it will cost to grow a crop”? To enable the question to be answered, we added expense calculator functionality to the mobile application as shown in Fig. 2. From the list of crops that will grow on the farm, a farmer can select a crop and specify the extent she/he is planning to grow. Then, it fetches the inputs required per unit area, such as fertilizer, pesticides, machinery labor, and seed required for the selected crop from the ontological knowledgebase and current market prices and presents the cost of production to the farmer. After exploring the cost of production for the different crops in the list of crops that will grow on the farm, the farmer can select a crop to grow and add it to a growing list. At this point systems ask what is the planned planting date and accordingly generate a crop calendar to guide the cultivation. By now the system has captured the crop and the variety, extent of cultivation and approximate planting date.

Once statistically significant numbers of crop selections from farmers are collected, the system can start predicting the current production level thus generating the information required to answer the next question: “How much of a selected crop variety is grown by other farmers?”. The current production level information is presented to the farmer by adding a color code to list of crops; green, yellow and red for low, medium and high production levels, respectively (Ginige, 2016, Silva et al., 2016) as shown in Fig. 1.

The developed mobile artifact integrates above mentioned modules to enhance the flow of information to farmers as shown in Figs. 1 and 2. (Giovanni et al., 2013, Ginige et al., 2013, De Silva et al., 2013).



This Smart Computing solution initially devised for an individual farmer was extended to connect all stakeholders of the domain to empower the society as a whole. This was achieved by predicting the input needs and expected harvest based on time and location, using these predications better coordinate the input and output sides of the supply chain and introducing a more granular credit rating for farmers based on time series data captured from farmers when they are performing a crop selection and cultivation activities using the mobile artefact.

With these developments the Digital Knowledge Ecosystem got transformed into a Digital Knowledge Agribusiness Ecosystem as shown in figure 3.

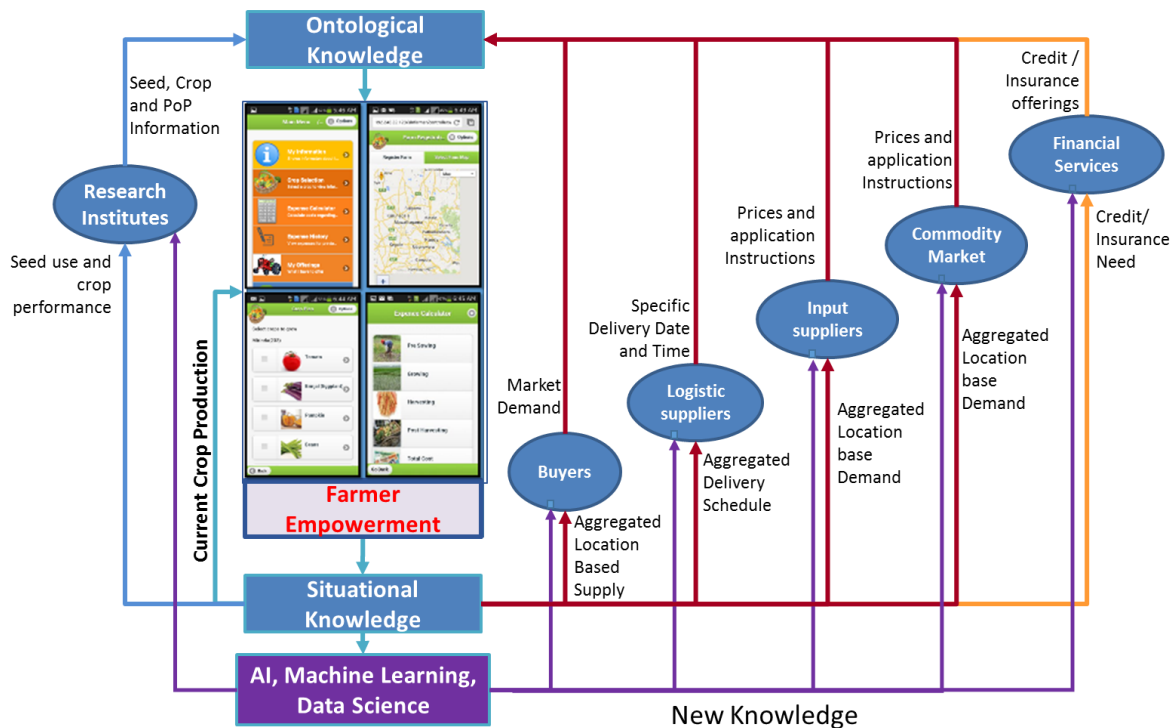


Figure 3: Digital Knowledge Agribusiness Ecosystem

This platform is now being trialled at scale in India and Sri Lanka in partnership with many agriculture and technology universities, government agencies and research institutions as well as private sector organisations.

Conclusion

Time has come to rethink how we practise agriculture at scale to achieve sustainable food production system that also meets the triple bottom line, economic sustainability, individual and societal empowerment leading to enhanced livelihoods for farmers as well as others in the society and environmental sustainability.

Our research has shown the key to this is to have efficient coordination at 4 broad levels; agronomy and other related knowledge, output supply chain, input supply chain and providing credit. Digital Knowledge Agribusiness Ecosystem provides a data driven Smart Computing solution that make use of evolving Digital Connectivity and advances in IoT to to achieve the required coordination.

The insights gained by developing the DKAE confirms the need for a Systems Approach to achieve a sustainable food production system.

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Farmer Need Assessment for Effective Implementation of ICT Solutions in Agriculture in the Mahaweli-Udawalawa Region

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Abstract

This study focused on the farmer-need identification for the effective implementation of e-agriculture solutions. The target population was paddy, vegetable and fruit farmers under Mahaweli authority in the Mahaweli-Udawalawa region. Four objectives were set: (a) collect general requirements of the farmers (irrespective of ICT needs), (b) identify the farmer needs which can be addressed by using ICT applications, (c) assess the acceptance of the existing software user interfaces (components, layout, appearance etc.) and (d) understand the farmers' expectations for better acceptance of the software user interfaces. An open-ended questionnaire was used in data collection. A sample of 70 farmers was selected through simple random sampling. The collected data were classified, tabulated, and analyzed using SPSS. Nearly 43% of the farmers stated "unsatisfactory market price" as the main problem they face and 27% stated "pests and diseases as their main problem for Agriculture. Roughly 41.4% of the respondents are obtaining information from the agriculture instructors (AI) and neighbor farmers. About 75% of the respondents use a feature phone and, about 8.6% use a smart phone. Only 8.6% of the smart phone users utilize it to send messages, to take photographs, to access the social media and to watch videos. The feature phone is used by the respondents regardless of their age category. Two people below 35 years and 4 people above 50 years use the smart phone. Furthermore, 67% of farmers are willing to test-drive the ICT solutions as a tool. About 53% of the respondents prefer to use the function-oriented approach to find the solutions to their problems. In the function-oriented approach the farmers seek the shortest pathway to the solution which is based on functions that directly solve the issue. The rest of the respondents favor the object-oriented approach in which the farmer reaches the solution by navigating through objects in a hierarchical structure. In conclusion, ICT is a proven tool to address the two main problems faced by the sampled farmers. However, the farmers' ICT awareness and usage were very poor and, majority of them do not possess the media such as smart phones or computers which are capable of delivering comprehensive ICT solutions. Therefore, farmers' expectations pertaining to the user interfaces and functions of ICT solutions could not be evaluated through this study except for the approach that they prefer to seek solutions for their problems.

Keywords: E-agriculture, Function-oriented, ICT solutions, Mahaweli-Udawalawa region

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Disease Recognition System for Sri Lankan Potato (*Solanum tuberosum*) Plants

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Abstract

Potato is a major crop in the upcountry areas in Sri Lanka such as Nuwara Eliya and Badulla Districts. The demand for local potatoes has increased oppose to the total demand for potatoes, but the production has not been increased that much over the years, because of diseases and pests that tend to infect potato plants. Agricultural instructors (AI) are responsible for determining new diseases and existing ones and also providing ways of treating the plants and preventing further infections. As AIs are assigned to a large area where there may be large number of farms and farmers, it is very difficult for the AI to keep track of every farm, and then the communication between the AI and the farmer can be hindered. Then farmers may try remedies that are not well tested and damage the whole field. As a solution, we develop a system to identify plant diseases from an image of the plant leaf, or any infected part of the plant and a set of symptoms that can be seen in the plant. The image and the set of symptoms are then fed into a deep neural network and the probability of the disease that the plant has is given as the output. With the advancement of deep neural network, very difficult problems such as pattern identification has been tackled, so applying that strategy for this problem also seemed like a good solution. Since deep models have influential ability to capture patterns and features, our prediction model achieves a validation accuracy of 99.3%. The management part was also developed in our proposed system for gathering all the submitted images, updating the set of diseases and also plants. Finally, the mobile-based application was developed to submit images to our prediction model, to get information about how to treat the infected plants and also to provide preventive measures. We evaluated our mobile-based application with selected potato farmers in Keppetipola and Nuwara Eliya areas. Evaluation results and positive feedback achieved through it clearly indicate that our system achieves effective performance over the current techniques of recognizing plant diseases.

Keywords: Image Classification, Mobile-based Application, Neural Network, Web-based Applications (Management Dashboard)

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Implementation of Data Mining Approach for Analyzing Customers Demands in Paddy Price Based on Rainfall Variation

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Abstract

Paddy production is one of the main factors in determining the economy of Sri Lanka. The price of paddy can be affected by changes in climate. This research focuses on the implementation of the data mining approach for analyzing customer demands in paddy prices, based on the long term rainfall variation. The analyzation of rainfall and price of paddy data for ten years from 2006 to 2015 was used to predict customer demands at the price of paddy along with changes in rainfall. The analysis of past ten years' meteorological data comprising the year, month and rainfall is important to predict the future state of rainfall accurately. It utilizes past weather data records on the premises that previous weather will be a repeat of the future. Pearson correlation between total selected rainfall and paddy price data is -0.064165 and p-value is 0.486270. In the beginning, K- means clustering algorithm was used to group the homogeneous paddy price data, then the most suitable cluster with a higher price was selected by correlation analysis between paddy price and rainfall. The random tree is used to predict the price of paddy based on the rainfall comprising month, price and rainfall. At the same time, long short-term memory Neural Network (LSTM) was used to forecast rainfall and the price of paddy which was compared with the predicted results from random tree. The correlation between rainfall and paddy price in cluster_0 is -0.603511, the p-value is 0.004842 and the prediction's root mean squared error is 4.1. In the future, it can be analyzed paddy price with temperature and humidity in the same way. LSTM predicting accuracy is increased along with the huge amount of data. From the result, day-wise data will give more accuracy compared with monthly data and adding more attributes for prediction will provide an exact result.

Keywords: Correlation analysis, K- means clustering algorithm, LSTM network, Random tree

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Factors that Influence on Making Decisions by Consumers for Buying Mobile Phones from E-Retailers

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Abstract

Based on the recent trend among consumers for buying products from e-Retailers, many researchers are motivated to inquire buying behaviour of such consumers. From the reviewed literature it was found that there is a research gap in Sri Lankan context to identify the factors that influence on making decisions by consumers when they purchase electronic or technological devices through e-Shopping. The purpose of present study was derived according to that direction and it was to identify the factors that influence on consumer decisions for buying mobile phones from e-Retailers. The quasi-experimental design was applied to achieve the study objective and the subjects of this experiment were the part-time postgraduate students and employees. The responses were collected by using a standardized questionnaire which was designed to get the responses in relation to the variables of attitude towards e-Shopping, trust on e-Retailers, past experience on e-Shopping, learning about shopping websites, intention to purchase, influence of opinion leader, and actual purchase using 5-point Likert scale. The sample was selected randomly from purposively selected five public and two private higher educational institutes in Sri Lanka. The questionnaires were distributed after briefing the subjects about the purpose of doing this study and the importance of their participation therein. The results revealed that there is a relationship between the independent variables of learning about shopping websites, trust, attitudes, and past experience and the dependent variable of intention to purchase of consumers for buying mobile phones from e-Retailers. However, the attitudes and past experience of consumers were the factors that significantly influenced on the intention to purchase of mobile phones. Moreover, the influence of opinion leader was not a significant moderator in the relationship between the intention to purchase and actual purchase of consumers for mobile phones. Finally, the study recommends future researchers to validate the research model using another similar electronic or technological device and to generalize the findings in wider area.

Keywords: E-consumer, E-retailer, E-shopping, Purchase intention

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A Mobile-Based Guidance for Sri Lankan Potato Farmers: Govi-Guru

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Abstract

Potato production in Sri Lanka has increased considerably during the last three decades and potato production is now successfully established in four regions mainly Nuwara Eliya, Badulla, Jaffna, and Puttalam districts. Potato is an economically attractive crop with various varieties and farmers tend to get higher yields by adopting extensively wrong agricultural practices which are not recommended by the Department of Agriculture, Sri Lanka. Agricultural Instructors (AIs) are responsible for providing proper guidance which is recommended by the Department of Agriculture. AIs are assigned to a large area where there may be a large number of farms and farmers. As a result, AIs face difficulties to keep a proper track and monitor every farm in their area. Further, there is no proper communication method between AIs and farmers to get advice to farmers' problems in real-time. Moreover, there is no proper way to get the total potato yield of all regions. In conclusion, it is very important to make certain decisions about the potato importing and exporting sector which also helps to reduce the potato wastage. To prevent this situation, we have developed a mobile-based and web-based application for potato farmers. In mobile application, it provides proper guidance to farmers to cultivate potato and also identify the most suitable varieties to cultivate based on their geographical location. Further, it facilitates real-time communication between farmer and AI. The web application was mainly designed for decision making by higher-level authorities, for example, total land area for cultivation, total average yield, required fertilizers, and decisions related to potato importing and exporting, etc. We received the feedback and comments to mobile application from twenty potato farmers in different regions in the Badulla district using questionnaires and more than 70% of participants satisfied with the core functionality of the application (i.e. step by step guidance for potato cultivation in farmer context). In conclusion, this research fills the knowledge gap of potato farmers by giving proper guidance for cultivation and further it supports the higher-level authorities in this domain to make informed decisions.

Keywords: Guidance provider, Mobile-based application, Potato farmers, Real-time communication, Web-based application

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Package of Practices for a Mobile Application to Improve the Yield and Long-term Sustainability of Potato Production in Sri Lanka

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Abstract

Potato is one of the main vegetable cash crops and it is grown and consumed all around the world under a wide range of climatic conditions. It plays a major role in the improvement of rural livelihood systems and economic support for the farmers in Sri Lanka. Currently, many agriculture-related mobile applications are available in Sri Lanka to develop the agriculture sector. However, gross domestic product contribution from agriculture is still being dropped and the average yield of the potato is still far below the potential yield. Therefore, a questionnaire-based study was carried out in major potato growing areas in Sri Lanka to analyze the needs and issues in potato production and to provide context-specific and actionable information through a mobile-based information system. The study revealed that farmers could not get a better decision at the right time for effective farming due to lack of vital information at the correct time, in an appropriate format and suitable knowledge delivery methods. Furthermore, farmers do not have a general guideline for potato production by covering all stages in the farming life cycle. Therefore, a mobile-based information system is being developed to provide all required information for farming activities in a context-specific manner. Hence conditions/ parameters/ factors/ constraints with respect to each stage of the potato farming life cycle have been identified and model those factors as the Package of Practices (PoPs). For an example, variety selection depends on many factors such as climatic, soil characteristics, location, input requirements, cultivation season, yield, market demand. Design models for the potato production were designed in each and every farming life cycle stage and a real-time mobile-based application is developed based on these design models.

Keywords: Contextual information, Mobile application, Package of practices (PoPs), Potato, farmers

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“Ruhuna Govi-Nena” Web-based Dashboard to Manage the Agricultural Activities in Sri Lanka

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Abstract

The “Ruhuna Govi-Nena” project is the real-time information system to achieve food security in Sri Lanka and to provide stable and sustainable prices for farmers and consumers. There are main areas covered by this project, such as crop information and knowledge, farmers details (registered users), agricultural activities based on different agro-ecological zones, weather conditions, supply-demand, market information, Govi-Nena certificate system details, microfinance and government incentives, and so on. Mainly, crop information and knowledge are organized by ontological knowledge base and others are managed by through databases. These databases are updated with new data and information entered by “Ruhuna Govi-Nena” mobile-based application. Decision-makers of the agriculture sector need to see the information through different analytical views to make quality decisions for successful farming. For that purpose, we have designed a web-based dashboard to increase efficiencies with faster access to agriculture business intelligence. GIMSI methodology is used to design the dashboard. Identification, conception, implementation, and permanent improvement are four main steps in GIMSI methodology. GIMSI is able to track analyze and display key performance indicators (KPI). The designed dashboard consists of multifunctional proper understandably interfaces including tables, charts, and graphs. The dashboard shows the relationship, comparison, composition and distributions of the knowledgebase. This dashboard increases the productivity of “Ruhuna Govi-Nena” project objectives and business process however it identifies the shortcomings of the Sri Lankan agriculture sector quickly as well as enhances collaboration and communication of Sri Lankan agriculture. Decision-makers can make quality decisions about food security in Sri Lanka and provide stable and sustainable prices. A knowledge gap of stakeholders in agriculture domain can be fulfilled through this and then introduce new trends in technological agriculture methods and best practices through decisions based on dashboard to Sri Lankan agricultural sector.

Key words: Agriculture, Knowledgebase, User friendly UI/UX, Web-based dashboard

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Developing Conceptual Close-loop Demand and Supply Models under *Govi Nana* Mobile Platform Development: Identification of Challenges in Implementation

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The majority of farmers make decisions based on a combination of approximate measurements, experience, and recommendations of fellow farmers. This leads to inaccurate predictions and unanticipated outcomes. Hence, developing demand and supply prediction models and the delivery of model outputs between multiple stakeholder levels would be more effective in a closed-loop agricultural market. Development of three types of models was required to the selected stakeholders in the close loop information flow facilitated by the *Govi Nana* mobile information system. First, the conceptual input model was developed. In the conceptual model, forecasting of aggregated demand for major inputs and providing the forecast to the input suppliers was addressed. Thereafter, the response of the suppliers was sent back to the farmers through the knowledge base. The second conceptual model is called as an output model that forecasts the aggregated supply and future demand. The output model informs the farmers about the potential risks of growing a particular crop. The third conceptual model known as the logistics model integrates transport and storage service providers to a closed-loop system. It predicts the future area-wise aggregated demand for transport and storage requirements and, sends relevant information to the logistics service providers while gathering the information about their capacities. Finally, those services will be sent to the farmers through *Govi Nana* mobile application. However, several challenges were identified while developing the conceptual models. Realtime data input and the accuracy is identified as the main challenge. The lack of skills in smart phone usage and language literacy among farmers and other stakeholders is a serious drawback. Survey revealed that most of the farmers and some of the stakeholders who involve in potato cultivation were more than 40-years old and most of them were not using smart phones. Further, farmers prefer to have intermediaries to deliver their harvest to the market easily. However, most farmers are willing to obtain the services of a digital intervention. The development process of the *Govi Nana* considered several important aspects which appear to be weak in other developments. While designing *Govi Nana* market information user interfaces, the views, ideas and preferences of the farmers and other stakeholders were studied. Moreover, the platform facilitates the delivery of information to the illiterate farmers through the agriculture instructors. This facility helps the agriculture instructors to clearly explain the risk levels of growing particular crops. Model verification using dummy data displayed very high level of accuracy in the predictions and, further verifications will be done using actual data to finetune the models.

Keywords: Close loop system, Conceptual model, Demand and supply, Mobile app

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Impact of ICT Based Information Management Systems on Excess Stocks and Price Fluctuations in Sri Lanka's Vegetable Industry

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Abstract

Agriculture is one of the most important segments in Sri Lankan economy. One third of Sri Lankans involve in agriculture-related activities as their livelihood and, most of them suffer from poverty. The contribution from agriculture sector for gross domestic production is less than 12% in Sri Lanka. Excess stock generation and sudden price fluctuations are common in Sri Lankan vegetable market and, both farmers and consumers are suffered severely. Being the main stakeholder of the vegetable cultivation is farmer, there are number of information sources including ICT-based information systems available in Sri Lanka to assist the farmers. These information sources have been established to minimize critical issues such as accumulation of excess stocks and price fluctuations. This article discusses possible reasons for ICT-based systems failures and possible options available to establish unbreakable attachment between farmers and the ICT based information systems. The study used published literature and field survey to identify the extent of the use of ICT-based information systems in agriculture sector in Sri Lanka and overseas. According to the literature and the results of the current study, most of such ICT-based information systems have failed. Average weekly wholesale prices of three vegetables during 52 weeks of the year 2019 was observed and drastic price fluctuations were identified. The "Continued use" is a key requirement for the sustainability of information systems. The survey identified that only 120 offers were received from farmers for an app which commercially promoted and the number of offers reduced with the increase in the market price. The results of the present study reports that only five out of 26 participated farmers used ICT-based systems for crop selection. Currently available information systems appear to be less capable of providing proper information regarding the crop cycle due to low level of interaction with farmers. The lifetime of the systems becomes shorter because of lesser usage. This could be attributed to the poor attractiveness of the systems to the farmers to make them bond with the information systems. A combination of strategies should be adopted to bind the farmers into the systems.

Keywords: Value chain, excess stocks, ICT in Agriculture

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Mobile-based Information System for Managing Pests and Diseases of Paddy in Sri Lanka

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Abstract

Several interrelated issues paved the way for the development and validation of a holistic mobile-based application, which necessarily includes real-time information for pest and disease management in the food crop sector. Frequently encountered issues such as heavy pre-harvest crop losses due to pest and disease incidents, poor awareness on recommended pest and disease management practices among the farming community, lack of access to real-time actionable information on pest and disease management, weak linkages between farmer and extension personnel, heavy dependence on unconfirmed information sources leading to higher cost for pest and disease management, and allied environmental and health hazards prompted the said inspiration. Initially, we have conducted a baseline survey among 180 progressive paddy farmers who have access to smartphones in three different districts of Sri Lanka. According to the study, farmers' knowledge of pest and disease management, pesticide selection, and overall handling is limited, and most of the time, farmers have been misled during the pest and disease identification stage. Also, the study emphasizes that the farmers need a way to manage pests and diseases in real-time. As a solution for the said problem, an international team consists of researchers embarked on a project to develop a user-centric mobile-based information system named 'Ladybird'. The system was intended to bridge the issues discussed earlier while being a tool to support existing agricultural extension services. 'Ladybird' promotes a community-based approach for early detection of pest and disease incidents and likely outbreaks through an in-built smart computing approach while providing real-time actionable information on integrated pest management practices. Also, it keeps the farmers vigilant on likely pest and disease incidents through frequent reminders on pest and disease management and agronomy practices that ensure vigorous crop growth. Moreover, it has become a database that has the potential to help sectoral policy formulation and designing appropriate development programs.

Keywords: Actionable Information, Mobile-based Information System, Paddy, Pest and Disease Management

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Livestock and Dairy Production Technologies



Keynote Speech

From Milk Deficiency to Sufficiency - Some Systematic Approaches

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Abstract

It is considered generally that dairy sector is the prime sector of livestock development. If the present status of dairy sector of Sri Lanka is analyzed, it will be observed that it stands fourth position in the world on the basis of importing milk powder worldwide. In the country the local demand is full filled by government and private industry, collectively providing powder and fresh milk. County herself can provide only 43% of its demand of milk. The deficiency of milk is mainly due to low productivity of animals, poor extension services and inadequate education on animal health among dairy farmers, failure to update the technologies, absence of new investments in the dairy sector, poor marketing option etc. However there is potentiality in dairy sector for reaching self-sufficiency due to availability of sufficient land area, higher labor availability, ability of integrated farming, ability of increasing milk yield by continuous breed upgrading, higher demand for value added dairy product like yoghurt, cheese etc. For this some steps may be taken such as upgrade the breed characteristics, adoption of low cost feeding strategies, control of cattle disease, reducing the price gap between farm gate price and selling price, establishing new technological equipment to increase the efficiency of milk production, establishing milk distribution networks, impose and regulate standards for the milk market, and strengthening the monitoring system for quality and safety etc.

Keywords: Dairy, Deficiency, Livestock, Sufficiency, Approaches

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In Sri Lanka the agriculture land is around 2 million hectares, which is 30% of the country's total area of 65,610 sq. km. Almost 75% of the agricultural land is under smallholdings, and the number of such holdings is estimated at 1.8 million, with over 90% of them having less than 2 ha. Almost one third of these smallholdings have a mixture of crops and livestock. The area of farm holdings with livestock is around 0.56 million ha, of which 99% are categorised as smallholdings. The total number of farmers involved in livestock production is estimated at 700,000, and between 30-60% of gross farm income is generated from livestock activities. The agricultural sector contributes around 13% to the national Gross Domestic Product (GDP). It provides employment to about 33% of the labour force, surpassing the contribution of any other major sector. The livestock sub-sector contributes around 6% to the agricultural GDP and around 1.2% to the national GDP. The dairy sector is regarded as the priority sector in livestock development. As per information of 'Animal Production and Health' the cattle and buffalo population in Sri Lanka (in 2017) were one million and 0.3 million, respectively. Total milk production is 483 million litter (in 2017).

Sri Lanka stands fourth position in the world in importing powder milk from New Zealand. The industry includes government and private companies (both local and multinational), collectively providing powder and fresh milk. Dairy production in the country has recorded positive growth after 2008. The growth was due to various initiatives, such as upgrading the chilling center

facilities of large, medium and small milk collectors, increased contribution from the Northern and Eastern Provinces, the provision of financial assistance, the provision of high-yielding cows, the promotion of liquid milk consumption by the government and the diversification of income generation avenues of the people.

The contribution of domestic milk production to the total milk requirement is ~ 42%. The deficit is met by imports, mostly in the form of powdered milk. Considering the quantity of imports over the last 15 years, there are ups and downs in importation which indicate the unsteady nature of milk imports indicate the unsteady nature of milk imports and its association with underlying factors such as world market prices, tax structure and local demand.

After detection of dicyandiamide (DCD) in imported milk powder in 2013, consumers are cautious during buying imported milk product. From consumer survey it was found that their preference is high for fresh milk and local milk powder which emphasizes that the poor availability and accessibility of poor availability and accessibility of safe and high quality local fresh milk and locally-processed milk based products have compelled to local products when there constrains are addresses. In this regard there is a good opportunity for development of the production and marketing system of milk in the country, while minimizing dependency on imported products.

It is fact that recently 5000 Australian cattle imported to Sri Lanka. It was found that 10% cattle died and many were diseased. For this instance many local farmers did suicide. Farmers were told each cow would produce 20 lit milk per day when they were only producing 10-15 lit per day, and a special imported feed the cows needed turned out to cost more than double what it was told it would.

The potentiality of dairy industry for reaching self-sufficiency in near future are -- suitability of pathways to enter export market, availability of sufficient land area, higher labor availability, ability of integrated farming methodologies, ability of increasing milk yield by continuous bread upgrading, higher demand for value added dairy product like yoghurt, cheese etc.

Besides above potentiality there are several constraints for dairy development in Sri Lanka. Such as -- low productivity of animals, poor extension services and inadequate education on animal health among dairy farmers, low farm gate price of milk, failure to update the technologies, absence of new investments in the dairy sector, absence of proper consumer education to appreciate the value of fresh milk and milk products, poor marketing option available.

Considering above constraints some recommendation can be suggested such as -

1. Provision of breeding services in order to upgrade the breed characteristics of local breeds
2. Increasing availability of quality animals suitable for different environment and production systems
3. Development of low cost feeding strategies
4. Taking action to control disease prior to an outbreak
5. Involvement of resource personnel like veterinary surgeons to facilitate efficient knowledge transfer
6. Establishing a pricing mechanism to reduce the price gap between farm gate price and selling price
7. Fresh milk consumption can be increased by reducing the price while increasing the quality. The market can also promote the consumption of fresh milk in Sri Lanka to a greater extent.
8. Improving quality of livestock products
9. Promoting and expanding liquid milk market

10. Strengthening of milk-processing capacities of large and small-scale milkprocessing plants
11. Establishing new technological equipment to increase the efficiency of milk production as well as convenience
12. Encouraging private sector involvement and combined development with subsistent level enterprises
13. Establishing milk distribution networks with sales outlets, setting up milk parlours, expanding retail selling, distribution by mobile vehicles to the doorstep and ensuring high availability in the locality
14. To increase quality and safety of milk, it is necessary to impose and regulate standards for the milk market

For strengthening the monitoring system for quality and safety, it is important to have continuous testing of imported brands for safety.

Keynote speech

New Horizons in Livestock and Dairy Production by Application of Animal Biotechnologies

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Animal Biotechnologies

Abstract

The efficiency of livestock and dairy productions are required to be improved from the points of view not only to grow economically but also to reduce greenhouse gas emission especially in Asia where those productions are dramatically increasing. To reduce the total gas emission in livestock and dairy production, we may need to replace with animals having high abilities to produce valuable meat, egg or milk efficiently and to reduce the total number of livestock. Animal biotechnologies have been contributing to genetic improvement and efficient production of domestic animals. Artificial insemination and embryo transfer have been well contributed to genetic improvement of livestock and the productions. Applications of sexed semen in artificial insemination has been now rapidly and widely become common. Technologies for in vitro embryo production have been applied both to livestock production and to human assisted reproductive medicine. Furthermore, genome editing technologies, such as CRISPR/Cas9, have currently accelerated the breakthrough to introduce mutations by homologous recombination. Successful in vitro production of gametes, spermatozoa and oocytes, from embryonic stem cells or induced pluripotent stem has proposed an idea “in vitro breeding” in livestock production. This review is reviewed about the application and progress of the above biotechnologies, including our recent research results.

Key words: Spermatozoa, Oocytes, Embryos, Sexing, Animal Biotechnologies

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Introduction

Currently, the total number of livestock and also the productions, such as meat, milk and egg, are significantly increasing in the world, especially in Asia (Ritchie and Roser, 2017). Since livestock production is responsible for about 14.5% of total anthropogenic greenhouse gas emissions (Grossi et al., 2019), the countermeasures are required to work out quickly. Reducing anthropogenic greenhouse gas emissions and sustainable livestock production may be achieved by improving the genetic ability and the low productive efficiency of livestock (Ritchie and Roser, 2017), and consequently, by decreasing the total number of the domestic animals without any reduction in the productive volumes. Since animal biotechnologies have contributed to genetic improvement and the diversity maintaining of domestic animals, progress in animal biotechnologies and the applications, including our recent research results, are discussed in the current review.

Innovations in artificial insemination (AI) and embryo transfer (ET)

Basic reproductive technologies, such as AI and ET, have improved livestock genetically. Especially, artificial insemination is the most powerful reproductive technology to provide the livestock industry for genetic improvement (Smith et al., 2018). Recently, timed AI has already become popular and the diffusion rate is still gradually increasing because this protocol does not require the estrous detection (Baruselli et al., 2017). A typical protocol of timed AI is taken place

by the insertion of a progesterone-releasing device plus the intramuscular administration of estradiol at random days of the estrus cycle defined as day 0, device removal and intramuscular administration of prostaglandin, estradiol and equine chorionic gonadotropin on day 8 and timed artificial insemination 48 h later (Baruselli et al., 2017). In addition, application of sexed semen sorted by flow cytometry for a small difference in DNA content between X-chromosome and Y-chromosome to AI has been contributed to predetermination of calf's sex with close to 90% reliability and has benefits to both dairy and beef productions (De Vries et al., 2008, Holden and Butler, 2018). However, the conception rate may be still lower than the rate following AI with conventional semen (Peres et al., 2016, Anderson et al., 2006, Seidel and Schenk, 2008), although sexed semen has recently apply successfully not only to heifers but also lactating cows (Butler et al., 2014). Recently, it has been reported that both Toll-like receptors 7 and 8, TLR7/8, coding on the X chromosome, were expressed in approximately half of spermatozoa populations and that ligand activation of TLR7/8 selectively suppressed the mobility of the X chromosome-bearing sperm (X-sperm) without altering sperm viability or acrosome function (Umehara et al., 2019). They also demonstrated that following in vitro fertilization using the ligand-selected high-mobility sperm, 90% of the embryos were XY male, whereas the TLR7/8-activated, slow mobility sperm produced embryos and pups that were 81% XX females (Umehara et al., 2019).

Following AI, many spermatozoa are phagocytized (Woelders and Matthijs, 2001) by polymorphonuclear leukocytes recruited into the cervix and uterus during estrus (Kaeoket et al., 2001). Currently, factors which can regulate the activity of phagocytosis of polymorphonuclear leukocytes have been examined (Matthijs et al., 2000, Li and Funahashi, 2010, Li et al., 2011) and utilized in AI for livestock production (Yamaguchi et al., 2009, Yamaguchi et al., 2013). Since total sperm number of sexed semen for AI is usually smaller than that of conventional one, management of the phagocytotic activity of polymorphonuclear leukocytes during timed AI with sexed semen may contribute to increase the following conception rate.

Current status of in vitro embryo production

In vitro embryo production (IVP) by using in vitro fertilization (IVF) or intracellular sperm injection (ICSI), have been applied to both livestock production and human assisted reproductive medicine. In cattle, in vivo oocyte collection by transvaginal ultrasound-guided follicle aspiration (ovum pick-up) and IVP are considered a reliable and cost-effective technique and have acquired a significant role in the breeding (Wrenzycki, 2018, Boni, 2012). Technologies of IVP for domestic animals have developed, the efficiency has been improving by adjusting each condition during oocyte growth and maturation, fertilization and early development (Funahashi, 2013, Funahashi, 2015, Romar et al., 2016, Luciano and Sirard, 2018, Appeltant et al., 2016, Wrenzycki, 2018, Sirard, 2018). Bovine IVF emerged as alternative to superovulation and has become the technique of choice for embryo production, especially in Brazil, where the application of IVP has been drastically increasing since 2002 (Viana et al., 2012).

For IVP, oocytes have usually been collected from medium or large follicles (3-6 mm or larger in diameter) of domestic animals' ovaries (Funahashi and Day, 1997, Romar et al., 2016, Day and Funahashi, 1996). Although the oocytes derived from small follicles (less than 3 mm in diameter) exist more on the surface of ovaries (Morbeck et al., 1992), both meiotic and developmental competences of the oocytes were significantly lower than those from medium follicles (Marchal et al., 2001, Yoon et al., 2000, Kohata et al., 2013). Efforts to improve the meiotic and developmental competences of oocytes derived from small follicles have been made by analyzing differences in characters of oocytes derived from middle and small follicles (Kohata et al., 2013, Okudaira et al., 2017, Kim et al., 2010, Matsunaga and Funahashi, 2017, Bui et al., 2017)

New horizons in animal biotechnologies

Technologies to produce transgenic and cloned animals has greatly contributed to the creation of pharmaceuticals and xenotransplantation organs (Wells and Prather, 2017). Furthermore,

new efficient technologies to introduce foreign DNA or modify endogenous genes in oocytes, embryos and somatic cells, namely genome editing, such as use of CRISPR/Cas9 (to cut the target DNA at the region where we want), have been developed and has made it possible to correct specific parts of the genome and introduce mutations by homologous recombination (Wells and Prather, 2017, Tan et al., 2016). In addition, male and female gametes, spermatozoa and oocytes, have been made from both embryonic stem (ES) cells and induced pluripotent stem (iPS) cells, and by using these gametes, pups have been produced successfully (Hayashi et al., 2011, Hayashi et al., 2012). The in vitro generation of germ cells from ES cells has also been succeeded in mice (Hikabe et al., 2016). In human, oogonia has been produced from iPS cells (Yamashiro et al., 2018). These breakthroughs in animal biotechnologies have proposed “in vitro breeding” that accelerates genetic improvement by shortening the generational interval (Goszczynski et al., 2019).

Conclusion

Various animal biotechnologies have successfully developed to improve the efficiency, to shorten the generational interval and to expand the application to animal production and biomedical field. To realize sustainable animal production in the current climate change, further development and integration of cut-in-edge animal biotechnologies will be required.

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Isolation, Identification and Antibiotic Sensitivity Testing for Bacteria Isolated from Mastitic Milk in an Up Country Dairy Farm in Sri Lanka

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Abstract

Mastitis is one of the important and common diseases among dairy cattle in the world and in Sri Lanka leading to severe economic losses. Identification of the predisposing factors and also the aetiology and their susceptibilities to remedial measures are of paramount important in mastitis. The use of antibiotics leads to the development of resistant bacteria which could have an adverse effect on human health. This study was aimed at isolating and identifying the common mastitis-causing bacterial species, i.e., *Escherichia coli*, *Klebsiella spp.* and *Staphylococcus spp.* and detecting the susceptibility of these isolates to six commonly used antibiotics Milk samples (n=31) were collected from cows suffering from subclinical and clinical mastitis. The susceptibility to commonly used antibiotics (Trimethoprim 05 µg, Oxytetracycline 30 µg, Chloramphenicol 30 µg, Cephalexin µg, Enrofloxacin 10 µg and Ciprofloxacin 30 µg) was tested by Kirby Bauer disk diffusion method. *E.coli*, *Klebsiella* and *Staphylococcus* were isolated from 31 milk samples. The occurrences of *Klebsiella*, *Staphylococcus* and *E. coli spp.* were 54.8, 51.6 and 41.9%, respectively. Among tested antibiotics, the highest (97.1%) and the lowest (31.4%) resistance were shown by Cephalexin and Chloramphenicol, respectively. Isolates were resistant to other antibiotics in varying degrees (Trimethoprim, 54.3%; Oxytetracycline and Enrofloxacin, 42.9%; Ciprofloxacin, 34.3%). Resistance to at least one antibiotic was observed for the isolated microorganisms. All three pathogens were resistant to Cephalexin. *E. coli* (10%) and *Klebsiella spp.* (27.3%) demonstrated the least resistance to Chloramphenicol. None of *Staphylococcus spp.* (0%) isolates showed resistance to Enrofloxacin. This study concluded that there is a potential of developing antibiotic resistance among the bacteria isolated from mastitic milk.

Keywords: Antimicrobial agents, Bovine mastitis; Isolation, Resistance

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Backyard Poultry Production in Trincomalee District, Sri Lanka: Management Aspects

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Abstract

A field survey was conducted in Trincomalee district to investigate the management practices adopted by the backyard poultry (chicken) farmers. One hundred farmers were selected from 3 Veterinary Surgeon ranges (Trincomalee Town & Gravets, Muttur and Kinniya) purposively, based on population size and interviewed using a comprehensive structured questionnaire. Descriptive analysis was carried out using Microsoft Excel (2013) while association between the categorical variables was determined by Pearson's Chi-squared test using SPSS (Version 20). Poultry flocks were managed mainly by women farmers (70%) as an extra source of income while engaging in other major income generating activity. The majority (41%) of the farmers earn from labour work. The average poultry flock size was 21.36 ± 12.33 . Scavenging was the major source of feed in all the farms, while some farmers feed their poultry mainly with rice bran (53%) and commercial feed (44%). Ground-level housing (59%) was the predominant housing type, whereas 53% of the farmers provided separate houses for chicks and growers. Farmers either purchased (56%) or used eggs from their own flock (44%) for incubation. Pearson Chi-squared test statistics showed a significant ($p < 0.05$) higher mortality percentage during the chick stage which was mainly due to diseases (53%) followed by predator attack (41%). Newcastle was the most prevalent disease condition (68%) and poultry diseases are mainly controlled by traditional methods (89%). The major constraints for backyard poultry production listed by the farmers were lack of extension and veterinary services (100%), intervention by the middlemen (37%) and poor market accessibility (30%), Immediate attention is needed on the above aspects for the benefit of the backyard poultry rearing farmers.

Keywords: Backyard poultry, Constraints, Management aspects, Scavenging

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A Comparison of Morphology and Egg Quality Characteristics of Frizzled Feathered Chicken and other Indigenous Poultry Breeds in Sri Lanka

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Abstract

A study was focused to study the morphology and egg quality characteristics of frizzle feathered chicken and the other indigenous chicken breeds in Sri Lanka. A total of 828 birds under five categories such as frizzle feathered chicken, frizzle feathered and bantam cross, pure village chicken, Asil chicken and village chicken cross and pure Asil chicken were selected throughout the country and were analyzed. Sampling method was purposive sampling method. Five farms which consist of only indigenous chicken and more than five birds from each district (25 districts throughout the country) were selected with the help of provincial veterinary officers. A total of hundred freshly laid were used to evaluate internal and external egg qualities such as egg weight, egg length, egg width and egg shape index, shell weight, shell thickness, egg volume, yolk weight, albumin weight, yolk ratio, albumin ratio and egg shell ratio. According to their different morphological characteristics, nine village chicken breeds such as frizzle feathered chicken, bantam chicken, asil chicken (Daththa, Rathu Porakukula, Kalu Porakukula), black chicken, common village chicken and crested chicken were identified. The management practice adapted was free ranging system. Frizzle feathered chicken had a significantly lower egg weight, length, width in comparison to the other breeds, however, there was no significant difference between the egg index of any of the breeds. The association between egg width and egg shape index in frizzle feathered cross were found to be positive and significant ($r = 0.773$; $p < 0.01$). Other egg parameters did not show a significant relationship, however, were negatively or positively correlated. The cross of pure village chicken fowl and cock showed higher mean values for albumin weight and the egg shell ratio compared to the other two crosses. It can be concluded that the introgression of the other breed genes into indigenous poultry could play a pivotal role in the genetic improvement of traditionally managed flocks and also the study indicates the presence of genetic and environmental variations with respect to egg quality traits highly within indigenous poultry populations and careful selection of economic egg quality traits and thereby selection of best local ecotypes can form the basis for genetic improvement through better breeding programs.

Keywords: Egg quality, Frizzle feathered, Genetic resource, Indigenous breeds, Morphology

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Ranking of Welfare Issues in Dairy Cattle Production in Tropics Based on the Attitudes of Different Social Strata: A Case Study

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Abstract

Animal welfare has become a global concern amongst consumers and producers. Objective of the study was to rank the welfare issues in dairy cattle production based on attitudes of three social strata; farmers (non-sexed;livestock rearers), academics (irrespective of Veterinary/Animal Science fields) and consumers (those purchase farm products regularly). Data were collected in Matara District by using a structured type questionnaire by adopting purposive sampling technique (n= 150). Questionnaire consisted of 46 welfare issues, listed under 8 domains [animal health care (AHC), feed/water, management practices (MP), breeding practices, human-animal relationships, housing and climate, suffering and stress (SAS) and engage in natural behavior (ENB)]. Prioritized welfare issues were ranked following five point likert scale (5- Very important, 4- Important, 3-Neutral, 2- Not important, and 1- Not important at all). Cronbach α values felled within the acceptable range ($\alpha=0.706-0.931$). Irrespective of the social strata, the most concerned welfare issues in dairy cows were supply of adequate amount of water, nutritionally balanced feed and treatments for bloating. Meantime, least concerned issues were exposure to strangers, allowing play behaviors and supplying appropriate space. Farmers category showed the highest concern (94. 83 % \pm 0) for MP and the lowest for SAS (65.00 % \pm 0). Consumers showed the highest and the lowest concerns for AHC (94% \pm 0) and ENB (84% \pm 0), respectively. Similarly academics also showed the highest concern for AHC (91% \pm 0) and the lowest for ENB (80% \pm 0). There were significant ($p<0.05$) interactive effects between age total welfare issues and education level total welfare issues. Meantime, academics recorded the highest concern (88 \pm 0 %) on dairy cattle welfare while farmers recorded the lowest. Highest concern (89 \pm 0%) was recorded by the above graduated people while the lowest (84 \pm 0 %) by those having A/L s. Further, it was recorded the highest (89 \pm 0.6 %) perception among 30-50 aged people and the lowest (85 \pm 0.82 %) was among 20-30 age group. Many people considered animal health and feed related issues as more important in dairy cattle welfare issues over stress condition of the cows and engaged in natural behavior. It is concluded that the perception of dairy cattle welfare issues are significantly affected by the age and the education level of social categories that can be included for the purpose of improving welfare of farm animals in Sri Lanka.

Keywords: Attitudes, Dairy cattle, Ranking, Social strata, Welfare issues

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Genomic Selection to Increasing Marbling in Hanwoo (*Bos taurus coreanae*) Steers without Increasing the Back Fat Deposition

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Abstract

Marbling (or the accumulation and distribution of intramuscular fat) is the most important factor determining the quality and the market value of beef. On the other hand, one of the major focus of the sustainable beef production system is to increase the marbling without increasing the overall fatness. Therefore, the present study was to evaluate the effect of genomic selection based on estimated breeding value for marbling score (MS-EBV) on carcass marbling and back fat deposition. Total of 100 castrated Hanwoo calves (*Bos taurus coreanae*) (average age six months and weight 196.97 + 18.5 kg) were genotyped using Illumina Bovine SNP50 BeadChip. Following the GBLUP approach, MS-EBVs were calculated using 2394 Hanwoo reference population. After the quality control, out of 54609 single nucleotide polymorphisms (SNP) a total of 34676 SNP were retained for further analyses. Then steers greater than mean MS-EBV were grouped for high MS-EBV and lower than the mean were grouped into low MS-EBV. Steers were managed under similar conditions throughout the growing, early fattening, middle fattening and final fattening phase until the average 30 months old. Finally, carcasses were evaluated for Marbling score (MS) and Back fat thickness (BFT). Results revealed a significant direct response to the selection for MS-EBV as carcass MS greater ($P < 0.05$) in high MS-EBV steers compared to the Low MS-EBV group. However, no ($p > 0.05$) correlated response for selection for MS on the back fat deposition. Therefore, the present study confirms the potential to increase the carcass MS of Hanwoo steers through selection for MS-EBV without adverse effect on BFT deposition.

Keywords: Back fat thickness, Genomic selection, Hanwoo, Marbling score

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Evaluation of Goat Farming Practices in Selected Veterinary Ranges in Anuradhapura District

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Abstract

Goat is an important farm animal in rural agriculture, and it is believed that they are well adapted to harsh environmental conditions. Anuradhapura district has the third highest goat population in Sri Lanka and a review of current status of goat management is important. The present study aimed at evaluating the socioeconomic aspects and goat farming practices in the Anuradhapura district. A field survey was conducted in 120 goat farms (out of 1286 farms) in 12 veterinary ranges in Anuradhapura district, and farmers were interviewed using a pre-tested structured questionnaire. This study revealed that the goat farming was mainly dependent on self-labor (62.5%; 75/120) and majority of goat farmers were influenced by their parents for goat farming (62.5%; 75/120). Level of education of most of the farmers was below the G.C.E. Ordinary Level (85.8%; 107/120). Only 10.8% (13/120) of the farmers were below 30 years of age. The majority of farmers were Buddhists (61.7%; 74/120). The major purpose of goat rearing was selling of live goats for meat and herding purposes (70%; 84/120). Further this study has shown that semi-intensive farming (75%; 90/120) as the popular management practice whereas 25% of the farmers practice extensive management system (30/120). Intensive management was not reported to be practiced and this was mainly due to the availability of abundant lands. Mainly, slatted-floor goat houses were found (58.9 % (53/90). Most of the farmers did not practice any identification method (80.8%; 97/120) and no proper record keeping was reported in the area. Ear tagging was practiced by 13.3 % (16/120) of the farmers as an animal identification method and record keeping was done only by 22.5% (27/120) of the farmers. Animals were bred only by natural mating using communal bucks due to the absence of an efficient artificial insemination service. Uncontrolled natural breeding practices have resulted non-descriptive crossbred goats in majority of the farms (70%; 84/120) and the rest comprised of indigenous goats (30%; 36/120). According to farmer awareness, goat paralysis (23.3%; 28/120), kid mortality (21.7%; 26/120), diarrhea (19.2%; 23/120) and skin diseases (15%; 18/120) were among the common health problems in goats reared in the area. In conclusion, goat farming practices were sub-optimal in Anuradhapura district. Lack of awareness of farmers on proper management practices and record-keeping and insufficient veterinary and extension services at field level hindered the growth of goat farming in the area.

Keywords: Anuradhapura, Farming, Field survey, Goat, Production

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Whole Genome Re-sequencing Reveals Population Structure and Population History of Sri Lanka Wild Boars and Domestic Pigs

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Abstract

Independent domestication in Europe and East Asia and dispersal of pigs has promoted the global agricultural blooming. Revealing the origin and history of Sri Lankan domestic pigs was of interest, since only mitochondrial DNA evidence was explored and suggested an Asian ancestry of Sri Lankan local pigs and wild boars. To address the population structure and population history, whole genome analysis of Sri Lankan wild boars and domestic pigs was conducted. Principal component analysis and phylogenetic trees showed that Sri Lankan wild boar was an ancient wild suid species and the domestic pigs had a close relationship with European pig breeds than with East Asian domestic pigs. Strong bottleneck effect was observed in the Sri Lankan wild population. Population admixture analysis supports that Sri Lankan pigs comprise a mixed group with much more components from Europe than from East Asia. Strong gene flow was observed between Sri Lankan domestic pigs and European pig breeds. This study suggested that Sri Lankan domestic pigs have a complex genetic background with pronounced European contribution, and Sri Lankan wild boars represent an ancient species that showed no evident genetic contribution to the genetic diversity of Sri Lankan domestic pigs.

Keywords: Domestic pigs, Genetic sequencing, Wild boars

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Effects of Supplementation of a Combination of Organic Magnesium, Zinc, Copper and Selenium Glycinates on Production Performance of High Producing Dairy Cows in Early Lactation

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Abstract

Minerals are required for better production performance and health of cows and they are consumed by animals through feed and mineral mixtures. Minerals in a mineral mixture can be of either inorganic (No carbon compound attached) or organic (Containing carbonic compounds such as an amino acid) form. It has been well documented that organic minerals improve the production performance of dairy cows than their inorganic counterparts. Therefore, the objective of the current study was to evaluate effects of organic (OM) vs. inorganic (IM) mineral mixture on the production performance of Holstein Friesian cows during early lactation. Twenty multiparous Holstein Friesian dairy cows at ± 20 days into lactation were randomly allocated to two treatments (n=10), either organic (OM) or inorganic (IM) based on body weight (BW), body condition score (BCS), milk production and milk composition. The two groups were fed with a TMR according to the nutrient requirements and supplemented either 50 g/day of OM (Fertiplus)[®] or the same amount of IM at two time intervals (25 g each in the morning and evening). The OM had the manufacture certification of four minerals as organic (Glycinates of Mg, Zn, Cu, Se) compared to the IM. During 90 days experimental period, milk yield recorded daily, milk samples collected last seven days of the experiment for composition and mineral analysis, BW and BCS measured weekly whilst number of heat detected was recorded throughout the study. Data analysed as a randomized block design (Non parametric) using statistical software SAS (Version 06). OM supplemented cows tends to had 14% higher (P=0.07) milk production (20.3 L/day vs. 17.4 L/day) than IM fed animals. When milk production improvement due to OM supplementation during last 7 days of the study is considered, extra income gained through that increase was about Rs. 148.00/day/animal than IM supplementation. BCS was also tends to be high (P<0.07) in OM supplemented cows than IM (3.02 vs. 2.80). Total number of heat detected during experimental period for OM and IM supplemented cows were 18 and 13, respectively. However, there was no effect on OM supplementation on milk composition, BW and mineral composition of milk. Based on results, it is concluded that organic mineral supplementation has a positive effect on milk production and reproduction performance of early lactation Holstein Friesian cows.

Keywords: Dairy cows, Milk production, Organic minerals, Reproduction, Supplementation

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Developing a Greenhouse Gas Emission Inventory for Sri Lankan Dairy Industry

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Abstract

Despite the vital role of dairy industry in Sri Lankan context, greenhouse gas (GHG) emission due to enteric fermentation has a significant impact on world wild climate change. To identify and implement sustainable strategies to mitigate dairy related GHG emission, it is crucial to have precise values. The objective of this study was to develop a more accurate GHG emission inventory of Sri Lankan dairy industry to improve mitigation practices of climate change. Tier 2 approach which was introduced by the Intergovernmental Panel for Climate Change (IPCC) was annotated country specific data for estimations thus producing a clear picture than Tier 1. Sri Lankan main four dairy production systems which consist with various country specific data; Up country and Mid country (UCMC), Coconut triangle (CT), Low country wet zone (LCWZ) and Low country dry zone (LCDZ) were selected. Therefore a country specific database should be developed for cattle and buffalo to get the precise emission factor (EF) value based on main criteria. They were population parameter of cattle and buffalo, cattle and buffalo head parameters (weight) and cattle/ buffalo feed basket (digestibility, crude protein). By using developed data base and IPCC equations, EF of an animal for male, female, calves of each cattle and buffalo and total emission in each production systems per year were derived. Derived EF for LCWZ was compared with an actual situation where calculations were done by using data from a cattle and buffalo farm located in LCWZ. The highest total methane emission was recorded in LCDZ (34.09 GgCH₄year⁻¹) and lowest in UCMC (6.45 GgCH₄year⁻¹). Emission factors vary with age, structure of animals, diet quality, reproduction performance and environment temperature.

Keywords: Dairy production systems, Enteric fermentation, Greenhouse gas, Livestock, Manure management

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Effect of Dietary Supplemental Bile Acid on Growth Performance, Nutrient Digestibility and Visceral Organ Weight of Broiler Chicken

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Abstract

Bile acid secretion is low in younger birds resulting in lower dietary fat digestibility and energy value. Objective of this study was to evaluate the effect of supplemental bile acid (BA) in diets with different energy levels on growth performance, nutrient digestibility, visceral organ weight and energy sparing effect of broilers. Eleven-day-old, Cobb 500 chicks (n=360) were allocated into 36 floor pens that arranged in 3 × 2 factorial design. Experimental factors were 3 dietary energy levels (standard, standard -45Kcal/kg and standard-90Kcal/kg) and 2 BA levels (with or without). Standard starter (12d to 27d) and finisher (28d to 42d) diets were formulated to contain 2960Kcal ME/kg and 3100Kcal ME/kg, respectively. A three day (36d-38d) total collection trial was performed to determine the nutrient digestibility. Results showed that dietary energy level had no significant effect on live weight on 42d. However, BA significantly ($p<0.05$) increased live weight on 42d. Live weight on 42d was significantly influenced by BA x energy level interaction. Bile acids when added to diets with lower dietary energy levels (-45 Kcal and -90) reported significantly lower live weight on 42d than when added to standard level of energy. Lower energy levels also reported significantly lower weight gain compared to standard energy level. Reduction of energy by 90 Kcal/kg significantly reduced the feed intake compared to -45 Kcal diet. Bile acid supplementation significantly increased the total weight gain from 12-42d. Standard dietary energy level also resulted in significantly higher weight gain compared to both of lower energy levels. Though the feed conversion ratio (FCR) was not significantly influenced by dietary treatments, the best FCR (1.69) was reported by the birds fed BA supplemented-standard energy diet. Empty carcass weight was significantly increased due to BA supplementation. Digestibility values were not significantly affected by the treatments. The total feed cost/bird was significantly different among three dietary energy levels where standard energy level reported the highest feed cost while the -90 Kcal diet gave the lowest feed cost. The study concluded that the supplementation of bile acid improved the growth performance of broilers. Bile acid had no energy sparing effect and thus supplementation of bile enriched diets with standard level of energy is recommended.

Key words: Bile acid, Broilers, Energy, Growth performance, Digestibility, Carcass parameters

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Essential Oils as a Feeding Strategy to Reduce Enteric Methane Emission for Environmental Sustainability

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Abstract

Enteric methane (CH₄) produced in the process of assimilating nutrition in ruminants have great contribution to the global greenhouse gas emissions (GHG). Methane production leads to loss of gross energy in animals which otherwise can be diverted for milk synthesis. Several chemicals including various Essential oils (EOs) that inhibit methanogenesis have been evaluated for their efficacy in ruminants. Combination of two EOs (Peppermint and Garlic oil) was tested *in vitro* for their effect on methane production, fermentation, volatile fatty acids, ammonia nitrogen, total bacteria and protozoa. The experiment was conducted with control and treatment group by *in vitro* gas production technique as described by Menke and Steingass (1988). The control group contained only the basal feed (60: 40 ratio of paddy straw: concentrate) whereas the treatment group contained basal feed along with EO combination (0.65 µl of garlic oil + 0.25 µL peppermint oil per 30 ml rumen liquor). EOs reduced total gas, methane production and percentage of methane in total gas significantly (P < 0.01) in the treatment group, the methane production in the control group was 7.29 ± 0.17 ml whereas in treatment group it was 4.44 ± 0.05 mL per 200mg of basal feed. *In vitro* true dry matter degradability (%), ammonia nitrogen (mg %), total protozoa (cells / mL), total bacteria (cells / mL) did not show any significant (P > 0.01) difference between the control and treatment group. With respect to the volatile fatty acid, there was highly significant (P < 0.01) reduction in acetate (mol %) production and significant (P < 0.05) increase of propionate (mol %) production in treatment group compared to control thereby reducing the acetate to propionate ratio. The pH, microbial biomass production (mg) and partitioning factor significantly (P < 0.01) increased in the treatment group when compared to control group. The blend of essential oil was effective in reducing methane production *in vitro* as it reduces methane by 39.17 % without affecting digestibility and fermentation characters. The feasibility of feeding essential oil can now be considered at farm system level as a methane mitigation strategy.

Keywords: Essential oil, Garlic oil, *In vitro* gas production technique, Methane mitigation, Peppermint oil

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Yield and Nutritive Value of Three Improved Fodder Varieties under Different Harvesting Intervals during the Yala Season in Sri Lanka

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Abstract

In Higher production potential of ruminant livestock could be obtained by the provision of improved pasture and fodder. Therefore, an experiment was conducted during the Yala season (from May to September) 2017 to compare the herbage yield and chemical composition of CO-3 (*Pennisetum purpureum* × *P. typhodium*) and CO-4 (*P. glaucum* × *P. purpureum*) hybrid fodder varieties and fodder sorghum (var. Sugar graze) (*Sorghum bicolor*) at the Faculty of Agriculture farm, University of Ruhuna, Kamburupitiya. The experimental design was a factorial arrangement in a randomized complete block design with three harvesting intervals at 4, 6 and 8 weeks. Total yield was recorded for the whole season and chemical analysis was done according to the respective AOAC methods. Total dry matter yield (TDM) of sugar graze was lower ($P>0.05$) at 4th week as compared with the TDM yields of CO-3 and CO-4 while no significant difference was observed amongst varieties at 8th week. Nutritive values were markedly decreased in all varieties with increasing stage of maturity. Dry matter contents among varieties were slightly different at all harvesting frequencies. Sugar graze had highest ($p<0.05$) crude protein (CP) (21.19%, 19.47%, 15.37%) at all three harvesting intervals compared to CO-3 and CO-4. At 4th and 6th weeks, ash content (12.78%, 8.68%) of sugar graze was high compared to that in CO-3 and CO-4, but at 8th week of harvest, it recorded the lowest ($P<0.05$). At 4th and 6th weeks of harvest, CO-4 had higher organic matter (OM) content ($P<0.05$) than CO-3 and sugar graze, but sugar graze had highest ($P<0.05$) OM content (93.19%) at 8th week. Ether extract (EE) content did not differ for all three varieties at 4 weeks of harvest, but differed slightly thereafter. Crude fiber (CF) content gradually increased with increasing harvesting interval, however, compared to CO-3 and CO-4, sugar graze recorded lowest ($P<0.05$) CF values at all three harvesting intervals (21.88%, 26.57%, 28.71%). The results revealed that sugar graze would be an ideal fodder for ruminant feeding in terms of nutritive composition. In order to obtain maximum nutritive values, CO-3 and CO-4 should be harvested at 6th week and sugar graze at 8th week.

Key words: Chemical composition, Hybrid Napier, Sorghum

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In-vitro Fermentation, Digestibility and Methane Production of Three Improved Forage Varieties Harvested at Different Cutting Intervals during the Yala Season in Sri Lanka

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Abstract

Methane (CH₄) emission from the ruminants is one of the major contributors to global warming. Methane productions from forages vary according to the stage of maturity, digestibility and energy content; however, there are no sufficient data available in Sri Lankan context. Hence, the present study was conducted to assess the CH₄ emission and in-vitro rumen characteristics of CO-3 (*Pennisetum purpureum* × *P. typhodium*), CO-4 (*P. glaucum* × *P. purpureum*) hybrid fodder varieties and fodder sorghum (var. Sugar graze) (*Sorghum bicolor*). Fodder samples were collected at three harvesting intervals as 4, 6 and 8 weeks. They were analyzed for Metabolizable energy (ME), Organic matter digestibility (OMD) and CH₄ production by in-vitro gas production technique. The data were analyzed using General Linear Model in Minitab 16. The ME and OMD values were gradually decreased with increasing harvesting interval. Results revealed that both highest ME (9.20, 8.7, 8.24 MJ/Kg DM) and OMD (63.18, 59.49, 55.87%) from Sugar graze in all harvesting intervals while the lowest ME (8.31, 7.53%) and OMD (57.34, 51.34%) from CO-3 at 4th and 6th weeks, respectively. However, there were no significant differences (P>0.05) in ME and OMD between CO-3 and CO-4 at 8th week. In contrast, CH₄ production was increased in all varieties with increasing harvesting interval while no significant difference was observed amongst varieties at 4th week and between Sugar graze & CO-4 at 6th week of harvest. At 8th week of harvest, Sugar graze recorded the lowest (P<0.05) CH₄ production compared to CO-3 and CO-4. Though, Sugar graze showed superior characteristics to hybrid Napier varieties in terms of ME, OMD and CH₄ production at all harvesting intervals but showed high HCN at 4th week, it cannot be recommended for animal feeding. In conclusion, Sugar graze is superior to both CO-3 and CO-4 in terms of higher ME content and lower CH₄ production at harvested between 6-8 weeks while CO-3 and CO-4 can be recommended harvested at 6th week for feeding.

Keywords: Organic matter digestibility, Methane, Sugar graze

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Anticoccidial Effects of *Phyllanthus emblica* (Beheth nelli) in Broiler Chickens *In vivo*

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Abstract

Coccidiosis is one of the most common infectious diseases in poultry industry worldwide causing huge economic losses and current control strategies have failed to control the disease due to development of anticoccidial resistance and vaccination failures caused by the *Eimeria* species. The use of natural remedies is becoming a promising alternative to combat this disease. Our study aimed to investigate the effects of *P. emblica* on the infectivity of *Eimeria tenella* oocysts *in vivo*, in order to evaluate it as a novel anticoccidial agent. In the trial, 21 day old cobb chicks (n=20) were randomly assigned into four treatment groups each with 5 replicates and infected with 1×10^4 sporulated oocysts. (A) infected with oocysts and un-supplemented diet, (B) infected with oocysts and supplemented diet (1g/bird/day from a mixture of 50% each fruit and leaf powder), (C) infected with *P. emblica* treated oocysts (24 hours exposure to fruit and leaf water extract) and un-supplemented diet, and (D) infected with oocysts and supplemented diet (as described in group 1) from day 14 post-infection. The oocyst per gram of faeces (OPG) count was negative on day 0 and 3 of the experiment. On day 7, 21 and 28 a reduced number of oocysts ($p < 0.05$) were excreted in the group B compared to all the other groups, except on day 14 with group C having the lowest count. In comparison to the negative control group A, the oocyst excretion in the group C varied from a lower initial OPG to increased OPG, while the group D demonstrated significant reduction in oocyst count from day 14 onwards. The chickens supplemented throughout the experiment (Group B) showed the highest weight gain and lowest OPG *in vivo*. In conclusion, fruit and leaf powder of *P. emblica* markedly reduced the fecal oocyst excretion in *E. tenella* infected chickens and reduced the pathogenic effects, fortifying its protective effect against coccidia infection in chicken. *P. emblica* demonstrates a great potential as an alternative to widely used commercial anti-coccidial drugs in poultry industry. *P. emblica* treated oocysts showed a potential for a possible development of a vaccine.

Keywords: Broiler chickens, Coccidiosis, *Eimeria* spp., *In-vivo*, *Phyllanthus emblica*

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Oil Palm Industry



Keynote speech

Prospectus of Palm Oil Industry in Global and National Levels

Dr. Rohan Fernando

Managing Director, Aitken Spence Plc

Palm oil has been a very versatile crop which has been around for almost 100 years in several countries like Malaysia, Indonesia and parts of Africa whilst palm oil has been in Sri Lanka too for just over 50 years.

The global demand for palm oil has been rising amidst several criticisms both in Sri Lanka and overseas. The versatility of palm oil as a product has also been increasing rapidly where its use in edible form and other forms of usage has seen a significant improvement. Palm oil also has been a major contributor to several national economies particularly Malaysia and Indonesia and has attracted large scale investments both in Sri Lanka and overseas, despite several negative sentiments expressed against its expansion.

At the same time, it's sustainability has also been challenged thus becoming a hot topic for discussion in several forums. This conference aims to take a pragmatic view of Palm Oil as a Plantation crop and discuss some of the issues that the industry is facing.

Investigating the Potential of using Micro Algae for Simultaneous Palm Oil Mill Effluent Treatment and Astaxanthin Production

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Abstract

Palm oil industry has a striking global demand of 62.6 million tonnes of palm oil annually. Nonetheless, environmentalists have expressed concerns towards the industry, due to higher generation of palm oil mill effluent (POME) and its tribulation of treatment. Therefore, requirement of an affordable and ecological treatment method for POME is aggravating. Thence, microalgae cultivation in POME with the aim of removing nutrients has emerged as a potential solution. The main objective of the research was to evaluate the efficacy of microalgae cultivation in POME with simultaneous biomass/carotenoid production, employing the microalgae species *Haematococcus pluvialis* and *Chlorella zofingiensis*. These species were selected based on their ability of accumulating the high-value carotenoid, astaxanthin. The cultures were grown in an array of lab-scale photobioreactors containing different dilution ratios of POME. Grown at room temperature under 12-hour illumination for 14 days, the cultures were subjected to the stress conditions by doubling the light intensity under 24-hour illumination to stimulate astaxanthin accumulation. Biomass concentration was determined via dry weight measurement and astaxanthin was quantified by solvent extraction followed by spectrophotometric analysis. The experiments were conducted in duplicate to avoid any variability in results and average values were reported. The significant differences of the results were compared to the control, wherever applicable using the 'Two-tailed t-test analysis'. Through obtained results, efficiency of POME as a high nutritional substrate, microalgal growth rates and astaxanthin production of both microalgae species were analyzed. The highest biomass concentration and astaxanthin content for *H. pluvialis* were obtained as 0.735 ± 0.021 g/L and 29.556 ± 0.738 mg/L in 7.5% POME concentration. For *C. zofingiensis*, it was 0.745 ± 0.007 g/L and 3.733 ± 0.372 mg/L in 7.5% dilution. The highest growth rates for *H. pluvialis* and *C. zofingiensis* were attained as 0.0991 ± 0.0072 /day in 7.5% dilution and 0.1095 ± 0.0289 /day in 2.5% dilution, respectively. Both species indicated significant nutrient removal with the highest removal percentages being 96.7% for total nitrogen, over 75% for total phosphorus and 70% for COD. The results of the present study indicate that POME is an economical alternative growth media for *H. pluvialis* and *C. zofingiensis* to produce microalgal biomass with ample yield of astaxanthin while performing phycoremediation.

Keywords: Astaxanthin, *Chlorella zofingiensis*, *Haematococcus pluvialis*, Palm oil mill effluent, Wastewater treatment

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Stakeholders' Perception and Attitudes on Converting Rubber into Oil Palm: A Case Study in Kegalle District, Sri Lanka

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Abstract

This study examined stakeholders' perception and attitudes toward crop transformation from rubber into oil palm in Kegalle district. Study was conducted from June (2018) to January (2019) at Panana division in Madeniya Estate, Warakapola. One hundred participants (n=100) of plantation workers (total=175) and 100 stakeholders from the village, were selected by using simple random sampling technique. Interviews were arranged with chief priests in nearby temples, estate superintendent, veterinarians, representatives at regional hospitals and plantation companies, environmentalists as exceptional to the selected sample. To represent the villagers' attitudes 100 members were interviewed from fifty houses nearby the plantation. Data collection was done using a pre tested structured questionnaire and water table depth of two wells which were located in oil palm and rubber plantations were measured. Results revealed that 3% of labours in 20-30 age category and it was cleared that future of rubber industry has to face severe labour scarcity. On the other hand, participants were not satisfied with the present wages. However, 60% of them satisfied about their job as they practiced rubber tapping for a long period. The results clearly showed that 100% of participants were aware of oil palm cultivation in the area by rumors which have created an emphatic public opinion against oil palm. Sociological disfavours such as loss of jobs, no added benefits from oil palm, spreading of skin diseases among dogs, increase of snake population and environmental problems including groundwater depletion and biodiversity degradation. Among the participants, 97% were believed that there is an environmental impact on oil palm cultivation. Among the participants, 37% were experienced difficulties faced due to oil palm cultivation in the area. According to the One-sample Wilcoxon signed ranked test there was a significant relationship between job satisfaction and service period. ($p < 0.05$) and there was a significant relationship between attitude toward the introduction of oil palm and service period ($p < 0.05$). There were no snake bites recorded in past 2 years in the estate and this was verified with the records in regional hospitals. According to the veterinarians the dog's skin irritations were because of common parasitic disease. The fluctuation of ground water table in oil palm and rubber plantations were depended on climatic factors. Water table decreased during the dry season (September and January) and increased during the wet season (October to December) in both plantations. Based on findings and future prospects of oil palm industry, awareness programs should be arranged with the support of all stakeholders. Before converting rubber into oil palm, it is necessary to conduct scientific researches, environmental assessments; geographical assessments and socio-economic analysis with intervene of government to measure the suitability of expanding oil palm cultivation in the study area.

Keywords: Land use conversion, Oil palm, Rubber, Stakeholders perception

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Socio Economic Status of Oil Palm Harvesters in Southern Sri Lanka

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Abstract

Oil Palm tree produces edible oil next to the coconut in Sri Lanka. Harvesters play an important role in the oil palm sector and they are trained for manual harvesting which is a high demanding and skillful job. A field survey was conducted to identify the socio economic status of the oil palm harvesters in Southern Sri Lanka targeting to improve their livelihood conditions. Fifty oil palm harvesters in Thalgaswella and Homadola estate were interviewed using a pretested structured questionnaire. Information including four livelihood capitals such as human capital, physical capital, financial capital and social capital were gathered. All the oil palm harvesters in the targeting group were males. Many harvesters were educated up to grade ten (38%). Monthly income of the majority of harvesters (42%) is less than Rs.20000. Only 18% earns Rs.30000-40000. The average monthly income of a family including oil palm harvesting and by other earnings is Rs.30225. According to the findings, income from oil palm harvesting is contributes for 75.86% of average monthly income of a family. Daily income of a harvester is around Rs.855. The average earnings of harvesters who engage in oil palm harvesting for 30 days (full time) earn more (Rs.28018) than those who involve less than 15 days (Rs.17666) and doing extra jobs. Some harvesters (44%) save a fraction of their income. The average saving is noted as Rs.2866 per month. Some harvesters (36%) had obtained loans from banks and from the estate for building houses and to spend on festivals. All the respondents had one story houses. Walls of the houses built up with bricks (82%) while few (18%) with clay. Some roofs were thatched (14%), with tiles (6%), with sheets (47%) and some were with corrugated sheets (32%). Most of the houses witnessed with the facilities like a television (92%) and refrigerator (62%). Respondents had their own motor bikes (32%), three wheels (14%) while 40% of them did not have a vehicle. Some respondents (44%) were members of the village associations. A sizable portion of the people was (68%) alcohol addicts and spends around Rs.3600 per month for purchasing alcohol. Workers are paid with interest free festival advances, gratuity payments for the service, over time payments as incentives by the estate. It is suggested to conduct training programs on harvesting, acknowledging programs on money saving and banking, alcohol prevention programs and provision of low interest house loans. Addressing the problems of oil palm harvesters while facilitating their socioeconomic development will attract more local workers to oil palm sector and their livelihood development will increase the oil palm productivity.

Keywords: Harvesters, Oil palm, Socio economic development, Southern Sri Lanka

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Is there any impact on grazing Buffalos in mature oil palm fields? A survey conducted in Thalagaswella estate in Galle district, Sri Lanka

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Abstract

Oil palm belongs to the palm family native to Africa, *Elaeis guineensis*, and the species native to South and Central America, *Elaeis oleifera*. Both species are perennial tropical trees in the family Areaceae which are grown for their oil. Palm oil is widely used as cooking oil, as an ingredient in many processed foods and as a substitute for butter. It was introduced to Sri Lanka as a commercial crop, around 50 years ago and first established in Galle district as a rain fed perennial cash crop. Fertilizers are the most important input that ensures optimum crop production and are broadly classified into chemical and organic fertilizers. The use of organic fertilizer dates back to man's early farming activities. Most of the oil palm fields are grazed by buffalos living adjoining to the plantations and hardly they go to their own cattle sheds. These buffalos are milked by owners inside the oil palm fields and buffalos are virtually living their life inside the oil palm fields. This study was focused to observe whether there is any impact on buffalo herd size versus growth, yield and soil properties variation in oil palm plantations. For this survey nine mature oil palm fields were selected according to buffalo density living in those fields. Selected fields were planted during year 2000, 2005 and 2009. Nine fields were divided into three categories according to their year of planting. Yield per Hectare (YPH), plant height, soil pH and Chlorophyll readings of 17th frond (Spad units) were recorded against the buffalo herd size. Data shows that there is a reduction in pH against the buffalo herd size (about 10% decline). Yield increment could be seen against the highest buffalo count versus lowest buffalo count (about 10% increment against the lowest yield among year 2000 planted fields). Chlorophyll readings of 17th frond against the buffalo herd size shows positive correlation (about 9.4% increment against the highest value). Buffalo herd size versus height showing an increment in palms planted in year 2000 (about 12.5% increments against the highest value)

Keywords: Buffalo, Chlorophyll, Macro and micro nutrients, Soil pH

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Possibilities of Intercropping with Immature Oil Palm at Thalgaswella Estate (WL2a) in Galle District, Sri Lanka

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Abstract

Oil palm (*Elaeis guineensis*) is identified as the world's leading edible oil producing plant and well established as a perennial plantation crop in tropical countries including Sri Lanka. Economic life span of the plant is around 30-35 years and stand per hectare is around 120-135 plants. At the initial stage of the plantations (age up to 3-5 years) there is an ample amount of free space available inside young plantations. During immature period growers will not getting any income from oil palm and have to spend several other agricultural practices such as soil conservation techniques and weeding. Intercropping with young oil palm is possible and practiced specially by small and medium scale farmers with suitable combinations of crop species. A research was conducted at Talgaswella estate of Elpitiya Plantations PLC., during the period of September 2019 to January 2020. The study was designed, RCBD with four treatments as banana, ginger, turmeric and control with three replicates. Initial stage results shows that there is a significant different in frond length in banana and turmeric plots compared to the control. Results revealed that the highest girth of oil palms recorded in banana plot ((F value = 0.25). Further studies should be conducted with yield data for a firm recommendation.

Keywords: Intercropping, Young oil palm, Sustainable resource utilization

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Establishment of Edible Bamboo (*Dendrocalamus asper*) as a Boundary Crop for Young Oil Palm (*Elaeis guineensis*) Cultivation- Awareness of nearby Residents

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Abstract

Oil palm (*Elaeis guineensis*) became more popular in recent decades among plantation companies due to high profitability. Its high rate of expansion in the wet zone of the country has raised severe public concern about ecological impacts. Depletion of the ground watertable is the main concern raised by the people in those areas. Thus, plantation companies were decided to plant another crop as boundaries in these estates. Therefore, this study was designed to identify the awareness of nearby residents on edible bamboo as a boundary crop. The edible bamboo plantation trial was established in lower division in Thalgaswala estate, Elpitiya plantation in Galle district. The area was purposely selected for this study. The questionnaire survey was carried out to collect information from 70 residents during July-September 2019. Results indicate that all people (100%) prefer edible bamboo cultivation and most of them were stated that this bamboo will be reduced oil palm root spreading (46%) and reduce the water loss problem (54%) as environmental services. A larger percentage (83%) of residents were stated planted bamboo can be useful as fuel while some residents were stated it will be given a cooling effect as benefits of bamboo. Most of the residents were suggested cinnamon and fruit crops are also suitable as the boundary crops. Juvenile shoots of edible bamboo can be used as a healthy food was known by all residents (100%, $P<0.05$). Although residents stated that these bamboo are edible, nutritive value of edible bamboo was unknown by the majority (76%) of these residents ($P<0.05$). Applicability of bamboo as substitute to wood resources, superior construction material, material for furniture, mats, handicrafts, etc were known by majority of people ($P<0.05$). The capability of edible bamboo for soil moisture conservation, riverbank protection, biodiversity conservation, etc was known by most of the residents. Therefore, the study revealed that there is a possibility to promote edible bamboo as a boundary crop in oil palm cultivation.

Keywords: *Dendrocalamus*, Edible bamboo, *Elaeis guineensis*, Oil palm

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Evaluate Growth Performance of 2nd Stage Nursery Plants and Immature Oil Palm with Different Levels of Bamboo Bio char

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Abstract

Oil palm (*Elæis guineensis*) is ranked as the world's leading edible oil producing plant and it grows well as a perennial plantation crop in tropical countries. In Sri Lanka low country wet zone is predominantly growing this crop, especially lands which were under tea or rubber previously. This has led soil to be very infertile, eroded and thus oil palm needs a sustainable nutrient supply to get a maximum productivity. In order to improve soil fertility and enhance fertilizer use efficiency by improving soil organic carbon content, introduction of bio char was tested. This trial was conducted in two phases namely a pot experiment and field experiment. Both the experiments were designed with Randomized Complete Block Design (RCBD) and field trial was conducted at Lelwala estate in Elpitiya Plantations PLC and pot experiment was conducted at faculty of Agriculture, university of Ruhuna. In nursery plants, highest height was observed in plants received 50g of bio char per pot. In field trial highest height was observed in plants received 200g of bio char per plant. In pot trial it was observed that 100g and 150g bio char received plants had highest number of new fronds and this was seen throughout the study period compared with the control. The same pattern observed in the field trial too with increasing rates of bio char compared with the control. It could be concluded that addition of bio char is improving soil fertility status and directly affects the plant growth in oil palm.

Keywords: Bio Char, Bamboo, Nursery plants, Oil Palm

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Assessing the Possibilities of Utilizing Oil Palm (*Elaeis guineensis*) Tree Trunks for Sustainable Agricultural Waste Management

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Abstract

Oil Palm covers nearly 9 600 hectares of Sri Lanka. The replanting process occurs once in 25-30 years creates nearly 200 tons of agricultural waste per hectare. The normal procedure of uprooting uneconomical plantations is by using bachore machine. Conventional methods of uprooting oil palm trunks and thereafter, remaining materials in the field cause problems such as increasing breeding places for pests like rhinoceros beetles and rats, increasing the disease incidents in immature plants, hindering field operations and taking considerable time to decompose. Therefore, sustainable utilization of oil palm trunk bio mass is important. Oil palm trunks from Elpitiya plantation were used for the experiment. A trunk has an average biomass of 1550kg with an 8m mean length. The average number of trees replaced per hectare is 125 per one replacement cycle. Bark was removed from trunks and chopped by using an electrical chopper. The chopped pulp (initial pulp) was grinded by mortar and pestle and blender separately to produce pulp 1 and pulp 2, respectively. Two 500ml solutions prepared by using pulp 1 and pulp 2 diluting up to 60%. Molasse produced by two sample solutions give final brix values of 58 and 54.4, respectively. Vinegar was produced using pulp 1 and pulp 2 shows an undesirable light brown suspension with an alcohol percentage of 2% and pH of 6.5. Pots and planting containers prepared from initial pulp can be used for nurseries. The brix value of two molasse samples are low compared to sugarcane molasse (75-85). The containers are biodegradable, effective in direct field planting and suitable for nurseries specially in tea plantations. This reduce the transplanting shock and root damage of plantlets. The study revealed there is a possibility of preparing molasse and planting containers from oil palm trunks. Vinegar production process needed to be further studied.

Keywords: Agricultural waste, Oil palm, Oil palm trunks, Sustainable use

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Yield Gap between Actual Yield and Potential Yield of Oil Palm in Yatadola Estate st. George Division

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Abstract

Oil palm, currently the world's main vegetable oil crop, is characterized by a large productivity and a long life span. Peak yields of 12t ha⁻¹ yr⁻¹ have been archived in small plantations, and maximum theoretical yield as calculated with simulation models are 18.5t ha⁻¹ yr⁻¹ in the area. Potential yield is defined as the yield of a crop cultivar when in environments to which it is adopted, with nutrients and water non-limiting and pest and disease effectively controlled. Actual yield means the amount actually produced of plant. Yield gap is different between actual and potential yield. This study aimed to assess to identify current situation of the field and to determine yield gap of the field and to suggest new recommendation to reduce yield gap between actual yield and potential yield during may to November in 2018. St. George division yatadola Estate. Following data was collected rainfall, actual and target yield of field. Plantation aims to obtain 156Kg/plant/year. According to results their actual yield is higher than target yield 22.99% in May, 8.18% in June and 11.76% in July month. But the actual yield less than the target yield 25.02% in August, 41.12% in September and 15.81% in October. According to that actual yield was higher than the target yield in many months. Some days harvested fruit bunches with more unripen fruits and collected only ripen fruits from the bunch by shaking and others were remained in the field until fruits become orange color and again collected orange color fruits and transported to factory after 2-3 days. It helps to increase the yield. According to the observations there are lack of specified/skilled labors for harvesting and other works.

Keywords: Actual yield, Oil palm, Target yield

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Monitoring Growth Rate of Oil Palm in New Clearing at Yatadola Estate

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Abstract

Oil palm is a tree which is considered as world highest oil producing tree that having 30-35 years economical lifespan. The first harvesting of the oil palm can be taken within 30-36 months after field planting under good management practices. This study was carried out to monitoring the growth rate of oil palm in new clearing and to examine the factors which are affected to retard the plant growth. The study was conducted during May (2018) to November (2019) in oil palm New clearing at Yatadola Estate, Matugama by using simple random sampling with 25 experimental units. Number of fronds developed per month were measured from selected plants to monitor the growth rate and the factors which are affected to retarded the plant growth were observed. According to the results, number of new fronds developed per month was one frond per month. 20% of the plants were showed abnormal growth behavior. In some plants 16%, leaves were curled and the some crowns of the plant were rotten and died. Results showed some rotten crown was partially recovered with the time. The reasons of the growth retarded the plant could be the poor weeding practices, not followed proper manner when applying fertilizers and some pest/disease attacks. It is concluded that applying Good Agriculture Practices (GAP) to the young field and proper actions should have been taken to control pest and disease attack as soon as possible with the consultation of agricultural specialist to obtain maximum economical life span of the oil palm.

Keywords: Oil palm, Growth rate, New clearing,

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Effect of Application of Palm Oil Mill Effluent and Recommended Fertilizer on Immature Oil Palm Intercropping with Pineapple, Low Country Wet Zone (WL2a) in Sri Lanka

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Abstract

Oil palm was introduced to Sri Lanka from Malaysia. At present, it has spread over 10,000 hectares' in the Island. Palm oil is widely used as cooking oil, as an ingredient in many processed foods and as a substitute for butter, produce bio-diesel, binding agent in cosmetics. In immature plantations, land productivity can be increased with some intercrops. Pineapple is highly demandable fruit crop and could be used as a better intercrop. Palm oil mill effluent (POME) is problematic waste to manage by mill operators generated during processing of fresh fruit bunch (FFB). The objectives of the study were evaluating the efficiency of POME, effective land utilization, compare the ground cover efficiency (cover crop/intercrop) and improvement of soil physical properties (pineapple and cover crop). A field trial conducted at Thalgaswella estate (WL2a) in Galle district, Sri Lanka. Experiment was designed with Randomized Complete Block Design (RCBD) with seven treatments and three replicates. Fertilizers were applied to the pineapple plots according to the recommendation. At monthly intervals growth parameters and chlorophyll content were measured. Physical parameters were measured at the beginning and end of the experiment. Data of last seven months, oil palm with cover crop and pineapple along with recommended fertilizer were shown highest physical, biological and growth performance. To come to a firm recommendation on POME as an organic amendment and performance of pineapple, research should be continued for at least more than two yield cycles.

Keywords: Intercropping, Palm oil mill effluent, Young oil palm

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Effect of Different Potting Types and Different Organic Manure Levels on Early Stages of Bamboo (*Dendrocalamus asper*) Growth in Side Oil palm Plantation in Low Country Wet Zone (WL_{2a})

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Abstract

Dendrocalamus asper is a bamboo species successfully grown in Sri Lanka. It has many uses in economic and environmental aspects. Bamboos are naturally propagating both sexually and asexually from seeds and rhizomes. It is difficult to find out proper same aged planting materials in medium to large scale bamboo plantations in Sri Lanka. Also suitable basal dressing, planting hole size and depth is not find out. Therefore find out proper potting type, basal dressing and planting depth is preferred. The objectives of the present study were to identify effective potting type with proper pot height and suitable basal dressing at nursery stage and effective hole depth at field level, measure the vegetative growth of bamboo. A field trial conducted at Thalgaswella estate (WL_{2a}) in Galle district, Sri Lanka. At the nursery stage seedlings were arranged in a Completely Randomized Design (CRD) with twelve replicates. At the field level plants were arranged in Randomized Completely Block Design (RCBD) with six replicates. According to the collected data of last seven months, at the nursery level 10" height black polythin pot with sand:coirdust:compost;top soil in 2;1;1/2;1/2 potting media and at field level bamboo plants planted in 2*21/2 feet size hole was shown highest growth performance. Therefore better to use 10" height black polythin pot with sand:coirdust:compost;top soil in 2;1;1/2;1/2 potting media at nursery level and when the plant transfer to field 2*21/2 feet size hole is more suitable for that.

Keywords: Bamboo, Hole, Potting media, Nursery stage

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Scientists Addresses Societal Concerns on the Oil Palm Crop through Local Research

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Abstract

Sri Lanka is not self-sufficient in its vegetable oil requirement. The supply from both coconut and oil palm cultivations currently around 70,000 MT whilst the demand is around 300,000 MT. Hence, each year more than 220,000 MT of palm oil is imported to the country spending more than Rs. 30 billion worth of foreign exchange of the country. Oil palm is the world's most efficient vegetable oil producing crop. It has a productivity of more than 4 MT of vegetable oil per hectare per annum whilst the other crops used for the production of vegetable oil, i.e. soya, canola, sunflower and oil seed rape produce only 0.3 to 0.4 MT per hectare per annum. Thus oil palm has the ability to meet the increasing demand for vegetable oil and at an affordable price to the consumers. If not for oil palm crop the land extent to meet its production would be more than four times the current global extent of oil palm. More cultivated land would create further pressure to natural forests whilst leading to other environmental issues. Under the current trading conditions and land productivity levels of plantation crops grown in the country oil palm generates the highest revenue per unit land area. It is around 10 to 15 times higher than that of tea and rubber. To bridge the current gap of around 220,000 MT of vegetable oil in the country around 220,000 hectares of additional coconut or additional 55,000 hectares of oil palm are needed. Land availability is a limiting factor for expanding plantation crops grown in Sri Lanka. In the light of above scenario oil palm appears to be the most potential crop for Sri Lanka to reach self-sufficiency in its vegetable oil requirement. However, certain fractions in the society are of the opinion that oil palm cultivations are not suitable to the country. Therefore, scientists in the country have undertaken research to address these concerns of certain fractions in the society. The objective of this paper is to review the findings of such research work undertaken. A study undertaken by the science and technology advisory committee of the Sri Lanka Association of Science in 1981 has shown that oil palm planting could be undertaken in the system B of the accelerated Mahaweli programme if irrigation and sub-soil drainage are provided. However, when comparing with double cropped rice possible in the area it will be a loss though it requires less irrigation. The study concludes that oil palm is more suitable for the low lands in the wet zone of the country under rain fed conditions. Under irrigated conditions greenhouse plants of rubber and oil palm showed a higher photosynthetic rate than tea. When the canopy photosynthetic rates were estimated it was high for oil palm than in other crops due to its relatively high total leaf area. The decline in photosynthetic rates due to moisture stress was relatively high in tea and oil palm relatively to rubber. Further, tea plants succumb to moisture stress much earlier than oil palm and rubber (Premaratne, et. al., 2018). The same study had revealed that the estimated soil water loss per hectare of land in a day was highest in tea whilst that of oil palm and rubber was not statistically different (Thudugala et. al., 2018). Studies undertaken in similar age commercial rubber and oil palm plantations revealed that soil moisture and soil carbon content to be not significantly different between the crops tea, rubber and oil palm (Liyanaagama et. al., 2016). A study on the communal perception revealed that plantation workers, staff and managers had not experienced water shortages that could be attributed to the oil palm crop. Further they are of the view that oil palm crop will not lead to loss of employment opportunities when considering the severe shortage presently experienced by the plantation sector of the country. However, almost 50% of the villagers living in the surrounding the oil palm plantations believe that oil palm causes water shortages. Interestingly, when asked whether they had experienced it in their real day to day life 30% of them said no but it is what they gathered from some (Madhubashini et al., 2019). A study conducted to identify the biodiversity and the ground cover of the undergrowth in tea, rubber and oil palm crops of

different maturity stages had been conducted in the WL2a agro climatic region of the country. It had revealed that the ground cover percentage from the undergrowth in all types of lands tested in this study had been higher and similar. Hence the chances of soil degradation due to lack of an undergrowth is not possible in commercial plantations of these crops. Further, according to the findings of this study the floral diversity in the undergrowth varies with age of the crop but similar among the three crops tested in this study. This finding contradicts the perception of some environmentalists that other species does not grow under oil palm cultivations (Seneviratne et al., 2018). Liyanagama et al., in 2016 had also reported that the undergrowth is similar in rubber and oil palm but oil palm had more moisture loving species. Additional potassium levels though increased the soil and leaf potassium levels did not show a significant effect on either the vegetative or the reproductive growth of oil palm grown in the south western part of the country. The study concluded that further studies are needed to provide a firm recommendation of the potassium fertilizer requirement of the oil palm crop (Dissanayake et al., 2018).

Keywords: Local research, Oil palm, Societal concerns

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Socio-economic and Environmental impacts of Natural Dispersion of different Oil palm types: A case study in Dodangoda - Kalutara district, Sri Lanka

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Abstract

Oil palm cultivation is popular due to its high demand in local and international market and low cost of production compared to other plantation crops in Sri Lanka. Recently, oil palm cultivation is being considered as a highly controversial issue and the general public believe it is one of the greatest threats to the sustainability of biodiversity in the area. The present study is a questionnaire based survey (60 participants) which was conducted in Dodangoda area in Kalutara district where high density of the wild variety of Oil Palm can be seen. The main objective of this survey is to find out the impacts of natural dispersion of both wild variety ("*Rata Pol*") and the commercially grown oil palm. Wild variety has a stem which is thin, large amount of spines, taller plant and smaller seed than commercial variety. Wild variety has a thin layer of mesocarp (0.1mm) but commercial variety has a thick mesocarp (5.5mm) which gives higher oil yield. Based on the survey, it was found that wild variety was established in the area before 50 years ago (100%) and commercial cultivation has been established in 2003. Wild variety shows higher germination percentage (66.67%) and a higher growth rate (70%) which result in higher dispersion limiting the space for other crops (60%). The thin layer of mesocarp of wild variety interfere the extraction of oil process efficiently (90%). Soil nutrients also depleted rapidly due to growing without proper spacing and management practices (86.67%). Since the high density of wild type, increase the reptile population and is getting higher (63.33%) which is challenging the natural balance of the biodiversity. Wild Oil palm fronds with spines often retained in the bottom of adjacent water ways (80%) which significantly limits the day to day activities of villagers due to health and safety reasons. The study reveals the need of value judgements for wild oil palm sustainability and can be concluded wild oil palm established before the establishment of commercial plantation in the area. But these need to be supported by science based evidence better guidance for the oil palm industry, organizations and government that develop policies and standards for Oil palm cultivation.

Keywords: Environmental impacts, Oil palm, Rata pol, Sustainability, Wild variety

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Fisheries and Aquaculture



Keynote Speech

Redefining agricultural & environmental policies: Emerging challenges and new horizons- Fisheries and Aquaculture

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Abstract

The article very briefly highlights major approaches and the importance of fisheries and aquaculture among other things, in food security, human nutrition, women empowerment and poverty eradication. In addition, major approaches and achievements of small- scale fisheries and aquaculture have been discussed. Finally, it highlights the emerging issues such as climate change and its threats, the sustainable development goals and other social issues to pay attention to in order to strengthens the growth of fisheries and aquaculture.

Keywords: Sustainable Development, Climate Change, Small-Scale Fisheries, Cooperation.

Introduction

Fish, be it from marine or freshwater origin, has a key role to play in the fight against hunger as it reduces poverty by generating incomes and malnutrition by providing valuable animal protein and essential micronutrients to vulnerable populations. According to FAO report (2018) global fish production in 2016 was about 171 million tones with aquaculture representing 47 percent of the total production. While capture fishery production remained relatively static since the late 1980s, aquaculture has been showing an impressive growth in the supply of fish for human consumption. China, by far the major producer of farmed food fish in 2016. The other major producers in 2016 were India, Indonesia, Viet Nam, Bangladesh, Egypt and Norway. In 2016, 59.6 million people were engaged (on a full-time, part-time or occasional basis) in the primary sector of capture fisheries and aquaculture of which 19.3 million were engaged in aquaculture and 14 percent of 19.3 million workers were women. The significant growth in fisheries and aquaculture production especially in the last two decades has enhanced world's capacity to fish consumption. Globally, in per capita terms, food fish consumption has grown from 9.0 kg in 1961 to 20.2 kg in 2015, at an average rate of about 1.5 percent per year. (FAO, 2018)

Approaches and Contribution

The Ecosystem approach

The ecosystem approach to fisheries (EAF) and the ecosystem approach to aquaculture (EAA) offers a strategy for a wider framework of planning, development and management of fisheries and aquaculture. It is an approach that provides room for consideration of the effects of fisheries and aquaculture on ecosystem as well as the effects of other sector on the fisheries and aquaculture. As mentioned earlier, the fisheries and aquaculture has witnessed has tremendous growth in the last few decades. It is important that we take into consideration the effects of fisheries and aquaculture on other economic sectors and other natural resources users. An integrated approach is needed to ensure the responsible fisheries for its long-term sustainability and to the best interest of all the sectors and systems involved.

So far, the implementation of eco system approach to fisheries and aquaculture across the globe has been contributing in many of the Sustainable Development Goals for the agenda 2030 such as eradication of poverty, zero hunger, good health and wellbeing, gender equality, Responsible consumption and production, Climate action, and Life below water. Despite the success of (EAF)

and (EAA), there are some issues and areas of concerns for us to consider. First, the issues of participation. This means participation of all stakeholders has to be meaningful for effective management and most importantly, through participation in the process of management all interest groups perceive that their roles are appreciated, fair and effective. Second, mechanism of regular monitoring which is built in the institutional process and management plans. In addition, a provision of mid-term review of the project with participation from all stakeholders is also important. Third, debunking the myth. Often time, EAF and EAA is perceived as an approach that facilitate conservation, in reality, it is rather a multi sectoral approach. In the near future, efforts will be needed to sustain the positive impacts of eco system approach to fisheries and aquaculture which can continue to positively affect the life and wellbeing of all stakeholders including the women and children.

Human Rights Based (HRB) Approaches

This approach considers fisheries as sources of livelihood not just as resources. Fisheries and aquaculture continue to provide income, food and employment and buffer against shocks for poor communities across the globe. This approach recognizes the discriminatory practices in resource distribution across gender, race, social origins, class age in many countries and societies. Therefore, this approach promotes adequate access to food and equitable development for all engaged in the fisheries and aquaculture. Effective participation of all fishers, workers in decision making process and enabling them to take more control over their life and livelihood is important to implement the human right-based approach in fisheries and aquaculture. However, unless we address the root cause of poverty such as discrimination, abuse and exploitation in the larger societies, it will take long to unpack the real positive impact of HRB approaches in fisheries and aquaculture.

Biodiversity, Fisheries and Aquaculture

Maintaining bio diversity is important for the long-term sustainability of fisheries and aquaculture. A disruption in bio diversity may affect the structure of entire eco system in addition to the new challenges such as the population growth and the threats from the climate change. Lately, international bodies have identified few areas of concerns for maintaining the bio-diversity in fisheries and aquaculture. And these are the following-

- Area-based management measures in coastal areas and inland waters
- Management and conservation of threatened species
- Aquatic genetic resources (FAO, 2018)

Small-scale Fisheries (SSF) and Aquaculture

Globally, the guideline for small scale fisheries follow a human right-based approach. This approach is much broader which looks fisheries and aquaculture beyond the sector. This is a holistic approach which takes into consideration of management, governance and fisheries-based livelihoods. The SSF guidelines can be instrumental in promoting SSF across the globe as the guidelines addresses issues such as social development, gender, disaster risk and climate change and responsible fishing.

Small-scale aquaculture contributes to global aquaculture production and to rural livelihood development through provision of food, livelihoods and income-generating opportunities, improving social equity and enhancing the quality of life of poor rural communities. Small scale aquaculture also has diversity in commodity, production system and locations and it is hard sometimes to measure the contribution of small-scale aquaculture in rural development.

Small-scale aquaculture has huge potentials to address the need of many countries economic, social and environmental goals. However, this sector also has some challenges such as-

availability of space, environmental concerns, animal diseases, limited production, social conflict, lack and risk of financing and growing external threats such as climate change and climate change induced disasters (FAO,2018). Thus, aquaculture spatial planning is crucial for integrated management of land. In addition, ensuring aquatic bio security and aquatic animal health is also important to pay attention to. To help address the fisheries and aquaculture in the context of climate change, climate-smart aquaculture is an alternative and innovative adaptation practice should be widely explored. However, to reap benefit from climate smart aquaculture, a new and holistic view of aquaculture will be required.

Food Security and Human Nutrition

Food security refers to access to nutritious food by all people, all the time so that they can lead a healthy life. The fisheries and aquaculture sector is crucial to improving food security and human nutrition and in the fight against hunger. Globally, the per capita human consumption of fish has been doubled since the 1960s. Fish and fish products are an excellent source of high-quality nutrients. Thus, ensuring the role of fish in food security and human nutrition policy is of paramount importance. It is very important in rural communities in developing countries who often have less diverse diets and lower food security rates. Fisheries also provide food and nutrition security of poor rural households in developing countries through livelihood diversification and income generation (Thompson and Amoroso, 2014; Béné *et al.*, 2015). Reliable data and management system are needed for pragmatic food security and human nutrition policy recommendations.

Poverty eradication

Fisheries and aquaculture can effectively address the issues of poverty eradication through increased income, livelihood, food security and women empowerment in rural communities. SSF guidelines addresses the issues of poverty eradication which is a central goal of the 2030 agenda. There are number of studies that explores the connections of fisheries and aquaculture and rate of poverty eradication in many countries. Those studies argue for a common platform and emphasis on the local contexts. In addition, poor fishers and their communities often suffers by the powerful actors in the fisheries sectors and beyond. Lack of decision-making power often made poor fishers and workers as the victims of politics of fisheries governance. Thus, empowering fishers and their communities should be in the forefront of the poverty eradication strategy through fisheries and aquaculture.

Women's empowerment

Recent scholarships on the role of women in fisheries and aquaculture indicate that women's contribution in fisheries and aquaculture is gradually becoming very important. However, participation of women in fisheries organization is relatively low and more actions and efforts are needed to ensure women's participation in key fisher's organization at local, regional and global levels. Barrier's to women's participation in fisher organization includes but not limited to, lack of recognition of their true value in fisheries. It is often believed by their male counterpart that women do not fish thus they are often excluded in the management of fisheries and aquaculture. Women themselves also believe that the management and planning of fisheries are the work of the male. These deep-rooted cultural values and norms restrict women's wider participation in fisheries and aquaculture. Collection actions at all levels are needed to address this issue to help ensure women's participation so that they can contribute to the sectors and in turn can improve their social and economic conditions.

International Trade

There are huge trade opportunity of fish and fish products. To take advantage of this trade, developing countries who are often the exporters must know the technical know-how, overcome the difficulties of trading and must meet the international standards of the fish and fish products. In addition, sustainability certification, post-harvest lost and waste and consumer protection

and addressing ocean pollution remain key in the international trade in fisheries and aquaculture.

Emerging Issues

Fisheries and Sustainable Development Goals

In 2015, the UN declared sustainable development goals and set the agenda for 2030. The vision for this collective global movement is to work for a just and sustainable world free from fear and violence and full utilization of human potential where no one is left behind. This commitment is highly relevant to the fisheries and aquaculture sector. Among other things, the slogan of no one left behind (LNB) is particularly essential for all fish workers, their families and communities as the vast majority of inland fishers are small-scale fishers who are often the marginalized and poorer groups of the society. Therefore, ensuring their food, nutrition and economic security go along with the SDG vision.

Towards the SDG goal, collective actions at both national, regional and global levels are needed in this sector that includes but not limited to, fish processing and trade, the need for good governance, policies, capacity development, investment, research and sustainable management. Having said the achievements of eco system approach in fisheries, the problem of illegal, unreported and unregulated fishing remains as one of the major challenges in achieving SDGs.

Climate Change Impacts

Global response to climate change recognizes specific vulnerabilities of food production system to the adverse impact of climate change. Although the impact of climate change on the entire eco system still inconclusive, however, through some important research, we all know by now that impact of climate change on fisheries and aquaculture reasonably well. Studies shows that some marine species have begun to change their mobility and moved to the deep water, the water will be more acidic, competition for water will increase and the severe and frequent storms, tidal surge and flood will destroy the inland fisheries and aquaculture production.

Adaptation is the key strategy within the overall context of fisheries and aquaculture sector to deal with climate change in the future. Uncertainty in climate variable is nothing new to fishers, fish farmers and workers however, adequate adaptive capacity is needed for sudden, long-term as well as unpredictable changes resulting from Climate change induced disasters. Thus, a comprehensive adaptive planning supported by increased monitoring and reporting is needed. Adaptation intervention can pay particular attention to institution and management, livelihood adaptation and resilience and risk reduction. Each country especially the ones who might be at higher risks of climate change have developed a national adaptation plan. The important task will be to provide guidance to those countries so that they can incorporate fisheries and aquaculture in line with their national adaptation plan. In addition, to respond to the climate change, the necessary actions in fisheries and aquaculture must include effective governance, improved management and conservation, efforts to maximize societal and environmental benefits from trade, , increased equitability of distribution and innovation in food production, and the continued development of low-input and low-impact aquaculture. (FAO, 2018)

Work Place

Working conditions is becoming major social issues in this sector. Often the problems such as human rights abuses and labour exploitation in fisheries are raising concerns in this sector. Irregular and low payments, forced labor, child labor, lack of occupational safety etc have become major problems in this sector. An ethical practice in work places and the successful implementation of the code of conduct for responsible fisheries in fisheries and aquaculture can be a viable response to these problems.

Regional Cooperation for Sustainable Development

Regional cooperation is a must for sustainable development in the fisheries and aquaculture. The framework of this cooperation should be based on the understanding of the fact that wider ecosystem has an effect on the fisheries and aquaculture and vice versa. Another building block of this cooperation should be the understanding of the scale of the fisheries management at appropriate geographical space and ensuring effective participation of all the stakeholders involved. In addition, a cross sectoral cooperation such as fisheries management, environmental protection and trade regulatory bodies at regional level is also important for the sustainable development of fisheries and aquaculture. A global governance of fisheries bodies and their transparency and accountability is also needed for the overall development of the fisheries and aquaculture. To sum up,

- The Fisheries and Aquaculture should support social, economic development along with the sustainable environment.
- All actors should promote and support implementation of the Code of Conduct for Responsible Fisheries and its related instruments.
- In addition, we need to generate scientific advice, strategic planning, and training materials for relevant stakeholders.
- A neutral platform in bringing together relevant actors to discuss issues related to international cooperation and multistakeholder approaches to fisheries and aquaculture management

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Case Study Analysis of Fisheries and Coastal Resources Co-management in Southern Sri Lanka

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Abstract

Co-management is an effective resource governance mechanism used to manage coastal resources sustainably. Interaction of all the stakeholders in the coastal area reduces conflicts and enhances the effectiveness of decision making. According to the Fisheries and Aquatic Resources Act of 1996, two management areas were declared in the southern coastal region and fifteen co-management committees were established for managing lobsters, live ornamental fish and chank fishery. This study mainly focused to find out the present situation, their effectiveness and limitations of the co-management committees. However, it was found that *Polhehena* co-management committee is the only committee actively operating at present. Therefore, two co-management committees (*Polhena* -active) and *Kirinda* -inactive) were selected purposely. Using simple random sampling, 20 members from *Polhena* and 40 members from *Kirinda* committees were selected. A pre-tested structured questionnaire along with Participatory Rural Appraisal tools were used to collect data. Results show that *Polhena* is actively operating as high degree of awareness about the concept, dedication and satisfaction of the participants. 56% of the interviewed 60 members are fully aware on the objectives and the purpose of the committee. Fifty-eight percent of the members in *Polhena* were satisfied with the services of the committee. It is a positive point that managing the lobster fishery in *Polhena* was initiated only after establishment of the committee. Results discover that decision making process and administrative system are not transparent of both committees and stakeholders' participation is not regular. Though the co-management concept is based on participatory, inclusive, interactive and holistic approach, these co-management committees indicated deviations from those concepts. There is no equal gender representation and less support and participation of the relevant authorities though it is mandatory. Members' commitment and dedication is the most influential factor for the functionality of the *Polhena* co-management committee. The issues raised at the committee level are not addressed well as there is no district level collaborative platform formed yet. Members believe that government try to regulate and monitor the coastal resources by issuing licenses and implementing government regulations other than incorporating them to manage the resource sustainably. This study concludes that resource users' level of awareness about the concept, and their dedication are the driving factors of the existing co-management committee. Hence, the real benefits of the co-management have not been reaped out yet.

Keywords: Co-Management, Coastal resources, Fishery, Governance, Sustainable

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Isolation and Identification of *Vibrio* spp. from Shrimp Landing Sites of Chilaw and their Sensitivity to Commonly used Antibiotics

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Abstract

Vibriosis is a devastating shellfish disease caused by vibrios. Antimicrobials are the drug of choice to control Vibriosis. However, indiscriminate use of antimicrobials leads to antimicrobial resistance in these bacteria. Thus control of vibrios has public and environmental significance. This study focuses on the isolation, identification and sensitivity assessment for commonly used antibiotics, for *Vibrio* spp. from shrimps collected from three landing sites of Chilaw. Forty three composite samples were collected from shrimp from all three places, over a period of one month, by weekly sampling. Homogenized samples were pre-enriched and grown on selective media (thiosulphate-citrate-bile salts-sucrose (TCBS) agar and CHROMagar™ *Vibrio*), for screening. Presumptive *Vibrio* colonies were identified by a battery of biochemical and phenotypical tests. Total number of 56 vibrios was isolated from 43 shrimp samples. Antibiotic sensitivity of 40 isolates (out of 56 total vibrios isolated) was investigated for trimethoprim 5µg, chloramphenicol 25µg, tetracycline 30µg and ciprofloxacin 30µg, ceftriaxone 30µg, by KirbyBauer disk diffusion method. *Vibrio harveyi* and *Vibrio alginolyticus* were the most abundantly isolated (8 for each spp out of 43 samples/8 out of 43) from biochemical and phenotypical tests followed by *Vibrio parahemolyticus* and *Vibrio anguillarum* (7/43 samples). Four samples were positive for *Vibrio damsela* and *Vibrio natriegens*, whereas both *Vibrio vulnificus* and *Vibrio campbellii* were present in 3 shrimp samples. *Vibrio proteolyticus* was present in three samples and 9 *Vibrio* isolates were not identified to the species level. While 72.5% (29/40) of the *Vibrio* isolates showed remarkable resistance to trimethoprim, 2.5% (1/40) showed intermediate resistance and 25% (10/40) exhibited sensitivity. Resistance to chloramphenicol was shown by 17.5% (7/40) of the isolates followed by 42.5% (17/40) showing intermediate resistance and 40% (16/40) being sensitive. Resistance for ceftriaxone was shown by 15% (6/40) of the isolates with 32.5% (13/40) and 52.5% (21/40) showing intermediate resistance and sensitivity, respectively. Five percent of the isolates (2/40) were resistant to tetracycline while 35% (14/40) showed intermediate resistance and 65% (24/40) were sensitive. Ciprofloxacin was the most effective antibiotic against tested vibrios with all isolates being sensitive. Interestingly, 22/40 isolates which were selected for ABST have shown multi-drug resistant, having resistant to more than two antibiotics group tested. In general, this study signifies the antibiotic resistance as a real factor to be considered in developing risk assessment strategies against Vibriosis.

Keywords: Antibiotic sensitivity, Isolation, Shrimp, Vibrios

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Assessment of the Shrimp Pond Sludge as a Potential Manure for Coconut Cultivation

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Abstract

Soil fertility plays a vital role in growth and yield of coconut. High amount of nutrients is removed continuously from coconut lands with the harvest. These nutrients should be supplied through regular fertilizing to sustain the coconut yield. Discharge of shrimp pond sludge creates many environmental issues. Therefore, this study aimed to evaluate the potential of using shrimp pond sludge as manure for coconut cultivation. A field experiment was conducted in adult coconut plantation of 20 years old, located in Mahayaya Estate, Makandura in the low country intermediate zone of Sri Lanka. Duration of the study was from June to October 2018. The treatments used in this study were no fertilizer (control) (T1), Inorganic fertilizer at recommended rate (T2) and Raw Shrimp Pond Sludge (RSPS) of 30kg/palm with Muriate of Potash (1.25kg) (T3). Treatments were applied to the manure circle of adult coconut palms and incorporated to the soil. Treatments were arranged in a Randomized Complete Block Design with three replicates. Before application of treatments, chemical composition of shrimp pond sludge was analyzed. pH, electrical conductivity (EC), organic carbon (OC), total nitrogen (N), available phosphorous (P) and bulk density (BD) of soil were analyzed before and two month after treatments application. Analysis of variance of data was determined by SAS software. RSPS reported pH, EC, OC, P and N, of 7.6, 7.8 dS/m, 2.8 %, 623 ppm and 0.23 %, respectively. Results showed that soils of treated palms with RSPS had the highest EC (0.63dS/m) when compared to all other treatments. There were no significant differences among the treatments in soil pH, organic carbon and total nitrogen. The BD of T2 (0.98 g/cm³) and T3 (1.00 g/cm³) treatments were also not significantly different but significantly lower than the control (1.25g/cm³) treatment. Available phosphorous was also not significantly different in T2 (944.74 ppm) and T3 (895.92 ppm) treatments, but significantly higher than the control (243.19 ppm) treatment. According to the results, pond sludge applied treatment showed soil nutrient levels similar to inorganic fertilizer applied treatment. This indicates that shrimp pond sludge can be used as a potential manure for coconut cultivation.

Keywords: Coconut, Organic fertilizer, Shrimp pond sludge, Soil nutrients, Soil properties

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Temporal Variation of Oceanographic Conditions and their Influence to Catch Rates of *Decapterus russelli* (Indian Scad) using Ring Net Fishery in North East Indian Ocean

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Abstract

Sri Lanka is an island nation in the Indian Ocean which has a long history of fishing activities since civilization to fulfil the protein demand of the country. Ring net fishing method was introduced in early 2000 and popular among multiday fishermen due to its' high efficiency. Indian Scad (*Decapterus russelli*) is the main target species of Sri Lankan ring net fishery. This study was focused on assessing the relationship between Indian Scad catches of ring net fishery in Sri Lankan exclusive economic zone and high seas (0°N–15°N and 77°E–91°E) and oceanographic parameters of sea surface temperature (SST), Sea Surface Height (SSH) and sea surface chlorophyll (CHL) derived from remote sensing data. Oceanographic condition data of SST and SSH averaged 8-day processed satellite data were achieved from COPERNICUS Marine Environment Monitoring Service and CHL multi-mission 8-day average data product from Globcolour of the year 2016. High catch rates were recorded under the oceanographic conditions of 28.0–30.0 °C SST, 0.1–0.4 mgm⁻³ CHL, and 0.4–0.6 m SSH. Generalized additive model (GAM) and empirical cumulative distribution function (ECDF) analysis were depicted catch per unit effort (CPUE) associate significant relationship with oceanographic parameters. Indian Scad CPUE monthly variability was depicted in certain areas. Results of the study have been demonstrated that high catch rates during January to March and June to August around southern and western parts of Sri Lankan waters. Monthly variability of SST, SSH and CHL can be used to predict Potential Fishing Areas. These predicted areas are economically significant to reduce the costs for fishing effort and upliftment of fish yield. Studying long-term oceanographic and fisheries catch data are essential to improve the results for advanced future predictions.

Keywords: Catch per unit effort, Ring net, Sea surface chlorophyll, Sea surface height, Sea surface temperature

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Quantifying the Waste Generation and Economic Potential: A Case Study of By-Catch Fishes in Pesalai

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Abstract

The fisheries sector has an important role in social and economic development of Sri Lanka. Large amount of by-catch fishes are being caught and wasted throughout the fisheries sector. Fish waste disposal becomes the major impact on the marine environment. It shows that treated fish wastes have the potential for many applications. The objectives of this study were (a) to estimate the fish waste generation (by-catch fishes) in Pesalai area and (b) to determine the economic potential of fish waste uses; bio fertilizer, poultry feed production, biogas and bio diesel production. By- catch fish data has been collected from five fish waste collectors in the area from September to November 2018. Production analysis data of poultry feed, biogas and bio diesel from fish waste has been obtained from the previous studies reported in the literature and bio fertilizer production data were obtained from the district agricultural training centre, Mannar. During the study period average per day by- catch has been estimated as 6,390 kg and the composition were 70.70% small bone fishes, 19.97% sea grasses, 6.27% crustaceans and 3.06% mollusks. Obtained fish waste to bio fertilizer conversion ratio and price of bio fertilizer were 1.5 L/kg and 100 LKR/L, respectively. Fish waste to poultry feed conversion ratio and price of fish silage poultry feed is 0.6656 kg/kg and 106 LKR/L, respectively. Fish waste to bio gas (73% methane content) conversion ratio is 0.164 m³/kg. Fish waste to bio fertilizer conversion ratio and price of bio fertilizer is 1.5 L/kg and 91.37 LKR/L. Production cost has been estimated in the basis of raw material, machinery, electricity and labour cost. According to the results, the amount of bio fertilizer, poultry feed, biogas and bio diesel production (monthly) were estimated as 88101 L, 39093 kg, 7402 m³ and 7553.2 L, respectively. With respect to the cost of production and economic value of products, the expected profit based on this study would be 3 million LKR for bio fertilizer and 1.5 million LKR for poultry feed production per month. Biogas and biodiesel production from fish waste is not economically feasible under present technological options as production cost is higher than the economic value. Production of poultry feed and bio fertilizer can be suggested to convert low economic value by- catch fishes to economically feasible products by managing the by-catch fish disposal problem.

Keywords: Bio diesel, Bio fertilizer, Biogas, By-catch fishes, Poultry feed

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Market Margin Analysis of Selected Dried Fish Varieties along the Value Chain: A Case Study in Jaffna

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Abstract

Dried fish is known as a main animal protein source of rural poor with a direct contribution on food security. Dried fish processing is an important venture in Sri Lankan small-scale fisheries with a well-established value chain. Although the domestic dried fish production provides 40 percent to the total demand, local value chains are not much studied from an economic perspective. Thus, this study was designed to assess market margin of few dried fish varieties along the value chain. Being a main district in northern Sri Lanka, hosting a large number of dried fish producers, wholesalers, collectors (agents), and retailers, Jaffna was selected for the questionnaire survey. A sample of 104 including 70 producers, 12 retailers, 10 market agents, and 12 wholesalers were selected. Producers and market agents were selected from Point Pedro and Valvettithurai employing snowball sampling technique. All the wholesalers and retailers in Jaffna town were interviewed. Five major dried fish varieties were identified based on the production quantities namely; sprats, leather skin fish, rainbow sardine, ray fish, and white sardines. The prominent dried fish value chain in Jaffna is selling through producer, market agent, wholesaler, and retailer. The highest market margin (12%-23%) is always obtained by the agents for all varieties followed by the wholesalers (8%-17%). Producers' and retailers' market margins were 6% - 13% and 5% - 8%, respectively. The highest market margins were obtained by selling white sardinella (7% - 24%) but producers receive only 13%. Locally produced sprats receive the lowest (5% - 12%) market margin compared to other dried fish varieties used for the study. Lack of capital for a smoothly running enterprise and lack of transportation facilities were the main problems for producers and agents, respectively. In contrast, the quality loss due to grading and further sorting was affirmed by the wholesalers whereas high purchasing prices reduce the profits and thwart the retailers. Despite the main value addition is undertaken by them market margin is lower for producers and therefore, policy intervention is recommended to make the marketing-effective with a fair profitability at each node.

Keywords: Fish processing, Marketing, Producer, Value addition

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Agribusiness Management and Entrepreneurship



Marketing Challenges Faced by Small Scale Natural Vegetable Producers: A Case Study of Natural Farming Vegetable Project by World Vision Sri Lanka

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Abstract

The demand for natural vegetable production is increased rapidly at present. The Natural Farming Vegetable Project of World Vision, Sri Lanka aims to promote natural farming vegetables in small scale producers. However, the status of the small scale natural farming beneficiaries under the world vision project, Sri Lanka is questionable. Therefore, a well-designed questionnaire was developed to collect data regarding the consumer awareness, consumers' expectation and examine the factors to access market for the natural farming vegetables from randomly selected 50 respondents. All of them were producers of the natural farming vegetable project. Another 50 from routine vegetable consumers in Koralai Pattu divisional secretariat Batticaloa District, Sri Lanka was selected. A questionnaire survey was conducted to collect primary data from the routine vegetable consumers, who are buying normal vegetables and natural vegetables from small scale producers under the natural farming project in World Vision and natural farming vegetable project beneficiaries. Results revealed that the higher numbers of the respondents (70.15%) were aware about natural vegetables and majority (97.6%) interested to consume organic vegetable products. Moreover, 40 % of them believe these products as the "natural vegetables" where selling at local vegetable outlets. However, comparatively lower percentage (25.4%) of them had the ability of differentiate natural vegetables from inorganic vegetables while majority (63, 17%) of the natural farming producers had the challenge on access the market and sell their vegetables. Mainly due to high distance from organic market, Poor transport facilities and high transport cost, lack of market information reach to the producers such as market price, promotion ways and packaging, availability of market places and discontinuous natural vegetable production those are the major issues faced by the natural farming vegetable markets located in Koralai Pattu area. Moreover, further studies need to be focused on enhancement of consumers' demand while eliminating challenges and problems. In addition, current study analysed the opportunities for further development of the organic farming and marketing in Koralai Pattu, Batticaloa District, Sri Lanka such as connect the natural vegetable producers with bridge market at Batticaloa town, provide some portable bicycles to active farmers to sell their vegetable among the villages. Facilitate the PGS (Participatory Guarantee System) certification for organic vegetables.

Keywords: Natural farming vegetables, Nutritional quality, Permanent agriculture, Profit maximizing

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Mitigation of Accidents through Occupational Risk Assessment at Workplace: A Case Study in Lanka Sugar Company Private Limited, Pelwatte

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Abstract

Occupational health and safety management is an important aspect in every industry, as a healthy workforce increases the success of a production. This study was conducted in Lanka Sugar Company (Pvt) Ltd, Pelwatte. The main objective of this research was to identify workplace hazards and apply the risk assessment tool to suggest appropriate mitigation measures. The sample consisted with 100 participants in the factory department, as Mill and boiler-26, process house-27, quality control-5, factory workshop-25, power generation and the electrical maintenance-13 and factory lab-4 according to the working sections. According to the job tasks welders, formen, labors, fitters, machine operators, Clarks, lab assistance, tool keepers, electricians, technicians and quality controllers were included. Selection was done using stratified random sampling technique. Data collection was done using a pre-tested structured questionnaire and observations through a factory visit. All the identified risks were tabulated and calculated the seriousness of the risk, using the risk matrix tool. Then risks were evaluated and appropriate mitigation methods were suggested. Electricians, welders and machine operators were engaged with higher risk oriented job tasks. 96.5% of workers were exposed to both heat stress and noise in boiler section. 86.1% of workers were having the risk of lighting, in welding. 74.9% workers were exposed to harmful chemicals at laboratory section. 10.6% of workers were having the risk of radiation effects in the laboratory section. Workers were not very much keen on safety during their work, even though the company arranged safety awareness programs in higher risk-oriented sections; mill and boiler, power generation and electrical maintenance and factory lab, only 56% of the employees had sufficient awareness while 44% others suggested the programs should be practical oriented. Conclusion of this study was there should be practical awareness programs on occupational health and safety, need to supply personal protective equipment at the time of need, the machines should be continuously inspected to avoid machinery errors and continued inspections of job performance and usage of safety precautions.

Keywords: Occupational health and safety, Risk matrix tool, Risks and hazard

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Impact of Value Chain Characteristics on Export Competitiveness: A Case of Ceylon Cinnamon Value Chain

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Abstract

Export competitiveness is the country's capability to produce and sell goods and services in foreign markets while managing sustainable trade over a long period concerning reasonable prices and quality. The research study was aimed to measure the export competitiveness of cinnamon industry in Sri Lanka, and investigate the impact of value chain characteristics on competitiveness of Ceylon Cinnamon export industry. Sri Lanka holds the 80% of the world market share for *Cinnamomum zeylanicum*. Principal data collection techniques were interviewer administrated questionnaire, key informant discussions, focus group discussions representing major cinnamon growing areas (Galle, Matara, Ratnapura, and Kalutara), and field observations. Total sample of the study was 48 Sri Lankan cinnamon exporters. Present study was measured the export competitiveness of cinnamon in Sri Lanka from year 2006 to 2018 by revealed comparative advantage (RCA) index. Principle component analysis (PCA) was performed to identify the key variables of value chain characteristics which were human resource strength (experienced cinnamon processors, on the job training); physical resource status (strength of the raw material suppliers); strength of financial resources (return on investment); processing and storage facilities; strength of market promotion; brand loyalty (level of continuous purchasing of buyers, level of export return, preference level of foreign demand to product in terms of origin & brand); product development (availability of research & development units, and team); product delivery (transport facilities, international sales outlet). Also, export market share and management support on strategy formulation were identified as key variables of export competitiveness through PCA analysis. Then, correlation analysis was used to identify the relationship between value chain characteristics that significantly impact ($p < 0.05$) on export competitiveness which were strength of the raw material suppliers ($p = 0.04$), availability of on the job training ($p = 0.04$), return on investment ($p = 0.03$), preference level of foreign demand to product in terms of origin & brand ($p = 0.05$), transport facilities ($p = 0.03$), and availability of online sales distribution ($p = 0.03$).

Keywords: Cinnamon industry, Export competitiveness, Value chain characteristics

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Employee Job Stress and Job Satisfaction: A Study in an Agro Chemical Repacking Firm

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Abstract

In today's business world, organizations create a dynamic environment when employees compete for recognition, thus translating into a competitive advantage for companies. Although this could lead to improved performance and it also leads to employee pressure on fulfilling duties, responsibilities and organizational functions. Job stress has physiological and psychological effects thus deviating employees from normal function. According to literature, stress is a factor that maintains a balanced job satisfaction (JS) level, but with a negative effect when in excess. The present study identifies the job stressors in present working environment and studies the relationship between existing JS and job stress levels. A total of seventy six manual workers were selected from a well- reputed agro chemical firm and total population was considered as the sample. Pre tested questionnaires and semi-structured interviews were used in primary data collection. Collected data was analyzed by using inferential and descriptive statistical tools. Out of the four age ranges listed, majority of manual workers (43.4%) were under 31-50 years old category having studied up to A/L. The determinants of job stress identified include factors related to the job, job role and personal factors. According to results, nature of the work, lack of career prospects, health problems and workload had a predominant effect on workers. The mean value of overall job stress (3.907) was indicated with slightly high levels of stress. With regard to JS, employees satisfied with working environment and job facilities. However, current salary, salary increments, behavior of boss, promotion system, performance appraisal system, welfare facilities and co-worker cooperation negatively affected JS. The overall mean value of manual workers' satisfaction level (-0.27) indicated very low satisfaction. Analysis also showed that job stress was negatively correlated with JS of employees ($r = -0.700, p = 0.000$). Job satisfaction level influences employee motivation, productivity, and absenteeism and turnover rates which are of principal importance in organization growth. Thus it can be concluded that it is necessary to implement proper human resource management practices to satisfy employees, hence managing job stress levels and effecting positive empowerment.

Keywords: Job stress, Job satisfaction, Manual workers

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Effect of Entrepreneurial Characteristics, Emotional Intelligence and Innovativeness on Entrepreneurial Success: A Study of Selected Small and Medium-sized Food Processing Enterprises in Galle District

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Abstract

Small and Medium-sized (SM) food processing enterprises play major role in manufacturing sector in Sri Lanka. In the challenging world of entrepreneurship, positive emotions are essential for entrepreneurs to understand and interact with employees, customers, suppliers, government, agencies. Entrepreneurial Characteristics (EC), Emotional Intelligence (EI) and Innovativeness are key success factors in highly competitive food processing sector. The study was mainly focused to evaluate the effect of EC, EI, and innovativeness on the Entrepreneurial Success (ES) of SM food processing entrepreneurs. It is important to know how EC, EI, and innovativeness could help ES. Primary data were gathered from field survey of 95 SM food processing entrepreneurs in 19 Divisional Secretariats (five from each). Stratified random sampling was used to select the sample from the list obtained by the District SM Entrepreneur Development unit. Likert Scale range from 1 to 5 was used in questionnaire for measuring variables. Entrepreneurial Characteristics were measured using key personal attributes, strong managerial competencies, need for achievement, desire for independence and self-confidence. Self-emotional appraisal, others' emotional appraisal, regulation of emotion and use of emotion were used to measure emotional intelligence. Meanwhile, entrepreneurial success was measured using financial outcomes, workplace relations, community impact, growth and personal balance. Reliability estimates (coefficient alphas) for the EC, EI, innovativeness and ES were 0.98, 0.96, 0.94, and 0.97, respectively. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity. EC, EI and innovativeness were positively and significantly related to the ES of SM food processing entrepreneurs. Regression results shows that effect of entrepreneurial characteristics was positive on entrepreneurial success ($\beta = 0.202$, $t = 2.22$, $P < 0.05$). Emotional intelligence ($\beta = 0.566$, $t = 5.72$, $P < 0.05$) and Innovativeness ($\beta = 0.226$, $t = 2.47$, $P < 0.05$) was positively effect on entrepreneurial success. This embellishes the past literature. Moreover EC, EI and innovativeness can explain 97.9% of the variability of entrepreneurial success. Therefore, based on the findings, study recommends strengthening the entrepreneur characteristics and emotional intelligence skills through awareness, training and development programmes. Present study considers only food processing entrepreneurs in the Sri Lankan context. Therefore, future investigations should be focused on entrepreneurs related to other industries and other countries as well in order to generalize these findings.

Keywords: Entrepreneurial characteristics, Emotional intelligence, Entrepreneur success, Food processing entrepreneurs, Innovativeness

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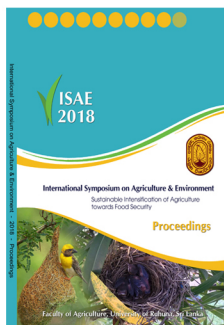
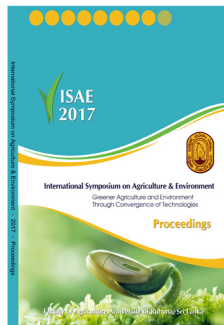
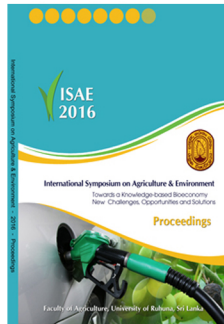
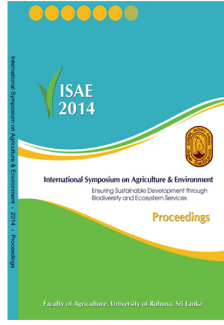
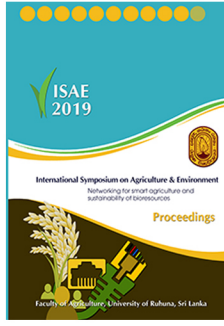
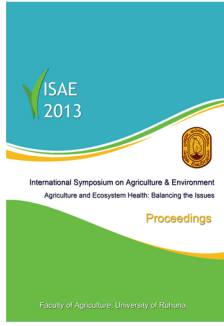
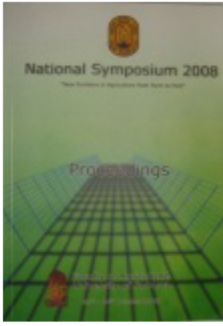


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