13th Asian Maize Conference
and Expert Consultation on
Maize for Food, Feed, Nutrition and Environmental Security

Ludhiana, India
October 8-10, 2018

ABSTRACTS

ORGANIZERS

भाकृअनुप ICAR

CIMMYT MR International Maize and Wheat Improvement Center

भामअनुसं IIMR

Punjab Agricultural University

CGIAR RESEARCH PROGRAM ON Maize

BISA Borlaug Institute for South Asia

13th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security

Ludhiana, India
October 8-10, 2018

ABSTRACTS

ORGANIZERS

भाकृअनुप ICAR

CIMMYT International Maize and Wheat Improvement Center

भामअनुसं IIMR

PUNJAB AGRICULTURAL UNIVERSITY 1962

CGIAR RESEARCH PROGRAM ON Maize

BISA Borlaug Institute for South Asia

Acknowledgements

The Organizers of the 13th Asian Maize Conference gratefully acknowledge the generous financial support received from the following Co-Sponsors:

PLATINUM SPONSOR:

USAID
FROM THE AMERICAN PEOPLE

GOLD SPONSORS:

BIOSEED

IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

CORTEVA™
agriscience
Agriculture Division of DowDuPont™

DEKALB

syngenta

SILVER SPONSORS:

syngenta foundation
for sustainable
agriculture

JK seeds®

BRONZE SPONSORS:

METAHELIX
Germinating Hope
Metahelix Life Sciences Limited
A TATA Enterprise

VNR

HYTECH™

CRYSTAL

Ajeet
Seeds Pvt. Ltd.

STAR
Beej

TRIMURTI
Plant Sciences

HDFC BANK

PREFERRED
POPCORN
Picked to be the Best

October 2018.

Table of Contents

TS3: Novel Tools for Increasing Genetic Gains

TS3-1: In Silico Interaction Analysis of Maize Transglutaminase

Alla Singh*, D.P. Chaudhary and Sujay Rakshit

ICAR-Indian Institute of Maize Research, PAU campus, Ludhiana -141004, India.
*Corresponding author Email: alla.singh@icar.gov.in; allasingh.panesar@gmail.com

The productivity of maize depends on the environment in which it is cultivated. A maize transglutaminase has been implicated in chloroplast bioenergetics and its over-expression in *Arabidopsis thaliana* has been shown to improve the photosynthetic functionality of plant cells. However, over-expression in *Nicotiana tabacum* reveals the propensity of maize transglutaminase to aggregate intracellularly. The resulting amyloid-like protein inclusions may have adverse effects on human health, as many human diseases are related to protein aggregation. Keeping the above in mind, present study was undertaken to find out the three-dimensional structure of maize transglutaminase and determine the 'aggregation hot-spots' in its amino acid sequence. The protein model of maize transglutaminase was obtained via template-based tertiary structure prediction. All the 534 residues of the protein were modelled. Refinement of the obtained structure was performed, resulting in a model with 97.7% residues in the Rama favored region. The protein has 49% region arranged in the form of eight helices. This was followed by analysis of protein sequence for aggregation hotspots. A motif in the terminal helix was found to be responsible for aggregation of the protein. The study discusses the orientation and function of the terminal helix, with a view to find possibilities to prevent protein aggregation inside the plant cells.

TS3-2: Using in Vivo Maternal Induction Haploid in Maize Breeding in Vietnam

Dang Ngoc Ha*, Hung Nguyen Huu, Thanh Nguyen Duc, Ha Luong Thai, Luan Kieu Quang, Thao Nguyen Phuong and Thoa Hoang Kim

National Maize Research Institute of Vietnam.
*Corresponding author Email: hanmri@yahoo.com.vn

Use of double haploid technology in maize (*Zea mays* L.) breeding has numerous advantages such as maximum genetic variance, complete homozygosity of the inbred lines, simplified logistics, reduced expenses and short release time of new hybrid varieties. The objectives of research were assessed based on the haploid induction rate (HIR) of three CIMMYT inducers as TAILP1, TAILP2 and their single cross TAILP1 x TAILP2; the chromosome doubling rate (the plants present both stigma and pollen on the field) of haploid seeds after being treated with colchicines at 0.04% concentration; and the doubled haploid (DH) lines that were made from 15 source materials of three maize hybrid groups, single cross (five crosses), three way cross (five crosses) and double cross (five crosses). The results showed that the HIR of 15 source materials with three inducers varied from 3.86 to 8.43 %; the full chromosome doubling rate of haploid seeds presented differently between source materials, which varied from 20.6 to 46.3 %; the DH lines presented good adaptation, some of them have good morphology and high yield (more than three tons per hectare). In conclusion, three of CIMMYT's inducers had good adaptation and can be used for DH line production in Vietnam. More than 200 DH lines

that have good adaptation and high yield were produced and selected from 15 source materials and will be evaluated for combining ability in next stages.

TS3-3: Allele Mining of Genes for Kernel Row Number (KRN) and Cob Length (CL) in Sub-tropical Maize (*Zea mays*. L)

Ganapati Mukri*, Thirunavukkarsau Nepolean, Jayant S. Bhat, R.N. Gadag and Jyoti Kaul

ICAR- Indian Agricultural Research Institute, New Delhi-110012, India.
*Corresponding author Email: ganapati4121@gmail.com

Maize grain yield is a complex quantitative trait controlled by numerous genetic factors and greatly affected by the environment. Yield component traits with stable heritability may provide a way for improvement of yield. Although genetic dissection of High KRN trait and Cob Length resulted in identification of underlying genes in temperate maize germplasm, they have not been explored in sub-tropical germplasm in which Indian maize breeding program is interested. Initially, 80 selected inbreds were screened for both KRN and CL traits and among them, 40 inbreds were finally selected and characterized. They comprised 10 each of High KRN, low KRN, High CL and Low CL lines. A total of 14 genes having varied roles in controlling KRN and CL traits viz., shoot meristem regulation (fea2, fea3, fea4, ct2), inflorescence branching (Ids1), ear fasciations (td1), quantitative variation in KRN (zfl1, zfl2, krn4), development of spikelet (cg1, tsh4, ub2, ub3) and ear length of maize (Kn1) were collected. Gene based primers were designed to capture the alleles. Targeted sequencing of selected 40 inbred lines for the above-mentioned genes are underway. Sequence analysis of contrast genotypes will be undertaken for discovering new SNPs, alleles/genes for KRN and CL traits. Using this information, new user-friendly markers for KRN and CL will be designed for marker assisted selection of yield component traits. Accelerated breeding for improved yield component traits is possible with the marker-based introgression of KRN and CL to new background. Inbred lines carrying novel alleles of KRN and CL may be further utilized in the maize breeding program to enhance grain yield.

TS3-4: In Silico Identification of MicroRNA and their Functional Targets in Maize for Biotic/Abiotic Stress

Kirandeep Kaur*, Naveen Duhan, Inderjit Singh Yadav and Yogesh Vikal

School of Agricultural Biotechnology, Punjab Agricultural University, Ludhiana. 141004, India.
*Corresponding author Email: k.k.flora20@gmail.com

Maize (Zea *mays* L.) is the third most important cereal crop in Asia and is affected by an average of almost 100 pathogens and plant diseases. MicroRNAs (~ 20-24 nt) have a critical role in various biological processes in the cell and gene regulation/down regulation which chiefly include the resistance, development, stress responses towards abiotic and biotic conditions, among other functions. Advancements in computational approaches have opened up ways for the prediction of MicroRNAs and their possible targets with functional pathways. A total of 2,019,524 downloaded ESTs from dbEST were processed and trimmed by SeqClean. The program trashed 264,000 and trimmed 284,979 sequences, and the resulting 1,755,524 sequences were submitted to Repeatmasker and TGICL for clustering and assembly. The contig database was used for finding the putative MicroRNAs by performing a local BLAST with the

matured and validated MicroRNAs retrieved from miRBase. Finally, 30 MicroRNAs were found to be hybridized with the potential targets such as respiratory burst oxidase, histidine kinase 2, lipoxygenase 1, HSP70 etc. These MicroRNAs may be used for other experimental uses, targeting major disease-causing genes.

TS3-5: Molecular Characterization of *teosinte branched-1* Gene of '*Sikkim Primitive*' – a Prolific Landrace of North-Eastern India

Nitish R. Prakash*, Rajkumar U. Zunjare, Rashmi Chhabra, Gulab Chand, Vignesh Muthusamy and Firoz Hossain

ICAR-Indian Agricultural Research Institute, New Delhi, India.
*Corresponding author Email: nitishranjan240@gmail.com

'Sikkim Primitive' is a unique maize landrace from North-Eastern India with seven to nine ears per plant, compared to one to two ears per plant found in traditional maize. *Teosinte branched-1* (*tb1*) has been implicated as the major locus governing the prolificacy in maize. So far, molecular characterization of entire *tb1* gene from *Sikkim Primitive* has not been undertaken. In the present study, ~2kb coding region of *tb1* was analyzed for sequence variation by designing 11 overlapping primer pairs. The sequence of *Sikkim Primitive* was analyzed and compared with five maize inbreds and four teosinte accessions belonging to *Zea mays* ssp. *parviglumis*, *mexicana*, *luxurians* and *perennis*. A total of 114 SNPs and 18 InDels were detected across genotypes. An InDel and four SNPs unique to *Sikkim Primitive* were identified in *tb1*. Gene prediction showed that *tb1* consisted of single exon with 366 amino acids in normal maize and 362-364 in teosintes, while >366 were coded in *Sikkim Primitive*. Phylogenetic analysis with Neighbor-Joining grouped all teosinte accessions together, while *Sikkim Primitive* was placed along with the maize inbreds. It was also observed that both maize inbreds and *Sikkim Primitive* possessed insertion of Hopscotch and Tourist transposable elements in upstream controlling region of *tb1*, while they were absent in teosinte accessions. The information holds immense significance in baby corn breeding program.

TS3-6: Haploid Induction Rate (HIR) of TAIL EC805127 under Sub-Montane North Western Himalayan Conditions

R.K. Khulbe*, A. Pattanayak, G.S. Bisht, M.C. Pant, D.C. Joshi, Vivek Pandey and Lakshmi Kant

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, India.
*Corresponding author Email: rajesh.khulbe@icar.gov.in; rkkhulbe@gmail.com

CIMMYT's Tropically Adapted Haploid Inducer Line (TAIL) EC805127 was used for generation of doubled haploids at ICAR-VPKAS, Almora in *kharif* 2017. A set of early maturity hybrids comprising two normal corn (VMH 45, CMVL 55), one QPM (FQH 106) and one sweet corn (FSCH 41) were used as female. The females were pollinated with the inducer only once. Data on total seed, putative haploid seed, self-seed and aborted seed was recorded on 18 selected cobs of each cross. The R1-nj marker system was found effective for haploid identification in all the hybrids, though CMVL 55 showed weaker kernel pigmentation. Average seed set per ear in the induction crosses ranged from 269 in FQH 106 to 182 in FSCH 41. Self/out-crossed seed per ear ranged from 0.30% in VMH 45 to 2.04% in CMVL 55. The

percentage of aborted seed ranged from 1.21 in VMH 45 to 2.27 in FSCH 41. Putative haploid seed percentage, that is, HIR of TAIL EC805127 varied from 7.66 in VMH 45 to 4.55 in CMVL 55. Lower proportion of haploid seed in CMVL 55 can be partly attributed to presence of weaker kernel pigmentation leading to mis-classification of a proportion of kernels. Highest percentage of putative haploid seed in a single ear was recorded in FSCH 41 (12.92%, 23 haploid kernels out of total 178 seeds) followed by VMH 45 (11.79%, 29/346). Lowest percentage was recorded in CMVL 55 (1.59%, 3/189) followed by FSCH 41 (2.03%, 3/148). Averaged over the four induction crosses, the seed set per ear was 223, the percentage of self/out-crossed and aborted seed was 1.08 and 1.55%, respectively, and the average HIR of TAIL EC805127 was 6.25%. The wide range of inter- and intra-hybrid variation observed for haploid induction in the hybrids suggested involvement of maternal and environmental influences in governance of the trait. The study also demonstrated potential use of haploid inducer line TAIL EC805127 for generation of early maturing doubled haploid lines in the sub-montane North Western Himalayan region.

TS3-7: Variation in Haploid Induction Rate (HIR) of TAIL EC805127 between Years

R.K. Khulbe*, A. Pattanayak, G.S. Bisht, M.C. Pant, D.C. Joshi, Vivek Pandey and Lakshmi Kant

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora.
*Corresponding author Email: rajesh.khulbe@icar.gov.in; rkkhulbe@gmail.com

Haploid Induction Rate (HIR) of CIMMYT's Tropically Adapted Haploid Inducer Line (TAIL) EC805127 was compared in induction crosses made during *kharif* 2016 and 2017 at ICAR-VPKAS, Almora. A set of five hybrids comprising two normal corn (VMH 45, CMVL 55), two QPM (Vivek QPM 9, FQH 106) and one sweet corn (FSCH 41) were used as female. The induction crosses were generated by pollinating the females with the haploid inducer line only once. The R1-nj marker system was used for identification of putative haploid seed. Putative haploid seed in the induction crosses ranged from 10.94% (Vivek QPM 9) to 3.51% (FSCH 41) in 2016, and from 11.93% (Vivek QPM 9) to 6.29% (CMVL 55) in 2017. Averaged over the two years, the highest percentage of haploid seed was recorded by Vivek QPM 9 (11.44) followed by CMVL 55 (7.34), VMH 45 (7.21), FSCH 41 (6.11) and FQH 106 (5.93). Variation in haploid induction percentage between the years in Vivek QPM 9 was only 0.99. Highest variation was observed in the case of FSCH 41 (8.71 and 3.51) followed by VMH 45 (8.65 and 5.77), which were 5.20 and 2.88, respectively. Though both FQH 106 (6.98 and 4.88) and CMVL 55 (6.29 and 8.39) exhibited variation of 2.10 per cent between the years, the percentage of haploid seed in FQH 106 was higher in 2016 than in 2017, whereas the reverse was true for CMVL 55. The observations of the study suggested presence of significant maternal and environmental influence on the governance of haploid induction trait.

TS3-8: Male Sterility in Maize: A Strategic Opportunity for IP Protection and Imposition of Heterotic Discipline in Tropical Asian Germplasm

Satish A. Takalkar[1*], S. Murali Mohan[1], P. Bhaskara Naidu[1], T. Dhliwayo[2] and B.S Vivek[1]

[1]CIMMYT Asia Regional Maize Program, ICRISAT campus, Patancheru, Hyderabad-502324, India;
[2]CIMMYT, Km 45, Carretera Mexico-Veracruz, El Batan, Texcoco, Mexico CP 56237.
*Corresponding author Email: t.satish@cgiar.org

In Asia, little attention has been paid to developing Cytoplasmic Genetic Male Sterility (CMS) in maize due to its monoecious nature and ready availability of labor for detasseling. However, in recent years, timely availability of labor for detasseling has become difficult and expensive. Exposure of Intellectual Property (IP) of proprietary inbreds during seed production has become a matter of concern in the seed industry. CMS is a maternally inherited trait that suppresses the production of viable pollen thus eliminating the need for detasseling and restricting female line multiplication to the legal owner of the maintainer line. A set of 14 elite CIMMYT Asia lines were crossed to CMS line LP1CMSHT (A632 temperate Ex-PVP stiff stalk line from Minnesota). The resultant 14 single crosses were evaluated, and those with 100% sterility were repeatedly backcrossed to derive BC_3F_1. Derivation of BC_6F_1 sterile (A) lines is in progress. *Per se* evaluation (especially *Turcicum*) of BC_3F_1 lines will be done during 2018 Kharif, whereas BC_4F_1 test cross evaluation will happen in 2019 Kharif. Of the pilot set of 14 lines, only five inbreds showed 100% sterility (potential A lines) while 9 lines were male fertile (potential R lines) in the F1. In a bigger set of lines, the restriction of the male sterile system could be used to impose a discipline of breeding within groups (A or R) for deriving new lines which, over time, could evolve into distinct heterotic groups, something that has been lacking in tropical maize germplasm.

TS3-9: Development of Mobile Apps for Digital Phenotyping of Maize

S.A. Bagum[1*], M. Hasan[1], M. Morsalin[1], S. Akther[2], N. Hossain[3], A. Ahmed[1], S.M. Hossain[1], M.A. Hakim[4], N.C.D. Barma[4], M. Amiruzzaman[1] and M.S. Uddin[1]

[1]Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh; [2]Patuakhali Science and Technology University, Patuakhali, Bangladesh; [3]Hajee Mohammad Danesh Science & Technology University, Dinajpur, Bangladesh; [4]Bangladesh Wheat and Maize Research Institute, Dinajpur, Bangladesh.
*Corresponding author Email: happyshalim@yahoo.com

Canopy cover (CC) is an important phenotypic trait that indicates overall plant growth and is helpful in predicting advanced traits like biomass and yield. Manual measurement of CC is laborious and has become a bottleneck for maize research. The goal of this research was to develop and evaluate a high throughput phenotyping (HTP) system using image analysis apps for measuring CC of maize under field conditions. The image was taken from 50cm above the plant height using a modified selfie stick. At first, we developed a software maize CC (MCC_BARI) for digital HTP in JAVA and Interface design in JFrame, then converted it to android mobile apps. A five-step algorithm was developed to measure the CC of individual plots by RGB. The output gives 27 digital trails value after analyzing an image including CC and NDVI. The field experiment was conducted split plot design with three replications. Leaf area, SPAD values, NDVI, Chlorophyll content, dry matter, were measured at different growth stages. The values of canopy cover were closely correlated with the normalized difference vegetation index and the ratio vegetation index. Models were calibrated to describe the relationship between canopy cover and four traits of maize There were close, linear relationships between canopy cover and four traits. The relationships for estimating maize aboveground total dry matter were most precise, the coefficients of determination ($R2$) value was 0.82-0.93. In conclusion, digital image has good potential for phenotyping of maize.

TS3-10: Use of LeasyScan: An Efficient Phenotyping Platform for Identification of Potential Maize Germplasm at Early Stage

Sunil N.[1]*, B. Rekha[2], P.L. Soujanya[1], J.C. Sekhar[1], V. Vadez[2] and Sujay Rakshit[3]

[1]Winter Nursery Centre, ICAR-Indian Institute of Maize Research, Hyderabad, India; [2]International Crop Research Institute for Semi-arid Tropics, Hyderabad, India; [3]ICAR-Indian Institute of Maize Research, Ludhiana.
*Corresponding author Email: sunilneelam9@gmail.com

In meeting the challenges of agriculture production systems, a huge untapped potential is the underutilized genetic resources among all the crop species. In maize, only 5% of the world's maize germplasm has been used. The utilization of maize genetic resources, which hold the answers to most of the threats and challenges, would be enhanced by their precise characterization and evaluation. Also, the data needs to be generated at a faster rate to meet the onset challenges. In the present study, we discuss and demonstrate the use of an imaging phenotyping platform- LeasyScan, coupled with lysimeters, to measure precise plant height and canopy traits affecting water use *viz.* leaf area, leaf area index (LAI) in six testing and two released maize hybrids *viz*. 14746185, 8315622, 22525674, 18270413, 4695575, 783527, 900MG and 30V92. We conclude that LeasyScan –phenotyping platform can be effectively used in the identification of genotypes/germplasm lines with high vigor (Plant height), efficient 3D-leaf area and LAI at early stage (1 month). Identification of such genetic stocks/ germplasm lines form the important pre-breeding steps towards effective utilization of the germplasm lines at a faster rate.

TS3-11: Cold Shock Protein *modiCspB* Gene Confers Drought Tolerance in Transgenic Vietnamese Maize

Thang Nguyen Xuan[1*], Thao Doan Thi Bich[1], Hoai Nguyen Thi Thu[1], Dung Ta Thi Thuy[1], Tung Le Cong[1], Cuong Bui Manh[1] and Hue Huynh Thi Thu[2]

[1]National Maize Research Institute, HaNoi, Vietnam; [2]Institute of Genome Research, Vietnam.
*Corresponding author Email: nxthangnmri@gmail.com

Cold shock protein B (*CspB*) from *Bacillus subtilis* could enhance plant resistance to environmental stresses such as drought and heat. In this study, an artificial–synthesis *modiCspB* gene was transformed into Vietnamese maize inbred lines via *Agrobacterium tumefaciens*-mediated transformation of immature maize embryos. The transformation efficiency was 0.56% after fertility assessment and PCR analysis. There was a high sequence similarity (96.6%) between the *modiCspB* gene in transgenic inbred lines and transgene. Southern blot and Real-time PCR analysis were performed to select lines containing one copy of *modiCspB* gene. Evaluation of morphological characteristics in drought condition at seeding stage showed that transgenic lines had a 7% - 10% higher resistance to drought, compared to wild-type.

TS3-12: Transformation of Drought-Tolerance Gene *Zmdreb2a* into Vietnamese Maize Mediated by *Agrobacterium Tumefaciens*

Thao Doan Thi Bich*, Thang Nguyen Xuan, Hoai Nguyen Thi Thu, Dung Ta Thi Thuy, Anh Le Tuan, Luc Le Cong, Tung Le Cong, Cuong Bui Manh and Hai Nong Van

National Maize Research Institute, HaNoi, Vietnam; [2]Institute of Genome Research, Vietnam.
*Corresponding author Email: thaobio@gmail.com

DREB2A (Dehydration Responsive Element Binding 2A) is an important transcription factor involving responses of plant to drought stress. It enhances drought tolerance of plants by interacting with subunits of DNA polymerase and binding to cis–acting elements such as DRE/CRT. In this study, the *ZmDREB2A* gene was transformed into three Vietnamese maize lines K1, K3, and K7 via *Agrobacterium tumefaciens*-mediated transformation of immature maize embryos. Transgenic lines were examined by PCR and sequencing. The percentage of regenerated plants was 1.36% - 1.8%, and the transformation efficiency ranged from 0.17% to 0.81%. There was a high sequence similarity (99.78%) between the *ZmDREB2A* gene in transgenic lines and the sequence designed in transformation vectors.

TS3-13: Factors Affecting Genomic Selection Revealed by Empirical Evidence in Maize

Xiaogang Liu[1], Hongwu Wang[1], Hui Wang[1], Zifeng Guo[1], Xiaojie Xu[1], Jiacheng Liu[1], Shanhong Wang[1], Wen-Xue Li[1], Cheng Zou[1], Boddupalli M. Prasanna[3], Michael S. Olsen[3], Changling Huang[1] and Yunbi Xu[1,2*]

[1]Institute of Crop Sciences, National Key Facility of Crop Gene Resources and Genetic Improvement, Chinese Academy of Agricultural Sciences, Beijing 100081, China; [2]CIMMYT, El Batán 56130, Texcoco, Mexico; [3]CIMMYT, ICRAF Campus, United Nations Avenue, Nairobi, Kenya
*Corresponding author Email: y.xu@cgiar.org

Genomic selection (GS) as a promising molecular breeding strategy has been widely evaluated and implemented for plant breeding, because it has remarkable superiority in enhancing genetic gain, reducing breeding time and expenditure, and accelerating the breeding process. In this study the factors affecting prediction accuracy (r_{MG}) in GS were evaluated systematically, using six agronomic traits (plant height, ear height, ear length, ear diameter, grain yield per plant and hundred-kernel weight) evaluated in one natural and two biparental populations. The factors examined included marker density, population size, heritability, statistical model, population relationships and the ratio of population size between the training and testing sets, the last being revealed by resampling individuals in different proportions from a population. Prediction accuracy continuously increased as marker density and population size increased and was positively correlated with heritability; r_{MG} showed a slight gain when the training set increased to three times as large as the testing set. Low predictive performance between unrelated populations could be attributed to different allele frequencies, and predictive ability and prediction accuracy could be improved by including more related lines in the training population. Among the seven statistical models examined, including ridge regression best linear unbiased prediction (RR-BLUP), genomic BLUP (GBLUP), BayesA, BayesB, BayesC, Bayesian least absolute shrinkage and selection operator (Bayesian LASSO), and reproducing kernel Hilbert space (RKHS), the RKHS and additive-dominance model (A+D model) showed credible ability for capturing non-additive effects, particularly for complex traits with low heritability. Empirical evidence generated in this study for GS-relevant factors will help plant breeders to develop GS-assisted breeding strategies for more efficient development of varieties.

TS3-14: A Comparative Study of Haploid Maize Seed Identification Based on Machine Learning Approaches

Yahya Altuntaş[1*], A. Fatih Kocamaz[1], Zafer Cömert[1], Rahime Cengiz[2] and Mesut Esmeray[2]

[1]Inonu University, Department of Computer Engineering, Malatya, Turkey; [2]Maize Research Institute, Sakarya, Turkey.
*Corresponding author Email: yahyaaltuntas@gmail.com

In vivo maternal haploid technique which shortens the breeding period and increases the efficiency of breeding is widely utilized in maize breeding programs. One of the major stages in this technique is the identification of haploid seeds. Performing this stage as manual reduces the selection success and causes time and labor loss. For this reason, it is necessary to design automatic selection methods that will save time and labor, and increase selection success. The main purpose of this study is to determine the performance of widely using and practical machine learning techniques to identify haploid maize seeds. In this study, 87 haploid and 326 diploid maize seeds' images obtained from cross-breeding between 150 donors and maternal haploid inducer RWD and RWK-76 were used. Each maize seed is segmented from its original image and five different color features were extracted from them. Obtained features vector is classified by using k-nearest neighbors, artificial neural network and support vector machine techniques. Performance of each machine learning technique was tested by tenfold cross-validation method. According to experimental results, although all machine learning techniques produced satisfactory results with the accuracy over 80%, k-nearest neighbors yielded the best results with the accuracy of 83.06%.

TS4: Agronomy and Sustainable Intensification

TS4-1: Influence of Weed Management Practices on Growth, Yield and Quality of Baby Corn (*Zea mays* L.) under the Temperate Conditions of Kashmir Valley, India

Aijaz Nazir, Zahida R.*, Bahar F.A., Kanth R.H., Aashaq Hussain and M. Anwar Bhat

Faculty of Agriculture, Sher-e- Kashmir University of Agricultural Sciences and Technology of Kashmir, J&K, India.
*Corresponding author Email: Zahida1926@gmail.com

Although manual weeding is very effective in controlling weeds, is more often than not cumbersome, labor intensive, expensive and time consuming (Warade *et al*., 2006). The use of atrazine herbicide has yielded encouraging results in maize at national and international level. Different mulches can be exploited for weed control in this crop and the different resources lying with the farming community can be used depending upon their availability and suitability. With this in mind, a study on the influence of weed management practices on growth, yield and quality of baby corn (*Zea mays* L.) was undertaken. A field experiment was conducted at Mountain Livestock Research Institute (MLRI), Manasbal, (SKUAST-K) during *kharif* 2014. The experiment comprising of 11 treatments [Farmers practice (W_1); Earthing up and weeding at 30 and 45 DAS (W_2); Atrazine at 1.5 kg *a.i* ha^{-1}pre-emergence at 1 DAS (W_3); atrazine at

1.5 kg *a.i*ha^{-1} early post-emergence at 10 DAS (W_4); straw mulch (paddy straw) at 1DAS (W_5); straw mulch (brown sarson) at 1DAS (W_6); polyethylene mulch (black) at 1DAS (W_7); polyethylene mulch (white) at 1DAS (W_8); saw mulch at 1DAS (W_9); weedy check (W_{10}) and weed free (W_{11})] was laid out in a randomized complete block design with three replications. Significant variation in growth, phenology, yield, quality and economics was recorded among the various treatments tested. The treatment W_{11} recorded significantly higher growth parameters like plant height (195.04 cm), leaf area index (5.38) and dry matter accumulation (118.41 q ha^{-1}) but was at par with the treatment W_2. The lowest plant height (171.78 cm), leaf area index (3.52) and dry matter accumulation (92.40 q ha^{-1}) were recorded for treatment W_{10}.The days taken to reach different phonological stages recorded striking variation among the various weed management practices. The treatment W_7 took lowest number of days to reach knee-high (33), tasseling (63) and silking (63) stages while the highest number of days to reach knee-high (37), tasseling (68) and silking (72) stages were recorded for W_{10}. The treatment W_{11} recorded significantly highest number of cobs plant^{-1} (2.83), cob length with husk (19.31 cm) and without husk (11.14 cm), cob girth with husk (47.55 mm) and without husk (37.66 mm), and cob weight with husk (36.29 g) and without husk (10.87 g) which, concurrently resulted in highest corn (102.55 q ha^{-1}) and green fodder (355.26 q ha^{-1}) yield while these were significantly lowest in the W_{10} treatment.

TS4-2: Effect of Plant Geometry and Integrated Nutrient Management on Production and Profitability of Sweet Corn – Horse Gram Cropping Sequence

A.K. Sinha

AICRP Maize, Ambikapur, India.
Email: amitsinhaagri@yahoo.co.in

Field experiments were conducted in two consecutive *kharif* seasons of 2016 and 2017 at Ambikapur, to work out the effect of plant geometry and integrated nutrient management systems on the productivity and profitability of sweet corn (*Zea mays* L.) and horse gram (*Macrotyloma uniflorum* L.) cropping system. The experiment was laid out in split plot design with three treatments of plant geometry (60 X 20 cm, 50 X 20 cm and 40 X 20 cm) in main plots and four levels of fertility (RDF, 75% of RDF + 5 t vermicompost, 75% of RDF + 5 t forest litter and 75% of RDF + 5 t FYM) with three replications. The horse gram was taken as utera crop sown one week before harvesting of sweet corn using common starter dose (20-50-20 kg N- P- K/ha). Green cobs, green fodder from sweet corn and horse gram yield were higher with plant spacing of 50 cm X 20 cm and application of 75% RDF + 5 t vermicompost. Similarly, planting geometry (50 cm X 20 cm) and application of 75% RDF + 5 t vermicompost resulted in significantly higher sweet corn-equivalent yield in terms of system productivity at 26.9 t/ha.

TS4-3: Normalized Difference Vegetation Index A Decision Support Tool for In-Season Nitrogen Management in Maize

Bandhu Raj Baral* and Bhanu Bhakta Pokharel

Nepal Agricultural Research Council (NARC), Regional Agricultural Research Station, Khajura, Banke, Nepal.
*Corresponding author Email: bandhu.baral@gmail.com

Precision agriculture technologies have developed optical sensors that can determine normalized difference vegetation index (NDVI) of plants, which is closely related to growth performance. Limited studies have been carried out for in-season N management of maize in Nepal. To evaluate the relationship among NDVI, grain yield and N levels applied, an experiment was conducted at farm land of Regional Agricultural Research Station, Parwanipur, Bara, Nepal, during winter season of 2013. The experiment was laid out in randomized complete block design. Eight different levels of N (0, 30, 60, 90, 120, 150, 180 and 210 kg N ha^{-1}) were applied for hybrid maize Rampur Hybrid-4 and replicated thrice. Periodic NDVI was measured at 15-day intervals, starting 65 days after sowing (DAS) to 95 DAS, using Green seeker hand held crop sensor. Analysis of variance showed that periodic NDVI measurements taken at a range of growing degree days (GDD) was critical for predicting grain yield potential. At 478 GDD (80 DAS) a strong correlation ($R^2 = 0.70$) was found between NDVI and grain yield, while NDVI measured during the same period was found highly correlated with plant height, dry matter yield and stover yield. It was found that N levels had significantly influenced NDVI, grain yield, periodic dry matter production, periodic plant growth, response index (RI) and grain N content. Poor exponential relationship existed between grain yield and NDVI measured before 316 GDD (65 DAS) and after 677 GDD (95 DAS), and variation in NDVI was indistinguishable. It was concluded that measuring NDVI by GDD allowed a practical window of opportunity for side dress N applications.

TS4-4: Influence of Farmyard Manure and Nitrogen Levels on Quality and Nutrient Uptake of *Kharif* Maize

Bhadra Parija[1*] and Mahesh Kumar[2]

[1]Punjab Agricultural University, Ludhiana, India; [2]Department of Plant Breeding and Genetics, PAU, Ludhiana.
*Corresponding author Email: bhadra.agro177@gmail.com

A field experiment was carried out at Research Farm, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana, during *kharif* season to study the influence of farmyard manure and nitrogen levels on quality and nutrient uptake of *kharif* maize. The field experiment comprised 20 treatment combinations from four main plot treatments (farmyard manure at 0, 10, 15 and 20 tons per hectare) and five nitrogen levels as sub plot treatments (0, 75, 100, 125 and 150 kg N/ha). The experiment was laid out in split plot design with four replications. It was observed that the protein content (%) of grains was increased while starch and total sugars content (%) decreased with increased levels of farmyard manure. Similarly, crop uptake of N, P and K was also higher with more farmyard manure. Among nitrogen levels, quality parameters such as oil, tryptophan, mineral matter, starch and total sugars content (%) remained unaffected under different nitrogen levels, whereas protein content (%) increased with increase in nitrogen level. Total N, P and K uptake was also maximum at N_{150}, which was significantly higher than other nitrogen levels. It was concluded that there wasn't much observable difference in quality parameters with increased levels of FYM and nitrogen, except for protein content (%). However, there was an increase in nutrient uptake by maize plant under higher doses of both farmyard manure and nitrogen.

TS4-5: Crop Productivity and Soil Carbon Dynamics under Long-Term Conservation Agriculture in India

C.M. Parihar[1], A.K. Singh[2], S.L. Jat [2], M.D. Parihar[3] and M.L. Jat[4]

[1]ICAR-Indian Agricultural Research Institute, New Delhi, India; [2]ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana, India; [3]CCS Haryana Agriculture University, Hisar 125004, Haryana, India; [4]CIMMYT, NASC complex, New Delhi, India.
*Corresponding author Email: pariharcm@gmail.com

Given the increasing scarcity of production resources such as water, energy and labor – compounded by growing climatic risks – maize based production systems in north-western India are potential alternatives to intensive rice-wheat (RW) rotation. Conservation agriculture (CA) based best-bet crop management practices may increase crop productivity, while conserving and sustaining natural resources. Such practices are also believed to provide mitigation co-benefits through reduced GHG emission and increased soil carbon sequestration. In a nine-year study of conservation agriculture experiment established in 2008, we have evaluated the performance of CA-based management practices [zero tilled permanent bed (PB) and zero tillage flat (ZT)] and conventional till flat (CT) in main plots for four intensified irrigated maize systems [maize-wheat-mungbean (MWMb), maize-chickpea-Sesbania green manure (MCS), maize-mustard-mungbean (MMuMb) and maize-maize-Sesbania (MMS)] in sub plots. The experimental design was split-plot with three replications. Significant ($P<0.05$) tillage and cropping system interactions were observed for cropping system productivity and carbon dynamics. Agronomic performance (yield attributes) of all the crops (except wheat) grown in sequence with maize was maximum with ZT. Wheat outperformed on PB over ZT and CT. In the initial two years, higher system productivity (maize equivalent yield) was recorded in PB (8.2-8.5 Mg ha-1). The soil organic carbon (SOC) content and its fractions were greatly affected by tillage, and crop establishment methods and cropping systems. The ZT and PB based crop establishment methods increased more SOC stock (0−30 cm) than CT system compared to initial value.

TS4-6: Intercropping Leafy Vegetables with Maize in Bangladesh: Multi-Criteria Analysis of Yield, Profitability and Potential Nutrition Benefits

D.B. Pandit[1], M.K. Gathala[1], T.P. Tiwari[1], M.A. Haque[1], M.A. Arafat[1], M.E. Haque[1], M.A. Alam[1], M.K. Adhikari[1], Reazul Haque[1], A.K. Ghosh[1], Shalim Uddin[2], M.M. Rahman[3] and T.J. Krupnik[1*]

[1]CIMMYT, Dhaka, Bangladesh; [2]Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh; [3]Bangladesh Agricultural Research Institute, Shyampur, Rajshahi, Bangladesh.
*Corresponding author Email: t.krupnik@cgiar.org

Available per-capita farmland is at a premium in South Asia, which is also a global 'hotspot' for malnutrition. We designed experiments using quick growing leafy vegetables - spinach and red amaranth - with maize and used an additive design with 36 farmer collaborators in Bangladesh over two winter seasons. The treatments included sole early sown maize (SM); sole late sown maize (LM), both as controls; spinach followed by late sown maize (Sp-LM); amaranth followed by late sown maize (Ra-LM); spinach intercropped with early sown maize (Sp+M); and amaranth intercropped with early sown maize (Ra+M). SP+M (18.5t/ha) and Ra+M (18.3t/ha) maize equivalent yields were significantly greater than SM (12.5t/ha), Sp-LM (15.5t/ha) and Ra-LM (15.1t/ha). Yield loss due to intercropping with spinach and red

amaranth was <5% of SM. LM was however 32% and 30% lower yielding when sown after spinach and red amaranth. Gross margins in Sp+M ($2,446) and Ra+M ($ 2,464) were significantly higher than SM ($1,480), Sp-LM ($,1789), Ra-LM ($1,751) and LM ($778). For 20% and 15% more investment in seed and labor for Sp+M and Ra+M, benefits increased 65% and 67% over SM. Production of fats, fibre, vitamins and nutrients important for improving the nutritional status of Bangladeshi smallholder households were significantly greater than controls. Our results suggest intercropping can be profitable and yield potential nutritional advantages where production can be linked to household consumption. Broader agri-food systems development efforts to align cold storage, distribution and market systems for perishables, as well as nutritional education for maize growing households, are required to realize these benefits.

TS4-7: Enhancing Water-Use Efficiency in Rainfed Maize through Tillage and Absorbent Polymer

Dilip Singh*, D. Chouhan and S.S. Sharma

MPUAT, Udaipur 313001, India.
*Corresponding author Email: dilipagron@gmail.com

Approximately 80% of maize area in Rajasthan is under rainfed conditions, which is a major cause of low productivity due to uncertainty and uneven distribution of monsoon. Maize growing area is exposed to 30-40% probability of moderate drought occurrence during monsoon period, which causes severe reduction in grain yield of maize - at initial stage, knee high stage or flowering and grain filling stage - and, sometimes, total crop failure. Moisture conservation strategies are critical, as are soil health and fertility, and adequate land preparation practices. These can be achieved through conservation tillage with residue incorporation and absorbent polymer on soil moisture holding and productivity. The present investigation was undertaken at fixed site for two years (2015 to 2017) with objectives to assess impact of tillage practices (Zero tillage (ZT), ZT+ Residue 4t/ha, conventional tillage (CT), and CT + Mulch) and absorbent polymer (control, 2.5 and 5kg ha^{-1}) on productivity, soil health and economics. The pooled data of two years revealed that adoption of ZT + residue incorporation enhanced organic carbon, water holding capacity (WHC) and recorded significantly higher maize yield, nutrient (N, P and K) content and uptake by grain and stover over all other treatments. Likewise, incorporation of 5kg absorbent polymer retains higher moisture and enhanced WHC, consequently increasing yield and economics over control. Present investigation suggests that adoption of ZT + Residue 4t ha^{-1} along with incorporation of absorbent polymer 5.0 kg ha^{-1} sustains productivity and soil health and proved economically beneficial compared to conventional practices under rainfed conditions.

TS4-8: Tillage and Nutrient Management for Sustaining Productivity, Soil Health and Economics under Maize-Wheat-Green Gram Cropping Sequence

Dilip Singh[1*], D. Chouhan[1], Urmila[1], M. L. Jat[2] and S.S Sharma[1]

[1]MPUAT, Udaipur 313001, India; [2]CIMMYT, New Delhi, India.
*Corresponding author Email: dilipagron@gmail.com

In Rajasthan, maize-wheat-green gram is a major cropping sequence. Approximately 80% of maize area is under rainfed conditions, which is a major cause of low productivity due to uncertainty and uneven distribution of monsoon. Poor fertility status and soil health, as well as inadequate land preparation, are also major contributors to low productivity. The present investigation was undertaken at fixed site in three maize-wheat-green gram cropping sequence from 2014-2017, with objectives to assess impact of tillage practices (Zero tillage, Bed planting and conventional tillage) and nutrient management (100% recommended dose of fertilizer, site specific nutrient management (SSNM) and farmers' practice) on productivity, soil health and economics. The pooled data of the latter two sequences revealed that adoption of zero tillage and application of balanced fertilizer based on SSNM recorded significantly higher maize, wheat and green gram yield, system productivity, and nutrient (N, P and K) content and uptake by grain and stover over all other treatments. There was also marginally lower water holding capacity and porosity, and significant buildup of soil bulk density, soil aggregation, nutrients (N, P2O5, K2O, sulphur, organic carbon, Zn, Cu, Fe, Mn), soil microbial biomass carbon, soil microbial biomass N & P, soil carbohydrates and population of soil bacteria, fungus, actinomycetes and Azotobactor in plough layer. Further, the combination proved economically beneficial over the other combinations, as the highest net returns and benefit cost ratio was recorded. Present investigation clearly suggests that adoption of zero tillage along with application of nutrient based on SSNM practices sustain productivity, soil health, and proved economically beneficial compared to conventional practices.

TS4-9: Management of Weeds in Maize (*Zea mays* L.) under Mid-Hill Conditions in North Western Himalayas

D.R. Thakur*, Vinod Sharma and Gurudev Singh

Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Hill Agricultural Research and Extension Centre, Bajaura, District Kullu, Himachal Pradesh, India.
*Corresponding author Email: thakur.dr@rediffmail.com

Maize is the most important crop of *kharif* season in mid-hills of the Western Himalayas yet faces severe crop losses caused by weeds if left uncontrolled. Traditional hand weeding - while effective – is labor intensive, prohibitively expensive and is complicated to carry out during the rainy season. Atrazine, the most popular pre-emergence herbicide used in maize, does not provide full season weed control. Therefore, various post-emergence herbicides require testing alongside their combination with pre-emergence herbicides to make weed control easy, cost effective and long lasting. The present study was carried out at CSKHPKV, Hill Agricultural Research & Extension Centre, Bajaura, with ten weed control treatments replicated thrice in RBD design with the objective to find out the most effective pre-, post- or combination of pre- and post- emergence herbicides for weed control in maize. Pooled analysis of data for three years (2015-2017) revealed that Pendimethalin (1000 ml a.i./ha) pre-emergence fb Atrazine (750 g a.i. /ha) + 2,4-D Amine (400 ml a.i./ha) at 25 DAS as PoE, and Atrazine (1.5 kg a.i./ha) pre-emergence fb Tembotrione (120 ml a.i./ha) at 25 DAS as PoE as being statistically at par. Both treatments gave significantly higher grain yield, stover yield and net return among various herbicidal weed control treatments due to effective weed control, as dry matter accumulation by weeds in these treatments was significantly low at both 50 DAS and harvest stages. These two treatments were as good as weed free in influencing the grain yield, stover yield and net return. Pendimethalin (1000 ml a.i./ha) pre-emergence fb Atrazine (750 g a.i. /ha) + 2,4-D Amine (400 ml a.i./ha) at 25 DAS as PoE, and Atrazine (1.5 kg a.i./ha) pre-emergence fb

Tembotrione (120 ml a.i./ha) at 25 DAS as PoE gave 104.56 and 99.21 per cent higher grain yield over weedy check respectively.

TS4-10: Effect of Planting Dates of Maize on the Incidence of Borer Complex in Inner Terai, Nepal

Ghanashyam Bhandari[1*], Resham Bahadur Thapa[3], Yagya Prasad Giri[2], Hira Kaji Manandhar[3], Pramod Kumar Jha[4] and Nava Raj Devkota[3]

[1]National Maize Research Program, Rampur, Chitwan, Nepal; [2]Nepal Agricultural Research Council, Sinhadurbarplaza, Kathmandu, Nepal; [3]Agriculture and Forestry University, Rampur, Chitwan, Nepal; [4]Department of Botany, Trivubhan University, Kathmandu, Nepal.
*Corresponding author Email: bhandarigb_1978@yahoo.com

Borer complex (*Chilo partellus* Swinhoe and *Sesamia inferans* Walker) is the major pest of maize in Nepal. Infestation of maize borer complex as well as climatic variability of growing areas result in low production and productivity of maize in Nepal. An experiment was conducted to find out the effect of planting date on open pollinated varieties and hybrid maize for the incidence of borer complex during winter, spring and summer seasons. This was carried out at experimental field of National Maize Research Program, Chitwan. The experiment was conducted in a factorial randomized complete block design with three replications using two maize genotypes at every 10 days' interval throughout 2016/ 2017. The results showed that borer incidence varied with maize planting dates and genotypes. The highest plant damage by stem borers was up to 29.9% in genotype S03TLEY-FM (open pollinated variety) and 29.0% in RML 95/RML 96 (hybrid variety) in May planting. The crop planted from January to February reached knee high stage when temperature was between 25-28°C in February to March, which was more favorable for the growth and development of borers. September planting was the best planting time for hybrids, and both September and March for planting open pollinated varieties, with respect to low borer incidence under inner Terai region of Nepal. Farmers can benefit by planting maize during September for winter season, mid-January for spring season and July for summer season to minimize maize stem borer damage.

TS4-11: Continuous Application of Fertilizers and Amendments on Productivity, Protein and NPKS Uptake of Maize in Western Himalayas

Gourav*, N.K. Sankhyan and R.P. Sharma

Department of Soil Science, CSK HPKV Palampur H.P. 176062, India.
*Corresponding author Email: gchouhan1@gmail.com

The present investigation studies the effect of continuous cropping and fertilization on the productivity, protein content and NPKS uptake by maize in a maize-wheat cropping system. This ongoing, long-term fertilizer experiment was initiated in 1972 at an experimental farm of the Department of Soil Science, College of Agriculture, CSK HPKV, Palampur, in randomized block design with eleven treatments replicated thrice. Soil in the experimental area was silty loam and taxonomically classified as *Typic hapludalf*. The study was set up to determine sustainability in quantity and quality of maize as affected by the continuous application of fertilizers and amendments. Standard methods were followed to determine the NPKS content in maize grain and stover. Protein content was obtained by multiplying the per cent nitrogen

content with the factor 5.70. The highest productivity of maize was recorded in the treatment comprising 100 per cent NPK + farmyard manure (FYM) and was statistically comparable with 100% NPK + lime. Protein content in both grain and stover was highest in treatment receiving FYM with 100% NPK, possibly due to higher available N. Application of FYM and lime along with 100% NPK resulted in significantly higher NPKS uptake by maize crop compared to other treatments due to higher availability of nutrients in these treatments. It can be concluded that for the higher nutritional quality of maize, integration of FYM with mineral fertilizer should be followed.

TS4-12: Effect of Plant Nutrient Omission Technique on Maize-Wheat Cropping System Productivity and Economic Returns in North-Western Himalaya

Gurudev Singh* and D.R. Thakur

Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Hill Agricultural Research and Extension Centre, Bajaura- 175 125, District Kullu, Himachal Pradesh, India.
*Corresponding author Email: gdevsaandil@rediffmail.com

Site-Specific Nutrient Management (SSNM) is vital for enhancement of productivity in maize-wheat cropping system. With SSNM, yield response to applied nutrients and indigenous nutrient supplying capacity of soils can be accessed through nutrient omission plot technique, which is a tool for determining the amount of fertilizer N, P and K required for attaining a yield target. Therefore, it is necessary to develop crop management strategies that help meet growing food demand in an economically feasible manner. Pooled data from a four-year study at CSKHPKV, HAREC, Bajaura, Kullu (H.P.) showed that treatment SSNM (N:P:K:Zn 188:79:0:25) gave the highest grain yield under maize-wheat cropping system at 266.50 % and 221.68% higher over the absolute control, respectively. This treatment also exhibited highest net returns of Rs. 77,815 per hectare in maize (HQPM 1) and highest B:C (Rs.1.12) ratio in wheat (HPW 155) crop. Omission of nitrogen may reduce grain yield by 193.31 % and 187.14 % in maize and wheat, respectively, with SSNM treatment. Omission of P may reduce the grain yield by up to 16.83% and 31.81 % in maize and wheat, respectively. However, the omission of K did not affect grain yield.

TS4-13: AAU's Liquid BIO NP biofertilizers to Supplement Nitrogen and Phosphorous in Tribal Maize (*Zea mays* L.)

H.N. Shelat, R.V. Vyas and Y.K. Jhala

Department of Agricultural Microbiology, B.A. College of Agriculture, Anand Agricultural University, Anand, India.
*Corresponding author Email: hnshel@ataau.in

Indiscriminate use of chemical fertilizers has resulted in deterioration of soil health, disturbed ecosystems and caused environmental pollution. It is high time to revert to long-established agricultural practices with emphasis on organic inputs. Biofertilizers-nitrogen fixers, phosphate cultures being live microbes are outstanding sources of bio input to improve soil health and reduce cost of cultivation. For a decade, large scale demonstrations on use of BIO NP (Nitrogen fixer *Azospirillum lipoferum* ASA 1 and PSB Bacillus coagulants PBA 16) liquid biofertilizers were held in farmers' fields in tribal areas of Gujarat viz. Panchmahals, Dahod, Mahisagar,

Chhotaudepur districts. Results revealed savings of ~25% Nitrogen and Phosphorous fertilizer inputs and 10-15% increase in maize yield.

TS4-14: Layering Sub-Surface Drip Fertigation with Conservation Agriculture in Maize and Rice Systems in North-West India: A Game Changer for Enhancing Crop Productivity with Dramatically Less Water Use

H.S. Jat[1*], P.C. Sharma[2] and M.L. Jat[1]

[1]CIMMYT, New Delhi, India; [2]ICAR-Central Soil Salinity Research Institute, Karnal, India.

*Corresponding author Email: h.jat@cgiar.org

In conventional RW system, repeated tillage, residue burning, and over-pumping of ground water are major concerns for soil health deterioration, serious water deficits and environmental pollution in north-west India. To address these issues and help achieve sustainable crop production, conservation agriculture (CA) would need synchronizing water and nitrogen (N) through sub-surface drip irrigation (SSDI) and replacing rice with maize crop. A research platform with five scenarios: i) conventional-till (CT) rice-CT wheat (Scenario I; farmers' practice; FP); ii) ZT rice-ZT wheat with flood irrigation (Scenario II; full CA); iii) ZT rice-ZT wheat with SSDI (Scenario III; full CA+SSDI); iv) ZT maize-ZT wheat with flood irrigation (Scenario IV; full CA); v) ZT maize-ZT wheat with SSDI (Scenario V; full CA+SSDI) were evaluated during 2016-2018 for their effect on crop and water productivity. On a two-year mean basis, MW system with full CA+SSDI recorded 11% higher system productivity, saved 88% (204 cm/yr) of irrigation water and increased WP_I by 808% compared to FP. RW system with full CA+SSDI recorded 3% higher system productivity, saved 57% (133 cm/yr) of irrigation water and increased irrigation water productivity (WP_I) by 141% compared to FP. Layering of sub surface drip fertigation in CA based RW system has potential to check ground water depletion in RW system. However, CA based MW system with SSDI is a potential game changing technology for sustaining productivity in north-west India, while conserving natural resources and ensuring food security.

TS4-15: Performance of Different Maize Genotypes under Contrasting Agronomic Management Systems in North-West India

H.S. Sidhu[1], Yadvinder-Singh[2], Naveen Gupta[1]*, K.M. Choudhary[1], L.K. Singh[1], H.S. Jat[2], P.H. Zaidi[2] and M.L. Jat[2]

[1]Borlaug Institute for South Asia (BISA), CIMMYT, Ladhowal, Punjab, India; [2]CIMMYT, NASC Complex, Pusa, New Delhi, India.

*Corresponding author Email: n.gupta@cgiar.org

Maize, an important crop for food and nutritional security in India, is grown in diverse ecologies and seasons. To meet rising demand, a quantum jump in maize production is the need of the hour. Maize genotypes are traditionally tailored under conventional tillage (CT) management system. However, performance of genotypes bred under CT may differ in their performance under upcoming conservation agriculture (CA) system. It is imperative to evaluate the performance of advanced breeding lines/genotypes under different agronomic management systems to realize maximum yield potential. A field experiment was conducted for two years to evaluate 15 Maize genotypes (pre-release and released hybrids) with diverse genetic

background under three management scenarios: (i) conventional tillage with flood irrigation (CT-Flood); (ii) zero tillage with flood irrigation (ZT-Flood); and zero tillage with subsurface drip irrigation (ZT-SSD) at Borlaug Institute for South Asia (BISA), Ladhowal (Punjab), India. Maize grain yield was significantly affected by management scenarios, genotypes and their interactions in both years. The increase in maize yield in ZT-SSD management scenario ranged from 6.3–21.7% compared to the other management scenarios. Maize genotypes CAH 153 and CAH 1414 in CT, VH 13079, VH 141733, PMH 3, CAH 1511 and CAH 162 in ZT-SSD out yielded other genotypes in 2016. Mean grain weight was significantly higher in ZT-SSD compared to ZT-flood, irrespective of genotypes. Total amount of irrigation applied under ZT-SSD was about 50% lower compared to conventional and ZT-flood irrigated maize. Results from this study revealed that the hybrids performed differently under varying management systems showing G x M interaction.

TS4-16: Response of Maize Hybrids to Different Doses of Chemical Fertilizers under Varying Densities at Rampur, Chitwan

Jagat Bandhu Adhikari* and Dhurba Regmi

National Maize Research Program, Rampur, Chitwan.
*Corresponding author Email: jagat.adhikari@gmail.com

Relatively low plant population and inadequate fertilizer application are the current problems for maize production among farmers in Nepal. To identify the integrated effect of plant density and fertilizer dose for production of hybrid maize, a series of on station experiments were carried out at National Maize Research Program (NMRP), Rampur, keeping three replications in strip plot design during winter season for two consecutive years, 2016-2017. Two promising hybrids (RML-95/RML-96 and RML-86/RML-96) were considered as vertical factors whereas five densities viz. 55,555 ha^{-1}, 66,666 ha^{-1}, 77,519 ha^{-1}, 87,719 ha^{-1} and 98,039 ha^{-1} as horizontal factors. Recommended dose (120:60:40 $NP_2O_5K_2O$ kg ha^{-1}) and rational doses required for these densities was calculated based on bench mark of recommendation for 53,333 plants ha^{-1}. Genotypic variation for grain yield, yield attributes and other agronomical parameters were found statistically analogous. However, differences were recorded among various densities and fertilizer doses. Significantly higher grain yield (7.91 t ha^{-1}) was observed when plant population was maintained at 77,519 ha^{-1} with fertilizer dose 174:87:58 $NP_2O_5K_2O$ kg ha^{-1} which was at par with the density 87,719 ha^{-1} along with 197:99:66 $NP_2O_5K_2O$ kg ha^{-1} fertilizer dose. Applying fertilizer as recommended and as rational dose enhanced yield up to the density of 66,666 and 77519 plants ha^{-1}, respectively, then yield gradually declined as the density increased. The present recommended national practices and doses regarding the plant population and fertilizer application should be updated accordingly for higher grain yield of hybrid maize.

TS4-17: Influence of Nitrogen Application on the Incidence of Shoot Fly, *Atherigona naqvii* Steyskal in Spring Sown Maize

Jawala Jindal*, Mahesh Kumar and J.S. Chawla

Punjab Agricultural University, Ludhiana, India.
*Corresponding author Email: jawalajindal@pau.edu

Shoot fly (*Atherigona naqvii)* is a key pest of spring maize, with various factors influencing its life history, behavior and ecology, as well as that of its plant hosts. In Punjab, farmers tend to apply more fertilizer to get higher yield. To ascertain influence of nitrogen application on population build up and damage by shoot fly in spring maize, a study was conducted at farmers' field in Hoshiarpur on unprotected crop. The hybrids JH 3459 (moderately resistant) and PMH 2 (highly susceptible) were flat sown at two nitrogen levels of 90 and 120 kg N ha^{-1}. The *A. naqvii* did not differentiate for oviposition on both the hybrids at varied nitrogen levels. At 21 days after germination, PMH 2 (14.41 and 24.92 %) had significantly more dead heart incidences than JH 3459 (9.50 and 17.06 %) during both years. At varied nitrogen levels, the dead heart differences were significant, with relatively more incidence in the second year has masked the effect of nitrogen on manifestation of damage. However, the increase in dead hearts under higher nitrogen was more pronounced in PMH 2 (3.82 %) than JH 3459 (1.50 %). The hybrid PMH 2 had significantly more yield (46.11 and 42.29 q/ ha) than JH 3459 (42.45 and 38.28 q/ ha) even at higher infestation levels, indicating inherent capacity of hybrids with positive response to nitrogen. In conclusion, the dose of nitrogen in spring maize is a result of genotype x nitrogen interaction with modest influence on damage by shoot fly.

TS4-18: Effect of Seed Film Coat Polymers on Seed Quality of Maize

Kanaka Durga K.*, T. Pradeep and M.V. Nagesh Kumar

Seed Research and Technology Centre, PJTSAU, Rajendranagar, Hyderabad, India.
*Corresponding author Email: kanakakilaruatyahoo.com

Maize seed (Hema) treated with Polymer (DISCO AG SP RED L-200) + Thiram + Vitavax; Polymer + Thiram + Genius Coat and Polymer + Thiram + Quick Roots along with control was used for initiating laboratory and field studies in 2015-2016. The objective was to validate the use of polymers for approval by seed certification agencies. Initial evaluation of seed for germination and seedling vigor index (SVI) indicated that seed treated with Polymer + Thiram + Genius Coat was superior and recorded 100% germination with an SVI of 1906, indicating that Genius Coat improved the germination, vigor and the growth of the seedling. A similar trend was noticed at two MAS, four MAS, six MAS and eight MAS. The incidence of seed borne fungi (*A. niger, Rhizophus* and *Fusarium* sps.) was more in Polymer + Thiram + FBS 1065, followed by Polymer + Thiram + Genius Coat, Polymer + Thiram + Carboxine and Control. Under field conditions, expression of polymer coating did not differ significantly from the treatments, including control. Though higher seed yield was recorded in control, it was at par with the other treatments. Postharvest studies indicated that germination percentage did not differ significantly among the treatments, both initially and up to four MAS. However, shoot length, total seedling length and seedling vigour index were found superior with Polymer + Thiram + Carboxin and control with similar trend at one MAS, two MAS, three MAS and four MAS. Therefore, the study indicated that maize seed treated with Polymer (DISCO AG SP RED L-200) + Thiram + Genius Coat could be used safely without loss in germination and vigor up to eight MAS.

TS4-19: Performance of Hybrid Maize Under Different Levels of Nitrogen and Phosphorus in Rabi Season

K.H. Patel*, M.B. Patel, A.S. Bhandavadia, P.K. Parmar and S.K. Singh

Anand Agricultural University, Godhra, Gujarat, India.
*Corresponding author Email: khp@aau.in

The field experiment was conducted during *rabi* season of 2015-2016 to 2016-17 at Main Maize Research Station, AAU, Godhra and Regional Research Station, AAU, Anand. The experiment aimed to assess grain yield and its attributing traits of new single cross hybrids, GAYMH-1 and GAWMH-2, under different levels of nitrogen and phosphorus, and under irrigated conditions. The study also assessed the quality parameters of hybrid maize. The experiment was laid down in RBD (factorial) design with three replications by keeping spacing at 75 x 20 cm, and net plot size of 3.0 m x 5.6 m. Nitrogen was applied in four splits and P_2O_5 as basal. The results of different nitrogen and phosphorus levels on hybrid performance showed that application of 150 kg N/ha and 40 kg P_2O_5 /ha (Soil having medium phosphorus status) in Middle Gujarat Agro Climatic zone in Panchmahal district, and application of 150 kg N/ha and 60 kg P_2O_5 /ha (Soil having low phosphorus status) in Anand district significantly increased grain yield, fodder yield, ear length, ear girth, test weight and number of grain rows/ear. There was significant effect of nitrogen application on oil %.

TS4-20: Effect of Intercropping Maize with Legumes on Stem Borer (C*hilo partellus* Swinhoe) Infestation in Maize

K.N.C. Gunewardena* and P.A.I. Sandaruwani

Field Crops Research and Development Institute, Department of Agriculture, Mahailluppallama, Sri Lanka.
*Corresponding author Email: nishanthigun@yahoo.com

Stem borer (*Chilo partellus*) is one of the most destructive pests of maize in Sri Lanka, whose management presently depends on insecticides that affect environment, biodiversity and human health. Implementation of cultural methods can reduce the problems caused by indiscriminate use of insecticides. Experiments were conducted at Mahailluppallama, Sri Lanka, during 2016 and 2017 cropping seasons to assess the effect of intercropping maize with legumes to reduce stem borer damage. The experiments were laid out in a randomized complete block design with five treatments replicated four times. Treatments were maize sole crop (MI Maize HY 01) and maize intercropped with four legumes separately (cowpea, mungbean, blackgram and soybean). The percentage of plants showing dead hearts were significantly higher in monocrop than in intercrops during both seasons. All intercropping systems showed significantly lower percentage of damage (23-31%) compared to monocrop (40%) in 2016. In 2017, monocrop had the highest number of damaged plants (47%) while maize intercropped with mungbean or cowpea had low incidences of 33% and 34% respectively. Severity of leaf damage and larval and pupal populations were significantly higher in the monocrop and maize-soybean intercrops compared to other intercrops during both seasons. Intercropping systems increased natural enemy population in maize fields. Higher natural enemy population was recorded in the maize-cowpea intercrops followed by mungbean and blackgram. Maize-cowpea intercrops increased maize grain yields by 72% and 44% compared to the monocrop during 2016 and 2017 respectively.

TS4-21: Influence of Different Planting Methods and Nitrogen Levels on Yield of *kharif* Maize (*Zea mays* L.)

Mahesh Kumar*, Jawala Jindal, J.S Chawla and G.K. Gill

Punjab Agricultural University, Ludhiana, India.
*Corresponding author Email: maheshkumarvats@pau.edu

Kharif sown maize in Punjab during end-May to end-June experiences high rainfall leading to flooding in flat sown crop, thereby affecting its germination. Suitable planting methods during *kharif* season can improve the drainage, facilitate good germination and result in optimum plant stand to enhance productivity. An experiment comprising three methods of planting (flat, ridge and bed planting) and five nitrogen levels as sub plot treatments (0, 90, 120, 150 and 180kg N ha^{-1}) was laid out in a split plot design. Significantly higher grain yield was obtained in bed planting compared to flat sowing. The magnitude of yield contributing attributes was also higher in crop sown on beds. However, the difference between bed and ridge sown crop was negligible. Maize crop sown on beds and ridges gave 10% and 6.4% higher yields than flat sowing, respectively. Different nitrogen levels greatly influenced maize grain yield up to 150kg/ha. However, application of 180kg N/ha produced maximum and significantly higher mean grain yield (67.4 q/ ha) than under 0, 90 and 120kg N/ha, but it was at par with 150kg N/ha (66.0 q/ ha). Mean data revealed that application of 180kg N/ ha resulted in 43.8%, 16.7%, 8.5% and 2.1% higher grain yield compared to 0, 90, 120 and 150kg N /ha, respectively. Based on experimental results, maize crop should be sown on beds or ridges to avoid germination losses from excessive rainfall.

TS4-22: Prescription of Soil Test Based Fertilizer Recommendations for Specific Targeted Yield of Maize in Alfisol

Madhavi A.[1*], T. Srijaya[2], M. Srinivasa Chari[2] and Pradip Dey[2]

[1]AICRP-Soil Test Crop Response, PJTSAU, ARI, Rajendranagar, Hyderabad 500 030, Telangana, India; [2]ICAR-Indian Institute of Soil Science, Bhopal, India.
*Corresponding author Email: madhavi.adusumilli@gmail.com

In an era of precision agriculture, the concept of "Soil test-based fertilizer recommendation" harmonizes much debated approaches such as "Fertilizing the soil‟ versus "Fertilizing the crop", ensuring real balance (not apparent balance) between the applied fertilizer nutrients among themselves, and with available soil nutrients. Field experiment was conducted on maize in Alfisol soils of Kadapa District, with the objective of developing soil test-based fertilizer recommendations for attaining yield targets under IPNS. With the help of nutrient uptake, soil test values and average basic data (i.e., nutrient requirement of N, P and K, percent contribution of N, P & K from soil, fertilizer and vermicompost), fertilizer recommendations for different maize production levels (60 q/ha and 70 q/ha) were calibrated. The basic data was transformed into simple workable fertilizer prescription equations for calculating fertilizer doses based on initial soil test values. Based on the study, the estimates of nutrient requirement (kg) for obtaining one quintal seed yield of maize were found to be 0.74 for N, 0.44 for P and 0.54 for K. The nutrient contribution from soil, fertilizer and vermicompost were found to be 7.19, 14.60 and 11.97 for N, 18.78, 49.02 and 13.47 for P and 3.34, 33.76 and 17.96 for K respectively. The response yard stick (kg output /kg input) was found to be 13.6 based on target yield coefficients. Using the fertilizer prescription equations, a fertilizer-ready reckoner was

developed for interpolating soil test-based optimal fertilizer doses for attaining desired maize yield targets in Alfisol soils. Fertilizer prescription equation was developed for maize in Alfisol:

TS4-23: Evaluation of Interactive Effects of Row Arrangement, Plant Geometry and Mulching on Yield of Early Maturity Maize Hybrid under Rainfed Conditions

Manjulatha G.*, E. Rajanikanth, K. Sumalini, D, Sravani, G. Usharani and B. Mallaiah

Agricultural Research Station, Karimnagar, Professor Jaya Shankar Telangana State Agricultural University, Hyderabad, India.
*Corresponding author Email: drgmanjulata@gmail.com

A field experiment was conducted at Agricultural Research Station, Karimnagar, during *kharif* 2011-2012 to study grain yield performance of early maturity maize hybrids under rainfed conditions, in relation to row arrangement, plant geometry and mulching. The experiment was carried out in red sandy loam soils, in a split-split plot design with main plots as row arrangement (2) i.) Equal rows at 67cm ii); paired row at 84 x 50cm (between and within paired rows), sub plots as plant geometry (3) i.) with 40,000 Plants/ha (intra row spacing of 37 cm) ii.) with 50000 Plants /ha (intra spacing of 30cm) iii.) with 60000 Plants/ha (intra row spacing of 25cm) and Sub-sub plots as mulching treatments (2) i.) without mulching ii.) with surface mulch at 5 t/ha. The results indicated that there is no significant difference in grain yield of early maturity maize hybrid, when the crop is grown in equal row spacing of 67cm (5148 kg/ha) or paired row spacing of 84:50cm (4962 kg/ha). The grain yield of maize crop with 60,000 Plants /ha (*i.e.,* 25 cm intra row spacing) recorded higher grain yield of 5339 kg/ha, followed by maize crop with 50000 Plant /ha (*i.e.,* 30 cm intra row spacing), and 4729 kg/ha with 40000 Plant/ha (*i.e.,* 37 cm intra row spacing). When crop rows were mulched with grass and dried weed material at 5t/ha, there was significant increase in the maize grain yield (5724 kg/ha) by 23% compared to the crop kept without mulch (4386 kg/ha), while the interaction for all parameters was non-significant. Thus, it can be concluded that farmers can either follow equal row spacing or paired row spacing based on situation, as there is no significant difference in terms of yield by using either method. Mulching of inter row of maize crop under rainfed conditions has resulted in 23% increased yield than that of crop kept without mulch.

TS4-24: Present Status and Future Prospects of Maize Crop in Pakistan

Muhammad Arshad*, Waseem Akbar, Aamir Hussain, Hafiz Mutahhar Javed and Ghulam Murtaza

Maize and Millets Research Institute, Yusafwala-Sahiwal, Pakistan.
*Corresponding author Email: directormmri@gmail.com

Maize is the third most important crop in Pakistan after wheat and rice. It is grown on an area of 1.33 million hectares with a production of 6.13 million tons, and average yield of 4.6 tons per hectare. Punjab is a major contributor of maize area (62%) and production (89%) followed by KPK with 37% area and 10% production. Maize crops are cultivated during two seasons in Pakistan: autumn and spring. Autumn season is the main crop season and contributes 80% area and 62% production. Pakistan has a well-established research network for maize crop dispersed throughout the country consisting of public as well as private seed companies with an outcome

of almost 65 maize hybrids/ OPVs. Half of these hybrids/ OPVs were contributed by the public sector, especially Maize and Millets Research Institute (MMRI), Yusafwala Sahiwal (Punjab) and Cereal Crop Research Institute (CCRI) Pirsbak (KPK). During the year 2016-2017 maize seed requirement was 33,270 MT which was achieved by indigenous (66%) and exotic sources (34%). Maize is consumed by feed industry (65%), wet-milling (20%), fodder/ silage purposes (10%) and for seed purposes (5%). Expanding poultry and dairy sector (at 8-10% per annum) not only ensures the stability of maize market, but also predicts the ever-increasing demand for maize grain and fodder. Silage industry, driven by the dairy sector, is also growing at higher rates. MMRI Yusafwala- Sahiwal is the only public research institute (with its sub-stations) in Punjab working for varietal development, improved production and protection of maize crop technology. Introduction of doubled haploid technology and nutritional enhancement of maize crop are two new projects funded by the Punjab Government. The institute is also working in collaboration with CIMMYT under AIP and HTMA programs.

TS4-25: Impact Quantification of Biostimulant for Economic Production of Spring Cultivated Maize

Muhammad Aslam[1*], Muhammad Arslan Akhtar[1] and Muhammad Yaseen[2]

[1]Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan; [2]Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan.
*Corresponding author Email: aslampbg@gmail.com

There is need to substitute inorganic fertilizers with organic nutrients, thus, a study was planned to evaluate the responses of maize against different treatment combinations of Plant Protector^{TM} (an organic biostimulant) and NPK fertilizers. Treatments comprised control (T1) only biostimulant at V5, V7 and V9 stages separately (T2, T3 and T4 respectively), recommended inorganic fertilizer only (T5), and half of recommended inorganic fertilizer along with biostimulant at V5, V7 and V9 stages separately (T6, T7 and T8 respectively). Biostimulant (Plant Protector^{TM}) was applied as foliar spray at the rate of 100ml/20L water. Data was collected for variance, contour plot and AMMI biplot analyses. Application of Plant Protector^{TM} at 5th and 9th leaf stages improved plant height, number of leaves, leaf chlorophyll content, cob diameter, cob length, cob weight, number of grains per cob and 100-grain weight. However, application of Plant Protector^{TM} at 7th leaf stage along with half of recommended dose of N:P:K showed 73.53% and 68.58% increase in cob yield as compared to control and recommended dose of N:P:K respectively. Treatments, genotypes and treatment × genotype interactions contributed 35.97%, 26.23% and 27.79% of total variation for cob yield respectively. AMMI biplot and contour plot showed highest grain yield at 60:30:30 N:P:K with Plant Protector^{TM} application at 7th leaf stage. It is concluded that maize is highly responsive to organic and inorganic fertilizers at 7th leaf stage. For economic yield, N:P:K could be reduced to half along with the application of Plant Protector^{TM} at 7th leaf stage.

TS4-26: Effect of New Herbicide on Weed Control in Maize Crop

Narender Singh*, Mehar Chand and M.C. Kamboj

CCS Haryana Agricultural University, Regional Research Station, Karnal.
*Corresponding author Email: narendersingh.bagri@gmail.com

Maize is the third most important grain crop in India after rice and wheat, and has the highest yield potential, which is influenced by various factors *viz*., weeds, nutrients, pests and diseases. Weeds compete with maize for light, space, water and nutrients - especially during the 15-30 days of growth period - and can cause 28% to 100% loss in grain yield. Wide spacing in maize encourages weed growth leading to reduced photosynthetic efficiency, dry matter accumulation, size of cobs, and, ultimately, affects plant population resulting in poor grain yield. A field experiment was conducted at CCS HAU, Regional Research Station, Karnal (Haryana) for three consecutive years (*kharif* 2015-2017) with ten treatments *viz*. T1: Control, T2: Weed free, T3 : Atrazine 1.5kg/ha pre-emergence, T4: Atrazine 750g/ha + Pendemathalin750ml/ha pre-emergence, T5 : Atrazine 1.5kg/ha fb 2,4-D Amine 0.4kg/ha at 25 DAS as PoE, T6: Halosulfuron 67.5g/ha at 25 DAS, T7: Atrazine at 1.5 kg/ha pre-emergence fb Halosulfuron 67.5g/ha 25 DAS, T8: Tembotrione 120g /ha PoE at 25 DAS, T9: Pendemathalin 1000ml/ha pre-emergence fb Atrazine 750g/ha + 2,4-D Amine 0.4kg/ha at 25 DAS as PoE and T10 : Atrazine 1.5kg/ha pre-emergence fb tembotrione 120g/ha PoE at 25 DAS with RBD with three replications. It was observed that T10 gave the highest grain yield on mean basis (64.1q/ha) compared to all others, followed by T8 and T9. No phototoxic symptoms were observed due to application of any herbicide. We conclude that Atrazine 1.5kg/ha pre-emergence fb tembotrione 120g/ha PoE at 25 DAS is the best herbicide for the control of complex weed flora in maize crop.

TS4-27: Effect of Zero Tillage Practice on Maize Production

Narender Singh*, Mehar Chand, Jitender Yadav and M.C. Kamboj

CCS Haryana Agricultural University, Regional Research Station, Karnal, India.
*Corresponding author E-mail: narendersingh.bagri@gmail.com

Conservation agriculture (CA), defined as minimal soil disturbance (no-till) combined with crop rotations, is a more sustainable cultivation system than those presently practiced. Intensive maize (*Zea mays* L.) cropping based on conventional tillage practices has resulted in degradation of soil quality and reduced water percolation rate in monsoon season. A field experiment was conducted at CCS HAU, Regional Research Station, Karnal (Haryana) for three consecutive years from *kharif* 2013-2015 with three sowing methods (Zero till, Conventional till, Permanent bed) in main plot; three fertilizer levels in sub plot RDF (150-60-60 N-P_2O_5-K_2O kg/ha), SSNM (172-65-74(N-P_2O_5-K_2O kg/ha); and farmers' fertilizer practice (210-95-50(N-P_2O_5-K_2O kg/ha)) in split plot design with three replications. Maize sown in the first year under permanent beds gave significantly higher grain yield (61.2 q/ha) than crop sown by conventional sowing on flat beds (57 q/ha), and zero tillage planting (59.0 q/ha). As for nutrient management, nutrient expert based SSNM being at par with RDF gave higher grain yield compared to RDF. In the 2nd and 3rd year, maize sown under zero tillage gave higher grain yield (62.6 q/ha) than crop sown by conventional (58.2 q/ha) sowing but was at par with permanent beds (60.8 q/ha). Among nutrient management practices, FFP gave higher grain yield (65.3q/ha) compared to RDF (55.3 q/ha) and SSNM (60.9 q/ha). Zero tillage practice also increased soil organic carbon and water use efficiency. We conclude that zero tillage practices can contribute to sustainable agriculture in maize growing areas of Haryana.

TS4-28: Effect of Zinc Fertilization on Maize Yield, Quality and Nutrients Uptake in Acid Soil of Northwestern Himalayas

Pardeep Kumar and Nagender Pal Butail*

CSKHPKV, Palampur, India.
*Corresponding author Email: nagender.butail597@gmail.com

Zinc deficiencies in soil have a direct relationship to its deficiency in crop plants, animals and, ultimately, in human nutrition. Zinc fortification through soil and foliar application could be a viable option to mitigate this problem. Therefore, study was initiated during *kharif* 2013 with the objective to investigate the effect of zinc fertilization on yield, nutrient uptake and quality of maize crop in acid soil of Northwestern Himalayas. The experiment was laid out in RBD arrangement and consisted of 13 treatments which were replicated three times. Four levels of zinc (2.5, 5.0, 7.5 &10.0 kg ha^{-1}) were applied to soil at three different frequencies (once, alternate year, every year) with one control plot (no Zn). The results obtained after four years of experimentation revealed that the DTPA-Zn concentration in soil was higher where Zn was applied at 10 kg ha^{-1} every year and declined with treatment where no Zn was applied. Highest maize grain yield (56.0 q ha^{-1}), protein (8.2 %) and nutrient (macro and micro nutrients) uptake was recorded where Zn was applied at 5 kg ha^{-1} every year compared to other treatments. Besides this, the highest zinc concentration in maize grain and stover was also recorded highest in the same treatment. Overall, the study suggests that zinc fertilization of maize through soil can enhance not only productivity and quality of maize both in grain and stover, but also improve nutrient uptake by maize compared to control, hence better nutritive food both for humans and animals.

TS4-29: Adoption of Rabi Maize in Southern Rajasthan: Success and Challenges

Pramod Rokadia

Agricultural Research Station, MPUAT, Banswara, India.
Email: rokadiap@gmail.com

The agro-climatic region of southern Rajasthan has congenial atmospheric conditions for *Rabi* maize production which has been successfully adopted by resource poor tribal farmers. The breeding approach favored development of hybrids with higher production and nutritional quality and biotic stress tolerance capacity, against post flowering stalk rot (PFSR) caused by *Fusarium* spp. Rabi maize takes 130-150 days to maturity, usually yielding 9-10t/ha or as high as 12-13t/ha with good agronomic practices. Suitable conditions for quality seed production and good quality seed set are key to the success of the breeding program. Higher single cross hybrid seed production with low ASI finds its way for assured seed production. Biotic stress of post flowering stalk rot needs to be addressed by resistance breeding approaches. Screening of various entries and selection of their inbreds to be included under resistant breeding program is in progress. Thus, breeding approach towards developing medium maturity hybrids is a priority. In this regard, a medium maturity hybrid WH-1010 has been developed with high protein content.

TS4-30: The Effect of Temperature and Relative Humidity of Storage on Seed Quality

Rahmawati* and Muhammad Aqil

Indonesian Cereals Research Institute (ICERI), Maros, Indonesia.
*Corresponding author Email: acchmad@yahoo.com

Orthodox seed storage requires relatively low temperature and humidity to maintain the quality of maize seed. Seed storage is influenced by various factors such as seed moisture content and type of seed packing material. Initial seed quality such as moisture content, temperature and relative humidity will affect the storage duration. This paper reviews the effect of seed storage on the seed quality of maize such as viability, vigor and dry matter of seed on grain yield and other agronomic components. In addition, the effect of hybrid and open pollinated maize on seed quality was also discussed. It concluded that the use of low temperature and relative humidity can suppress the rate of seed deterioration and seed vigor.

TS4-31: Evaluation of New Bio-Fertilizers in Maize Crop

Rajanikanth E.*, G. Manjulatha, D. Sravani, B. Mallaiah, G. Usharani and A. Vijaybhaskar

Agricultural Research Station, Karimnagar, Professor Jaya Shankar Telangana State Agricultural University, India.
*Corresponding author Email: eligetiraj@yahoo.com

Biofertilizers are becoming increasingly popular, but very few studies on their effect on maize grain yield have been conducted. A field experiment was carried out at Agricultural Research Station, Karimnagar, for two years (*kharif* 2016-2017 and 2017-2018) to evaluate the suitable biofertilizers for maize crop in red sandy loam soils. The initial soil status indicated high available N, P, K (613.9, 62.8, 436kg/ha respectively). The experiment was carried out in randomized block design with 12 treatments (T1- Control *i.e* Recommended N & K), T2- PSB-I, T3- PSB- II, T4- NPK consortia, T5- 60kg P2O5/ha, T6- 30kg P2O5/ha + PSB-I, T7- 60kg P2O5/ha + PSB-I, T8- 30kg P2O5/ha + PSB-II, T9- 60kg P2O5/ha + PSB-II, T10- 30 kg P2O5/ha + NPK consortia, T11- 60kg P2O5/ha + NPK consortia, T12- 90kg P2O5/ha). Among the different biofertilizer applications to maize crop, the 30kg P2O5/ha + PSB- II (8566kg/ha) along with recommended dose of N and K recorded the highest grain yield. This study revealed that as available soil P increased, there was no response to biofertilizer application - and with or without phosphorous application – in terms of grain yield.

TS4-32: Zero Tillage with Residue Retention: A Promising Technology to Conserve Resources, Optimization and Profitability of Maize (*Zea mays* L.)

Rajbir Singh Khedwal[1]* and Dharam Bir Yadav[2]

[1]Department of Agronomy, Punjab Agricultural University, Ludhiana, Punjab (141004), India; [2]Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana (125004), India.
*Corresponding author Email: rajbirsinghkhedwal1524@gmail.com

Maize (*Zea mays* L.) has become one of the leading food grain crops due to its high nutritive value and as a basic raw material in numerous industries. An experiment was conducted at Regional Research Station, Karnal, of CCS Haryana Agricultural University during *kharif*

2015 to study the promising technology of maize hybrids under different planting methods and residue retention. Zero tillage (ZT) with residue, ZT without residue, raised bed with residue and raised bed without residue were kept in main plot treatments. Maize hybrids (HQPM-1, HM-4 and HM-10) in combination with two weed control treatments *viz*., atrazine 750g/ha pre-emergence (PRE) followed by (*fb*) one hand weeding (HW) at 30 days after sowing (DAS), and unweeded check were kept as sub-plots in split plot design with three replications. Maximum leaf area index (LAI), crop growth rate (CGR), plant dry matter accumulation (PDMA), 100-grains weight (27.37 g), grain yield (7.32t/ha) and net returns (₹ 59958/ha) were recorded under ZT with residue at 60 DAS and harvest. LAI increased up to 60 DAS under all treatments but declined at harvest which might be attributed to drying of leaves**.** HM-10 recorded higher LAI, CGR, PDMA over HM-4 and HQPM-1 at 60 DAS; but at harvest HM-4 performed better with respect to CGR. Hybrid HM-4 produced maximum 100-grains weight (26.96g), grain yield (7.04t/ha) and net returns (₹ 58749/ha). Application of atrazine 750g/ha (PRE) *fb* 1 HW at 30 DAS gave higher LAI, CGR, PDMA, 100-grains weight, grain yield and net returns than unweeded check at 60 DAS and at harvest. Therefore, maize sown in place of rice in rice-wheat system in ZT with wheat residue is a promising technology for resource conservation, optimization and profitability of maize. This technology also promotes sustainable and diversified cropping systems.

TS4-33: Evaluation of Fodder maize (*Zea mays L.*) Cv. African Tall and its Response to Different Rates of FYM and Biofertilizers under Cold Arid Conditions of Kargil

Raies A. Bhat[1*], Raihana Habib Kanth, Zahida Rashid, T.A Shiekh and Waseem A. Raja

Division of Agronomy, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir, Wadura, Sopore-193201, J&K, India.
*Corresponding author Email: drraies1980@gmail.com

Fodder availability in cold arid region is 40-50 per cent of the actual requirement. Alfalfa, the only fodder available to farmers in Kargil, cannot cover the 73% deficit reported in the region. Fodder development in the region is therefore of paramount importance. The cold arid region of Ladakh suffers severe winter, lasting seven to eight months, devoid of any vegetation, thus affecting animal rearing in winter as it depends on stored fodder. A field experiment was carried out at the research farm of Mountain Agriculture Research and Extension Station Kargil (2015-2016 and 2016-2017) on silty clay loam soil with low available nitrogen, medium available phosphorus, and potassium with neutral pH. The experiment comprising three factors viz. biofertilizers (Azotobactor, PSB and Azospirillium) and three FYM rates (R_1= 10t ha^{-1}, R_2 =20^t ha^{-1} and R_3 = 30t ha^{-1}) were laid out in a randomized block design replicated thrice and given nitrogen, phosphorus and potassium as per recommended package. Highest plant height, number of leaves, stem girth and fodder yield were realized from the treatment comprising FYM at 20t/ha+ Azotobactor + PSB. It was observed that fodder maize Cv. African tall performed better in cold arid conditions provided regular irrigation was done at intervals of seven days maximum.

TS4-34: Evaluation of the Bio-Efficacy of Herbicide in Maize at Satpura Plateau of Madhya Pradesh

Rajesh Khavse, Vijay Paradkar* and A.K. Rai

AICRP on maize, Zonal Agricultural Research Station, JNKVV, Chhindwara, India.
*Corresponding author Email: khavse@gmail.com

The cultivation of maize based cropping system is most popular in Madhya Pradesh, India. Pre-emergence herbicides are widely used for control of weeds in maize, but post-emergence herbicides are less available in the market. The experiment was conducted to find best management practice in maize based systems in Chhindwara under rainfed conditions during *Kharif* 2015 to 2017 at experimental farm, JNKVV, Zonal Agricultural Research Station, Chhindwara, Madhya Pradesh. The evaluation of bio-efficacy under different treatment combinations of herbicide were T1 control (weedy check); T2 Weed free; T3 Atrazin at 1.5kg/ha. Pre-emergence; T4. Atrazin (750g/ha.) + pendemathalin (750ml/ha) pre-emergence; T5. Atrzine (750g/ha) + 2,4-D, Amin (500g/ha) at 25 DAS as PoE; T6. Halosulfuran 60g/ha at 25 DAS; T7. Atrazine at 1.5kg/ha pre-emergence, fb Pre-emergence Halosulfuran 60g/ha 25 DAS; T8. Tembrotrione (laudis) 120g/ha PoE at 25 DAS; T9. Pendemathlin (1000ml/ha) Pre-mergence fb Atrazin (750g/ha) + 7 2,4-D Amin (500g/ha) at 25 DAS as PoE; T10. Atrazin at 1.5kg/ha pre-emergence followed by tembotrione 120g/ha PoE at 25 DAS. Results revealed that the best weed management treatments were Atrazine at 1.5kg/ha pre-emergence and Atrazine (750 g/ha) + pendamethalin (750 ml/ha) pre-mergence. The maximum yield was recorded under weed free (T2).

TS4-35: Identification of Appropriate Fertilizer Dose for Maize Hybrid RML-95/RML-96 in Chitwan Nepal

Reena Sharma*, Parbati Adhikari and Keshab Babu Koirala

National Maize Research Program, Rampur, Chitwan, Nepal.
*Corresponding author Email: sharma_reena006@yahoo.com

The increasing demand for cereal production - and looming food insecurity - is urging work for optimum fertilizer management and high yielding hybrids. There is no updated information regarding the recommendation of fertilizer doses for hybrids in Nepal. Research was carried out at National Maize Research Program, Rampur, during winter in 2016 and 2017 with the objective to identify optimum fertilizer dose for hybrid RML-95/RML-96. The recommended fertilizer dose for hybrid maize in Nepal is 180:60:40 kg/ha N_2O:P_2O_5:K_2O. Experiment was conducted in randomized complete block design with three replications and consisted of four levels of nitrogen viz. 120, 160, 200 and 240kg/ha, phosphorus at 60kg/ha (split or no split) and full dose of potassium at 40kg/ha was applied at the time of planting. During winter 2016, the grain yield ranged from 5225kg/ha from 120:60:40 N_2O:P_2O_5:K_2O kg/ha to 8398kg/ha from 200:(40+20):40 N_2O:P_2O_5:K_2O kg/ha. Similarly, in 2017, grain yield ranged from 6.14t/ha from 120:60:40 N_2O:P_2O_5:K_2O kg/ha to 7.39t/ha from 200:(40+20):40 N_2O:P_2O_5:K_2O kg/ha. Significant differences in grain yield were recorded in both years. Based on experimental results fertilizer dose 200 :(40+20):40 N_2O:P_2O_5:K_2O kg/ha has been recommended for the hybrid maize variety RML-95/RML-96 for profitable commercial cultivation.

TS4-36: Precision Nutrient Management in Conservation Agriculture-Based Maize-Wheat System of Eastern Gangetic Plains of India: Profitability, Nutrient use Efficiency and Environmental Footprints

R.K. Jat[1,2*], Deepak Bijarniya[1], J.M. Sutaliya[1], M.K. Jat[3], Tek B. Sapkota[1] and M.L. Jat[1]

[1]CIMMYT, DPS Marg, NASC Complex, New Delhi 110012, India; [2]Borlaug Institute for South Asia (BISA), Pusa, Bihar 848125, India; [3]Chaudhary Charan Singh Haryana Agricultural University, Hisar 125 004, India.
*Corresponding author Email: r.jat@cgiar.org

Monsoon maize grown in rotation with wheat following conventional tillage-based management systems has very low productivity in eastern Gangetic plains of India. The primary reasons for this are (i) inappropriate input use and sub-optimal management considering high weather risks with probability of maize crop failure. Under such situations, conservation agriculture (CA) based management practices have demonstrated multiple benefits with lower risks of aberrant weather. However, the precise nutrient management (rate, method, time, e.t.c) under CA based systems is not known and plays a major role in overall system performance. A strategic research trial on precision nutrient management practices in CA based (permanent beds: PB) in maize-wheat MW) system was conducted under CIMMYT-CCAFS at BISA, Pusa, Bihar, India for two consecutive years (2014-2015 and 2015-2016). The treatments include farmers fertilizer practices (FFP), state recommended dose of fertilizer (SR) and precision nutrient management using Nutrient Expert® and Green Seeker based nitrogen rates applied with two methods; broadcasting and drilling. The NE, NE+GS and SR based nutrient management strategies with drilling significantly increased yield, nutrient use efficiency as well as net return compared to NE-broadcasting, SR broadcasting and farmers' fertilization practice (FFP) broadcasting methods. System productivity and net returns under NE+GS-drilling on PB were significantly increased by 31.2%, 49.7% compared to FFP respectively. Significantly higher NUE (11-18%) was recorded under NE+ GS+ drilling as compared to FFP. Mitigation options tool (MOT), an empirical model to estimate greenhouse gases (GHGs) from agriculture production, was used to quantify GHG emissions under different treatments. Global warming potential (GWP) of maize and wheat production was lower with NE-drilling compared to FFP-broadcasting. NE-drilling recorded 15.2% (two-year average) carbon sustainability index (CSI) compared to FFP-broadcasting.

TS4-37: Evaluation of the Pest Management Potential of Inorganic Salts against *Chilo partellus*

Sarbjit Kaur*, Kamaljit Kaur, Jawala Jindal and Gurjit Kaur Gill

Punjab Agricultural University, Ludhiana.
*Corresponding author Email: kaursarbjit31@gmail.com

Zinc, copper, iron and calcium required for the growth and development of insects can prove to be toxic at higher concentrations. For pest management studies, bioassay experiments were performed on *Chilo partellus* larvae with different concentrations of zinc chloride, copper sulphate, ferrous sulphate and calcium nitrate. The late third instar of *C. partellus* was treated with 2.5-20 mM concentration of each chemical through leaf dip method. Antifeedant index, food consumption, larval weight gain, relative consumption rate (RCR), relative growth rate (RGR), larval period, percentage pupation, pupal period, adult emergence, growth index and mortality of the insect were determined. It was noticed that these parameters were affected by

all the chemical treatments. Based on larval mortality, RCR, RGR and growth index, it was concluded that 7.5 mM concentration each of copper sulphate and ferrous sulphate, while 10 and 15 mM of zinc chloride and calcium nitrate were effective against *C. partellus* larvae respectively.

TS4-38: Consequences of Drought in Maize Production in Bangladesh

S. Khandoker*, M.A. Monayem Miah, M.A. Rashid, M. Khatun and M.Z.A. Talukder

Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh.
*Corresponding author Email: skhandoker_86@yahoo.com

Maize is the third most important cereal crop in Bangladesh after rice and wheat. Drought is one of the major abiotic stresses which adversely affect productivity of maize in north-west region of Bangladesh. Every year, farmers in these areas incur high production costs and huge crop losses due to drought. The study was conducted in four districts (Rajshahi, Chuadanga, Comilla and Rangpur) in 2015-2016 to estimate the profitability of maize, identify effect of drought in maize production and explore adaptation strategies for maize farmers. Rajshahi and Chuadanga were selected as drought prone areas whereas Rangpur and Comilla as normal environments. A total of 200 farmers - 50 from each district - were selected randomly. Total cost per hectare of maize cultivation in drought prone areas and normal environment was Tk. 92,582 and Tk. 79,594 respectively. Net return per hectare in drought prone and normal areas was Tk. 28,062 and Tk. 59, 871 respectively. Benefit cost ratio (BCR) of maize in drought prone and normal areas was 1.31 and 1.75 respectively. Maize production decreased by 22.4% in drought prone areas than normal environment. Loss of yield (70%), loss of plant growth (55%) and problem in flowering stage (43%) were the dominant effects of drought. The major adaptation strategies in the drought prone areas were increasing irrigation (77%) and amount of fertilizer (42%). Availability of drought tolerant maize seed at low cost will help to increase production of maize and farmers income in drought prone areas.

TS4-39: Weed Menace and Post Emergence Herbicide Solution for Sustainable Maize Production in India

S.L. Jat[1*], C.M. Parihar[2], D.R. Thakur[3], B.A. Alaie[3], Nareder Singh[3], Mahesh Kumar[3], Amit Bhatnagar[3], A.K. Sinha[3], M.V. Singh[3], M. Kumar[3], Sonali Biswas[3], C.S. Singh[3], Pramila Naik[3], A.P. Shivamurugan[3], U.K. Hulihalli[3], D. Sreelatha[3], G. Manjulatha[3], P. Thukkaiyannan[3], Hargilas[3], V.K. Paradkar[3], Dilip Singh[3] and A.K. Singh[4]

[1]ICAR-Indian Institute of Maize Research, Pusa Campus Unit, New Delhi, India; [2]ICAR-Indian Agricultural Research Institute, New Delhi, India; [3]AICRP on Maize; [4]ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana, India.
*Corresponding author E-mail: sliari@gmail.com

Maize mostly cultivated in tropical conditions suffers from various biotic and abiotic stresses. Granted, while crop improvement has led to less disease and pest losses due to host plant resistance in maize hybrids, these factors still cause substantial yield losses of maize in India. In the event of incessant rains and unavailability of herbicides, farmers are not able to control weeds through pre-emergence herbicides and manual weeding. Such circumstances, compounded by escalating labor prices, demand effective post-emergence herbicide to manage

weeds for sustainable and profitable maize production. To find effective post-emergence herbicides, field experiments were conducted at 20 locations in various agro-ecologies of India for three consecutive years (2015-2017). It was found that weeds caused 32.1 to 59.4% grain yield losses of hybrid maize in the *kharif* season in India. The losses from the weed in absence of weed management in hybrid maize were maximum in Central Western Zone (55.4 to 60.8%), followed by Northern Hill Zone (43.0 to 49.4%), North Western Plain Zone (44.1 to 49.1%), North Eastern Plain Zone (36.4 to 48.8%); and least in Peninsular zone (26.9 to 40.3%). These losses indicate that the rainfed ecosystem has the maximum yield reduction in *kharif* maize in central and northern India. The application of Atrazine (1.5kg a.i./ha) as pre-emergence followed by Tembotrione (120ml a.i./ha) at 25 DAS as post-emergence gave the best weed control and higher yield as well as net returns compared to the other pre- and post-emergence herbicide-based management practices at most of the locations. The study suggests that the Tembotrione at 120 ml a.i./ha at 25 DAS could be a better option for weed management in maize in India and similar agro-ecologies.

TS4-40: Nitrogen and Residue Management Effects on Yield, Profitability and Soil Health in CA Based Maize Systems

S.L. Jat[1*], C.M. Parihar[2] and A.K. Singh[3]

[1]ICAR-Indian Institute of Maize Research, Pusa Campus, New Delhi, India; [2]ICAR-Indian Agricultural Research Institute, New Delhi, India; [3]ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana, India.
*Corresponding author Email: sliari@gmail.com

Conservation agriculture (CA) was found to be effective for enhancing profitability of maize based cropping systems in India, but there are no CA-specific fertilizer management practices developed. A study was conducted for five years at Delhi in two cropping systems; maize-mustard-mungbean (MMMb) and maize-wheat-mungbean (MWMb) with two residue management practices of permanent beds with residue (WR) and without residue (WoR) application, having four nitrogen management practices, (*viz*., absolute control, N through prilled urea (PU), N through Neem coated urea (NCU) and N through sulphur coated urea (SCU)). The analysis of five-year data showed that the residue application increased MMuMb and MMMb system yield by 13% with significant decrease in the soil penetration resistance (at 20cm depth) and increased soil organic carbon stocks (0-45cm) and microbial properties over WoR. This underscores the residue application need for successful CA in sandy loam soil of Indo-Gangetic plains. A significant canopy temperature depression was also recorded in WR compared to WoR. The SCU gave 8% higher productivity of the MMuMb system, while NCU gave 5% higher productivity of MWMb system over prilled urea (PU) application. The highest net returns of the MMuMb system was fetched with residue and SCU application, which was 11.3% and 12.4% higher over WoR and PU application, respectively. However, in MWMb system, highest net returns obtained in NCU and residue application, which was 10.9% and 10% higher over PU and WoR. Based on the five-year study, it was concluded that application of residue and neem/sulphur coat could be a better alternative for sustainability of maize systems under conservation agriculture in sandy loam soils of western IGP.

TS4-41: Response of Maize (*Zea mays* L.) Hybrid to Planting Density and Targeted Yield Approach During *Rabi* Season

Sonali Biswas[1*], Srabani Debnath[1] and Anirban Maji[2]

[1]AICRP on Maize, Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya, Kalyani-741235, Nadia, West Bengal, India; [2]AICRP on Wheat and Barley Improvement, Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya, Kalyani-741235, Nadia, West Bengal, India.
*Corresponding author Email: sonali.saha80atgmail.com

A field experiment was carried out at District Seed farm, West Bengal, India, during *rabi* season of 2016-2017 to study the effect of planting density and targeted yield approach on yield, yield attributes and economics of maize hybrids by involving SSNM, STCR targeted yield approaches. The soil of the experimental field was alluvial having silty clay loam in texture, pH neutral in reaction (7.32) and medium in organic carbon content (0.53 %). The experiment was laid out in split-split plot design with two genotypes (P 3396 and JKMH 502) in main plots, two planting densities (60x20 cm and 50x 20 cm) in subplots and three nutrient managements (RDF-120:60:60 kg NPK ha^{-1}, STCR-173:16:20 kg NPK ha^{-1} and SSNM-120:40:46 kg NPK ha^{-1}) in sub-sub plots having three replications. The experimental results showed that maize hybrid JKMH 502 recorded higher grain yield (9059 kg ha^{-1}), yield attributing characters (cob length, cob diameter, grain rows/cob, grains/row and 100 seed weight), net return (Rs. 60,614 ha^{-1}) and B:C ratio (2.27) of maize. The high density of planting (50 x 20 cm) obtained significantly higher grain yield (8767 kg ha^{-1}), net return (Rs. 57,353 ha^{-1}) and B:C ratio (2.20) than low density planting. Application of nutrients through STCR recorded significantly higher yield (8948 kg ha^{-1}), cob length (14.7 cm), cob diameter (15.9 cm), grain rows/cob (16.6), grains/row (32.5), 100 seed weight (33.3 g), net return (Rs. 60,420 $ha^{-1)}$ and B:C ratio (2.30) by maize compared to other treatments. Based on results, it is concluded that maize hybrid JKMH 502 with 50 x 20 cm spacing STCR based nutrient management is a recommendable option for achieving higher yield and economic benefit of maize during *rabi* season in West Bengal, India.

TS4-42: Effect of Agronomic Biofortification of Maize with Zinc and Iron on Performance of maize

S.R. Salakinkop

All-India Co-Ordinated Maize Improvement Project, University of Agricultural Sciences, Dharwad-580005 Karnataka, India.
Email: salakinkop@gmail.com; salakinkopsr@uasd.in

A field experiment on agronomic bio-fortification with zinc and iron micronutrients in maize was conducted during two consecutive *kharif* seasons of 2015-2016 and 2016-2017, at Agricultural Research Station, Bailhongal. The experiment was laid out in randomized block design and factorial concept with three replications, consisting of 10 treatment combinations. Results of pooled data revealed that soil application of farmyard manure (FYM) enriched with ZnSO4 and FeSO4 each at 20 and 15kg ha-1 recorded significantly higher grain yield and yield attributes. Similarly, foliar spray of ZnSO4 and FeSO4 each at 0.5 % at 45 DAS was found superior over no foliar spray. Treatment combinations involving soil application of FYM enriched ZnSO4 and FeSO4 each at 20 kg ha-1 and foliar spray recorded the higher grain yield (73.5q ha-1), stover yield (86.6 q ha¬-1) and yield parameters viz., cob length (17.0 cm), cob girth (17.2g) and test weight (29.9 g). Higher plant height, leaf area index, SPAD values and

dry matter production compared to other interactions of soil and foliar application of Zn and Fe were also recorded. However, it was at par with treatment combination involving soil application of FYM enriched ZnSO4 and FeSO4 each at 15 kg ha-1 and foliar spray with respect to all growth, grain and yield attributes. Density of zinc and iron content in grain after harvest of crop increased significantly due to foliar and soil application of different levels of FYM enriched Zn and Fe. Further, interaction effect showed that there was increase in grain concentration of Zn from 36.2 g kg-1 in control to 48.1 g kg-1in combined foliar and soil application of FYM enriched ZnSO4 and FeSO4 each at 20 kg ha-1. Similarly, iron content improved from 48.5 g kg-1 in control to 75.8 g kg-1 in combined foliar and soil application of FYM enriched ZnSO4 and FeSO4 each at 20 kg ha-1.

TS4-43: Efficacy of New Post-Emergence Herbicides in Maize Based Cropping System

Sreelatha D.[1*], V. Swarnalatha V., M. Lava Kumar Reddy, V. Narsimha Reddy and T. Ramprakash

[1]Maize Research Centre, PJTSAU, ARI, Rajendranagar, Hyderabad, Telangana, India; [2]AICRP on Weed Control, Rajendranagar, Hyderabad, Telangana, India.
*Corresponding author Email: lathadogga@gmail.com

Crop-weed competition is critical during the first 40 days after sowing, and pre-emergence herbicides offer weed control up to 25-30 days after sowing. To control the weed flushes emerging late in the season, application of post-emergence herbicides is necessary. A field study was undertaken for three years (2015-2017) during *kharif* season to evaluate the efficacy of a new molecule of post-emergence herbicides alone, or in combination with pre-emergence herbicides (10 treatments). The study was done on clay loam soils in randomized block design. The pooled results revealed that broad-leaved weeds were predominant (60%) followed by Grassy weeds (30%), and sedges (8%). *Cynaodon dactylon* (grassy weeds), and *Trianthema portulacastrum*, *Partheneum hysterophorus*, *Digitaria minima*, *Cynotis accullata* and *Digeria arvensis* (broad-leaved weeds) were most dominant. All the weed management practices significantly reduced the density and dry weight of weeds over weedy check. Among the herbicidal treatments, higher mean grain yield (7544 kg ha-1) was recorded with Atrazine at 1.5kg/ha pre-emergence, followed by Tembotrione (Laudis) 120g/ha as post emergence at 25 DAS with higher WCE (77.1%) and WI (6.2), and was comparable with HW at 20 and 40 (7989 kg/ha). Maximum net returns (Rs.65879 ha-1) and B:C ratio (2.47) were found with Atrazine at 1.5kg/ha pre-emergence followed by Tembotrione (Laudis) 120g/ha as post emergence at 25 DAS.

TS4-44: Effect of Post Emergence Weed Management Practices on Maize in Peninsular India

Thukkaiyannan P.[1*], A.K. Singh[2] and S.L Jat[2]

[1]Maize Research Station, Vagarai, TN, India; [2]ICAR-Indian Institute of Maize Research, Ludhiana, India.
*Corresponding author Email: thukkaiyannan@gmail.com

A field experiment was conducted during *kharif* season of 2015, 2016 and 2017 on evaluation of post emergence weed management practices in maize at Maize Research Station, Vagarai (TN-Peninsular zone). The experiment comprised different weed management practices, such

as pre-emergence herbicide combinations and post-emergence herbicides with different combinations, - including weedy check - in randomized block design with three replications. The study revealed that there was no significant difference in growth parameters (population at harvest and plant height) and yield parameters (number of cobs and 100-seed weight) due to weed management practices. Significantly higher grain yield (9768 kg/ha) was recorded in pre-emergence application of atrazine at 1.5kg/ha followed by halosulfuron at 60g/ha at 25 DAS as post emergence, which was at par with weed free treatment and atrazine (750 g/ha) + pendimethalin 700 ml/ha) and 2,4-D amine (500 ml/ha) and tembotrione (120 g/ha) as post emergence application. The net returns and benefit cost ratio were also significantly higher in atrazine as pre-emergence followed by halosulfuron application. It was concluded that combined pre-emergence application of atrazine + pendimethalin or atrazine as pre-emergence followed by application of either of the post emergence herbicide (halosulfuron / tembotrione / 2, 4-D amine) should be adopted on rotational basis for sustainable weed management in maize in Peninsular India.

TS4-45: Precise Maize (*Zea mays* L.) Cultivation under Changing Climate Scenario in Malaprabha Command Area in North Karnataka, India

U.K. Shanwad*, B.C. Punitha, P.S. Kanannavar and Kumar Lamani

University of Agricultural Sciences, Dharwad, India.
*Corresponding author Email: shanwaduk@uasd.in; shanwad@gmail.com

Maize area in Karnataka is increasing, but productivity remains the same or decreases due to poor management of nutrients and water, decreased seed treatment adoption and non-application of organic manures and micronutrients. Since maize is a nutrient exhaustive crop, water use and nutrient efficiency is critical. This study was framed at IWMRC, Belavatagi during *Kharif* 2017 with the objective to assess the nutrient and water use efficiency in maize crop under changing climate scenarios. The KMH-2589 (DRONA) Maize hybrid of Kaveri Seeds was used for the study. The experiment was planned under split plot technique with main plots having two irrigation levels i.e., 80 % and 60 % evaporation levels and sub plots with eight nitrogen splits. Soils on the site were vertisols with pH 8.1. Different growth parameters of maize did not differ considering irrigation level or nitrogen split applications in vertisols during *kharif* 2017. However, the inverse was true for test weight and maize yield. Irrigation with drip at 80% evaporation recorded the highest seed yield (115.85 q/ha) than irrigation with drip at 60% evaporation (104.40 q/ha). Highest gross returns (Rs. 150,611/ha), net returns (Rs. 106,732/ha), B:C ratio (3.52) and water use efficiency (14.77 kg/ha mm) were recorded with 80% evaporation and among the sub-plots highest net returns (Rs. 1,15,207/ha) and B:C ratio (4.03) was recorded with 100% RDF for Maize (N- 5 splits= 10% basal+ 20% at 20DAS+30%at 35DAS +30%at 50DAS+10%at 65DAS). Highest water use efficiency (15.78 kg/ha mm) was recorded at 150% RDF for Maize (N- 3 splits= 50% basal+25%at 30DAS+25%at 60DAS). Among the interaction effects, irrigation at 80% evaporation along with 100% RDF for Maize (N- 5 splits= 10% basal+ 20% at 20DAS+30%at 35DAS +30%at 50DAS+10%at 65DAS) recorded high net returns (Rs 123,054/ha), B:C ratio (4.24) and water use efficiency (15.79 kg/ha). The results clearly indicate that the long duration maize hybrids like drone requires more splits of nitrogen with drip irrigation at 80% evaporation level.

TS6-46: Impact of Climate Change on Nutritional Quality of Maize (*Zea mays* L.)

U.K. Shanwad[1*], M.L. Jat[2], A.G. Srinivas[3], M.R. Umesh and Santosh Javoor[4]

[1]University of Agricultural Sciences, Dharwad, India; [2]CIMMYT, NASC Complex, New Delhi, India; [3]University of Agricultural Sciences, Raichur, India; [4]National Fertilizers Ltd (NFL), New Delhi, India.
*Corresponding author E-mail: shanwaduk@uasd.in; shanwad@gmail.com

An increase in atmospheric CO_2 concentration and temperature, plus other climate change factors could greatly affect agricultural productivity and quality of produce. Our study focused on response of two maize genotypes to climate change with respect to quality aspects. An experiment was conducted in open top chambers (OTC's) at Main Agricultural Research Station, University of Agricultural Science, Raichur. Two maize genotypes *i.e.* CP-818 and Hema were evaluated for two CO_2 levels (ambient CO_2 and elevated CO_2 at 550 ppm) along with combination of temperature (ambient and elevated temperature at 2^0C) for *kharif* season of 2015. Results were analyzed through two factor-CRD design with five replications. Maize quality parameters like oil, protein and starch content were analyzed by NIR Transmission at UAS, Raichur. Under elevated CO_2 at 550 ppm conditions, protein content in maize was 8.1%, whereas under ambient CO_2 condition was 9.8%. Carbon compounds (starch, oil content and fatty acids) increased under elevated CO_2 conditions. Oil content under elevated CO_2 condition of maize was 6.7%, whereas under ambient condition was 6.6%. Thus, the elevated temperature had negative effect on quality aspects (decreased protein, oil and fatty acid composition) of the maize crop. Among the maize genotypes Hema recorded significantly higher protein and oil content (9.2 % and 6.7 %) as compared to CP-818 (8.4% and 6.4%). The highest starch content was recorded in ambient carbon dioxide with ambient temperature treatments *i.e.* T_4 and T_5 (71.3%) treatments. Least starch content of grain was recorded in elevated CO_2 at 550 ppm with ambient temperature T_1 (70.2%). Between the genotypes, Hema recorded lower starch content (70.7%) than CP-818 genotypes (71 %). The CO_2 enrichment enhances the accumulation of carbon containing compounds, such as starch, sucrose and hexoses. Thus, the climate is the primary determinant of plant growth, development, yield and quality aspects. Different levels of CO_2 and temperature significantly influenced different quality parameters maize. Elevated CO_2 and temperature led to decrease in nitrogen related compounds like protein, but oil and starch content was increased. Response differed between genotypes too.

TS4-47: Soil Organic Carbon Dynamics, Soil Fertility and Yield of Maize in Relation to Organic and Inorganic Fertilization under Maize-Wheat System in Aquic Hapludoll Soil of North India

Veer Singh*, Amit Bahtnagar and Maneesh Bhatt

G.B. Pant University of Agriculture & Technology, Pantnagar, U.S. Nagar, Uttarakhand, India.
*Corresponding author Email: veer1969_singh@yahoo.co.in

Use of different organic manure in combinations and in a cumulative manner can meet the nutrient requirement of maize and wheat in maize-wheat cropping system. This study investigated the four-year (2014-2015 to 2017-2018) effects of application of NPK fertilizer and zinc, with and without use of farmyard manure in sole or intercropped maize, on yield and soil properties in maize-wheat system in mollisols of *tarai* region. Field experiment includes the treatments viz., 100% RDF, 50% RDF, FYM 10t/ha + Azotobactor, Maize + cowpea with FYM 10 t ha^{-1} + azotobactor, 100% RDF + 5 t/ha FYM, 50% RDF + 5 t/ha FYM, 100% RDF

+ 5 kg Zn, FYM 5 t/ha and unmanured. Significant differences in yields of maize, wheat and system were recorded under conjoined use of inorganic fertilizer and FYM. Application of FYM at 5t ha^{-1} along with 100% RDF gave significantly higher yields of maize (5.8q ha^{-1}), wheat (4.9q ha^{-1}) and system (11.2q ha^{-1}) over other combinations. Inclusion of FYM at 5t ha^{-1} and Zn 5kg ha^{-1} increased grain yields of maize by 10.2% and 3.3%, respectively, but decreased from 8.5% to 32.0% in other practices over 100% RDF. Soil properties were influenced by different organic and fertilizer management practices. Application of 100% NPK + FYM at 5t ha^{-1} and 100% NPK + Zn at 5kg ha^{-1} improved organic carbon, available N, P and K and available Zn, respectively, whereas control plot decreased the most. The cowpea with FYM 10 t/ha+ azotobactor system was significantly more remunerative with the highest net return (`80860, 111445 ha^{-1}) and B:C ratio (2.98, 2.40) for maize and maize-wheat system, respectively. The SOC pool was the lowest in control at 16.6Mg C ha^{-1} and maximum to 22.6Mg C ha^{-1} with 100%NPK+FYM. Treatments control, 50% RDF and 5t FYM ha^{-1} recorded the negative rate of soil carbon sequestration, while 100% RDF + 5 t FYM ha^{-1} sequestrated maximum rate of carbon (0.81 Mg C ha^{-1}). Balanced application of NPK fertilizers with FYM was the best option for higher crop yields in maize–wheat rotation.

TS4-48: Effect of Different Levels of Zinc and Boron on Productivity and Profitability of Late Sown *kharif* Maize (*Zea mays* L.)

Virendra Singh*, Satybhan Singh and Rabish Datt Shukla

College of Agricultural Sciences & Engineering, IFTM University, Moradabad, U.P., India
*Corresponding author Email: virendra.singhed@gmail.com

A field experiment was conducted during *kharif* 2016 and 2017 on sandy loam soil at the research farm of IFTM University, Moradabad, to study the effect of different levels of boron and zinc on productivity and profitability of late sown maize (*Zea mays* L.). The experiment, consisting of ten treatments, was laid out in randomized block design and replicated thrice. Zinc and boron were applied as soil and foliar application as per the treatment. Leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), plant height, fresh and dry weight, yield attributes (cob length, number of grains per cob, 1000-seed weight), seed yield, stover yield, harvest index, gross returns, net returns and benefit-cost ratio were to be enhanced significantly by the soil application of boron and zinc. However, the foliar application of zinc and boron remained at par on all the growth, yield attributes and yield. Application of zinc and boron increased the dry matter accumulation of maize, hence other growth indices like CGR and RGR also increased. The crop achieved the highest CGR in between 30-60 DAS while the RGR values were recorded at initial stage of crop growth and declined thereafter. The highest seed yield (46.75 and 48.30 q ha-1 during 2016 and 2017 respectively) and stover yield (289.79 and 285.45 q ha-1 during 2016 and 2017 respectively) were obtained with the application of boron at 0.5kg ha-1 and zinc at 5kg ha-1 (soil application). Net returns and benefit-cost ratio was also significantly increased with the soil application of boron at 0.5 kg ha-1 and zinc at 5 kg ha-1.

TS4-49: Site Specific Nutrients Management and Conservation Tillage Practices in Maize–Mustard Relay Cropping under Rain Fed Conditions

V.K. Paradkar*, R. Khavse and R.K. Sharma

AICRP on Maize, Zonal Agricultural Research Station, JNKVV, Chhindwara, India.
*Corresponding author Email: paradkarvkp@yahoo.co.in; paradkar_vk@rediffmail.com

Maize-mustard relay cropping system is observed to play a key role in improving grain productivity under rainfed conditions. An experiment was designed on relay cropping system of maize and mustard with fertility levels compared with site specific nutrients management (SSNM),; and conservation tillage practices were compared with conventional production system during *kharif* 2014-2015 and *rabi* 2016-2017 at ZARS, Madhya Pradesh. In SSNM the three conservation management sowing practices (viz., conventional, permanent plot and zero tillage) with equal number of NPK treatments and 50% RDF (60:30:20 kg/ha), 100% RDF (120:60:40 kg/ha) and SSNM (140:34:71 kg/ha) were used. Results revealed that the grain yield of both crops, were highest in SSNM than 50% RDF and 100% RDF. In addition, conventional method of sowing showed significantly higher grain yield, 4573kg/ha of maize and 1002kg/ha mustard, under zero tillage practices. Highest grain yield, 6803kg/ha, was observed in maize coupled with mustard planted in zero tillage relay. The status of NPK after harvesting mustard increased significantly with successive increase in fertilizer level. Treatment with SSNM 140:34:71 N P K kg/ha exhibited highest NPK (192 N, 22.2 P, 307 K kg/ha) status that was significantly higher than 100% RDF (135 N, 16.8 P, 281 K kg/ha) and 50% RDF (126 N, 14.8 P, 300 K kg/ha). The SSNM with conventional method of sowing showed increased grain yield, and its attributing characters in maize under maize-mustard relay cropping in rainfed conditions. Therefore, relay cropping system - which is environmentally friendly, socially acceptable and economically feasible - offers a better alternative production system over the conventional production system.

TS4-50: Response of Maize NSX042022 to Nitrogen Fertilizer in Black Clay-Clay Loam Soil, Nakhon Sawan Province, Thailand

Worakarn Yodchompoo*, D. Kongtien, S. Luanmanee, S. Thaitad and S. Lapbanjob

Nakhon Sawan Field Crops Research Center, Nakhon Sawan, 60190, Thailand.
*Corresponding author Email: gummachon11@hotmail.com

This study investigated nitrogen fertilizer efficiency on maize NSX042022 in black clay-clay loam soil, from which a nitrogen fertilizer rate can be recommended for maize. The experiment was conducted at Nakhon Sawan Field Crops Research Center (NSFCRC) and farmer field, Nakhon Sawan Province, in rainy season of 2017. The experiment was designed in randomized complete blocks (RCB) with four replications. The treatments consisted of five nitrogen fertilizer rates, namely 0, 46.8, 93.8, 140.6 and 187.5kg N/ha. Phosphate and potassium fertilizer was applied based on soil test at the rate of 62.5 kg P_2O_5/ha and 31.2 kg K_2O/ha. The maximum NSX042022 yield was 7.45 and 7.72 ton/ha at NSFCRC and farmer field respectively. Additionally, the use of nitrogen fertilizer at the rate of 46.8-62.5-31.2 kg N-P_2O_5-K_2O/ha has the highest agronomic efficiency and the most economic return at NSFCRC, while use of nitrogen fertilizer at the rate of 93.8-62.5-31.2 kg N-P_2O_5-K_2O/ha has the highest agronomic efficiency and the most economic return at farmer field.

TS6: Breeding and Stress Resilience

TS6-1: Performance Study of Short Stature Maize Genotypes Across Locations

A. Ahmed[1*], M. Amiruzzaman[2] and M.A. Alam[3]

[1]Wheat Research Centre, Bangladesh Agricultural Research Institute, Nashipur, Dinajpur, Bangladesh; [2]Plant Breeding Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh; [3]Spices Research Centre, Bangladesh Agricultural Research Institute, Shibgong, Bogra, Bangladesh.
*Corresponding author Email: asgar.gene@gmail.com

Maize is the second most important cereal crop in Bangladesh and faces different natural disasters during its highest growing season (rabi/winter). For this reason, Bangladesh Agricultural Research Institute (BARI) took the initiative to introduce short stature, high yielding maize varieties. In this trial, 10 previously selected short stature genotypes were evaluated against three local and standard checks (BHM-9 of BARI released latest variety; 981 of Monsanto company and Sunshine of Syngenta company) in randomized complete block design with three replications. Combined analysis over locations and seasons indicate that Sunshine, 981 and G10 were the top three high yielders and G1, G2, BHM-9 and Sunshine were the most stable genotypes/ varieties. On the other hand, five genotypes G3, G4, G6, G8 and G9 had below average mean yield and the genotypes G6 and G9 were the most unstable. Among the seven environments, Jamalpur, Joydebpur and Dinajpur were most discriminating and Ishwardi least discriminating, whereas Joydebpur was more representative and Borisal was least representative of other test environments. In the case of plant and ear height, most of the genotypes showed lower value than all the checks, which was desirable. However, among the top three high yielders, G10 had the lowest and more stable value for both plant height and ear height. Although there were other genotypes which had lower plant and ear height, considering yield, stability, maize growing area and natural calamities at a time, the genotype G10 was recommended for release as commercial variety and has been released as a new maize variety in Bangladesh with local name BARI Hybrid Maize – 16 (BHM-16).

TS6-2: Open Pollinated Maize Varieties: Do They Have Scope in South Asia? Lessons from Pakistan

AbduRahman Beshir[1]*, Muhammad Amir Maqbool[2], Ehtisham Shakeel Khohkar[2], Muhammad Waheed Anwar[3], Salman Saleem[4] and Muhammad Imtiaz[2]

[1]International Maize and Wheat Improvement Center (CIMMYT), South Asia Regional Office, Nepal; [2]CIMMYT, Islamabad, Pakistan; [3]UN-Food and Agricultural Organization, Islamabad, Pakistan; [4]National Agricultural Research Center (NARC), Islamabad, Pakistan.
*Corresponding author Email: a.issa@cgiar.org

Over 70% of Pakistan's six-million-ton maize production comes from the Punjab province where 90% of farmers use predominately hybrid maize. However, hybrids cover about 30-40% of the maize area in Pakistan and farmers in the northern areas use open pollinated varieties (OPVs). The current study explored the grain yield potential of improved OPVs and their adaptation pattern at different agro-ecologies of Pakistan. A total of thirty white grain maize OPVs, including one best commercial check, were subjected to agronomic evaluation across ten maize growing environments of Pakistan during spring 2014. Heritability of the

grain yield ranged from 0.36 (ARS-Gilgit) to 0.90 (NARC). Rug plot showed the data distribution of grain yield across the locations and ranges of 2.0 t/ha (NARC) to more than 12 t/ha (PSC) across different locations. GGE biplot for location comparison showed that 4B, NARC and PSC were the most discriminating and representative locations for evaluation. MMRI, CCRI and UAF were moderately discriminating and representative locations, while Quetta and Gilgit-Baltistan were least discriminating. GGE biplot for genotypic comparison showed that genotypes CZP132002, TP1219, CZP132006 and CZP132001 were among the stable and high yielding OPVs compared to local checks. CIMMYT, under the Agricultural Innovation Program for Pakistan (AIP), has allocated 13 best performing OPVs to five public and one private company for commercialization in Pakistan. The current study justifies the importance of OPVs in increasing productivity in South Asia where farmers have limitations in adopting high input agriculture.

TS6-3: Grain Yield Performance of Heat Stress Tolerant Maize Hybrids Under Heat Prone Areas of Pakistan

AbduRahman Beshir[1]*, Muhammad Amir Maqbool[2], Ehtisham Shakeel Khohkar[2], Muhammad Waheed Anwar[3] and Muhammad Imtiaz[2]

[1]CIMMYT, South Asia Regional Office, Nepal; [2]CIMMYT, Islamabad, Pakistan; [3]UN-Food and Agricultural Organization, Islamabad, Pakistan.
*Corresponding author Email: a.issa@cgiar.org

Day temperature may rise above 45°C in major maize growing areas of Punjab, Pakistan. Therefore, deployment of heat stress tolerant maize varieties is among the coping strategies to mitigate increasing challenges in maize farming in Pakistan. CIMMYT, under the Agricultural Innovation Program (AIP) for Pakistan, evaluated the performance of 16 heat stress tolerant hybrids in six locations in Sahiwal, Faisalabad and Multan districts in Punjab, in collaboration with public and private partners during spring 2016. Box-plot graph revealed wide range of variability in grain yield (t/h) across the locations with ranges from 0.00 to 9.00 t/h. Size of boxes, whiskers and positioning of the boxes on plots indicated the differential responses of the genotypes across different locations. Mean comparison for individual locations showed that genotype ZH15381 (9.0t/h), VH12333 (6.4t/h), ZH138088 (4.6t/h), ZH15445 (1.9t/h), CAH153 (2.4t/h), CAH151 & ZH169 (4.2t/h) were among the high yielding genotypes in the various locations. GGE biplot for location comparison showed that ICI was most discriminating and representative of location, followed by Tara Crop Science and UAF for the evaluation of heat stress hybrids. HiSell Seeds Plc and MNSUAM were found to be least discriminating and representative of locations because temperature at these locations was too high to express genotypic yield potential. GGE biplot for genotypic comparison showed that ZH15381, VH12333 and ZH169 were among the high yielding and stable genotypes for most discriminating locations. These high yielding and stable genotypes are recommended for commercialization in the heat prone maize growing areas of Punjab, Pakistan.

TS6-4: Can Public-Private Partnership Help Nepal Become Self-Sufficient in Hybrid Maize Seed?

AbduRahman Beshir*, Hari Kumar Shrestha, Dyutiman Choudhary, Narayan Khanal, Shriniwas Gautam and K.C. Dilli[1]

CIMMYT, South Asia Regional Office, Nepal.
*Corresponding author Email: a.issa@cgiar.org

The National Seed Vision (2013-2025) of Nepal targets the local development and promotion of at least 17 hybrid maize varieties by both the public and private sector by 2025. The CIMMYT led and USAID funded Nepal Seed and Fertilizer Project is currently testing the adaptation of 250 market ready maize hybrids. The testing is being done with seven private seed companies in collaboration with Nepal Agricultural Research Council (NARC). The involvement of the private sector in hybrid maize seed production and marketing is at budding stage and the sector has not fully tested its competitiveness with imported hybrids. CIMMYT, in partnership with NARC, is enhancing the capacity of local seed companies in product testing and validation as well as supporting in seed production and other complementary technologies across the seed value chain. NARC also started sharing parental lines of publicly released hybrids with local seed companies to enhance seed production and marketing. The Seed Quality Control Center (SQCC), the regulatory body of the government, is developing guidelines and quality standards to streamline product registration, licensing and promotion of locally developed hybrids. CIMMYT is facilitating linkages in seed sector financing where seed companies can have access to customized financial products to alleviate the major constraint of the sector. Through this tripartite collaboration, five seed companies started their own R&D, and initiated the process of hybrid seed production. This initiative needs to be sustained with favorable policy formulations and enforcements to realize a self-sufficient and robust hybrid maize seed system in Nepal.

TS6-5: Evaluating Corn for Growth in Drought Conditions Under Low-Cost Pre-Fabricated Mini-Hoop Modules

Ajaz A. Lone[1]* and K. Raja Reddy[2]

[1]Sher-e-Kashmir University of Agriculture Sciences & Technology of Kashmir, India; [2]Mississippi State University, Starkville, MS, USA.
*Corresponding author Email: ajaz999@gmail.com

Drought stress is a major abiotic stress factor that affects corn growth and development at all growth stages. Drought at earlier stages is detrimental to plant stand and ultimately yields. Developing a screening tool to identify drought stress tolerance during seedling establishment is important in identifying genotypes for use in development and / or deployment of corn cultivars suited to water-limited environments. An experiment on response of corn to drought was conducted at the Rodney Foil Plant Science Research facility of Mississippi State University under Low-Cost Pre-Fabricated Mini-Hoop Modules with four stage growth evaluation. Both above ground and root scan traits were analyzed to assess corn responses. It was observed that with drought tolerant hybrid DKC 6581, the pace of overall growth at all experimental stages was higher than susceptible hybrids particularly in biomass related traits. Drought induction at four leaf stage induced hastened growth increments, particularly in water tapping parameters, as evident by root scans and traits like number of crossings (21.87%), root tips (79.46%), root Volume (29.68%) and total root length (21.62%) being

prominent. Average leaf area and root diameter were comparatively at par in both sets at 342cm^2 and 0.52mm respectively. Second harvest stage at 10 days after emergence revealed maximum growth in all traits, and subsequent harvest stages revealed uniform increments in terms of overall growth. The study revealed that immediately after emergence, hybrids - irrespective of their drought reaction - tend to maximize the overall build up and establish optimum plant-soil interaction platform. Further enhanced early vigor in corn will ensure optimum plant stand at latter crop growth stages.

TS6-6: Prospectus of Growing Maize in Cold Arid Himalayan Province of Ladakh India

Ajaz A. Lone*, F.A. Bahar, Z.A. Dar, B.A. Alie, M.I. Mokhdoomi and T.H. Masoodi

Sher-e-Kashmir University of Agriculture Sciences & Technology of Kashmir, India.
*Corresponding author Email: ajaz999@gmail.com

Cold arid climate of Ladakh province of Jammu and Kashmir State, and the resulting fragile ecosystem, challenges crop diversification options. Success of crop production rests with genotype plasticity and necessary human interventions for crop raising suitability. High Mountain Arid Agriculture Research Institute of Sher-e-Kashmir University of Agriculture Sciences & Technology of Kashmir, India, is a pioneer institute in taking up the Agri-challenges and ensuring sustainable livelihood security of tribal farmers of Ladakh. Experiments on introducing maize cultivation among farming masses were initiated and the results are interesting. Warm season, which has limited but ample sunlight, ensured optimum growth using different germplasm lines. Response by stakeholders was encouraging, as genotypes with the highest green biomass were liked by most farmers, who enjoyed the feel of the cobs hanging on the maize plants. Late maturing African Tall did particularly well in terms of forage recovery for Pashmina goat herds for long lean winter season. Limited sowing window ensures that the kernels are sown in good time and early maturing genotypes end up producing satisfactory yields. Babycorn as a commercial venture can offer a viable long-term bio intervention for huge demand from restaurants catering to 0.25 million tourists annually. Growing baby corn ensures three pickings with ample T.S.S content and very high green fodder recovery. In pursuit of popularizing corn growth, research trials are being laid using wide array of germplasm lines, including CIMMYT pools and temperate blood lines, from various sources. Focused research on maize and interventions by relevant National and International research amalgams can pave way for harnessing maize potential of Ladakh Niche. Further, this ecology can serve as an effective hotspot for natural screening of cold arid stress tolerant germplasm lines of diverse origins.

TS6-7: Evaluation of Characters, Heterosis and Resistance to Downey Mildew Result of Crosses of some Genotypes of Maize

Amzeri Achmad* and Badami Kaswan

Agriculture Faculty of Madura Trunojoyo University, Indonesia.
*Corresponding author Email: aamzeri@gmail.com

Agronomic characters, heterosis effect and resistance to downey mildew are important criteria in parent selection for assembling hybrid maize varieties. The objective of this study was to evaluate agronomic characters, heterosis effect and resistance to downey mildew in F1 plants.

This research was conducted in Experimental Garden of Agrotechnology Study Program of Agriculture Faculty of Madura Trunojoyo University. Combination of crosses was T12 x L1, T16 x L1, G10 x L1, G14 x L1, E02 x L1, Td 04 x L1, T12 x G10, G10 x E02, G10 x Td 04, and Td 04 x E02. The research design used in this study was Randomized Block Design with four replications. Data for four traits including flowering time, harvesting time, productivity and resistance to downey mildew was gathered and analyzed by F-test, followed by Duncan test (α = 5%). Results showed that T12 x L1, E02 x L1 was a combination of crosses that is selected based on productivity (T12 x L1 = 6,40 t ha^{-1}; E02 x L1 = 5,90 t ha^{-1}), heterosis effect (T12 x L1 = 65,80%; E02 x L1 = 54,65%) and resistance to downy mildew (T12 x L1 = 72,37%; E02 x L1 = 72,37%).

TS6-8: Yield Performance of 60 Maize Testcross Hybrids with CML161-Nei9008 as Tester at Two Trial Locations

Andi Takdir M.*, Sigit Budisantosa, Muzdalifah Isnaeni and R. Neni Iriany M.

Indonesian Cereals Research Institute (ICERI), Maros, Indonesia.
*Corresponding author Email: takdirmaize@yahoo.com

The interaction between Genotype x Environment is essential knowledge for a plant breeder to know and utilize, because performance of genotype in multiple environments can obtain different yield results. Constraints in achieving similar results due to Genotype x Environment interactions can cause difficulties in maize breeding, even though analysis of these interactions are widely used to estimate extent of the adaptability and stability possessed in a genotype. This study used sixty testcross hybrid genotypes, which were tested based on its yield performance at two locations (Muneng experimental station in East Java and Bajeng experimental station in South Sulawesi) during dry season of 2017. The objective of the study was to find out performance and Genotype x Environment interaction of 60 hybrids obtained from testcross with tester CML161-Nei9008. In each location genotypes including check varieties (Bima-3, Bima-7, Bima-9, and Bima-10) were arranged in Randomized Complete Block Design with three replications. Combined analysis for yield and yield components was carried out according to standard procedure for maize. Results of this study showed that the interaction between Genotype x Environment for yield trait was highly significant in genotypes. Line CML2012042 had the highest yield potential and suitability for development in Muneng of East Jave, whereas line CML2012040 appeared to have high yield potential and suitability for both Muneng and Bajeng. These genotypes had over 15% higher yield compared to check varieties (Bma 3, 7, 9, and Bima 10). Genotypes with advantage in a specific location will be released as new varieties and will increase the efficiency and effectiveness of varietal release, as well as shape "regional buffering" which will suppress the spread of pests and diseases.

TS6-9: Identification of Drought-Stress Responsive MicroRNAs in Tropical Maize

Anuradha Gautam[1,2*], Krishan Kumar[1], Ishwar Singh[1], Shivani Sharda[2], K.C. Upadhyaya[3] and Pranjal Yadava[1,4]

[1]ICAR-Indian Institute of Maize Research, Pusa Campus, New Delhi-110012, India; [2]Amity Institute of Biotechnology, Amity University, NOIDA (U.P.) – 201313, India; [3]School of Life Sciences, Jawaharlal Nehru University, New Delhi-110067, India; [4]Department of Biology, Stanford University, 385 Serra Mall, Stanford, CA, 94305, USA.
*Corresponding author Email: anu.gautam10@gmail.com

Maize (*Zea mays* L.) crop suffers significant decrease in yield under drought stress. Among other factors, MicroRNA (miRNA) mediated gene regulation has been found to play a crucial role in stress adaptation. The present investigation aims at identification of differentially expressed miRNAs under drought stress. Two contrasting tropical maize genotypes- HKI-335 (drought tolerant) and MGUD-22 (drought susceptible) were grown in controlled environment and drought was imposed at the seedling stage. A 32.43% decrease in Relative Water Content of the leaves was found in MGUD-22 as against 15.66% in HKI-335 under drought conditions. Leaf RNA samples of both genotypes were subjected to small RNA profiling through Next Generation Sequencing (NGS) for miRNA identification. MiRNA differential expression analysis across the two genotypes revealed 30 known miRNAs in HKI-335 and 44 miRNAs in MGUD-22 to be differentially expressed. We also discovered 132 novel miRNA candidates in HKI-335 and 178 in MGUD-22. Treatment wise, comparison under the control and drought conditions revealed 35 known miRNAs in control against 49 under drought conditions. Novel miRNAs identified were 172 and 147 respectively. Gene Ontology Enrichment analysis of the miRNA target genes identified three different functional categories: biological processes, molecular function and cellular component. In the biological process category, major functions included gene expression and regulation of cellular process. Molecular functions included transcription factor activity and binding. The results indicate a fine regulatory network of genes and miRNAs responsible for drought tolerance. Identification of master nodes of this network may allow us to perturb the network for designing drought adapted genotypes in future.

TS6-10: Evaluation of Insecticides Against Stemborers in Maize

Anuradha M.

Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana, India.
Email: kasuanu@yahoo.co.in

Among the biotic stresses in maize, yield losses due to *Chilo partellus* and *Sesamia inferens* in different regions of India range from 26.7-80.4% and 25.7-78.9% respectively. Endosulfan was being recommended against stem borers in maize until it was banned. Field experiments with 14 treatments and three replications in RBD were conducted during kharif 2012 and *rabi* 2012-13 at Maize Research Centre, Rajendranagar, to find out an alternative to Endosulfan. Insecticides were sprayed at the recommended dosages at 12DAG and observations were recorded at 45DAG and subjected to two factor analysis. Mean infestation was observed to be the lowest in the plot treated with chlorantriniliprole 18.5 SC (1.28%) followed by £cyhalothrin 5CS (2.33o/o). Mean per cent deadhearts was lowest i.e., 0.41 in the £cyhalothrin treated plot, followed by 0.61 in lndoxacarb treatment.

TS6-11: Molecular Diversity Analysis in Maize Inbred Lines by Using SRAP Markers

Anurag Tripathi[1] and Sitar SinghVerma[2*]

[1]Division of Genetics, IARI, New Delhi-110012, India; [2]Department of Genetics and Plant Breeding, GBPUAT, Pantnagar 263145, India.
*Corresponding author Email: sitarsinghverma@gmail.com

Present experiment was undertaken with ten maize inbred lines during *Kharif*-2015 at N. E. Borlaug Crop Research Centre, GBPUA&T, Pantnagar, India. These parental inbred lines were

crossed in all possible combinations in a half-diallel fashion to produce 45 direct crosses. These hybrids were evaluated against two hybrid checks, PSM- 1 and Vivek 43, in a randomized block design with three replications during *Kharif* 2015 under two plant density environments, normal and high. These parental inbred lines were used for molecular diversity using a set of eight SRAP markers. Analysis of molecular polymorphisms showed that average number of alleles per marker was 7.24 with a range from four to 10 alleles. The PIC values of SRAP markers ranged from 0.450 (K2T3) to 0.891 (K1T4) with mean value of 0.767, in which marker K2T2 was least informative due to lowest PIC value, while marker K1T4 was most informative due to highest PIC value among other markers. Therefore, this type of marker system could be efficiently used to detect polymorphism in maize. The Jaccard's similarity coefficients between pairs of parental lines were found to vary from 0.13 to 0.80. Cluster diagram based on Jaccard's similarity coefficients and UPGMA algorithm showed that major cluster A had only one parent, while cluster B had nine parents. Genotypes in the same cluster were closer to each other at molecular level compared to genotypes in different groups. Clustering of parental lines indicated the presence of enough genetic diversity among them.

TS6-12: Promising Parents for Grain Yield and its Components in Maize for High Plant Density (HPD) Environment

Anurag Tripathi[1*], Jeet R. Choudhary[2], Nitish R. Prakash[2], S.S. Verma[1] and N.K. Singh[1]

[1]GBPUAT, Pantnagar, Uttarakhand, India; [2]ICAR-Indian Agricultural Research Institute, New Delhi, India.
*Corresponding author Email: anuragtripathi855@gmail.com

The present experiment was undertaken with ten maize inbred lines which were initially screened for various desirable characters. These inbred lines were first grown for their seed multiplication, then crossed in all possible combinations in a half diallel fashion to produce F_{1S} during *Rabi,* 2014-15 at N.E. Borlaug Crop Research Centre, Pantnagar. The study was undertaken to estimate the general combining ability effects in maize, which in turn helped in identification of the potential parents for yield and its components in maize. Parents P9 was the best general combiner for grain yield per plant (458.83***). The second preference can be given to Parents P8 with positive significant gca value for grain yield per plant (241.99*) along with two other component characters i.e. ear diameter (0.06*) and number of kernel per rows (1.16***). The third promising parent was P2 with positive significant gca value for grain yield per plant (239.99*) along with six other component characters i.e. Days to 50 percent tasselling (-0.29*), Days to 50 percent silking (-0.49***), Anthesis–silking interval (-0.22***), Plant height (10.69***), Ear height (11.14***), Number of kernel rows per ear (0.20*). For characters Days to 50 percent tasselling, Days to 50 percent silking, Anthesis–silking interval, negative gca values are desirable.

TS6-13: Identification of Stable Late Wilt Disease Resistant Maize Inbred Line(s)

Aruna K.[1], E. Gangappa[1], Dharanendra Swamy[2]* and S. Ramesh[1]

[1]Department of Genetics and Plant Breeding, College of Agriculture, University of Agricultural Sciences, GKVK, Bengaluru 560 065, India; [2]Monsanto Mega Breeding Centre, Kallinayakana Hally, Chikkaballapur District, Karnataka, India.
*Corresponding author Email: egangu@gmail.com

Maize is known to be affected by 112 diseases globally, 35 of which are reported in India. Late

wilt disease (LWD) caused by *Harpophora maydis* is a recently reported and widespread disease globally. It is also involved in post flowering stalk rot (PFSR) disease complex, one of the most serious, destructive and widespread group of diseases in maize. Identification of stable LWD resistant source is an expedient, economical and eco-friendly approach to combat losses from LWD. An investigation was undertaken to identify LWD resistant inbred lines by subjecting 308 inbred lines to preliminary screening, followed by identification of stable LWD resistant lines by studying selected inbred lines from preliminary screening in three temporal environments. 308 inbred lines were subjected to preliminary screening by artificially inoculating *Harpophora maydis* spore suspension to stalks at 55 DAS (1st inoculation) and 65 DAS (2nd inoculation) at University of Agricultural Sciences, Bengaluru, Karnataka, during rainy season of 2016. 30 days after the second inoculation, disease severity and intensity were recorded in split opened stalks on individual plant basis using 1-9 scale. 14 inbred lines with the ≤4 LWD response score were selected and were grown at three different dates of sowing with fortnightly intervals to estimate their stability of response to LWD during post rainy season 2016 at Bengaluru. Pooled analysis of variance indicated significant inbred line×environment interaction. Based on the GGE biplot, AMMI stability value (ASV) and stability index (SI) in four stable LWD resistant inbred lines were identified. These inbred lines can be used to develop LWD resistant hybrids.

TS6-14: Estimation of Components of Genotypic Variance for Grain Yield and its Contributing Traits in Maize (*Zea mays* L.)

Arunkumar B.[1*], Gangappa E.[2], Ramesh S.[2], Savithramma D.L.[2], Nagaraju N.[2] and Lokesha R.[3]

[1]COA, Bheemarayanagudi, UAS, Raichur-585287, Karnataka, India; [2]University of Agricultural Sciences, GKVK, Bengaluru-560 065, Karnataka, India; [3]COA, Raichur, UAS, Raichur-584104, Karnataka, India.
*Corresponding author Email: b.arunkumar@rediffmail.com

Combining ability provides useful clues about components of genetic variation and selection of desirable parents for synthesis of superior hybrids and identifying the superior hybrid combinations. The present study was undertaken to assess the potential of 20 selected maize inbreds *per se* and in hybrids combination, and to estimate relative contribution of additive and dominance components of genetic variance through 20×20 full diallel analysis. ANOVA for combining ability revealed that the estimates of mean squares due to *gca* were highly significant for grain yield and its component traits and *sca* were highly significant for all traits except ear circumference and 100 grain weight indicating the importance of both additive and non-additive components in controlling these traits. GCA/SCA variance ratio was less than unity for all the traits, suggesting the predominance of non-additive gene action. Significant negative *gca* effects were observed in inbreds BGUDI 118, MAI 349, VL 109252, MAI 769, MAI 283, MAI 749 and MAI 387 for ASI. Inbred MAI 283 recorded highest *gca* effects in positive direction for grain yield and significant *gca* effects in desirable direction for days to silking, ASI, shelling percentage, 100 grain weight and ear circumference. The inbreds with significant *gca* effects in desirable direction for flowering traits and grain yield can be used in synthesizing early maturing and high yielding hybrids for commercial cultivation if the hybrids exhibit high heterosis. Crosses MAI-283×KDMI-16 and M 04×KDMI-16 registered highest significant *sca* effects in desirable direction for grain yield and ASI.

TS6-15: Assessing the Genetic Potential of Maize (*Zea mays* L.) Inbred Lines for Grain Yield and its Contributing Traits

Arunkumar B.[1*], Gangappa E.[2], Ramesh S.[2], Savithramma D.L.[2], Nagaraju N.[2] and Lokesha R.[3]

[1]COA, Bheemarayanagudi, UAS, Raichur-585287, Karnataka, India; [2]University of Agricultural Sciences, GKVK, Bengaluru-560 065, Karnataka, India; [3]COA, Raichur, UAS, Raichur-584104, Karnataka, India.
*Corresponding author Email: b.arunkumar@rediffmail.com

The development of new cultivars depends mainly on the magnitude of genetic variability in the base material for the desired character. The knowledge of genetic variability, heritability, genetic advance and relationship between yield and its contributing characters in a given crop species is of paramount importance for the success of any plant breeding program. With this objective, 422 maize inbred lines were evaluated over two seasons at UAS, GKVK, Bengaluru following augmented design. Data on the 12 quantitative traits was recorded. ANOVA revealed the significant differences among the inbreds for all the traits except shelling percentage, indicating the prevalence of ample variability. Mean sum of squares for inbreds×season for days to anthesis and silking, anthesis-silking interval (ASI), ear length, ear circumference, kernel rows ear^{-1} and fodder yield plant^{-1} differed significantly, indicating the influence of season in expression of these traits. Highest PCV and GCV estimates for ASI, grain and fodder yield plant^{-1} indicated the larger variation, whereas lower estimates for other traits indicated the need for exploring the variability. Days to silking and anthesis registered higher estimates of heritability in broad sense ($h^2_{(BS)}$) indicating lesser environmental effects. Higher estimates of $h^2_{(BS)}$ and GAM for ASI, plant height, ear length, kernel row^{-1} and fodder yield plant^{-1} indicated that selection is effective in improving these traits. Lower estimates of $h^2_{(BS)}$ and GAM for shelling % and higher estimates of $h^2_{(BS)}$ and lower GAM for grain yield plant^{-1}, indicated non-additive gene action and provides limited scope for improvement through selection.

TS6-16: Comparative Transcriptomics Reveals Differential Gene Expression Related to Heat Stress Tolerance in Maize (*Zea mays* L.)

Ashok B. Jagtap[1*], Inderjit Singh Yadav[1], Tosh Garg[2] and Yogesh Vikal[1]

[1]School of Agricultural Biotechnology, Punjab Agricultural University, Ludhiana-141004, Punjab, India; [2]Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana-141004, Punjab, India.
*Corresponding author Email: ashok01biotech@gmail.com

Maize (*Zea mays* L.) is a major cereal crop in India and globally, and whose production and productivity are greatly affected by high temperature stress. To have insight into heat stress tolerance mechanisms, we performed comparative transcriptome profiling for maize heat susceptible (HS) inbred line LM11 and heat tolerant (HT) inbred line CML25. Three different HS and HT tissue samples viz. leaf, pollen and ovule were collected at heat stress conditions during spring season. Total RNA was isolated using the RNeasy Plant Kit (Qiagen, Hilden, Germany). RNA quantity was assessed, and quality control was performed using 2100 Bioanalyzer (Agilent Technologies, Böblingen, Germany). Library preparation and RNA sequencing were performed at the Nucleome Informatics Private Limited, Hyderabad, using an Illumina HiSeq2500 sequencing machine. A total of 2,164 differentially expressed genes (DEGs) were detected in differential comparisons between LM11(HS) and CML25(HT) inbreds heat stress samples, with 1151, 451 and 562 DEGs being identified in comparisons of

leaf_LM11 vs leaf_CML25, pollen_LM11 vs pollen_CML25 and ovule_LM11 vs ovule_CML25 respectively. Functional annotations of DEGs suggested that many DEGs identified were known to respond to heat stress in plants, including transcription factors (HSFs), heat shock proteins (HSP20 & HSP70) and genes related to photosynthesis (PsaD & PsaN) and antioxidant (Peroxidases). Collectively, the result of this study contributes to a better understanding of maize transcriptome changes under heat stress conditions. Further, we aim to develop functional SNPs markers using transcriptomics data and identify genomic region/QTLs associated with heat stress tolerance.

TS6-17: Evaluation of Drought Tolerance Indices and their Association with Grain Yield of Maize *(Zea mays* L.) Under Drought and Optimal Moisture Conditions

Ashok Singamsetti[1], J.P. Shahi[1]*, P.H. Zaidi[2], K. Seetharam[2] and Munnesh Kumar[1]

[1]Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P, India; [2]International Maize and Wheat Improvement Centre (CIMMYT), Asia Regional Office, Hyderabad, India.
*Corresponding author Email: jpshahi1@gmail.com

Selection for drought tolerance typically involves evaluating genotypes for either high yield potential or stable performance under drought stress. To select drought tolerant lines among 75 maize hybrids procured from the pool of CIMMYT maize germplasm, an experiment was conducted in an alpha lattice design with two replications under two different moisture regimes *i.e.* drought and optimal moisture conditions during the growing season *rabi* 2017-18 at Banaras Hindu University, Varanasi, Uttar Pradesh, India. Twelve drought tolerance/resistance indices including stress tolerance index (STI), stress susceptibility index (SSI), tolerance index (TOL), geometric mean production (GMP), mean production (MP), yield index (YI), yield stability index (YSI), drought resistance index (DI), relative drought index (RDI), stress susceptibility percentage index (SSPI) and modified stress tolerance (K_1STI and K_2STI) were calculated based on grain yield under drought (Y_p) and optimal moisture (Y_s) conditions. The drought resistance should be based on yield stability under water deficits. Thus, the genotypes with low fluctuations under different stress environments can be considered as drought resistant genotypes. In this study RDI, STI, GMP, MP, YI, DI and K_2 can be used to screen drought resistant genotypes as they are strongly associated with YSI (yield stability index). Yield in stress condition (Y_s) was significantly and positively correlated with RDI, STI, GMP, MP, YI, DI, YSI and K_2STI. Also, yield in optimal condition (Y_p) was significant and positively correlated with STI, GMP, MP and K_1STI showed that these criteria were more effective in identifying high yielding hybrids across different moisture regimes. The results revealed that genotypes *viz.,* ZH1610511 followed by ZH161285, ZH161384, ZH161438 and ZH161311 were found highest tolerance to drought.

TS6-18: Genetic Variation for Root Architecture in Maize Inbred Lines in Response to Drought Stress

Asima Gazal[1*], Ajaz Ahmad Lone[1], Zahoor Ahmed Dar[1], B.A. Alaie[1], R.S. Sudan[2], V. Swaranlatha[3] and B. Kumar[4], S. Naseer[1], N. Yousuf[1] and S. Gulzar[1]

[1]AICMIP Srinagar Centre, SKUAST, Kashmir, India; [2]Division of genetics and plant breeding, SKUAST, Jammu, India; [3]AICMIP, Hyderabad Centre, India; [4]IIMR, New Delhi, India.
*Corresponding author Email: asimagazal@gmail.com

Plants rely on healthy root systems for water and nutrient storage, absorption and anchorage, and are the first organs responding to water stress. Therefore, evaluating root architecture for selection of drought tolerant genotypes is carried out on priority basis. In this study, 100 maize lines were used to compare root architectures under different irrigation treatments over two years. Significant amounts of genetic variation and correlation with high heritability were recorded. The procedure for selecting 15 elite drought tolerant maize lines based on variability and per se performance was efficient at the germination and early seedling growth stages. The same set of lines were then evaluated under well-watered and water-stressed conditions in column culture. Root traits showed higher values under well-watered conditions. The highest and lowest allocation of roots to total biomass was found for KDM-362B and KDM-1051 under well-watered treatment, and for KDM-935A and KDM-463 under water-stressed conditions. The lowest and highest values of root to shoot ratio were recorded for KDM-372 and KDM-361A under well-watered conditions, whereas under water-stressed conditions lowest and highest values were found for KDM-935A and KDM-1156. The selected inbred lines exhibited substantial variability in root traits as well as biomass partitioning. They therefore have potential for developing single cross hybrids/ composites and for extensive line evaluation for drought adaptation traits under managed stress conditions in the field at adult stage in future breeding programs.

TS6-19: Assessment of Open Pollinated Maize Genotypes for Improving Food Security in the Hills of Nepal

B. Bhandari*, K.B. Koirala, R.B. Katuwal, N.B. Dhami, R. Acharya, A. Poudel, K.R. Sharma, B.P. Ghimire, B. Luitel and M.P. Tripathi

National Maize Research Program, Rampur, Chitwan, Nepal.
*Corresponding author Email: balram.bhandari2009@gmail.com

Maize is the second most important cereal crop of Nepal. It has low yield potential in the hill because of the low seed replacement rate, low plant population and rain fed farming in most areas. With the objective to find out the opposite high yielding open pollinated full season varieties, different genotypes were assessed in Intermediate Yield Trial (IYT) and Coordinated Varietal Trial (CVT) at different hill research stations, namely ARS, Pakhribas; HCRP, Dolakha; ABD, Khumaltar; RARS, Lumle; GRP, Salyan and HRS, Dailekh in 2015 and 2016. At each location RCB design was used with three replications. Years, locations, genotypes and all the interactions were significant except genotypes × years in terms of grain yield in IYT. Among the 14 tested genotypes, Manakamana-3 (5841 kg/ha), Rampur S03F08 (5836 kg/ha), Rampur S13F28 (5680 kg/ha) and ZM 627 (4762 kg/ha) were found high yielding and stable. In CVT, years, locations, genotypes and all the interactions were significant except genotypes × locations × years in terms of grain yield. Amongst the 10 assessed genotypes, 05SADVI (5125 kg/ha), KSYN10 (5035 kg/ha), KSYNF10 (4929 kg/ha) and ZM 401 4914 (kg/ha) were high yielding and stable. High yielding and most stable genotypes of IYT will be reassessed in CVT. Similarly, those of CVT will be reevaluated in Coordinated Farmer Field Trial (CFFT). Finally, outstanding genotypes will be forwarded to the release process for the hilly regions of Nepal.

TS6-20: Molecular Mapping of MLB Resistance and Flowering Time in Sub-Tropical Maize Germplasm

Bhupender Kumar[1]*, Karambir Singh Hooda[1], Pravin Kumar[1], Harleen Kaur[2], Harbinder Singh[3], Shyam Bir Singh[1], Pradeep Kumar[1], Phool Chand[4], Sonu Kumar[1], Meenakshi[1], Harpreet Kaur[1], Pradeep Bhati[1], Hans Raj[1] and Sujay Rakshit[1]

[1]ICAR-Indian Institute of Maize Research, Ludhiana-141004, India; [2]PAU, Ludhiana-141004, India; [3]HAU, Regional Research Station, Karnal-132001, India; [4]RAU, Pusa, Samastipur–848125, India.
*Corresponding author Email: bhupender.iimr@gmail.com

Maydis leaf blight (MLB) resistance and flowering time are the important yield determining traits in maize. Breeding for MLB resistance and maturity types can be accelerated using molecular markers. Two different Recombinants Inbred Lines (RILs) mapping populations of size of 283 and 275 have been synthesized from crosses HKI4C4B (S) × CML269 (R) and ESM113 (S) × P72clXbrasil1117 (R) respectively. Either of the parents in each cross expressed contrasting phenotypes for disease response as well as flowering time. The RIL mapping populations were screened under artificial inoculated conditions at four hot-spots. Race O inoculums were artificially inoculated in the leaf whorl of each plant at fourth to sixth leaf stage. The field was kept adequately moist with irrigation to allow the fungal growth. The inoculation was repeated after 8-10 days of first inoculation to avoid any chance of disease escape. The significant negative correlation was observed between disease scores and flowering time. Of 147 simple sequences repeats (SSR) markers used for parental polymorphism survey, 62 were polymorphic between the contrasting parents. Genotyping of the first RILs population is under progress. Bulk segregant analysis (BSA) of P1 (R), P2(S), F1, F2 (RB) and F2 (SB) has identified the genomic regions for disease resistance and flowering time on chromosome #1. The RILs genotypic and phenotypic data will be utilized to fine map the new genomic regions and validate the BSA results for MLB resistance and flowering time in tropical maize.

TS6-21: Dynamic Expression of Mirnas in Response to Drought and Water Logging Stresses in Maize

Bhupender Kumar*, Krishan Kumar, Mukesh Choudhary, Sonu Kumar, Meenakshi Hans Raj and Sujay Rakshit

ICAR-Indian Institute of Maize Research, Ludhiana-141004, India.
*Corresponding author Email: bhupender.iimr@gmail.com

Maize, a widely grown rainfed crop in South Asia, faces moisture stresses from in-season dry spells (drought) and heavy downpour (water logging). Identification of key genes and their regulatory elements can help in developing stress resilient maize genotypes. MicroRNA-mediated gene regulation plays a crucial role in controlling drought and water logging stress tolerance in plants. To harness this, a set of 100 inbred lines were evaluated for water logging and drought stress under glass house conditions. Water logging stress was imposed by maintaining 3.5±0.5 cm water level in pots after germination continuously for 15 days. Similarly, drought stress was given at seedling stage and sustained for 20 days. Observations were recorded on all important shoot and root parameters. Seven inbred lines were found tolerant to water logging and four to drought stress. Interestingly, one line, viz., IMR27 showed combined drought and water logging stress tolerance. The root and shoot samples

from highly tolerant and susceptible genotypes under drought and water logging stress were used for MicroRNA studies. In total, 39 MicroRNAs (20 up and 19 down-regulated) in shoot and 21 (12 up and 19 down-regulated) in root expressed differentially under stress in drought tolerant genotype. Similarly, in water logging tolerance, 35 (17 up and 18 down-regulated) MicroRNAs in shoot and nine (two up and seven down-regulated) in root were found differentially expressed. Interestingly, 13 MicroRNAs of families miR156, miR159, and miR319 in root and five MicroRNAs, viz., miR169b, miR397a, miR408b, miR528a, miR528b in shoot were identified common for drought and water logging tolerance. This implies the availability of common MicroRNA/genes for drought and water logging tolerance in maize which can help to develop stress resilient genotypes.

TS6-22: Effect of Northern Corn Leaf Blight Disease Caused by *Exserohilum turcicum* to Yield and Quality of Sweet Corn Varieties

Chaowanart Phruetthithep[1*], Kallaya Withee[2], Chalong Kerdsri[1], Wassamon Mongkol[1], Peerawan Patanavipart[3], Siwilai Lapbanjob[4] and Sumana Ngampongsai[1]

[1]Chai Nat Field Crops Research Center, Muang, Chai Nat 17000, Thailand; [2]Chiang Mai Field Crops Research Center, San-sai, Chiang Mai 50290, Thailand; [3]Plant Protection Research and Development Office, Department of Agriculture, Chatuchak, Bangkok,10900, Thailand; [4]Nakhon Sawan Field Crops Research Center, Takfa, Nakhon Sawan 60190, Thailand.
*Corresponding author Email: chaovanaj@yahoo.com; chaowanart_p@hotmail.com

The objective of the experiment was to examine the impact of northern corn leaf blight caused by *Exserohilum turcicum* on yield and quality of sweet corn. The experiment was conducted at Chiang Mai Field Crops Research Center in the dry season, 2017. A split plot with three replications was used. Main plots comprised four severity levels of northern corn leaf blight including 1-10, 11-25, 26-50 and 51-100% of leaf area inflection. Subplots were three sweet corn varieties, Chainat 86-1, Hibrix 3 and Wan 54. There were no interactions in all parameters found between the severity levels of disease and sweet corn varieties. Statistically significant differences in plant heights and ear heights among severity levels were not observed. The severity levels of leaf blight remained at 1-10 percent of leaves gave ear with husk fresh weight of 9.3 ton/ha which was significantly greater than the others. However, husk fresh weights and cutting percentage among severity levels of disease inflections (6.3-6.5 ton/ha) were similar. Leaf inflection at 51-100% had the lowest sweetness (10.7 %brix). Wan 54, attained the greatest ear with or without husk fresh weight (12.6 and 9.1 ton/ha, respectively) and sweetness (13.6% brix) compared to the others. Kernel cutting percentage of Wan 54, however, was significantly lower than Hibrix3.

TS6-23: Genome-Wide Association Study Dissects Yield Components Associated with Low-Phosphorus Stress Tolerance in Maize

Cheng Xu[1], Hongwei Zhang[1], Jianhao Sun[2], Zifeng Guo[1], Cheng Zou[1], Wen-Xue Li[1], Chuanxiao Xie[1], Changling Huang[1], Ruineng Xu[4,5], Hong Liao[4,5], Jinxiang Wang[4,5], Xiaojie Xu[1], Shanhong Wang[1] and Yunbi Xu[1,3*]

[1]Institute of Crop Science, Chinese Academy of Agricultural Sciences, 12 South Zhongguancun Street, Beijing 100081, China; [2]Institute of Soil Fertilizer and Water-saving Agriculture, Gansu Academy of Agricultural Sciences, Lanzhou, China; [3]CIMMYT, El Batan, Texcoco, CP 56130 México; [4]State Key Laboratory for Conservation and Utilization of Subtropical Agro-Bioresources, South China Agricultural University, Guangzhou, China; [5]Root Biology Center, College of Natural Resources and Environment, South China Agricultural University, Guangzhou, China.
*Corresponding author Email: y.xu@cgiar.org

Phosphorus deficiency in soils severely affects maize (*Zea mays* L.) growth and development, which ultimately decreases yield. Deciphering the genetic basis of yield-related traits can benefit our understanding of maize tolerance to low-phosphorus stress. However, considering that yield-related traits should be evaluated under field conditions with large populations rather than under hydroponic condition at a single-plant level, searching for appropriate field experimental sites and target traits for low-phosphorus stress tolerance remain very challenging. In this study, a genome-wide association analysis using two natural populations was performed to detect candidate genes in response to low-phosphorus stress at two experimental sites representative of different climate and soil types. In total, 259 candidate genes were identified, and these candidate genes are mainly involved in four major pathways: transcriptional regulation, reactive oxygen scavenging, hormone regulation and remodeling of cell wall. Among the 259 candidate genes, 98 genes showed differential expression by analyzing transcriptome data. Based on a haplotype analysis of grain number under phosphorus deficiency condition, the positive haplotypes with favorable alleles across five loci increased grain number by 42% than those without favorable alleles. To further verify the feasibility of conducting genomic selection for improving maize low-phosphorus tolerance, we also validated the predictive ability of five genomic selection methods and suggested that moderate-density SNPs were sufficient to make accurate predictions for low-phosphorus tolerance traits. All these results will facilitate elucidating genetic basis of maize tolerance to low-phosphorus stress and improving marker-assisted selection efficiency in breeding processes.

TS6-24: Improving Seed Size and Seed Weight for Enhancing Grain Yield in Maize (*Zea mays* L.)

Chethan Kumar V., Ganapati Mukri*, R.N. Gadag, Jayant S Bhat and T. Nepolean

ICAR- Indian Agricultural Research Institute, New Delhi-110012, India.
*Corresponding author Email: ganapati4121@gmail.com

A prime target of crop breeding is to improve grain yield, which is complex in nature. Kernel size and weight are primary yield components that contribute significantly to, and have a direct effect on, final grain yield. Productivity of the targeted genotypes could be enhanced by improving yield component traits. Although kernel size and weight have been extensively studied and utilized by biologists and plant breeders in the past, information on their genetic basis and interaction with other yield components in maize are limited. In a preliminary evaluation, 80 genotypes were screened for seed size and weight. An average of 10 grain size

was taken as seed size, and 100 seed weight was considered as seed weight of maize. Tremendous variability was found among the tested genotypes. Seed weight varied from 8.10g to 38.00g and seed size varied from 3.30mm to 7.00mm. We grouped inbred lines into small, medium and bold seed. Inbred AI 243 was characterized as small seeded and BM 1441 as bold seeded. This variation can be exploited to understand the genetics and molecular mechanism necessary to enhance the seed size and seed weight in maize. Bold seeded inbred lines can be used for introgression breeding program to improve the existing elite maize inbred lines to bold seeded inbred lines. Since seed size also correlated with the amount of starch present in endosperm, it can be utilized in the development of high yielding and/or high starch maize hybrids.

TS6-25: Heterotic Grouping of Indian Maize Inbred Lines Based on Combining Ability

Chikkappa G. Karjagi[1*], Sunil Neelam[2], Ramesh Kumar Phagna[3], S.B. Singh[4], Ganapati Mukri[5], Yathish K.R[3], Abhijit Kumar Das[3], Vishal Singh[3], Mukesh Kumar[3], Pradip Kumar[3], Alla Singh[3], Vinay Mahajan[3], K.S. Hooda[3], J.C. Sekhar[2] Sujay Rakshit[3].

[1]ICAR-Indian Institute of Maize Research, Unit Office, Pusa Campus Unit, New Delhi, India; [2]Winter Nursery Centre, ICAR-Indian Institute of Maize Research, Rajendra Nagar, Hyderabad, Telangana, India; [3]ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana, Punjab, India; [4]Regional Maize Research and Seed Production Centre, ICAR-Indian Institute of Maize Research, Kushmahut Farm, Begusarai, Bihar, India; [5]ICAR-Indian Agricultural Research Institute, Pusa Campus, New Delhi, India.
*Corresponding author Email: cg.karjagi@icar.gov.in; chikkappagk.icar@gmail.com

The fundamental requirement of a science-based hybrid development program for any crop requires classification of breeding material or germplasm into different heterotic groups. Countries like USA, China, Brazil, Argentina and Europe have well defined heterotic groups in maize at National level but the same is missing in India. The two basic aspects considered for heterotic grouping are combining ability for yield and genetic divergence, out of which the combining ability for yield was considered the most practical and reliable method. Effort was made to group inbred lines into different heterotic groups based on combining ability for yield using line × tester method. In the present study, 33 inbred lines were crossed with three testers namely LM13, LM14 and LM17 during *rabi* 2014-15 to generate 99 test-crosses. Multi-location trials comprising test-crosses were conducted at Hyderabad and Ludhiana during *Kharif* 2015 to estimate combining ability effects for yield. The results showed that out of 33 inbred lines, 17 and 16 inbred lines showed positive GCA at Hyderabad (7-1259 kg/ha) and Ludhiana (53-2115 kg/ha) respectively, including 12 common lines at both locations. The SCA effects were considered for heterotic grouping of inbred lines, and, based on the SCA effects, 15 of 33 lines combined very well with either one of the three testers, whereas the remaining lines were heterotic to any two of the three testers. The test-crosses were also evaluated with standard check cultivars namely PMH1, PMH3, PMH4 and PMH5. As an off-shoot of the present study, few test-crosses were found >10% superior over the best check cultivars with yield potential of 7.2 to 8.2 t/ha at Hyderabad, and 9.4 to 9.6 t/ha at Ludhiana. Such test-crosses have the potential to become new hybrids with enhanced yield levels.

TS6-26: Evaluation of Multinational Companies' Hybrids Maize at Different Locations of Nepal

Chitra Bahadur Kunwar

National Maize Research Program, Rampur Chitwan. Email: chitra2058@yahoo.com; chitra2058@gmail.com

Long, cool waves cause pollination failure in hybrid maize during winter season in hybrid growing areas of Terai district, Nepal. The objective of this study was to evaluate the performance of different multinational companies' maize hybrids and identify suitable hybrid varieties to tackle this problem. During winter 2015/2016, a total of 26 hybrids were evaluated for their yielding ability, sensitivity to cool waves and agronomic traits in randomized complete block design at three locations namely Rampur, Parwanipur and Tarahara. Similarly, in 2016/2017 winter 51 hybrids were evaluated with one additional location, Nepalgunj. Among the tested hybrids, P3533 produced the highest grain yield (7.03 t/ha) at all locations. At Parwanipur, Tarahara and Rampur P3355 (9.20 t/ha), NMH007 (Bon) (9.20 t/ha) and P3533 (5.13 t/ha) respectively recorded higher grain yield of maize hybrids in 2015/016 winter. Similarly, PPS-4291 out yielded (9.02 t/ha) others in 2016/2017. At Parwanipur, Tarahara, Rampur and Nepalgunj MM2562 (10.77t/ha), NK7720 (10.62t/ha), P3355 (10.47t/ha) and S6217 (7.13 t/ha) respectively recorded higher grain yield in 2016/2017 winter maize. In addition to grain yield the phenological traits - like days to 50% tasseling, days to 50% silking, anthesis-silking interval, plant height, ear height, cob diameter, test weight, and shelling percentage - were studied. Analysis of variance was performed for genotypes, location and genotype × location interaction.

TS6-27: Use of Special Trait Donors in Tropical X Temperate Crosses for Improving Maize Yield and Yield Stability

Dan Jeffers[1*], Fu Yan Jiang[2], Wei Dong Cheng[3], Yunbi Xu[4], Chuan Xiao Xie[5] and Xing Ming Fan[2]

[1]International Maize and Wheat Improvement Center (CIMMYT), Yunnan Academy of Agricultural Sciences, Institute of Food Crops, 2238 Beijing Road, Kunming, Yunnan 650200, China; [2]Yunnan Academy of Agricultural Sciences, Institute of Food Crops, Kunming, China; [3]Maize Research Institute, Guangxi Academy of Agricultural Sciences, Nanning, China; [4]International Maize and Wheat Improvement Center (CIMMYT), Institute of Crop Science, Chinese Academy of Agricultural Sciences, Beijing, China; [5]Institute of Crop Science, Chinese Academy of Agricultural Sciences, National Key Facility for Crop Gene Resources and Genetic Improvement, Beijing, China.
*Corresponding author Email: d.jeffers@cgiar.org

Biotic and abiotic stresses are significant in reducing yields and yield stability in maize. CIMMYT germplasm can offer diverse sources of donors for disease resistance and abiotic stress tolerance due to its broad genetic background, and characterization for stress resilience traits have identified useful donors. In the Yunnan Academy of Agricultural Sciences/ CIMMYT collaborative breeding program, over 3000 introduced lines have been characterized for per se performance, and in hybrid evaluation in Southern China. Resistance to turcicum leaf blight, gray leaf spot, banded leaf and sheath blight, maize rough dwarf disease, *Fusarium verticillioides* and *Gibberella* (*Fusarium graminearum*) ear rots have been identified through phenotyping trials carried out in China. Abiotic stress tolerance donors for drought, high temperatures, flooding, and reduced nitrogen have been identified in this group of biotic stress resistance donors. Under reduced nitrogen conditions, several promising hybrids outperformed

the commercial checks with higher yield potential, better foliar disease and ear rot resistance, while having higher nitrogen content in the grain. Tropical introgression lines into temperate US and Chinese germplasm, including backcross one to backcross three lines, have been developed and express many of the donor traits in improved agronomic backgrounds. They are being tested in both subtropical and temperate environments. Key temperate inbred lines included in new recycling efforts include: the US Reid inbreds LH195, PHHB4; Non-Reid inbreds LH123Ht and PHG47; Iodent inbred PH207; and Chinese Reid inbred Zheng 58 and Non-Reid inbred Chang 7-2.

TS6-28: Studies on Genetic Variability, Association of Characters and Path Analysis in Maize (*Zea mays* L.) Inbreds

D.B. Lad*, U.M. Borle, V.S. Supe and N.U. Dhumal

Zonal Agricultural Research Station, Ganeshkhind, Pune-411067, Maharashtra, India.
*Corresponding author Email: dattaladuup@gmail.com

In the present investigation, 40 inbreds of maize were assessed for genetic variability, association of characters and path analysis. The analysis of variance revealed highly significant differences among the genotypes for all the 12 characters studied, indicating the wide range of genetic variability in the existing material. High magnitude of heritability was observed for ear length and ear head height followed by 100-seed weight, plant height and number of grains per cob. High heritability coupled with high genetic advancement was recorded for number of grains per plant, grain yield and plant height, suggesting the role of additive gene effects and possibilities of achieving high genetic progress through selection. The phenotypic correlation coefficients were numerically higher than genotypic correlation coefficients. The characters viz; plant height, ear head height, ear length, number of grains per cob, 100-grain weight, number of cobs per plant, days to 50% tasselling and silking showed significant positive correlation with seed yield per plant. In the association among component characters, days to 50% tasseling significantly and positively correlated with days to 50% silking, plant height, days to 50% maturity, ear-head height, shelling percentage and seed yield per plant; whereas protein content was negatively correlated. Days to 50% maturity was positively correlated with ear head height, ear length and shelling percentage. Path analysis revealed that number of grains per cob, 100-grain weight, days to 50% maturity, number of cobs per plant and plant height recorded the maximum and positive direct effects on seed yield per plant, and their association with seed yield per plant was also positive and highly significant except days to 50% maturity.

TS6-29: Assessment of Genetic Diversity in Maize (*Zea mays* L.) Inbreds

D.B. Lad*, A.A. Bhagat, V.S. Supe and N.U. Dhumal

National Agricultural Research Project (NARP), Ganeshkhind, Pune–411067, India.
*Corresponding author Email: dattaladuup@gmail.com

The experiment was laid out in Randomized Block Design (RBD) during *kharif* 2014. Forty inbreds of maize procured from AICRP on maize, Kolhapur, were randomly planted in three replications. Each entry was represented by a single row of 4m length spaced at 75cm between the rows and 20cm between the plants. The 40 inbreds were evaluated for 12 yield and yield

contributing characters. The experiment was undertaken to assess the genetic diversity among 40 inbred lines of maize. In the present investigation D2 value ranged from 18.38 to 1671.13 and a total of six clusters were formed, with cluster I accommodating a maximum of 15 inbreds, followed by cluster II and III with 8 inbreds, and cluster IV with 7 inbreds. Clusters V and VI were monogenotypic, indicating wide divergence from other clusters. The maximum intra-cluster distance was observed in cluster IV (D2= 212.86) followed by cluster III (D2=174.24) and cluster II (D2=131.56), suggesting that inbreds present in these clusters possess varied genetic architecture and might have originated from different genetic pools. The maximum inter-cluster distance was observed between cluster V and cluster VI (1664.64) followed by cluster III and cluster IV (D2=982.16), indicating wide divergence among the clusters and suggesting that the genetic architecture of the inbreds in one cluster differ entirely from those included in another cluster. Based on inter cluster distance, cluster means per se performance observed in the present study QMI-1427, QMI-1455, QMI1440, QMI-1432and QMI 1461 were found to be superior inbreds for future breeding program.

TS6-30: Evaluation of Maize Hybrids for Vigor Traits under Ambient Conditions after Cold Storage

D. Bhadru*, V. Swarna Latha, T. Pradeep and V. Narsimha Reddy

Maize Research Center, ARI Campus, Rajendranagar, Hyderabad, Telangana, India.
*Corresponding author Email: badrigpb@gmail.com

Generally, farmers purchase seed from private/ public companies and sow when there is adequate soil moisture, especially under rainfed conditions. Most times sowing may be delayed by 45-60 days and the status of the seed stored during this period under ambient conditions is not known unless germination is tested. It is in this context that a systematic study has been undertaken to evaluate the performance of seed lots of two popular maize hybrids viz., DHM 117 and DHM121 which were kept in a cold storage unit for one year (2015-16), and seeds collected from different lots were evaluated the following year (2016-17). Seed germination was found to be more than 90% up to six months - with a reduction of 1.7 to 6.1 percent in seven different lots - and thereafter drastically reduced in both hybrids. Seedling vigor traits had more than 50% reduction under ambient conditions after one year of cold storage. The study suggested that the seed material stored in cold storage can be revalidated for another six months and supplied to farmers safely. However, the exact storage period between six and 12 months wherein the germination is falling below the minimum standards of 90% prescribed for maize hybrids, must be worked out to have more precise data on seed germination dynamics of seed under ambient conditions following a cold storage period.

TS6-31: Combining Ability Estimation for Grain Yield of Maize Exotic Germplasm Using Testers from Three Heterotic Groups

Fan Xingming[1]*, Xingfu Yin[1], Yudong Zhang[1], Yaqi Bi[1], Li Liu[1], Hongmei Chen[1] and Manjit Kang[2]

[1]Yunnan Academy of Agricultural Sciences, Institute of Food Crops, 2238 Beijing Road, Kunming, Yunnan 650200, China; [2]Department of Plant Pathology, Kansas State University, Manhattan, KS 66506.
*Corresponding author Email: xingmingfanat163.com

Combining ability estimates of lines to be used in breeding are useful for maize breeders. The objectives of this study were to (i) evaluate combining ability of 25 improved exotic germplasm using different numbers of testers from Suwan1, Reid, and non-Reid heterotic groups; (ii) study differences in combining ability estimates obtained with different number of testers from the same vs. different heterotic groups; and (iii) determine the appropriate segregating ('S') generation in which line selection should be done to obtain stable general combining ability (GCA) estimates of lines. The results showed that three testers (one from each of the three heterotic groups) were economically best for estimating GCA effects of lines, and if a tester from one of the three heterotic groups was missed, GCA estimates for some lines were biased when compared with GCA estimates with testers from all three heterotic groups. Second, the specific combining ability (SCA) effects of test-crosses were quite similar regardless of whether one or two testers were used from each of the three heterotic groups. Thus, to obtain reliable SCA estimates, at least one tester would need to be used from each of the heterotic groups. Third, to obtain stable estimates of GCA effects for a line, S4 or S5 generation should be the earliest generation in which to begin selection. However, to select lines with diverse genetic backgrounds, S3 should be the key generation for selection.

TS6-32: The Use of Suwan and Cateto Tropical Maize Germplasm in Southern China for Hybrid Development

Fan Xing Ming[1*], Yu Dong Zhang[1], Dan Jeffers[2], Ya Qi Bi[1] and Xing Fu Yin[1]
[1]Yunnan Academy of Agricultural Sciences, Institute of Food Crops, 2238 Beijing Road, Kunming, Yunnan 650200, China; [2]International Maize and Wheat Improvement Center (CIMMYT), Yunnan Academy of Agricultural Sciences, Institute of Food Crops, Kunming, China.
*Corresponding author Email: xingmingfanat163.com

Tropical germplasm can provide many valuable traits for improving yield stability and broadening the genetic base of a breeding program. To effectively utilize the introduced germplasm requires per se and line x tester evaluation for identifying favorable and unfavorable attributes, and heterotic group classification for its effective use. Promising lines are evaluated in a line x tester mating design for calculating general combining ability (GCA) and specific combining ability (SCA) for key agronomic traits affecting grain yield, plant and ear height. The tri-heterotic grouping with the Suwan1 heterotic group is utilized because it improves breeding efficiency in the identification of more superior germplasm as compared to a two heterotic grouping utilizing a Reid and non-Reid classification. Heterotic classification at the S4 level of inbreeding provides stable general combining ability estimates versus early generation testing. Recently, germplasm including the Cateto landrace from South America has been evaluated and was found to possess several valuable yield and disease resistance traits in the formation of promising hybrids. The Cateto based germplasm was obtained in mixed genetic backgrounds, where most were classified in the Suwan1 heterotic grouping, with high positive GCA effects. In the Cateto based lines, resistance to *turcicum* leaf blight and *Fusarium verticillioides* ear rot were observed, but little variation was identified for providing *Gibberella* ear rot resistance which needs to be considered in environments where this ear rot is important. Suwan and Cateto lines combine well with temperate maize derived germplasm, and their hybrids have broad adaptation across Southern China.

TS6-33: Heterosis and Combining Ability Among Early and Dwarf Inbred Lines of Maize (*Zea mays* L.) by a Diallel Fashion

F. Begum[1*], M.Z.A. Talukdar[1], N.A. Ivy[2], M.A.K. Mian[2], M.G. Rasul[2] and Jalal Uddin Ahmed[3]

[1]Plant Breeding Division, Bangladesh Agricultural Research Institute, Gazipur 1701, Bangladesh; [2]Department of Genetics and Plant Breeding, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Bangladesh; [3]Department of Crop Botany, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh.
*Corresponding author Email: ferdousi20@gmail.com

Heterosis and combining ability help inform selection of genotypes and breeding procedure. It was studied for growth parameter and yield components in seven elite maize inbred lines. Variance due to GCA and SCA were highly significant for the characters studied, indicating that both additive and non-additive types of gene action were important for controlling traits. Predominance of additive gene action was observed for all the traits except yield. Parent P2, P5 and P6 were excellent general combiners for earliness and short plant. Parents P4 and P7 exhibited good general combining ability for yield. Estimation of heterosis percentage was carried out using commercial variety 900m Gold, and kernel yield varied from -69.09 to 20.22%. Among the 21 F1s, four crosses exhibited significant positive heterosis for kernel yield. The highest heterosis 20.22% was exhibited by cross P4×P7 followed by P6×P7 (13.38), P3×P7 (11.12) and P1×P5 (8.23). Two crosses exhibited significant positive heterosis for kernel yield. The highest heterosis 14.54 was exhibited by cross P4×P7 followed by P6×P7(8.23). The crosses showing significant positive SCA values could be used for variety development after verifying them across the agro-ecological zones of Bangladesh.

TS6-34: High Kernel Row Number (HKRN): A Novel Breeding Target for Enhancing Grain Yield in Sub-tropical Maize (*Zea mays*. L)

Ganapati Mukri[1*], Thirunavukkarsau Nepolean[1], Jayant S. Bhat[1], R.N. Gadag[1], Jyoti Kaul[1], Ramesh Kumar[2], Rajesh Kumar[1] and Digvender Pal[1]

[1]ICAR-Indian Agricultural Research Institute, New Delhi, India; [2]ICAR-Indian Institute of Maize Research, Ludhiana, India.
*Corresponding author Email: ganapati4121@gmail.com

Maize is the queen of cereals and, by virtue of its C4 nature, has high yield potential. Yield is a complex trait and its expression varies depending on the relative contribution of the component traits, which directly or indirectly decide the yielding potential of individual genotypes. It is a challenge to directly explore the genetic architecture and molecular mechanism of grain yield and utilize them in breeding programs owing to low heritability. But yield component traits exhibit higher heritability and better stability across environments compared to yield. So, improvement in grain yield could be achieved through improving yield components. High Kernel Row Number (HKRN) is an important yield component trait of the female inflorescence (ear) and has high heritability among all yield components. Genetic dissection of HKRN was undertaken by several researchers and identified number of loci which control the trait. However, no information is available on sub-tropical maize lines in which Indian maize breeding program is interested. To find out genetic variability in KRN, a set of 80 germplasm were screened, and preliminary results indicated significant variance for KRN trait. Genotypes showed varied number of KRNs were classified as Low KRN (up to 12 KRN),

Medium KRN (14-18 KRN) and High KRN (20 and above) lines. Among the studied genotypes, 16 belonged to Low KRN, 42 were medium KRN and 22 were categorized as High KRN lines. These inbred lines will be utilized to unravel the genes controlling HKRN in Indian maize and will be utilized systematically in future maize breeding programs to enhance grain yield in maize.

TS6-35: Farmers' Field Evaluation of Heat Tolerant Maize in Nepal

Govind K.C.[1], T. Rijal[2], J.K. Shrestha[3], D.B. Bhandari[4] and D. Poudel[5]

[1]NMRP, Rampur, Presently Agronomy Division, Khumaltar, Lalitpur, Nepal; [2]NMRP, Rampur, Nepal; [3]RARS Nepalgunj, Nepal; [4]Hariyali Seed Company, Nepal; [5]SEAN Seed Company, Nepal.
*Corresponding author Email: kc.govindkc@gmail.com

Maize is a major staple food and feed crop in Terai region of Nepal. Out of total maize area (891,583 ha) in Nepal, 83.2% lies under rainfed and hilly region where drought stress is the major abiotic problem. In lower elevation (Terai) maize occupies 0.1 million hectares as winter and spring maize but could soon occupy more due to its growing popularity. However, the crop is prone to heat stress. This study was conducted to evaluate the high yielding and best performing maize hybrids in heat stress ecologies of Nepal, in collaboration with CIMMYT/HTMA project. The best performing entries in on-station trials were tested under farmers' field conditions from 2015 to 2017. In 2015, Nepali promising hybrids yielded 9.48 to 9.67 mt/ha and tested lines # 478-2, 478-3, 478-4 and # 376-26 have shown second best performance with 9.16 to 9.39 mt/ha yield compared to commercial hybrids check (900M Gold 8.39 and 30V92, 8.26 mt /ha). In the second year of evaluation, CAH 151, CAH 153, CAH 1513, CAH 1515, ZH 114228 showed better performance with 8.22 to 13.0 mt/ha yield compared to Nepali hybrid checks. Based on yield performance and different stakeholders' performance at a field day event, CAH 151 and CAH 153 were selected and officially registered in Nepal as Rampur Hybrid 8 and Rampur Hybrid 10 for both heat stress and normal environments.

TS6-36: Multiple Disease and Pest Resistance in Advance Breeding Lines of Maize (*Zea mays* L.)

Harleen Kaur*, Jawala Jindal, Gurjit Kaur Gill and J.S Chawla

Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana.
*Corresponding author Email: harleenkaur@pau.edu

A set of 44 genotypes were screened against maydis leaf blight (*Drechslera maydis*) and charcoal rot (*Macrophomina phaseolina*) under artificial inoculation conditions, and bacterial leaf streak (*Acedovorax avenae subsp. avenae*) under natural conditions during *Kharif* 2016 and 2017 at Ludhiana. The same set was screened against shoot fly, *Atherigona naqvii*, using fish meal technique during spring 2017. Ideal plant type (medium plant height, low ear placement and medium broad erect leaves) with multiple disease and pest resistance is the best option for sustainable maize production. Out of these, 11 lines were identified with medium height, low ear placement and erect leaves. Out of 44 genotypes, 11 genotypes were found resistant to maydis leaf blight (≤2.0), and 17 to charcoal rot (≤3.0). Twenty-five genotypes were completely free from bacterial leaf streak. The data clearly indicated that four genotypes

(JCY-45, JCY-3-7 and HS2787-2) were found resistant against all the pathogens, whereas one genotype was found highly susceptible (SW 3853KUI Thailand EC468662-b). Preliminary results concluded that lines possessing multiple disease resistance were found stay green with medium ear placement and erect leaves. Dead heart incidence due to shoot fly in different genotypes ranged from 26.3 to 89.5 per cent. Out of these, six promising lines with significantly lower dead hearts (26.3 -38.1 %) were found. These resistant sources are being confirmed for multiple resistance before being utilized in conferring the same to potential maize hybrids.

TS6-37: Tolerance Index and Evaluation of the Hybrid Maize Selection Character on Low N Fertilization

Herawati* and Roy Efendi

Indonesian Cereal Research Institute (ICERI), Maros, Indonesia.
*Corresponding author E-mail: herawati.serealia@yahoo.com

Low N tolerant maize is one of several technologies developed to resolve N limitation in the growth and production of maize. Therefore, tolerance index analysis and evaluation of the hybrid maize's specific low N tolerant characteristic is needed. This study aimed to find out the hybrid maize genotypes that are tolerant to low N, and characters that can be used as selection indicators to low N. Research was conducted at the Experimental Farm of ICERI, Maros, from June to November 2014. This research was arranged in split plot design with three replications. The main plot was nitrogen fertilizer with three levels, i.e 0 kg N/ha, 100 kg N/ha (low N fertilization dosage) and 200 kg N/ha (dosage of normal N fertilization). The subplots were 56 hybrid maize genotypes. There were four check varieties ie P-27, NK-33, Bisi-2 and Bima-3. The results showed that HLN 32 had the highest grain yield on low N (10,02t/ha). Genotypes of hybrid maize tolerant to low N were HLN03, HLN17, HLN18, HLN24, HLN25, HLN32, HLN35, HLN39, HLN46, and HLN47. The plant height, ear height position, stem diameter, leaf width, leaf area, age of male flowering, age of female flowering, leaf chlorophyll at age 80 after planting, leaf senescence, percentage of normal cobs, percentage of abnormal cobs, ear height, ear diameter, number of kernels per row, number of kernels per cob, and shelling percentage were recorded. Characteristics that directly influence grain yield were shelling percentage, percentage of abnormal cobs, ear height, ear diameter and leaf area.

TS6-38: Evaluation of Maize Genotypes for Drought Tolerance Using PEG Mediated Water Stress

Ishan Ahmad Dar[1]*, Zahoor Ahmad Dar[1], Kamaluddin[1], Parvez Ahmad Sofi[1], Ajaz Ahmad Lone[1], Dilip Singh[2], N. Sunil[3] and V. Swarna Lata[4]

[1]Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir, India; [2]MPUAT, Udaipur, India; [3]ICAR-IIMR, New Delhi, India; [4]Professor Jayasankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad, Telangana, India.
*Corresponding author Email: dareshan.786@gmail.com

Drought stress is one of the most important environmental factors affecting growth, development and production of plants. Germination of each seed is the most fundamental life stage of a plant, on which successful growth and yield production depend. To study the effect of PEG stress on germination and seedling stages of maize, an experiment was laid out at laboratory conditions of Division of Genetics and Plant Breeding SKUAST-K FoA/RRS Wadura. Effect of water stress was induced by different osmotic potential levels [0 (control),

10, 15 and 20 %] of PEG 6000 treatments on germination were studied. Thirteen varieties of maize were evaluated in the present study viz., Shalimar maize composite-4 (C-4), C-6, C-8, C-15, Shalimar maize composite -7 (KDM-72), Kishan Ganga-1 (KG-1), Kishan Ganga-2 (KG-2), Pratap Makka -3 (PM-3), Pratap Makka-4 (PM-4), Pratap Makka-5 (PM-5), Pratap Makka-Chari-6 (PM Chari-6), Aravali Makka-1 (AM-1), Gujrat Makka-6 (GM-6). This investigation was performed as factorial experiment under Complete Randomized Design (CRD) with three replications. At the end of the seventh day, the length of radicle (cm) and radicle weight (g) of seeds were measured. Polyethylene glycol stress induced in the laboratory caused progressive decline in both parameters across all genotypes with increase in Polyethylene glycol from 0-20% and both parameters (length of radical and root biomass) had highest value under control. Length of radical and root biomass were found highest in C-6 and C-15 respectively, whereas length of radical and root biomass was found lowest in PM-4, PM-Chari-6, KDM-72 and KDM-72 respectively.

TS6-39: Azoxystrobin: An Alternative Fungicide to Manage the Sorghum Downy Mildew Disease in Maize

Jadesha G*, N. Mallikarjuna, Puttaramanaik, Shobha D., H.C. Lohithaswa and Swapna G.

[1]AICRP (Maize), Zonal Agricultural Research Station, V.C. Farm, Mandya, University of Agricultural Sciences, Bengaluru, India.
*Corresponding author Email: jadesha.uasb@gmail.com

Sorghum downy mildew (SDM) caused by *Peronosclerospora sorghi* (W. Weston & Uppal) is a destructive disease of maize causing systemic infection and resulting in yield loss proportional to the disease incidence. Metalaxyl fungicide has been used as an effective fungicide against SDM in maize for many years. However, recent studies indicated that *P. sorghi* has gained resistance against metalaxyl, suggesting that it might not be as useful for managing the disease in future. In this context, a study was conducted during *kharif* 2016 and 2017 to identify an alternative fungicide to mataxayl to manage the disease. The experiment consisted of ten treatments including three bioagents viz., *Bacillus amyloliquefaciens*, *Trichoderma harzianum* and *T. viride* and three fungicides viz., Fosetyl-al, Azoxystrobin and Metalaxyl + Mancozeb, with three replications under Randomized Complete Block Design. The study revealed that seed treatment with Azoxystrobin at 0.2% showed 80.90% disease reduction over control with increased grain yield (43.63 q/ha) over untreated control (6.41 q/ha) and recorded better C:B ratio of 2.03. Additionally, Azoxystrobin at 0.2% seed treatment was at par with seed treatment using Metalaxyl + Mancozeb at 0.25% disease reduction, grain yield and C:B ratio. Hence seed treatment with Azoxystrobin at 0.2% can be effectively used to manage the SDM disease of maize as an alternative to Metalaxyl + Mancozeb at 0.25% seed treatment.

TS6-40: Integrated Management of *Turcicum* Blight of Maize Caused by *Exserohilum turcicum*

Jagadish Baraskar* and V.K. Paradkar

AICRP on Maize, Zonal Agricultural Research Station, JNKVV, Chindwara 480001 India.
*Corresponding author Email: baraskar.jagadish@gmail.com

Maize (*Zea mays* L.) is an important cereal crop with high economic value, after wheat and

rice, in the world. It has a short growing season and is drought resistant, making it very easy to grow in different climatic conditions of the world (Amin 2011). Insect pest infestation is a major threat to maize due to the crop's high susceptibility throughout the crop cycle. Maize stem borer (*Chilo partellus* Swinhoe) is the most common destructive insect pest of maize crop (Andow and Hilbeck 2004, Groote et al. 2011). It causes dead hearts, reduced translocation, ear damage, lodging, initial leaf senescence and in severe cases, complete crop failure (Naz et al. 2003, Gupta et al. 2010). The experiment was conducted for the management of insect pest of maize in Chhindwara under rainfed conditions during *kharif* 2017 at experimental farm JNKVV, Zonal Agricultural Research Station, Chindwara. The study of the bio efficacy of different doses of Carbofuron 3% G and other insecticides under different treatments were T1- Carbofuron 3% G at 33kg/ha (Whorl application), T2 - Carbofuron 3% G at 66kg/ha (Whorl application) , T3 - Carbofuron 3% G at 133kg/ha (Whorl application), T4- Dimethoate 30 EC at 660ml/ha (Foliar application), T5- Monocrotophos 36% SL at 625ml/ha (Foliar application, T6- Thiamethoxam 12.6 % + Lambda Cyhalothrin 9.5 % ZC at 125ml/ha (Foliar application) and T7- Untreated control. The first application of insecticides was made 15 days after crop germination. Results revealed that among the different treatments of insecticides, the best treatment was T3 - Carbofuron 3 % G at 133kg/ha (Whorl application) with the highest yield, followed by T2, T1, T4 and T6.

TS6-41: Study the Bio Efficacy of Different Doses of Carbofuron 3% G and other Insecticides Against the Insect Pest of Maize Crop

Jagadish Baraskar* and V.K. Paradkar

AICRP on Maize, Zonal Agricultural Research Station, JNKVV, Chindwara 480001 India.
*Corresponding author Email: baraskar.jagadish@gmail.com

Maize (*Zea mays* L.) is an important cereal crop with high economic value, after wheat and rice, in the world. It has a short growing season and is drought resistant, making it very easy to grow in different climatic conditions of the world (Amin 2011). Insect pest infestation is a major threat to maize due to the crop's high susceptibility throughout the crop cycle. Maize stem borer (*Chilo partellus* Swinhoe) is the most common destructive insect pest of maize crop (Andow and Hilbeck 2004, Groote et al. 2011). It causes dead hearts, reduced translocation, ear damage, lodging, initial leaf senescence and in severe cases, complete crop failure (Naz et al. 2003, Gupta et al. 2010). The experiment was conducted for the management of insect pest of maize in Chhindwara under rainfed conditions during *kharif* 2017 at experimental farm JNKVV, Zonal Agricultural Research Station, Chindwara. The study of the bio efficacy of different doses of Carbofuron 3% G and other insecticides under different treatments were T1- Carbofuron 3% G at 33kg/ha (Whorl application), T2 - Carbofuron 3% G at 66kg/ha (Whorl application) , T3 - Carbofuron 3% G at 133kg/ha (Whorl application), T4- Dimethoate 30 EC at 660ml/ha (Foliar application), T5- Monocrotophos 36% SL at 625ml/ha (Foliar application, T6- Thiamethoxam 12.6 % + Lambda Cyhalothrin 9.5 % ZC at 125ml/ha (Foliar application) and T7- Untreated control. The first application of insecticides was made 15 days after crop germination. Results revealed that among the different treatments of insecticides, the best treatment was T3 - Carbofuron 3 % G at 133kg/ha (Whorl application) with the highest yield, followed by T2, T1, T4 and T6.

TS6-42: Enhancing Prolificacy in Maize Through Marker-Assisted Introgression of *Teosinte Branched-1* Gene from *Sikkim Primitive* Landrace

Jeet R. Choudhary*, Rajkumar U. Zunjare, Rashmi Chhabra, Aanchal Baveja, Gulab Chand, Vignesh Muthusamy and Firoz Hossain

ICAR-Indian Agricultural Research Institute, New Delhi, India.
*Corresponding author Email: jrchoudhary1993@gmail.com

Cultivated maize possesses one to two ears per plant, while teosinte accessions are prolific with multiple ears and tillers per plant. *Sikkim primitive*, a novel landrace from North-Eastern Himalayan region of India, produces seven to nine ears per plant. However, the landrace cannot grow well in different agro-climatic zones due to specific adaptability. *Teosinte branched-1* (*tb1*) has been identified as the major gene that governs prolificacy in maize. So far, *Sikkim primitive* has not been utilized in the Indian maize breeding program. The present study thus aimed to introgress *tb1* gene from *Sikkim primitive* into seven elite inbreds (HKI-323, HKI-1105, HKI-1128, HKI193-1, HKI-193-2, HKI-161, and HKI-163) using marker-assisted breeding strategy. These inbreds are the parents of nine commercially released hybrids in India. 100-120 individuals across populations in BC1F1 and BC2F1 were genotyped using *tb1*-specific markers viz., PZD00101, GS-7 and PZD000117 present in the controlling region of the gene. Heterozygotes in BC2F1were selfed to generate BC2F2 populations. Background selection was used for recurrent parent genome recovery. Selected segregants resembled their recurrent parents for plant, ear and grain characteristics. The introgressed genotypes being developed here hold significance in baby corn breeding program.

TS6-43: Agro-Morphological Characterization of Maize Inbred Lines in Rampur, Nepal

Jharana Upadhyay[1*], Surya K. Ghimire[1], Jiban Shrestha[2] and Krish H. Dhakal[1]

[1]Department of Genetics and Plant Breeding in AFU, Rampur, Nepal; [2] Nepal Agricultural Research Council, Nepal
*Corresponding author Email: jharana.up@gmail.com

Genetic diversity, the basis for hybrid maize breeding, has practical importance to establish heterotic groups and patterns of inbred lines. To assess the genetic diversity of maize, 30 selected inbred lines received from different sources in the past at the National Maize Research Program were evaluated for agro-morphological traits. The experiment was laid out in alpha lattice design with three replications at agronomy farm of NMRP, Rampur during winter season of 2016/17. High magnitude of genetic variation was observed for grain yield and other important agro-morphological traits among the studied inbred lines. The grain yield had significantly positive correlation to plant and ear numbers per unit area, ear length and girth, numbers of kernel rows per ear, numbers of kernel per row and 1000 kernel weight. Commonly used testers for hybrid maize breeding at NMRP namely, RL-111, RML-115, RML-97, RML-85 and RML-96, showed more divergence and higher grain yield performance among the tested entries. The principal component analysis revealed that plant and ear height, and numbers of kernel per row are the major contributors to the total divergence. The studied inbred lines were grouped into six clusters from multivariate analysis where cluster I contained highest numbers of inbred lines (15), cluster II, IV and VI contained lowest number of inbred lines (one). Cluster III had 10, while cluster V had two inbred lines. Inbred lines RL-105, RML-17, RL-101 might be possible broad-based tester for hybrid maize breeding. From this study, wider variability

found among the different clusters suggest higher probabilities of getting heterotic hybrids if selection of parents is done from these pairs of groups.

TS6-44: Variability for Grain Filling and Associated Traits in Maize Germplasm Under Sub-Tropical Production Conditions

Jyoti Kaul*, T. Nepolean, Ganapati Mukri, Jayant S. Bhat, R.N. Gadag, Digvender Pal and Rajesh Kumar

Division of Genetics, ICAR-IARI, New Delhi, India.
*Corresponding author Email: kauljyoti1@yahoo.co.in

In maize (*Zea mays* L.), the efficiency of a breeding program depends mainly on the direction and magnitude of the association between grain yield (GY) and its components - especially kernel number (KN) and individual kernel weight (KW) - which are influenced by environmental conditions during the flowering stage and grain-filling period (GFP), respectively. KW is determined by biomass accumulation within kernels during GFP that is dependent mainly on kernel growth rate (KGR) and the duration of the effective filling period (EGFP), both of which are affected by assimilate availability and environment. Understanding the contribution of GFP and KGR to GY is therefore critical in improving the selection method for enhancing GY in maize under short-season sub-tropical production conditions, with erratic precipitation. The objectives of the present study were to estimate the variability in grain filling and associated traits in a set of inbred lines (derived from sub-tropically adapted germplasm) and identify associations between the target traits. The preliminary results based on the study of 37 inbreds during 2016 and 2017 cropping seasons at ICAR-IARI, New Delhi (28° 38' N and 77° E and an elevation of 222 masl), indicated significant variability for grain filling and associated traits. An average of 25.9 days (with a range of 20-30 days) was worked out for total GFP (TGFP) based on days to silking and days to physiological maturity among the lines tested. Significant associations were detected between GFP and phenological and yield component traits. This information would be utilized in identifying QTLs for grain filling which in turn may be used in improving selection efficiency and enhancing per day productivity of subtropical maize.

TS6-45: Classification and Cataloguing of Indian National Gene Bank- Germplasm of Maize Based on Passport and Characterization Data

Jyoti Kaul[1*], Sunil Neelam[2], S.K. Guleria[3], J.S. Chawla[4], Amit Kumar[5], Khushboo Jain[1], D.S. Olakh[1], Sherry Rachel[6], R.K. Tyagi[6] and O.P. Yadav[1]

[1]ICAR-Indian Institute of Maize Research, Pusa Campus, New Delhi, India; [2]ICAR-Winter Nursery centre, Indian Institute of Maize Research, Hyderabad, India; [3]Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Regional Research Station, Bajaura, Himachal Pradesh, India; [4]Punjab Agricultural University Ludhiana, India; [5]Maharana Pratap University of Agriculture & Technology, Udaipur, India; [6]ICAR-National Bureau of Plant Genetic Resources, New Delhi, India.
*Corresponding author Email: kauljyoti1@yahoo.co.in

The efficient exploitation of conserved genetic resources in crops is vital in overcoming problems associated with narrowing genetic base of present-day cultivars. In maize (*Zea mays* L.), the utilization of ~10,000 accessions that are housed in Indian National Gene Bank is hampered by lack of proper characterization and evaluation data. This Gene Bank-held

germplasm represents a potentially useful resource for augmenting maize improvement and maintaining genetic diversity in India. Hence a systematic study initiated in 2014 resulted in classifying and cataloguing of 5000 of these accessions (2369 exotic and 2631 indigenous collections) over a period of two years. Among the exotic germplasm characterized included lines, pools, populations, hybrids, and OPVs that originated from geographically diverse maize growing areas of the world, viz. USA, Mexico, Brazil, Argentina, Italy, Thailand, Indonesia, etc. The indigenous collections were mainly land races/ farmers' varieties, registered germplasm, parental lines of the released hybrids, composites, hybrids etc. The phenotypic characterization data was generated using 30 descriptors, 12 of which were quantitative and the other 18 qualitative. 19 of these were recorded at standing crop and 11 at post-harvest stage, respectively. A wide range in variability was estimated for almost all the traits including days to anthesis (40-68 d) and silking (42-74 d); plant (55-290 cm) and ear (45-180cm) height; leaf, tassel and silk attributes; ear and kernel characteristics, etc. Phenotypic correlations displayed significant associations between various traits in the data-set. The accessions were classified and catalogued based on agro-morphological, phenological and kernel attributes to illuminate their usefulness in subtropical maize breeding.

TS6-46: Genetic Analysis of Water Logging Tolerance in Subtropical Maize

Jyoti Kaul*, Kanika Arora, Shikha Mittal, Ganapati Mukri, M.G. Mallikarjun, Firoz Hussain, Jayant S. Bhat and T. Nepolean

Division of Genetics, ICAR-IARI, Pusa, New Delhi 110 012.
*Corresponding author Email: kauljyoti1@yahoo.co.in

Among various abiotic tresses, water logging (WL) is one of the most important constraints for maize (*Zea mays* L.) production in Asia, frequently affecting around 18% of the total maize growing area in South and Southeast Asia. Such water-logged soils adversely influence seed germination, seedling establishment and early seedling growth which in turn impact overall plant stand and eventually depress grain yield (GY). Therefore, one of the major objectives is to understand functional/ molecular mechanism of water logging tolerance; identify gene/s and develop tolerant hybrids through genetic as well as genomic approaches. During 2014-2016, a set of 50inbred lines were screened for water logging tolerance under managed as well as field conditions. Of these, 10 promising lines were identified and 45 F1 crosses were developed and evaluated in RBD with three replications for GY under managed water logging stress and optimum growing conditions at three and eight locations, respectively. Based on overall performance and yield superiority to the checks (HM9 and HM10), two high yielding hybrids, viz. AWLH1 (CML425 x MGUD1) and AWLH2 (CML425 x HKI1105) were identified. Out of 50 inbreds that were screened under WL stress, HKI1105 emerged as the most tolerant line and was utilized for Transcriptome analysis of the roots using RNA sequencing technique. The investigation provided significant evidence of genes operating under WL stress in the adaptive traits such as ethylene production and aerenchyma formation. Efforts on utilizing RNAseq derived SNPs in improving selection and breeding efficiency in developing genetically diverse WL tolerant hybrids through introgression breeding are being undertaken.

TS6-47: Current Status of Maize Diseases in India

Karambir S. Hooda[1]*, P.K. Bagaria[1], Sujay Rakshit[1], S.S. Sharma[2], Harleen Kaur[3], N. Mallikarjuna[4], R. Gogoi[5], V.K. Malik[6], R.K. Devlash[7], VK Rathee[8], R.P. Singh[9], Pradeep Kumar[9], S.I. Harlapur[10], Rajashekara, H.[11], Phool Chand[12] and P. Renukadevi[13]

[1]ICAR- Indian Institute of Maize Research, Ludhiana, India; [2]MPUAT, Udaipur, India; [3]PAU, Ludhiana, India; [4]UAS, ZARS, Mandya, Mysore, India; [5]IARI, New Delhi, India; [6]CCSHAU, Hisar, India; [7]CSK HPKVV, HAREC, Bajaura, India; [8]CSK HPKVV, HAREC, Dhaulakuan, India; [9]GBPUAT, Pantnagar, India; [10]UAS, Dharwad, India; [11]VPKAS, Almora, India; [12] Tirhut College of Agriculture, Muzaffarpur, India, [13]TNAU, Coimbatore, India
*Corresponding author Email: hoodaks@gmail.com

Among the economically important diseases of maize, *turcicum* leaf blight (TLB: *Setosphaeria turcica*), maydis leaf blight (MLB: *Cochliobolus heterostrophus*), post-flowering stalk rots (PFSR: *Fusarium verticilloides*, *Macrophomina phaseolina*) and banded leaf and sheath blight (BLSB: *Rhizoctonia solani* f.sp. *sasakii*) regularly cause varying degrees of yield losses at different growth stages of crop at national level. MLB (NEPZ and NWPZ); PFSR (NWPZ, PZ and CWZ) and BLSB (NWPZ, NEPZ and CWZ) predominantly damage crop in rainy season whereas TLB is restricted to relatively cooler climates of the country (NHZ, NEPZ and PZ). Five diseases of equal importance viz.; polysora rust (*Puccinia polysora*), sorghum downy mildew (SDM: *Peronosclerospora sorghi*) and late wilt (*Magnaporthiopsis maydis*) in PZ, Rajasthan downy mildew (RDM: *Peronosclerospora heteropogoni*) and cyst nematode (*Heterodera zeae*) in CWZ are restricted to specific regions of India. Recently, BLSB, MLB, common rust (*Puccinia sorghi*), brown spot (*Physoderma maydis*), curvularia leaf spot (CLS: *Curvularia lunata*) and head smut (*Sphacelotheca reiliana*) are also reported from NHZ. Bacterial stalk rot (BSR: *Dickeya zeae*) is restricted to Dhaulakuan and Tarai areas. Interestingly, brown stripe downy mildew (BSDM: *Sclerophthora rayssiae* var. *zeae*) has not appeared in severe form in Dhaulakuan (NHZ) in the last three years, whereas it appeared in high severity in CAL-1443-CIMMYT line at Mandya (PZ) in 2017. This necessitates exploiting host-plant resistance, development of IDM strategy and disease forecasting models for combating these diseases considering changing disease scenario in India.

TS6-48: Evaluating Early Maturing Maize Genotypes in the Hills of Province 7, Nepal

Keshav Prasad Shrestha*, Rabin Giri and Bishnu Prasad Joshi

Nepal Agricultural Research Council, Agricultural Research Station, Doti, Nepal.
*Corresponding author Email: rarsdoti@gmail.com

Evaluating the performance of early maize genotypes is important in constructing breeding materials and implementing selection strategies. With the objective to assess the variation on yield and yield related traits of early maize genotypes in the hill ecology of Province 7, the study was conducted at research field of Regional Agricultural Research Station (RARS), Dotiin summer seasons of 2016 and 2017. A set of fourteen early maize genotypes were evaluated in the experiment laid out in Randomized Complete Block Design (RCBD) with three replications in each year. The significant variation among genotypes was observed for grain yield and yield related traits. The genotype Rajahar Local produced the highest grain yield (2.51 t/ha) in 2016 whereas SO3TEY-LN/PP yielded highest (2.63 t/ha) in 2017. The combined analysis over years revealed that SO3TEY/LM produced highest grain yield (2.37 t/ha), which was statistically similar to ZM-621/POOL-15 (2.31 t/ha) and Rajahar local (2.27

t/ha), whereas Farmers variety recorded the least (0.76 t/ha). Farmers variety was earlier in tasseling (36.83 days) and silking (39.33 days), followed by S97TEYGHAYB (3) and ARUN-4 in tasseling (46.33 days) and S97TEYGHAYB (3) in silking (48.83 days). The lowest plant height and ear height was recorded from Farmers' variety (177.5 cm and 81.67 cm respectively) whereas Rajahar Local was found with highest (267.3 cm and 150.2 cm respectively). Plant breeders in their work of varietal improvement would utilize such information on variation for the agro-morphological traits among studied early maize genotypes.

TS6-49: Heritability, Genetic Advance and Heterosis Study in Maize Doubled Haploid Inbred Lines

Khunsa Khakwani* and Muhammad Aslam

Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan.
*Corresponding author Email: khunsakhakwanioops@gmail.com

The efficiency of maize breeding programs would be significantly enhanced if superior crosses could be predicted before field evaluation based on screening of parental inbred lines. In present study forty doubled haploid maize inbred lines were evaluated for broad-sense heritability (Falconer, 1996), narrow-sense heritability using offspring-parent regression, genetic advance (Falconer, 1989) and heterosis and heterobeltiosis values (Falconer and Mackay, 1996), in a randomized complete block design experiment with three replications, in 2016-17. Data of ten plants from each replication for plant height (cm), cob height (cm), cob diameter (cm), kernel rows per ear, kernels per ear row, 100 grain weight (g), grains per plant and grain yield per plant (g) was recorded. The broad sense heritability and narrow sense heritability was recorded higher for all the studied traits. Higher broad sense heritability was found in grains per cob (99.6%), grain yield per plant (98.8%), cob length (98.2%) and kernels/grains per cob row (98.1%). Higher narrow sense heritability was found in grain yield per plant (87.7%), cob height (79.8%), kernels/ grains per cob row (79.5%), cob diameter (68.7%) and grains per cob (66.1%). Most of the crosses exhibited very high values of Heterosis and heterobeltiosis and ranged from -0.01 to 47.3 % percent for grain yield. The F1 hybrids, L1×T1, L1×T2, L1×T3, L2×T2, L4×T1, L4×T2, L5×T1, L5×T2, L5×T3, L2×T3, L3×T3 and L5×T3 were found to be the best hybrids with very good heterosis and heterobeltiosis values for most of the grain yield related traits, and would be tested at multiple locations for their yield performance. These doubled haploid lines can be directly utilized for varietal development.

TS6-50: Effect of Waterlogging on Biochemical Aspects of Maize

Khushboo Goyal[1*], Kamaljit Kaur[1] and Gurjit K. Gill[2]

[1]Department of Biochemistry, Punjab Agricultural University (PAU), Ludhiana, India; [2]Department of Plant Breeding and Genetics, PAU, Ludhiana, India.
*Corresponding author Email: kgoyal0838@gmail.com

Water logging is a serious threat to crop productivity worldwide. The present investigation was carried out to study the effect of water logging on various biochemical parameters of two maize genotypes, viz., LM-5 (relatively susceptible towards water logging) and I-167 (relatively tolerant towards water logging). One-month-old plants were exposed to water logging

maintained in the field for ten consecutive days. Afterwards, activities of alcohol dehydrogenase (ADH), acid invertase and nitrate reductase (NR) and the contents of total soluble sugars, reducing sugars, sucrose, nitrate and nitrite were determined in the roots and leaves of the genotypes. The roots of I-167 plants had increased ADH but decreased acid invertase activity under waterlogging stress, which showed the efficient tolerance mechanism of this genotype under anaerobic conditions. The roots of I-167 plants showed increased NR activity under flooding stress. Nitrate content increased in roots of flooded I-167 plants but decreased in leaves of both genotypes. Nitrite content decreased in roots of LM-5 plants but increased in leaves under hypoxic conditions. The content of total soluble sugars and reducing sugars increased in the leaves of LM-5 and I-167 genotypes but decreased in the roots of LM-5 plants. The unaltered sucrose contents in I-167 roots might be responsible for the improved stress tolerance efficiency of I-167 plants under water logging conditions.

TS6-51: Mapping of QTLs for Drought Tolerance Component Traits in Maize

Kiranpal Kaur, G.K. Gill*, Y. Vikal and Neha Gupta

Department of Plant Breeding & Genetics, Punjab Agricultural University, Ludhiana, India
*Corresponding author Email: gurjit.gill@pau.edu

Drought is considered as one of the major limiting factors in sustainable maize production all over the world. The objective of this study was phenotypic evaluation of recombinant inbred line (RIL) population for drought tolerance. 160 F_7 RILs from the cross between CM123 (susceptible) female parent and CM140 (tolerant) male parent along with parents were evaluated for drought stress just before and during flowering, and data recorded for morpho-physiological and yield traits. Parental polymorphism survey was done with 317 SSR markers and 90 were found polymorphic. A linkage map of 674.76 cm length was constructed with 90 polymorphic SSR markers on 86 RILs. Both genotypic data and mean value of phenotypic data of each trait was analysed using QTL cartographer and QTLs on chromosome 1, 3, 4, 6, 7 and 9 were identified for drought tolerance under both stressed and non-stressed water regimes. In total, 12 QTLs were detected out of which seven QTLs were found in drought stressed population and five QTLs in well irrigated plants. Three QTLs were found each for SPAD and RLWC, one QTL for each of the other traits (i.e. days to silking, ear length, ear weight, cob weight) and remaining two for number of kernel rows. The putative QTL *qKPE1* for number of kernel rows was found on chromosome 6 (bnlg1617-bnlg1740) which explained maximum phenotypic variance of 31.62% under stressed environment. Fine mapping of identified QTL regions may provide useful information of genes underlying quantitative drought tolerance that can be further used in for genetic and breeding studies.

TS6-52: Variation in Phenotypic Characters of Maize Genotypes at Mid-Western Region of Nepal

Kiran Pariyar, Pradeep Sapkota, Sashi Ram Sharma and Binod Prasad Luitel*

Horticulture Research Station, Kimugaon, Nepal Agriculture Research Council, Dailekh, Nepal.
*Corresponding author Email: binodsan@yahoo.com

An experiment was conducted to evaluate the morphological characters of maize genotypes at Horticultural Research Station, Dailekh, in 2016 and 2017. Altogether, seven genotypes

consisting of BGBY POP, BLSPRSO7, Across 9942/9944, Across 9331/RE, TLBRSO7 along with two check varieties (Deuti and Local) were tested. The trial was laid out in Randomized Complete Block Design with three replications. Data on morphological and yield attributing traits were recorded. The results over the years revealed significant differences for days to maturity, plant height, ear height, number of kernels per row and grain yield. Furthermore, highest grain yield was recorded in Across 9944/9942 (7.24 t/ha) followed by BLSPRSO7 (6.73 t/ha). Similarly, number of kernels per row was maximum in Across 9942/9944 (37.6) followed by Deuti (37.1). Significant variation in ear height was observed, which ranged from 125.4 cm (Across 9944/9942) to 146 cm (local variety). Local variety was found to be early maturing (114 days after sowing) while Across 9942/9944 was late maturing (119 DAS). Correlation analysis revealed that ear population, plant population and plant height determined yield and simultaneous selection for these traits might improve grain yield. This study revealed that Across 9931/RE is a potential genotype for yield and for further maize breeding.

TS6-53: Towards Mapping of QTL for Resistance to Fusarium Stalk Rot in Maize

Lalit[1], Maninder Kaur[2], Harleen Kaur[1], J.S. Chawla[1] and Yogesh Vikal[2*]

[1]School of Agricultural Biotechnology, Punjab Agricultural University, Ludhiana-141004; [2]Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana-141004.
*Corresponding author Email: yvikal-soab@pau.edu

Development of maize cultivars with genetic resistance is the most important and environmentally friendly approach for control of devastating diseases. Fusarium stalk rot (FSR) caused by soil-born fungi *Fusarium verticillioides,* is a widespread and disastrous disease of maize causing total yield losses of up to 38%. Present investigation was undertaken to identify genomic loci controlling FSR resistance using a RIL mapping population derived from a cross between LM5 as the resistant (female) parent and CM140 as the susceptible (male) parent. Using toothpick method of inoculation, 169 RILs and parents were inoculated with mycelium of *Fusarium verticillioides* at post-flowering stage in spring and *kharif* seasons. Disease reaction data showed normal distribution, indicating that the inheritance of FSR is under the control of quantitative loci. Parental polymorphism survey was done with 567 SSR markers and 193 SSR markers were found to be polymorphic. A linkage map of 632.28 cM was constructed by genotyping 92 RILs using 95 polymorphic SSR markers. The quantitative trait loci (QTL) for FSR resistance were detected on chromosomes 3, 8 and 9. Five minor QTL identified in either or both seasons explained phenotypic variance from 5.0 to 11.24%. A putative major QTL peak at LOD score of 4.2 on chromosome 3 between the flanking markers umc2118 and bnlg1647 explaining maximum phenotypic variation of 23.07 per cent was detected in both environments. The study is being extended to genotype all 169 RILs by applying more SSR markers of chromosome 3 to saturate the QTL region. This may provide useful information for genetic and breeding studies on FSR resistance and development of markers to practice marker assisted selection (MAS).

TS6-54: Resistance of Improved Maize Germplasm to Rice Weevil *Sitophilus oryzae* L.

Lakshmi Soujanya P.[1]*, Chikkappa G.K.[2], Sekhar J.C.[1], Suby S.B.[2], Sunil N.[1] and Sujay Rakshit[3]

[1]Winter Nursery Centre, ICAR-Indian Institute of Maize Research, Rajendranagar, Hyderabad - 500 030, India; [2]ICAR-Indian Institute of Maize Research, Pusa Campus, New Delhi Unit - 110 012, India; [3]ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana - 141001, Punjab, India.
*Corresponding author Email: soujanyak.scientist@gmail.com

Postharvest loss in maize is caused by a wide array of insect pests. Rice weevil (*Sitophilus oryzae* L.) is the most destructive insect pest which damages maize grain during storage. In tropical countries, up to 80% loss has been reported in untreated maize due to infestation by *Sitophilus* sp. Although synthetic chemical insecticides are effective, their use is restricted due to negative effects on the environment and development of resistance in insects. In this context, use of host plant resistance would be a sustainable option, especially to resource poor farmers. Understanding the genetics of resistance is the first step to transfer host plant resistance from one genetic background to another. In the present study, the seeds of five inbred lines comprising two resistant lines (CM 149, Ent 2-3), one moderately resistant (EC 645987) and two susceptible (5183, Acc No 527290), F_1s - involving either resistant/moderately resistant and susceptible inbred lines - along with $F_{2:3}$s were evaluated for their relative susceptibility to *S. oryzae* by No-Choice test method under laboratory conditions. The Dobie index of susceptibility was used to group the genotypes. The weevils that fed on the resistant genotypes produced low number of F_1 progeny, had a high median developmental time and caused low grain weight loss. None of the F_1s were resistant. However, the seed of $F_{2:3}$s of a cross 5183 × EC 645987 was found to be resistant, while CM 149 × Acc No 527290, EC 645987 × 5183 and CM 149 × 5183 were found to be moderately resistant. The above result indicates the complex nature of genetics of resistance involving maternal effects and needs further investigation.

TS6-55: Efficacy of Bio-Pesticides against Spotted Stem Borer *Chilo Partellus* (Swinhoe) in Maize

Lavakumar Reddy M.[1*], P. Lakshmi Soujanya[2], J.C. Sekhar[2], D. Sreelatha[1] and V. Narsimha Reddy[1]

[1]Maize Research Centre, PJTSAU, ARI, Rajendranagar, Hyderabad 500 030, Telangana, India; [2]Winter Nursery Centre, ICAR-Indian Institute of Maize Research, Hyderabad 500 030, Telangana, India.
*Corresponding author Email: mlkreddy2003@yahoo.co.in

Maize (*Zea mays* L.) is the most widely grown cereal crop in India after rice and wheat, and is grown for various purposes including fodder, food and as a basic raw material for industrial products. The productivity of maize is challenged by various biotic and abiotic factors. Among biotic factors, over 130 insect pests cause varying degrees of damage from seedling to maturity stage of maize crop. Out of these insect pests, stem borers cause yield losses ranging from 25.7 to 78.9 percent (Chatterjee *et al.*, 1969). The spotted stem borer, *Chilo partellus* (Swinhoe) is the key pest throughout India during rainy season (Siddiqui and Marwaha, 1993) and has a wide host range in cultivated and wild species (Khan *et al.,* 1997: Van den Berg *et al.,* 2001). The shift from synthetic insecticides to biopesticides is necessary for the management of *C. partellus* due to environmental concerns and insecticide resistance. Hence, a field experiment was conducted in randomized block design during *Kharif* 2016 and 2017 at Maize Research Centre, Hyderabad, Telangana to evaluate the efficacy of bio-pesticides against *C. partellus*

with single cross hybrid DHM 117. There were eight treatments including formulations of three different isolates of *Beauveria bassiana*, single isolate of *Metarhizium* sp., *Bacillus thuringiensis*, neem, monocrotophos (state recommended chemical) along with untreated control. Among the treatments, neem formulation (1500 ppm) at 5 ml/l of water followed by *Bt* formulation at 5 g/l of water and Bb-5a isolate of *Beauveria bassiana*, $1x10^8$ spores per ml at 10 ml/l of water proved effective based on leaf injury rating and grain yield. However, chemical control with monocrotophos at 1.6 ml/l of water was found to be superior among all the treatments in reducing the *C. partellus* damage.

TS6-56: Selection of Maize Hybrids for Lands Shifting from Rice-Growing Areas of Less Economic Efficiency in the Mekong Delta of Vietnam

Le Quy Kha

Institute of Agricultural Sciences for Southern Vietnam, 121 Nguyen Binh Khiem Street, District 1, Ho Chi Minh City, Vietnam.
Email: lquykha@gmail.com

Within a national project of hybrid maize development for Mekong Delta since early 2014, yield trials of 20 officially and provisionally released maize hybrids - sourced from Vietnamese institutions and the private sector as checks including Syngenta (NK67) and Dekalb (DK9901) - were sown in Dong Thap, Hau Giang and Long An provinces in the Mekong Delta, in minor acid sulphate soils with a pH of 5.0-5.5. The trial included three replications in an Alpha lattice design conducted during spring-summer in 2014. The hybrids flowered at 50-52 days after planting and physiologically matured between 93-97 days after planting, suggesting they would be suitable for cropping systems with three seasons per year. The average yield of the genotypes across locations was 52.03, 54.92 and 57.60 quintals/ha, respectively, and the heritability of genotypes in each location was 0.51, 0.81 and 0.61, respectively. The mean yield of DK9901 was 58.19 quintals/ha, ranking 7th among 20 hybrids, and NK67 was 47.58 quintals/ha, ranking 19th. The grand mean was 54.92 quintals/ha and heritability for all genotypes was 0.79. The highest yield was produced by the Southern Seed Company hybrid SSC474 (69.39 quintals/ha), significantly higher than DK9901 (58.19 quintals/ha) at $P < 0.05$, followed by VS71 from National Maize Research Institute (NMRI) at 63.52 quintals/ha, and LCH9A from NMRI at 63.39 quintals/ha. Although the yield of the VS71 hybrid was greater than the DK9901 hybrid, the ear characteristics were less desirable. Therefore, after comparing these hybrids, it was concluded that SSC474 and LCH9A were the two most suitable hybrids to produce in the Mekong Delta.

TS6-57: Results of Breeding Maize Hybrid MN585 for the Mekong Delta of Vietnam

Le Quy Kha

Institute of Agricultural Sciences for Southern Vietnam, 121 Nguyen Binh Khiem Street, District 1, Ho Chi Minh City, Vietnam.
Email: lquykha@gmail.com

By 2020, close to five million tons annual maize supply in Vietnam will be deficient. The government responded by shifting 80,000 ha of low-efficiency rice production areas in Mekong delta, which is expected to increase growing area to 150,000 ha by 2016-2020. The objective of maize hybrids for this region are high yields, tolerance to acid sulphate soil (a pH of 5.0-

5.5), lodging, BLSB disease and good-looking ear aspects. General combining ability among ten inbred lines showed the highest GCA of inbred line B451 being 35.308, best combined with water logging tolerant tester IAS1 (with GCA value of 1.253). This combination was named MN585, which produced highest yield (12.56 tons/ha) in spring 2014. In spring-summer season, 2016, MN585 produced higher yield in alluvial soils of Dong Thap (12.44 tons/ha) against DK6919 (11.5 tons/ha) and grey soils of Long An (6.41 tons/ha) against DK6919 (5.67 tons/ha). In high water table soils of Hau Giang province, yield of MN585 and DK6919 were equal at 8.27 tons/ ha. Since 2015, promising MN585 has faced four testing seasons, and undergone 13 author testing sites, 17 national VCU testing locations and four large scale demonstrations. This variety produced an average yield of 10.06 tons/ha, which was 9.7% higher than that of checks DK9901/DK6919 (9.17 tons/ha). MN585 silked at 53-55 days after planting, physiologically matured at 97-102 days with ear aspect of 2.0 – 2.5 scores, stiff stalk and low root lodging percentage, tolerance to rust *(Puccinia maydis*), BLSB (*Rhizoctonia Solani*), leaf blight (*H. Turcicum* and H. *maydis*) and low percentage of stem borer (*Ostrinia nubilalis*). Under favorably intensive farming area in Mekong delta, provisionally released MN585 (2018) produced >12 tons/ha.

TS6-58: QTL Mapping for Heat Tolerance Tropical Maize using SNP Markers

Mahendra Tripathi[1*], Sudha K. Nair[2], Surya K. Ghimire[3], M.T. Vinayan[2], Shrawan K. Sah[3], K. Seetharam[2], Madhav P. Pandey[3] and P.H. Zaidi[2]

[1]National Maize Research Program, Rampur, Nepal; [2]CIMMYT, Hyderabad, India; [3]Agriculture and Forestry University, Nepal.
*Corresponding author Email: mptripathi@gmail.com

A set of 202 doubled haploid (DH) tropical maize population derived from a cross between heat tolerance (CML165 x KI145)-B-14-1-B*4-1-BB) and susceptible parent CML286-BB were used to construct a genetic linkage map. The two parents exhibit contrasting characteristics for most of the traits that were mapped. In this study (using a linkage map with 195 SNP markers), quantitative trait loci (QTLs) for flowering traits, agro-morphological traits, key secondary traits, and yield component traits were characterized under natural heat stress conditions of ICRISAT, Hyderabad and OUAT, Bhubaneswar, India in 2016. A total of 49 QTLs (28 in Hyderabad and 21 in Odisha) on 34 QTL positions were identified for anthesis days, silking days, anthesis silking interval, plant height, ear height, internodes length, SPAD index, senescence, leaf firing, tassel blasting, ears per plant, and grain yield on nine chromosomes. Fourteen QTLs were detected with single function, five QTL regions were identified with an effect on two or more traits, six QTL region were tightly linked to effect on the same two or more traits, and nine QTL regions identified with two or more tightly linked expression of separate traits. Two or more overlapping QTLs suggest the presence of genes with pleiotropic effects as well as genetic confirmation of positive correlation between these traits. A comparative analysis of the QTLs herein identified for different traits in heat tolerance maize may have future potential use in molecular marker assisted selection.

TS6-59: Outbreak of Crazy Top Disease of Maize Incited by *Sclerophthora Macrospora* in Karimnagar District of Telangana State, India

Mallaiah B.[1*], Bhadru D.[1], Rajinikanth E.[2] and Manjulath. G.[2]

[1]Maize Research Centre, PJTSAU, ARI, Rajendranagar, Hyderabad 500 030, Telangana, India; [2]Agricultural Research Station, Karimnagar, Telangana, India.
*Corresponding author Email: mallyagrico@gmail.com

Maize (*Zea mays* L.) is the third most important cereal after rice and wheat in the world, as well as in India, contributing about 20% of world's total cereal production. It is known as "Queen of cereal" because of its high production potential and wider adoptability. Maize is affected by several biotic and abiotic stresses, among them, fungal diseases which cause major yield losses. A disease diagnostic survey was conducted in different villages of Karimnagar district in Telangana state to study the incidence of different diseases on maize crop in 2016 and 2017. The pooled data of two years indicated that crazy top incidence was recorded up to 34.5% in certain villages of Karimnagar district, where maize hybrids were sown from 15th September to 10th October. The disease was previously rare in the area. The least incidence of crazy top was recorded in maize fields sown after 15th October in both 2016 and 2017. The disease's prevalence was mostly associated with sowing dates and field conditions rather than hybrid type and has become a major threat in some fields. The major contributors for outbreak of disease in some fields include changing climatic conditions, cultivation practices and season, shifts in sowing dates, introduction of new hybrids with diverse genetic background, and higher adaptability and modified survival mechanisms of fungal pathogen. Results from this survey indicate the need for regular monitoring, formulation and development of effective disease management strategies even for minor diseases to ensure good maize yields under changing climatic conditions.

TS6-60: Identification of New Sources for Southern Polysora Rust Disease Resistance in Maize Germplasm

Mallikarjuna N.*, B.S. Shivakumar, Puttaramanaik, Shobha D. and Jadesha G.

University of Agricultural Science, ZARS, V.C. Farm, Mandya, Karnataka, India.
*Corresponding author Email: malliksmsf@gmail.com

Southern corn rust (*Puccinia polysora*) is an important rust disease that can cause economic damage across the maize growing belts. The disease may quickly increase in intensity when weather conditions are favorable. In view of this, a study was conducted to identify resistant sources against polysora rust disease. A total of 118 genotypes were used to evaluate and identify the source of stable polysora rust resistant lines at All India Co-ordinated Research Project on Maize, ZARS, V.C. Farm, Mandya, for five consecutive years. This was done by artificial inoculation of urediniospores collected from infected foliage the previous season. Of the 118 inbred lines evaluated, six stable polysora rust resistant inbred lines were identified and maintained viz., NAI-138, NAI-175, NAI-197, NAI-204, NAI-207, NAI-209 and CML-410 on rating 1-9 scale. These identified elite lines could be potentially utilized as resistant source in breeding program.

TS6-61: Stability of Turcicum Leaf Blight Disease Resistance in Indian Maize Germplasm

Mallikarjuna N.*, B.S. Shivakumar, Puttaramanaik, Shobha D., and Jadesha G.

University of Agricultural Science, ZARS, V.C. Farm, Mandya.
*Corresponding author Email: malliksmsf@gmail.com

Investigation was carried out to identify and maintain genotypes which show stability for Turcicum leaf blight disease resistance. Present study was carried out at All India Co-ordinated Research Project on Maize, ZARS, V.C. Farm, Mandya. After three consecutive years of screening (2015-2017) under artificial eptiphytotic conditions through leaf whorl inoculation technique, a total 118 inbred lines were evaluated to identify stable resistant lines. Of these, six inbred lines viz., NAI-138, NAI-175, NAI-197, NAI-226, KUI-1411, and KUI-1411A showed high level of stable resistance (≤ 3.0 by 1 – 9 scale), and seven inbreds viz., NAI-165, NAI-174, NAI-176, NAI-178, CML-410, NAI-142 and NAI-125 (3.1–5.0 by 1 – 9 scale) showed moderate level of resistant reaction to TLB. Therefore, lines with high level of resistance (low disease score) in the present study could be used successfully in developing genotypes having desirable level of resistance against TLB disease endemic areas to achieve for sustainable productivity.

TS6-62: Nanotechnology: An Emerging Potential Technology for Sustainable Maize Production

Mamta Gupta[1,2]*, Sarvjeet Kaur[1], Alla Singh[2], Mukesh Choudhary[2], Krishan Kumar[2] and Sujay Rakshit[2]

[1]Division of Molecular Biology and Biotechnology, ICAR-Indian Agricultural Research Institute, New Delhi, India; [2]ICAR- Indian Institute of Maize Research, PAU Campus, Ludhiana, India.
*Corresponding author Email: mamta14biotech@gmail.com

Among all other scientific fields, nanotechnology is emerging as a potential technology for inventive research in maize. It has wider applicability to enhance productivity through unremitting innovations. The benefits and utilities from nanotechnology are enormous. Emergence of nanotechnology creates hope among maize scientists to address the problems or issues which cannot be solved through conventional approaches. Nanoparticles of 1 to 100nm size, which attain different physio-chemical properties, can alter seed germination, overall plant growth and quality of maize plant. This technology can become a prominent strategy for disease and pest management in maize through application of metallic and bio-conjugated nanoparticles-based pesticides and fungicides, nanosensor-based detection of maize pathogens. This will assist maize researchers to formulate novel management strategies against phytopathogens and insect-pests. It has wider utility in delivering and slow release of fertilizers, micronutrients and water; detection of crop nutrient status; soil fertility; pH and temperature; enhancement of herbicidal penetration efficiency through nanoencapsulated formulations; pesticide absorption through cellulose-based nanofibers; nanoclays in water purification; cheaper production of ethanol by using nanoengineered enzymes; mesoporous silica based nanoparticle (MSN) mediated gene transfer; and use of maize husk in preparation of bio-nanocomposites for industrial use. These applications of nanoparticles and nanosensors will provide the opportunities for precision farming through judicious use of resources with more efficacies during cultivation of maize crop, with eventual benefit in

sustainable maize production. So, it is necessary to bring this technology to farmers' field in a cost effective and professional manner.

TS6-63: Naturally Bt-Fortified Native Corn in the Philippines: Status and Challenges

Merdelyn Caasi Lit[1*], Artemio M. Salazar[2], Jefferson F. Paril[3], Sancho G. Bon[3] and Bryan V. Novio[1]

[1]Entomology Laboratory, Institute of Plant Breeding, College of Agriculture and Food Science, University of the Philippines Los Baños (UPLB), College, 4031 Laguna, Philippines; [2]Retired Research Professor, Cereals Breeding, Institute of Plant Breeding, College of Agriculture and Food Science, UPLB, Philippines; [3]Institute of Plant Breeding, College of Agriculture and Food Science, UPLB, Philippines.
*Corresponding author E-mail: binglit610429@gmail.com

Several varieties of native corn - mainly germplasm collection from the National Plant Genetic Resources Laboratory - were used in breeding for Asian corn borer (ACB) resistance in the Philippines in the 1980s by the Institute of Plant Breeding (IPB). Efforts to collect were continued after hundreds of accessions were destroyed by supertyphoon Milenyo (Typhoon Xangsane) in 2006. Only recently, a government banner program entitled "Corn Germplasm Utilization through Advanced Research and Development (CGUARD)" has been spearheaded by the Department of Agriculture (DA) through the Bureau of Plant Industry in collaboration with IPB. The program aims to collect and conserve native corn around the country and screen these materials for resistance/tolerance to biotic and abiotic stresses, particularly for ACB resistance. However, what happens to the native corn after the introduction of Bt corn in the country in 2003? At present, out of almost 2,000 accessions collected, 200 were screened for ACB resistance and some of these accessions have been detected to have been naturally introgressed with the gene for toxic Bt crystal protein. This poses a great challenge to improving agronomic traits of native corn that are already well adapted to local conditions and stresses, and that possess greater protection against ACB. The paper aims to discuss the status and challenges of native corn in the Philippines with emphasis on resistance to the Asian corn borer, *Ostrinia furnacalis* (Guenee).

TS6-64: Genetic Analysis of Some Maize Inbred Lines

Mesut Esmeray[1] and Kayıhan Z. Korkut[2]

[1]Maize Research Institute, Sakarya, Turkey; [2]Namık Kemal University, Tekirdağ, Turkey.
*Corresponding author Email: mesut.esmeray@tarim.gov.tr

The study was carried out to determine genetic parameters of grain yield and other quantitative traits by crossing ten diverse maize inbred lines in half diallel cross. In this study, plant height, number of grains per row, number of rows per ear, 1000 grain weight, flowering time, grain moisture and grain yield were investigated. The purpose of this study is to evaluate ten inbred lines and their 45 F1 hybrids in half diallel cross for heterosis, combining ability and some genetic parameters; identify the high general combining ability (GCA) lines that could be used as parental lines in breeding program for specific traits; to identify promising hybrids with high specific combining ability (SCA) that could be used commercially; and to study the possibility of predicting heterosis and combining ability in maize traits. GCA and SCA estimation of genetic parameters analysis of these traits were performed. GCA were significant in all features. SCA were significant in all features except grain moisture.

TS6-65: Present Status and Future Prospects of Maize Crop in Pakistan

Muhammad Arshad*, Waseem Akbar, Aamir Hussain, Hafiz Mutahhar Javed and Ghulam Murtaza

Maize and Millets Research Institute, Yusafwala-Sahiwal.
*Corresponding author Email: directormmri@gmail.com

Maize is third most important crop in Pakistan after wheat and rice. It is grown on an area of 1.33 million hectares, with a production of 6.13 million tons and average yield of 4.6 tons/ha. Punjab constitutes 62% of the total maize area and 89% of production, followed by KPK with 37% area and 10% production. Autumn and spring are the two main cultivating seasons for maize in Pakistan. Pakistan has a well-established research network for maize crop, consisting of public and private seed companies, with an outcome of almost 65 maize hybrids and OPVs. Half of these hybrids and OPVs were contributed by the public sector, particularly the Maize and Millets Research Institute (MMRI), Yusafwala Sahiwal (Punjab) and the Cereal Crop Research Institute (CCRI) Pirsbak (KPK). In 2016/ 2017 maize seed requirement of 33,270 MT was achieved by indigenous (66%) and exotic sources (34%). Maize is consumed by feed industry (65%), wet-milling (20%), fodder/ silage purposes (10%) and for seed purposes (5%). Expanding poultry and dairy sectors (8-10% per annum) not only ensure maize market stability, but also predict increasing demand of maize grain and fodder. Silage industry, driven by the dairy sector, is also growing fast. MMRI Yusafwala- Sahiwal is the only public research institute (with its sub-stations) in Punjab working for varietal development in addition to development of production and protection technology of maize crop. Introduction of doubled haploid technology and nutritional enhancement of maize crop are two new projects funded by the Punjab Government. The institute is also working in collaboration with CIMMYT under AIP and HTMA programs.

TS6-66: White Maize Hybrids to Mitigate Climate Change in Pakistan

Muhammad Ashraf[1*], AbduRehman Beshir[2], M. Shafiq Zahid[1], M. Amir Maqbool[1] and Ehtisham Shakeel[1]

[1]Pakistan Agriculture Research Council, National Agriculture Research Center, Crop Sciences Institute, Maize Sorghum Millet & Fodder Program, Pakistan; [2]CIMMYT, Nepal.
*Corresponding author Email: mashraf59@yahoo.com

Multi-environment performance trials are essential to identifying superior genotypes for final selection cycles, particularly using genotype-environment (GE) interaction. The objective of this study was to identify stable hybrids through biplot statistics. Thirty-six white maize hybrids developed by public and multinational seed companies (MSC) - including hybrids from CIMMYT - were evaluated under nine environments in maize cropping zone of Pakistan during autumn 2015 in a randomized complete block design. Significant effects of genotypes (G), environments (E) and their interaction (GE) were reported. However, the highest percentage of variation was explained by E (56.42%) while G and GE effects together explained the rest of variation (<40%). Joint effects of genotype and interaction (G+GE) were partitioned using GGE biplot analysis where the first two components were significant, explaining 33.9% PC, and 17.9% PC2, respectively. It is concluded that four locations, viz, Mangamandi, Faisalabad, Yousafwala and Sahiwal showed higher stability as closer to origin (shorter vector), while the other five were unstable as far away from origin, viz., Islamabad, Mardan, Swabi Dadu and

Pirsbak (greater vector). Similarly, eight hybrids (WHYB-7, WM-3388, WHYBL-12, MEXWHYB-4, WHYBL-11, 3055, WHYBM-20, WHYB-3) were closer to origin and considered more stable. Three hybrids (DK- 4130, NARC-2704, MEXWHYB-1) showed maximum distance from origin and considered as unstable.

TS6-67: Catalase and Ascorbate Oxidase Correlate with Salinity Tolerance in Maize Seedlings

M. Motiar Rohman[1], Shahnewaz Begum[1], M. Amiruzzaman[1] and M. Aziz Zilani Chowdhury[2]

[1]Plant Breeding Division, Bangladesh Agricultural Research Institute, Gazipur 1701, Bangladesh; [2]Crops Division, Bangladesh Agricultural Research Council, Dhaka 1215, Bangladesh.
*Corresponding author Email: motiar_1@yahoo.com

Catalase (CAT, EC 1.11.1.6), Ascorbate peroxidase (APX, EC 1.11.1.11), Glutathione peroxidase (GPX, EC 1.11.1.9) and Peroxidase (POD, EC 1.11.1.7) are important reactive oxygen species (ROS) scavengers in plant cells controlling their potential impacts on cellular metabolism and functions. Therefore, it is important to know the particular scavenger contributing tolerance to maize under salinity. Ten-day old seedlings of five preselected maize hybrids (P1×P7 as tolerant, BMH-5 as sensitive and BHM-7 and BMH-9 as moderate tolerant) grown on rock media were subsequently transferred to a hydroponics culture supplied with Hoagland nutrient solution containing 150 mM NaCl. Fully expanded leaves of 0, 3, 6 and 9 days stressed seedlings were subjected to measure ROS (super oxide (O2•-) and H2O2), NADPH-oxidase (NOX), malondialdehyde (MDA), lipoxygenase (LOX) and ROS related metabolites. Phenotypes of the hybrids under stress correlated with ROS generation, MDA concentration and activities of NOX and LOX. Higher activities of CAT and APX in P1×P7 followed by BHM-7 and BHM-9 focused their important role in ROS scavenging, while lower activities of those enzymatic antioxidants in sensitive hybrids were unable to remove ROS efficiently. Time dependent expression of SOD isozymes were almost similar in all the hybrids. The intensification in the protein bands of CAT and APX isozymes in tolerant hybrids suggested their role in ROS metabolism. On the contrary, almost similar changes in POD and GPX isozymes signified their role in both tolerant and sensitive hybrids. Therefore, highly expressed CATs and APXs could be utilized in improving salinity tolerance in maize through biotechnological approaches.

TS6-68: Effects of Smog on Yield and Quality of Autumn Maize Crop in Punjab, Pakistan

Muhammad Rafique*, Khunsa Khakwani, Ahsan Raza Malhi, Muhammad Altaf and Saira Saleem

Maize Research Station, Ayub Agriculture Research Institute, Faisalabad, Pakistan.
*Corresponding author Email: maizefsd@gmail.com

The main corn growing area of the province of Punjab is under the worst smog crisis; from early grain filling stage to final cob harvesting i.e., October to December. In images released by the National Aeronautics and Space Administration (Nasa), winds filled with smoke emitted from stubble burning (about 32 million tons of previous crop residue) created a heavy thick curtain of photochemical smog, blotting out the sunshine. With the start of smog precedence at first half of October, the maize crop is at "full canopy" development with the ability to collect maximum sunlight. The most sensitive periods of crop growth (early grain filling) is the most

susceptible to this stress of insufficient light. Amount of PAR available to the crop is reduced by more than 50%, which has a large effect on crop yield and quality. The shading significantly decreased maize yield, endosperm filling status, starch quantity and grain weight. In addition, aborted ear tip kernels, poor stalk quality and premature plant death was reported. Root development was affected in the upper soil layer, significantly decreasing root dry weight, root/shoot ratio, root length density and root absorption area. The crop is susceptible to disease (stock rot) and pest (termite) attacks under these adverse meteorological conditions. Growers should monitor stalk quality and schedule harvesting based on lodging potential, rather than just grain moisture. The results of the study will be helpful for hybrid selection and improving cultural practices for enhancing maize smog resistance cultivars in the affected region.

TS6-69: Development of Multiple Abiotic Stress Tolerance Hybrid Maize for Climate Smart Agriculture

M.S. Uddin[1*], Begum F.[1], Rohman M.M.[1], Hossain M.G.[1], Ahmed A.[1], Ahmed M., Billah M.[2], Hossain N.[3], Akther S.[2], Bagum S.A.[1], Rahman M.A.[1], Sarker M.B.[1], Hossain M.I.[1], Azam M.G.[4], Hakim M.A.[5], Barma N.C.D.[5] and Amiruzzaman M.[1]

[1]Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh; [2]Patuakhali Science and Technology University, Patuakhali, Bangladesh; [3]Hajee Mohammad Danesh Science & Technology University, Dinajpur, Bangladesh; [4]Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur; [5]Bangladesh Wheat and Maize Research Institute, Dinajpur, Bangladesh. *Corresponding author Email: shalimuddin@yahoo.com

Maize is exposed to multiple abiotic stresses in field. We conducted a series of experiments in both green house and field to determine combining ability over the environment, multiple trait-multiple environment selection index, and identification of a climate smart maize hybrid. A total of 145 inbred lines were crossed with two testers at two locations in isolation. Test-crossed hybrids were evaluated at green house under hydroponic culture for salinity, drought, water logged and low-phosphorus stresses at seedling stage, in six different field locations in Bangladesh - including saline and drought – and with six popular commercial checks. The heritability (h2) ranged from 0.49 to 0.95. Genetic variance was found to be low to moderate (0.15–0.47) for most traits. BLUPs revealed strong positive correlation between BLUPs and means, which is shrinkage of the BLUPs toward the mean of population. The hybrid × traits biplot showed superior hybrids with a relatively greater expression of combinations of favourable traits. GCA, SCA and SCA×Environment variances were highly significant for seedling characters and yield in different environments. The GGE biplot comprises both hybrids and environments. The two axes explained 70.6% of the total variation. The six environments fell in four of the nine sectors. The stability of the 296 hybrids tested using GGE biplot revealed that some had good adaptability with high yield, and others were poorly adapted and low yielding. Three distant mega-environments were identified. Based on results, five highly promising hybrids were selected for commercial exploitation.

TS6-70: GGE Biplot and AMMI Analysis of Multi-Environment Yield Trials in Imported and Local Maize Hybrids in Bangladesh

M.Z.A. Talukder, M.S. Uddin, M.A. Miah, A.A. Mondal, S. Hossain, M.A. Islam and M. Amiruzzaman

Plant Breeding Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh.
*Corresponding author Email: zahirbari@yahoo.com

Multi-environment yield trials in maize are important for evaluation of genotype by environment (GE) interaction, and identification of superior stable hybrids with high grain yield. Every year hybrid maize seeds are imported by seed companies and are popular amongst maize growers. The experiment was conducted with 14 hybrids evaluated at six different locations viz; Gazipur, Rangpur, Jamalpur, Barisal, Jessore and Hathazari, following alpha lattice design with three replications in 2015/ 2016. The objective of this study was to evaluate stability and adaptability of grain yield of imported and locally bred maize hybrids by AMMI model (additive main effects and multiplicative interaction) and GGE (Genotype and Genotype by Environment Interaction) biplot analysis for selection of stable hybrids for farmers. Significant variation for genotypes (G), environment (E) and GEI were observed for the character studied. The environment Gazipur, Hathazari, Jessore and Jamalpur were poor, but Rangpur and Barisal were suitable for hybrid maize production. Considering the mean, bi and S2di all the hybrids showed different adaptability responses under different environmental conditions. Among the hybrids, IM 8119 produced the highest yield (12.29 t/ha) followed by MZ04 (11.28 t/ha). Hybrids MZ04, 981, 9120, 9155, IM8119 and BHM 9 exhibited high yields as well as stability across all environments. Although the hybrids PAC 999 super and Pacific 559 were high yielding, they were location specific. CN-WC 002 was a stable but low yielding hybrid. Imported hybrids IM8119 and MZ04 were stable according to both AMMI and GGE methods.

TS6-71: Evaluation of Early Maturity Maize Genotypes for Resistance Against MLB and Charcoal Rot

Mukesh Choudhary*, Vishal Singh, Pravin Kumar Bagaria, M.C. Dagla and Vinay Mahajan

ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana-141 004, India.
*Corresponding author Email: mukesh.choudhary1@yahoo.com

Maydis leaf blight (MLB) and charcoal rot caused by *Cochliobolus heterostrophus* and *Macrophomina phaseolina*, respectively, are the serious fungal diseases of maize in India. MLB shows its prevalence in warm and wet temperature whereas charcoal rot occurs in arid regions. In the present study, a set of 28 early maturity genotypes along with a susceptible check (CM 600) were screened to identify stable sources of MLB and charcoal rot resistance. The screening against MLB was carried out at Karnal and Ludhiana in *Kharif* 2017, whereas screening against charcoal rot was carried out in Spring and *Kharif*, 2017, at Ludhiana. The disease reaction was scored based on 1-9 rating scale and the genotypes were classified into resistant, moderately resistant, moderately susceptible and susceptible categories. The ANOVA for disease score revealed significant differences among genotypes for MLB and charcoal rot resistance. The location and genotype-location interaction effect were significant for MLB. For charcoal rot, season effect was not significant, but the genotype-season interaction effect was. The results indicated that ML70062 exhibited resistance against MLB, whereas five genotypes (ML104118, ML104030, ML70337, ML7021 and ML70307) exhibited resistance against charcoal rot. Three genotypes (ML104121, ML70485 and ML70062) exhibited moderate resistance against both MLB and charcoal resistance. Cluster analysis revealed the presence of significant diversity among genotypes grouping them into three major clusters. Thus, the identified sources of resistance can be utilized for the development of promising hybrids with inbuilt resistance against MLB and charcoal rot.

TS6-72: Genetic Gain under Heat Stress Condition

Muttappa Hosamani[1*], Prakash H. Kuchanur[1], I. Shankergoud[1], Ayyanagouda Patil[1], M.T. Vinayan[2], K. Seetharam[2] and P.H. Zaidi[2]

[1]University of Agricultural Sciences, Raichur, Karnataka, India; [3]International Maize and Wheat Improvement Centre (CIMMYT)-Asia, c/o ICRISAT, Patencheru, Hyderabad-502324, Telangana, India.
*Corresponding author Email: muttu.agricos@gmail.com

Maize is highly productive under optimal environmental and crop management conditions. However, it is very susceptible to drought and heat. Global warming has necessitated the development of heat resilient maize hybrids all over the world, including India. The Multi-parental synthetic (MPS-3) population is derived by crossing 10 elite inbred lines (belonging to heterotic group A) known for their abiotic stress tolerance. All possible single crosses among the 10 selected lines were made. The F1s were intermated and families were derived by selfing. A total of 332 F2 derived F3 families were crossed with tester CML470, belonging to heterotic group B. These test-crosses were evaluated at Bheemarayanagudi, Karnataka, along with local checks under heat stress during spring 2015. The results revealed that among the F2:3 lines, 10 of the top ranking F2:3 lines demonstrated very good test cross performance for grain yield and for other secondary traits - such as tassel blast, leaf firing and anthesis to silking interval (ASI) - compared to the heat resilient check variety 31Y45. These selected F2:3 maize lines provided a gain of 1.69 t/ha representing 35% improvement over the population under heat stress condition. Top 5% of the families involved in producing the superior test cross progenies would be used for the formation new improved population for heat stress, and to derive elite inbred lines.

TS6-73: Genetic Evaluation Against Turcicum Leaf Blight of Maize Involving CIMMYT Germplasm

Nandan L.P.[1*] and Rajashekhar M.K.[2]

[1]Department of Genetics and Plant Breeding, UAS, Dharwad, India; [2]AICRP-Maize, UAS, Dharwad-580005, India.
*Corresponding author Email: tryanother609@gmail.com

Maize is an important cereal crop of Karnataka whose production and productivity are challenged by foliar disease Turcicum leaf blight (TLB). To develop hybrids resistant to TLB, the present study was initiated by identifying 22 female lines from CIMMYT nursery with varying levels of resistance to TLB and crossing them with three testers in Line x Tester design. The 66 resulting hybrids were evaluated in replicated trial for yield and in a single row of 4.0-meter length for TLB disease along with resistant and susceptible checks. The hybrids were artificially inoculated with disease inoculum at 40 days after sowing (DAS) and scored at dry silk stage on a 1 to 9 scale. Ten hybrids were resistant (15.15%) i.e. GH 1641 with TLB score 2.0 and per plant yield of 383 grams followed by GH 1646 with TLB score of 3.0 and per plant yield of 312 grams. The higher yield in GH 1641 may be due to significant GCA effects of the female parent for yield attributes such as no. of kernel rows and cob length. Fifteen hybrids were moderately resistant (22.73%) i.e., GH 1647 with TLB score 4.0 and per plant yield of 327 grams. The susceptible check had a TLB score of 8.0 and per plant yield of 40 grams. The hybrids with VL 1018527 as female parent were resistant irrespective of the male parent. Among the testers, CM 111 (a resistant tester) resulted in eight resistant hybrids (61.53%) whereas, GPM 581 (a susceptible tester) resulted in only two resistant

hybrids (15.39%), indicating that male parents have significant influence on hybrid resistance. The susceptible hybrids from R X R cross and resistant hybrids from R x S cross may be due to epistatic gene interactions. However, to develop a TLB resistant hybrid it is ideal to go for R X R cross.

TS6-74: Genetic Divergence Studies Among Maize Inbred Lines of North East Hill Region (NEHR) of India Based on SSR Markers

Naveen Kumar K.L, Shimreiso Vashum and Devyani Sen*

School of Crop Improvement, College of Post-Graduate Studies, Central Agricultural University (Imphal), Umroi Road, Umiam 793103, Meghalaya, India.
*Corresponding author Email: devyani.sen@gmail.com

A set of 111 sixth-generation inbreds developed from landraces collected from Meghalaya (M-9, M-22), Manipur (Ma-5), Nagaland (N-11, N-25), Sikkim (S-16) and Tripura (T-9) - identified from previous studies to be tolerant to biotic/ abiotic stresses predominant in North East Hill Region (NEHR) of India - were studied for genetic divergence using 48 simple sequence repeat (SSR) markers evenly distributed across the ten chromosomes. The objective of the study was to obtain information on genetic divergence between inbreds to identify potential parents for a hybrid breeding program. Cluster analysis using Unweighted Pair Group Method with Arithmetic mean (UPGMA) allocated the inbreds into three major clusters. Similar results were obtained using Principal coordinate analysis (PCoA). The genetic distance based on dissimilarity matrix ranged from a minimum of 0.083 to a maximum of 0.555. The polymorphism information content (PIC) values ranged from 0 to 0.57 with an average of 0.34. Eleven SSR markers with PIC values ranging from 0.49 to 0.57 could sufficiently discriminate the genotypes into three distinct clusters. Heterozygosity percentage for the SSR markers used varied from 0.89 to 29.14%. A total 40% of inbreds studied recorded a homozygosity of 90% and above, with 20 inbreds recording more than 95% homozygosity. Clustering of genotypes was irrespective of state of origin and, based on both cluster analysis and PcoA, inbreds M9 and T9 were allocated into two distinct clusters while the remaining inbreds grouped into a third distinct cluster. These results indicate presence of sufficient genetic divergence for exploitation of heterosis.

TS6-75: Phenotyping of Hybrid Maize Through Hydroponic Culture at Seedling Stage under Salt Stress

N. Hossain[1]*, M. Hasanuzzaman[1], M. Billah[2], S. Akter[2], S.A. Bagum[3] and M.S. Uddin[3]

[1]Hajee Mohammad Danesh Science & Technology University, Dinajpur, Bangladesh; [2]Patuakhali Science and Technology University, Patuakhali, Bangladesh; [3]Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh.
*Corresponding author Email: neelima.hossain@yahoo.com

Maize (*Zea mays* L.) grows in a wide range of agro-ecological environments of the world. Production of maize is important to meeting global food security. Salinity is a principal challenge in affected agricultural zones of the world. An efficient study of 45 testcross hybrid maize was carried out in hydroponic culture at greenhouse of Plant Breeding Division, Bangladesh Agriculture research institute (BARI), Gazipur, using Hoagland solution. Two

treatments were applied (Control and 12 dS m-1 NaCl) for phenotyping of salt stress tolerant hybrid maize. Ten-day old maize seedlings were transplanted to hydroponic pot, and after 18 days of exposure to salinity seedlings were evaluated. Analysis of variance (ANOVA) was given for control and saline conditions individually, which showed significant variations among the hybrids. Path analysis indicated that SDW is a highly reliable component of total dry matter. Cluster analysis placed the 45 hybrids into five main groups. Group3 showed the highest number mean value of traits. From the genotype × traits biplot of eight traits of 45 genotypes, the highest positive relationship was found in MSL, SDW and SPAD, RDW traits. Through analysis it was concluded that P-16 x IPB911-16 was the most salt tolerant genotype, followed by P-14 x IPB911-16 and P-19 x IPB911-16, while very susceptible genotypes were CZI-26 x IPB911-16, CZI-08 x IPB911-16, P-62 x IPB911-16 and P-1 x IPB911-16. The selected hybrids will be helpful for future maize breeding to develop salt stress tolerant maize.

TS6-76: Domesticating Wild Alleles to Improve Climatic Resiliency in Maize

N.K. Singh*, Amarjeet Kumar, Sneha Adhikari and Anjali Joshi

Department of Genetics and Plant Breeding, G.B. Pant University of Agriculture & Technology, Pantnagar-263145, Udhamsingh Nagar, Uttarakhand, India.
*Corresponding author Email: narendraksingh2@gmail.com

Evolution, followed by integration of racial diversity, in intensive selective breeding under favorable environment makes maize a high yielding cereal crop. However, it also experiences accelerated genetic erosion of adaptive alleles globally as well as locally, leading to narrow genetic base in cultivated maize than in wild relatives. Thus, domesticating wild adaptive alleles seems to be a potential corrective measure to manage domestication, breeding bottlenecks and complexity of climate change. With this assumption, Teosinte (*Zea mays* ssp. *Parviglumis*) was experimented on with objectives to determine its worth and further use in crossing program. Results indicate that teosinte rarely flowers when planted in winter but thrives in hot and dry summer. Anthesis and silking in teosinte varied from 67-86 days. Apart from tall height, branching and multiple ears, teosinte possessed tolerance to many diseases. No damage was noted when teosinte kernels were exposed to three main stored grain pests of maize. F1 plants of maize-teosinte cross took 53-64 days in flowering, possessed 9-18 modified ears/plant, both lateral and basal branching and higher fodder yield. Both F_2 and BC_1F_1 kernels were drastically modified in shape, size, color and hardness. Characterization of teosinte derived BC_1F_4 population indicates wide range of variations: prominent being flowering duration (51-65 days), ears/plant (one to five days), ASI (two to five days), semi-erect leaves, lodging tolerance, long ears, stay green and plant greener than maize. Screening against diseases is yet to be done, but the results indicate great prospects of teosinte alleles in improving adaptability and productivity of maize.

TS6-77: Field Evaluation of Maize Inbred Lines for Tolerance Towards Southern Corn Leaf Blight Caused by *Helminthosporium maydis*

Pashupat Vasmatkar[1]*, Kamaljit Kaur[1], P.P.S. Pannu[2], Gurjeet Kaur Gill[3] and Mandeep Singh Hunjan[2]

[1]Department of Biochemistry, COBSH; [2]Department of Plant Pathology; [3]Department of Plant Breeding & Genetics, COA Punjab Agricultural University, Ludhiana-141004, Punjab, India.
*Corresponding author Email: vasmatkar-bcm@pau.edu

Helminthosporium maydis is a necrotrophic fungal pathogen that causes southern corn leaf blight (SCLB) in maize. This disease is commonly found in hot and wet maize growing areas and is a major problem in almost all maize growing regions of India. It has the potential to cause grain yield losses of ≥40%. In the present study, ten maize inbred lines were screened for SCLB tolerance in randomized complete block design (RCBD). After 40 days of sowing, the whorls of test plants were artificially inoculated with *H. maydis* spores at the concentration of 10-15 spores per microscopic slide. After inoculation, the intensity of the disease was recorded weekly by scoring the randomly selected five plants from each plot using 2-5 disease scale. The per cent disease index (PDI) was also determined. Significant variability in the severity of this disease was observed among inbred lines. Anthesis to silking interval was observed to be inversely related to grain yield of infected plants. Significant differences in terms of ear weight, kernels per ear, ear length and girth were observed in SCLB infected plants. Based on results obtained LM 13 and CM 140 were observed to be highly tolerant while LM 15 was observed to be highly susceptible to SCLB. In addition, LM 16 and CM 143 were found to be moderately tolerant while LM 14 showed symptoms of moderate susceptibility.

TS6-78: Effect of Climate Change on the Distribution of Maize Insect Pests in The Major Maize Growing Areas

Payuda Jankua*, W. Yodchompoo, S. Lapbunjob, S. Thaitad, and T. Budthong

Nakhon Sawan Field Crops Research Center, Nakhon Sawan, 60190, Thailand.
*Corresponding author Email: yum_mix@hotmail.com

The effect of climate change on the distribution of insect pests of corn and their natural enemies in corn crop areas of Thailand was studied. The objective was to guide adaptation of corn production. Ten to twelve areas in Nakhon Sawan province were selected and surveyed in rainy season and late rainy season from 2014 to 2016. The results showed that in rainy season, there was increased distribution of corn leaf aphid (*Rhopalosiphum maidis* Fitch) and corn thrips (*Frankliniella williamsi* Hood) more than in late rainy season due to days of no rain and high temperature. High temperature and low humidity increased presence of corn leaf aphid and corn thrips, and their natural enemies, including ladybird (*Micraspis discolor* Fabricius) and lynx spider (*Oxyopes javanus* Throll) in late rainy season more than in rainy season. Asiatic corn borer (*Ostrinia furnacalis* Guenee) (ACB) was present in late rainy season more than in rainy season because of many consecutive days without rain (5-21 days) and with a relatively small amount of rainfall each time (0.3-5.4 mm/time).

TS6-79: Breeding Maize Hybrid Max 7379 for Across Regions and Rice Growing Land with Less Economic Efficiency in the Mekong Delta of Vietnam

Pham Van Ngoc and Le Quy Kha*

Institute of Agricultural Sciences for Southern Vietnam, 121 Nguyen Binh Khiem Street, District 1, Ho Chi Minh City, Vietnam.
*Corresponding author Email: binglit610429@gmail.com

With a view to breeding domestic maize hybrids suitable for restructuring maize cropping systems - including in Mekong delta of Vietnam - Max 7379 was developed by the Institute of

Agricultural Sciences for Southern Vietnam in 2015/ 2017. Max 7379 was derived from parent inbred lines NV67 x NV 7-3 which were extracted from commercial hybrids in 2009 - 2014. NV67 was developed from high yielding hybrid of Missouri, and NV 7-3 from hybrids tolerant to diseases and insects in Vietnam. Max 7379 has maturity time of between 100 to 105 days in Southeast and Mekong delta regions, 114 to 120 days in central highland, and 103 to 120 days in Northern regions. It also has a plant height of 180-245 cm, is tolerant to BLSB (*Rhizoctonia Solani*), leaf blight and rust, and achieves 79-80% shelling. Over VCU testing sites, this hybrid showed high average grain yield of 6-11 tons/ha, as well as stability and adaptation to all major maize production regions in Vietnam. Max 7379 had good looking aspect with flint and orange color of kernels (2 – 2.5 score). Results of testing in large scale plots showed that Max 7379 (Provisionally released in 2018) produced 8.24-10.77 tons/ha in Southeast region; 7.87-10.40 tons/ha in rainfed areas of central highland; 8.05-8.70 tons/ha in sulphate acid soil of Mekong delta regions; and 8.88-10.25 tons/ha in Northern regions. This is 1-10.45% higher yield than of check NK67 (Syngenta), and 37.7% higher yield than of check CP888 (CP Group).

TS6-80: Holistic Approaches for Management of Maize Diseases in India

P.K. Bagaria[1]*, K.S. Hooda[1], Chikkappa G. Karjagi[1], Bhupender Kumar[1], J.C. Sekhar[1], D.S. Olakh[1], S.S. Sharma[2], B.L. Baheti[2], Harleen Kaur[3], N. Mallikarjuna[4], R. Gogoi[5], R.K. Devlash[6], VK Rathee[7], R.P. Singh[8], Pradeep Kumar[8], Rajashekara, H.[9], S.I. Harlapur[10], Phool Chand[11], P. Renuka Devi[12], V.K. Malik[13], R. Mehra[13], Srabani Debnath[14] and S.K. Singh[15]

[1]ICAR- Indian Institute of Maize Research, Ludhiana, India; [2]MPUAT, Udaipur, India; [3]PAU, Ludhiana, India; [4]UAS, ZARS, Mandya, Mysore, India; [5]IARI, New Delhi, India; [6]CSK HPKVV, HAREC, Bajaura, India; [7]CSK HPKVV, HAREC, Dhaulakuan, India; [8]GBPUAT, Pantnagar, India; [9]VPKAS, Almora, India; [10]UAS, Dharwad, India; [11]Tirhut College of Agriculture, Muzaffarpur, India; [12]TNAU, Coimbatore, India; [13]CCSHAU, Hisar, India; [14]BCKV, Kalyani, West Bengal, India; [15]MMRS, AAU, Godhra, India.
*Corresponding author Email: pravin87hau@gmail.com

Diseases are one of the major constraints in attaining potential yield of maize, hence efforts were made to identify potential components of disease management in testing network of the AICRP on Maize from 2013 to 2017. In HPR studies, 29 out of 782 tested hybrids were resistant or moderately resistant to major diseases, whereas 29 out of 47 inbred lines were identified as stable sources of disease resistance to be utilized in developing maize hybrids with inbuilt disease resistance. Amongst chemicals, foliar sprays of propiconazole and carbendazim+mancozeb controlled MLB up to 40%; Trifloxystrobin+Tebuconazole up to 34-70% BLSB, 40-64% common rust and 69-72 % TLB. Tebuconazole alone would control TLB and common rust up to 69% and 60% respectively. Seed treatment with *Trichoderma* sp.+ bioagent fortified FYM followed by their foliar sprays were effective in management of RDM and SDM. Botanical extracts (Neem and Garlic) and cow urine were effective against MLB and TLB. Cultural practice like stripping of basal leaves was effective in 13-70% control of BLSB. Soil amendment with neem cake at 2 q/ha+seed treatment with *Trichoderma viride* at 2% w/w were effective in management of maize cyst nematode. Thus, resistant or tolerant hybrids and inbred lines, along with management components identified, can ensure sustainable maize production in India. Thus, an additional two million MT of maize (worth approximately 29 billion rupees annually) could be added to the food basket by bringing down yield losses from 13.2 to 6.2 per cent.

TS6-81: RCRMH2: First Generation Heat Resilient Maize Hybrid of India

Prakash H. Kuchanur[1*], Ayyanagouda Patil[1], Shyamrao Kulkarni[1], C.M. Kalibavi[1], Anand S.R.[1], K. Seetharam[2], M.T. Vinayan[2] and P.H. Zaidi[2]

[1]University of Agricultural Sciences, Raichur-584104, Karnataka, India; [2]CIMMYT–Asia, c/o ICRISAT, Patancheru, Hyderabad-502324, Telangana, India.
*Corresponding author Email: prakashkuchanur@yahoo.co.in

Warming climate conditions have necessitated the development and management of crop genotypes under potentially increasing temperatures. About 75% of the maize area in India is prone to moisture stress during *kharif* (rainy season) and prevalence of high temperature during such moisture stress period cannot be ruled out. Further, there is need to diversify the unsustainable Rice-Rice system, one of the major cropping systems, into a more sustainable Rice-Maize system in south India in general, and Hyderabad-Karnataka region in particular. University of Agricultural Science, Raichur, in collaboration with CIMMYT-Asia, identified a heat resilient maize hybrid, RCRMH2. In experiments conducted during spring 2014 across multiple locations, this hybrid performed 21% better than the best check. When it was evaluated across temperature regimes in northern Karnataka (the region known for high temperatures during summer) at different locations with larger plot size during 2014-15, it gave a stable grain yield of 5050 kg ha-1, with 24% superiority over the best check, GK 3059. Other checks - CP818, 900 M Gold and NK 6240 - recorded drastic reduction in their grain yield under severe heat stress conditions at Raichur (date of sowing- 21.3.2015). This hybrid has been proposed for release for cultivation in heat stress zones Karnataka. Further, RCRMH2 has been sub-licensed to M/s Maharashtra Hybrid Seeds Company Private Limited, Mumbai, for commercialization in all the maize growing regions of India except Odisha.

TS6-82: Association of SSR Markers with Field Screening of Maydis Leaf Blight Resistance

Preeti Sharma*, M.C. Kamboj and Rakesh Mehra

CCS Haryana Agricultural University, Regional Research Station, Karnal-132001.
*Corresponding author Email: sharmapreeti.genetics@gmail.com

Maize is an economically and nutritionally important cereal crop cultivated in different agricultural zones around the world under diverse rainfall and altitude situations. In the past few decades, emergence of maydis leaf blight (MLB), or southern corn leaf blight (SCLB), has caused substantial yield losses worldwide. Study of MLB's genetic nature, with the aid of molecular markers, may help in selection and adoption of breeding approaches suitable for improving yield, quality and disease resistance. Present study was set up with the objective to find the associated molecular markers containing the MLB resistant gene, and to determine the genetic nature of the disease. An experimental research comprising six generations (P1, P2, F_1, F_2, BC_1 and BC_2) was carried out at CCS Haryana Agricultural University, Regional Research Station, Karnal, during 2013 to 2016 harvest season. Artificial inoculation conditions using standard disease rating scale of 1-5 was used to study the infection caused by MLB and detect the resistance parents and hybrids. Fresh young leaves were collected, and DNA of each parental line was isolated using CTAB procedure. PCR amplification conditions were optimized after qualitative and quantitative estimation of DNA. A total of 43 SSR primers were

used to screen five parental genotypes, out of which three inbred lines (HKI 209, HKI 1332, HKI 325-17AN) were susceptible to MLB and two inbred lines (HKI 1128, HKI 163) were resistant to MLB based on their disease reaction for polymorphism. The F_2 and backcrosses of each of the six crosses (HKI 209 x HKI 1128, HKI 209 x HKI 163, HKI 1332 x HKI 1128, HKI 1332 x HKI 163, HKI 325-17AN x HKI 1128 and HKI 325-17AN x HKI 163) were then analyzed with the polymorphic primers to detect segregation pattern and association of DNA markers for MLB. Out of 43 primers, 37 showed amplification in all parents under study. However, five were monomorphic *viz.,* p-umc2253, p-umc1525, p-bnlg1732, p-bnlg2241and p-umc1159, and 32 were polymorphic. The six primers *viz.,* p-umc1500, p-umc1250, p-umc1622, p-umc1641, p-umc1184, p-bnlg2248 did not show amplification. All F_2 plants and 10 backcross plants were individually genotyped for these 32 SSR markers. The number of alleles confirm the wide genetic base of the maize varieties and the number of alleles at each locus ranged from two to four. The overall size of PCR amplified products ranged from 105 bp (p-umc1380, p-bnlg1712, p-umc1020 and p-umc2158) to 230 (p-umc1086). The molecular size difference between the smallest and the largest allele at a SSR locus varied from 5 bp (p-bnlg1064) to 50 bp (p-bnlg1496). The polymorphic information content (PIC) value ranged from 0.36 (p-umc1812) to 0.84 (p-phi085). It has been observed that there was a strong association between field results for inheritance of MLB and SSR markers studied due to high similarity between the two in all the six crosses. The field results concluded that inheritance of MLB is governed by more than two genes which were also confirmed by SSR marker analysis.

TS6-83: Maize Breeding and Varietal Deployment in Turkey

Rahime Cengiz

Maize Research Institute, Sakarya, Turkey.
Email: rahime.cengiz@tarim.gov.tr

Corn is the most produced cereal in the world due to its multi-usage, adaptability and efficiency. The kernel is made up of four major components; starch, fiber, protein and oil that can be processed in different ways and used in all kinds of products. Turkey corn production decreased to 5.9 million tons in 2017 due to decreased planting area. Of the total grain corn produced in our country, 78% is used in the feed industry and 15% in the starch industry. In recent years, the cultivation of corn for silage has become widespread. Through breeding, many valuable populations, inbred lines and varieties have been released. Seed production rights of varieties were transferred to the private sector with the aim to reach more farmers. National project is tasked with increasing productivity; improving quality of grain and silage; development of abiotic and biotic stress tolerant or resistant varieties; and enriching the country's maize germplasm resources using advanced breeding, cultivation and biotechnological methods. Hybrid varieties of dent, waxy, sweet and popcorn kernel types are being developed. Determination of high temperature and drought tolerance of inbred lines is ongoing. Genetic distance detection, purity analysis and marker-assisted selection have been conducted since 2008, while doubled haploid techniques have featured in national maize breeding program since 2011. A public-private partnership project has been initiated to develop more domestic varieties and ensure that seed production is mostly carried out by the domestic private sector.

TS6-84: Identification of Resistant Sources to Banded Leaf and Sheath Blight (BLSB) Pathogen in Maize Inbred Lines from Himalayan Region of Uttarakhand

Rajashekara. H.*, R.K. Khulbe, K.K. Mishra and A. Pattanayak

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, India.
*Corresponding author Email: rajashekara.h@icar.gov.in; rajaiaripath@gmail.com

Sixty-three maize inbred lines were artificially screened with two isolates (Almora and Ranchi) of *Rhizoctonia solani* pathogen to identify sources of banded leaf and sheath blight disease resistance. The pure culture of pathogen was isolated on Potato Dextrose Agar medium and mass multiplied on sterilized grains of barnyard millet. The pathogen was inoculated into 30- to 40-day old seedlings under artificial epiphytotic conditions with help of mycelium and sclerotia. Proper humidity was maintained by spraying water at regular intervals. Typical symptoms development was observed, and disease scoring was done based on 0-5 disease rating scale. Based on two replication data, inbred lines viz., V335, V351, V391, V400, V431, VSL-26, VSL-27 and VQL-392 were found tolerant to Almora isolate, while lines V351, V402, V431, V 440, VSL-27 and CM 141 were tolerant against Ranchi isolate. Among the tested inbred lines, three entries (V351, V431 and VSL-27) showed highly tolerant reaction to both isolates. These lines will be further evaluated at different hotspot locations under AICRP Pathology trials to confirm resistance.

TS6-85: Identification of Elite Combiners through Heterotic Grouping in Newly Derived Early Inbred Lines of Maize (*Zea mays* L.)

Rajashekhar M.K.*, Siddramappa C.T., Sharnappa I.H. and Shiddappa R.S.

AICRP- Maize, UAS, Dharwad, Karnataka, India.
*Corresponding author Email: rajashekhar.kachapur@gmail.com

Identification of elite combiners to develop early maturity hybrids was initiated by selfing promising early maturity genotypes from the advanced varietal trials during *Rabi,* 2010. The selfed ears were advanced by ear-row up to S_3-S_4 stage. At S_4 stage based on top cross test, 16 lines were identified. Based on *per se* and reaction to Turcicum leaf blight disease, ten of the 16 lines were were crossed to two diverse testers, CM-111 and CM-500. The test crosses were evaluated in a replicated trial during *kharif*, 2016, to determine combining ability. The line DMEI-207 recorded significantly high and positive combining ability for grain yield i.e., GCA (23.11), followed by DMEI-165 (17.7), DMEI-73 (12.95) and DMEI-196 (10.23). The inbred lines were grouped into two heterotic groups based on average yield of test cross hybrids, SCA and Standard heterosis. After being arranged in the decreasing order of their GCA status within each group, the inbred lines were crossed in all possible combinations with lines from the opposite group. These hybrids were evaluated with early maturity check in a replicated trial during *kharif*, 2017, and the cross combination of DMEI-165 X DMEI-73 recorded highest grain yield of 10.0 t/h. The cross combination of DEMI-73 X DMEI-196 recorded yield of 9.78 t/ha whereas the check hybrid PEMH-5 recorded 5.17 t/ha. The female parent of the top five hybrids was either DMEI-165 or DMEI-73, indicating that these two lines were the elite combiners. Even though the inbred line DMEI-207 recorded highest GCA for yield, it was not a good combiner as evident from its cross combinations. This also indicates it is not always true that when lines with High x High GCA are crossed they will always result in heterotic hybrids.

TS6-86: Efficacy of Newer Molecules against Banded Leaf and Sheath Blight of Maize

Rakesh Devlash[1*], S.K. Guleria[1], D.R. Thakur[1] and Vinod Sharma[2]

[1]CSKHPKV, Hill Agricultural Research and Extension Centre, Bajaura, Distt. Kullu, H.P., India; [2]CSKHPKV, Highland Agricultural Research and Extension Centre, Kukumseri, Distt. Lahaul & Spiti, H.P., India.
*Corresponding author Email: devlashbajauraatrediffmail.com

Banded leaf and sheath blight (BLSB) caused by *Rhizoctonia solani.* (f. sp. *sasakii*), and common in high rainfall areas, is devastating maize production. Under favorable environmental conditions the pathogen spreads from the basal sheath to the developing ear causing complete damage by prematurely drying up, and caking of husk leaves. The disease can cause yield losses of between 23-40%, or even 100% in extreme situations. As no true resistance has yet been identified for this disease, farmers are still dependent on chemical management. Therefore, present studies were carried out to evaluate six new generation fungicides for the management of BLSB. A replicated field trial on the management of BLSB was conducted during *Kharif* 2014/ 2015 using maize variety Early Composite at experimental farm of CSKHPKV, Hill Agricultural Research and Extension Centre, Bajaura. Single spray of test fungicides was given with the initiation of disease. Observations on the disease were recorded using 1-5 disease scale. The results revealed that all the fungicides significantly reduced the BLSB and increased the yield compared to control (no spray). Fungicide Trifloxystrobin 25%+Tebuconazole 50% at 0.05 % was found most effective in managing BLSB, giving 49.5% disease control with 43.5 % increase in yield.

TS6-87: Development and Evaluation of High Yielding Stress Tolerant Maize Hybrids for Food and Feed Security over Mid-Hills of Nepal

Ramesh Acharya[1*], A. Parajuli[1], B. Maharjan[1], N.B. Dhami[2], N. Rawal[3], C. Manandhar[4], B. Bhat[5] and D. Acharya[6]

[1]Agriculture Botany Division, Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur, Nepal; [2]Hill Crop Research Program, NARC, Kabre, Dolakha, Nepal; [3]Soil Science Division, NARC, Khumaltar, Lalitpur, Nepal; [4]Plant Pathology Division, NARC, Khumaltar, Lalitpur, Nepal; [5]Entomology Division, NARC, Khumaltar, Lalitpur, Nepal; [6]Tri-Chandra College, Kathmandu, Nepal.
*Corresponding author Email: rameshacharya.narc@gmail.com; ramesh.acharya@narc.gov.np

Majority of maize planting farmers in the hill regions of Nepal prefer traits like high yield, drought tolerance, disease/insect tolerance along with non-lodging, dwarf and early to medium maturing varieties. The study focused on mid-hill farmers' preferences. Different inbred lines - developed by the National Maize Research Program and CIMMYT - were used as testers and crossed with homozygous inbreds developed by Agriculture Botany Division in a line x tester design to evaluate combining ability and heterosis during 2014/ 2015 season. The different promising hybrid maize genotypes selected were tested under mid-hill research stations along with farmers' field in 2016 and 2017. Both general combining ability (GCA) and specific combining ability (SCA) variances were significant regarding yield and yield attributing traits, indicating the importance of additive and non-additive gene actions in controlling various concerned traits. From the investigation, we were able to identify high yielding hybrid maize genotypes having best performing combiners to produce a reliable amount of hybrid seeds. Among the parent lines high yielding inbred lines are: KML-4(A) [6.012 Mt/ha], KML-5(A) [5.498 Mt/ha], KML-2(A) [5.125 Mt/ha], KML-16 [4.639 Mt/ha], etc. while the best testers identified include: RML-4 [4.545 Mt/ha], KYM-33 [6.322 Mt/ha], RML- 32 [2.156 Mt/ha] and

NML-2 [3.213 Mt/ha]. From three years' trials we were able to select five most promising hybrid maize genotypes, which are also preferred by farmers when tested under their field conditions. The elite high yielding and stress resistant varieties include: KML-5(A) x RML-4 [14.76 Mt/ha], KML-3(A) x RML-4 [14.46 Mt/ha)], KML-4(A) x RML-4 [13.66 Mt/ha], KML-1(A) x RML-4 [13.55 Mt/ha] and KML-8(A) x RML-4 [13.48 Mt/ha]. These varieties are to be released/registered soon, and mostly target the mid-hill farmers of Nepal.

TS6-88: Yield Stability of Maize Hybrids Through GGE and AMMI Analysis under Ideal and Stress Environments

Ramesh Kumar[1*], Yashmeet Kaur[1], A.K. Das[1], M. Choudhary[1], S.B. Singh[2], Chikkappa G.K.[3], B. Kumar[3], M.C. Patel[4], J.P. Shahi[5], P.H. Zaidi[6] and Sujay Rakshit[1]

[1]ICAR-IIMR, Ludhiana, India; [2]RMR&SPC, Begusarai, India; [3]ICAR-IIMR, New Delhi, India; [4]ARS, Godhra, India; [5]BHU, Varanasi, India; [6]CIMMYT, Hyderabad, India.
*Corresponding author Email: rk.phagna@gmail.com

Maize is produced around the world on over 184 million ha in 165 countries, with a production of 1016 million tons and productivity of 5.52 tons per hectare. Identification of high yielding stable genotypes across distinct environments is necessary to counter genotype x environment interaction (GEI) which could affect the cultivar selection and recommendation process. Forty-seven single cross maize hybrids were evaluated under four environments (ideal, rainfed, waterlogging and drought) in 2016 and three environments (ideal, rainfed and waterlogging) in 2017. All the trials were conducted in randomized block design with three replications during wet season except the drought trial which was conducted during winter. Analysis of variance revealed that most of the variation was explained by environments (65% & 52 %) followed by genotype × environment interactions (G×E) (14% & 21%) in 2016 and 2017 respectively. Stability of genotypes was assessed by genotype and genotype x environment (GGE) biplot method using 'R' software. GGE biplot explained 83.69 % and 91.59 % of the total variation for 2016 and 2017, respectively. AMMI1 biplot has identified genotypes, *viz.,* ZH161082, ZH161089 and ZH161135 in 2016 and ZH161071, ZH161093 and ZH161095 in 2017 as stable high yielding genotypes. 'Which won where' graph depicts that genotype ZH161039, ZH15449, ZH161276 and ZH161285 were the best performing genotypes under ideal, rainfed, drought and waterlogging conditions, respectively in 2016. However, before recommendation for commercial cultivation, the identified hybrids may be tested in larger plot size to assess the yield under the target ecology.

TS6-89: Effects of Imazamox on Inbred Maize Lines

Recep Yavuz*, Rahime Cengiz, Mesut Esmeray and Vesile Urin

Maize Research Institute, Sakarya, Turkey.
*Corresponding author E-mail: recep.yavuz@tarim.gov.tr

This study was conducted to investigate the natural tolerance of the imazamox active ingredient herbicide to inbred maize lines. The research was conducted in greenhouse and field conditions in 2017. A total of 790 inbred maize lines developed by the Maize Research Institute were grown in pots. Imazamox active ingredient herbicide has been applied to 3-4 leaf inbred maize lines in the spraying cabinet. Inbred maize lines were used as materials and were evaluated as

tolerance ADK 310, ADK 912, ADK 451, ADK 926, ADK 722, ADK 931, ADK 732, ADK 1026, ADK 866, DH 166, ADK 875, DH 332. The investigation was replicated four times using randomized blocks factorial design. *Xanthium strumarium* L., *Echinochola crus-galli* (L.) P.B. and *Portulaca oleracea* were identified as dominant weeds in the experimental area. The height difference obtained from ADK 926 (188.75 cm), DH 332 (183.75 cm) and ADK 931 (182.50 cm) inbred maize lines, where the highest plant length was obtained, was found to be statistically significant. The yield of DH 166 and ADK 310 inbred maize lines, which yielded the highest, is statistically significant. According to the results of this study, it was determined that inbred maize lines showed different tolerance to imazamox active ingredient herbicide. Studies will continue by making crosses between tolerant inbred maize lines. It is evaluated that chemical mutagen Ethyl Methanesulfonate (EMS) applications should be utilized for the imazamox active herbicide tolerance in maize.

TS6-90: One-size doesn't fit all: Maize for various stress-prone agro ecologies in Asian tropics

Reshmi Rani Das[1], M.T. Vinayan[1], K. Seetharam[1], S. Vishwanadh[1], Salahuddin Ahmad[2], Suriphat Thaitad[3], Thanh Nguyen[4], Dang Ngoc Ha[4], M.B. Patel[5], Ramesh Kumar Phagna[6], Devraj Lenka[7], Rajan Gupta[8], Vijai Tiwari[9], Baban Anarse[10] and P.H. Zaidi[1]

[1]CIMMYT Asia Regional Maize Program, ICRISAT Campus, Hyderabad, India; [2] Division of Plant Breeding, Bangladesh Agricultural Research Institute, Jodebpur, Gazipur, Bangladesh; [3]Nakhon Sawan Field Crops Research Center, Nakhon Sawan, Thailand; [4]National Maize Research Institute, HaNoi, Vietnam; [5]Anand Agricultural University, Godhra, India; [6]Indian Institute of Maize Research, Ludhiana, India; [7]Orissa University of Agriculture and Technology, Bhubaneshwar, India; [8]Rasi Seeds (P) Ltd., Bengaluru, India; [9]Bisco Bio-Sciences Pvt. Ltd., Hyderabad, India; [10]Ajeet Seeds Pvt. Ltd., Aurangabad, India.
*Corresponding author Email: d.reshmi@cgiar.org

In Asian tropics, maize is predominantly grown during the summer-rainy season. However, huge yield losses are incurred due to unpredictable weather, with intermittent dry spells and/or excess rainfall. High yielding cultivars with stable performance across varied weather conditions would largely help farmers mitigate the stress. This study aimed at identifying superior hybrids that performed well across different management regimes that are most likely observed during the rainy season across the region – optimal/ irrigated, rainfed/random stress, and flowering-stage drought stress. A set of 65 advanced stage hybrids were evaluated during rainy season of 2016/ 2017 across 21 locations of South and Southeast Asia (India, Bangladesh, Vietnam and Thailand). Among these, nine sites were managed with optimum levels of irrigation, five sites were managed under flowering stage drought stress and seven sites were under rainfed/random stress condition. Site regression (SREG) analysis was performed to identify superior hybrids across these management regimes. A large portion of the observed yield variation across the three managements was accounted due to environments (30 to 70%) followed by the GEI (13 to 50%). A cumulative 60-70% of the variation observed in the interaction component was explained by the estimated first two factors across management. Hybrids CAH-153, CAH-1511 and CAH-1519 were found as most widely adaptable and promising across management regimes and locations. The combined average yield performance of these identified stress resilient hybrids was between 7.0 and 7.5 t/ha under irrigated condition, 3.5 to 4.0 t/ha under managed drought stress and 5.0 to 5.5 t/ha under rainfed conditions.

TS6-91: Response of Elite and Commercial Forage Maize (*Zea mays* L.) Single Cross Hybrids to Salt Stress

Saeed Khavari Khorasani[1]* and Farshid Ghasem Zade Gnjee[2]

[1]Seed and Plant Improvement Department, Khorasan Razavi Agricultural and Natural Resources Research and Education Center, ARREO, Mashhad, Iran; [2]Soil Science Department, Khorasan Razavi Agricultural and Natural Resources Research and Education Center, ARREO, Mashhad, Iran.
*Corresponding author Email: khavaris80@yahoo.com

Salinity is widespread in the world. FAO estimated that globally, 19.5 percent (about 32 million ha) of irrigated lands are salt-affected. In Iran, soil and water salinity is a significant problem in arid and semi-arid lands. In this study, the effects of two planting methods (raised bed and furrow planting) and five elite and commercial single cross forge maize hybrids (KSC703, KSC704, KSC705, KSC706 and KSC715B) were evaluated on Abbas-Abad agricultural station, Mashhad, north east of Iran in 2017. The experimental design was factorial based on randomized complete block design (RCBD) with four replications. The electrical conductivity of soil and water of experimental field was 15.1 and 4.9 ds m-1, respectively. The results showed planting in furrow was significantly better than raised bed planting for many of studied traits like seed emergence percentage, anthesis and silking time, ASI, plant height, ear height, stem diameter and forage yield. The highest wet and dried forage yield (51.18 and 17.31 t/ha) was observed in furrow planting method. The results showed significant differences between hybrids for plant height, ear height, tassel length, ear diameter, ear length, stem diameter, kernel no./row, rows no. and dried forage yield. The KSC706 single cross has the highest forage yield (49.97 ton/ha). The ear weight to biomass weight ratio as forage quality index varied from 0.18 to 0.39 for KSC715B and KSC703 hybrids, respectively. We observed significant differences between single cross hybrids for quality and quantity of forage yield and related traits, therefore screening of hybrids and their parental inbred lines is necessary in field study.

TS6-92: Short Term Low Temperature Stress in Cold Tolerant Maize (*Zea mays* L.) from Kashmir Himalayan Region Elicits Changes in Osmolyte Accumulation, Antioxidant Gene Expression and Trehalose Metabolism

Salika Ramazan[1] and Riffat John[2]*

[1]Plant Molecular Biology Research Lab, Department of Botany, University of Kashmir, Srinagar, India; [2]Department of Botany, University of Kashmir, Srinagar, India.
*Corresponding author Email: riffatminhaj@kashmiruniversity.ac.in

The present study reports the response of low temperature tolerant maize (*Zea mays* L.) genotype from Kashmir Himalayan region subjected to short term low temperature stress (6℃). The seeds were sown and allowed to grow at 24±2℃, 70% humidity and 16h light/8h dark photoperiod. After two weeks' growth, at three-leaf seedling stage, plants were subjected to short-term LT stress (6℃) for 12h and the samples harvested after every 2h interval were processed for various assays. We observed that LT stress enhanced production of stress markers like H_2O_2 and MDA (Malondialdehyde) and modulated transcript profiles of antioxidant enzymes. Moreover, plants survive low temperatures by fine adjustments of vital osmoprotectants like trehalose, proline, soluble sugars, glycine betaine, phenolics and protein, besides altering plant pigment composition like anthocyanin, total chlorophyll and carotenoids. Relative gene expression using qRT-PCR of some selected antioxidant enzymes including

ascorbate peroxidase (APX), monodehydroascorbate reductase (MDHAR), dehydroascorbate reductase (DHAR), glutathione reductase (GR), superoxide dismutase (SOD), peroxidase (POD) and catalase (CAT) revealed that significant changes occur in the transcripts levels of these antioxidant enzymes in response to LT stress. The present study also revealed that enzymes trehalose-6-phosphate synthetase (TPS) and trehalose-6-phosphate phosphatase (TPP) involved in trehalose biosynthesis show differential expression pattern in response to LT stress in maize. Hence, robust osmolyte accumulation and elevated antioxidant gene expression help the plant to survive in low temperatures, although elaborate mechanisms need to be unraveled further for better understanding of low temperature acclimation in the plant.

TS6-93: Characterization of *Rhizoctonia solani* f.sp. *sasakii* Isolates Causing Banded Leaf and Sheath Blight of Maize

Sanjay Kumar[1*] and Harleen Kaur[2]

[1]Department of Plant Pathology, Punjab Agricultural University, Ludhiana-141 004, Punjab, India; [2]Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana-141 004, Punjab, India.
*Corresponding author Email: sanjay_verma1991@yahoo.com

Forty-four isolates of *Rhizoctonia solani* were collected from different maize growing districts of Punjab. Morphological characteristics of different isolates viz; growth rate, colony characters (color, texture, saltation, pigmentation) and sclerotial characters (color, texture, pattern, position and number) were studied. Data analysis was done using unweighted pair group method with arithmetic mean and categorized 44 isolates into five groups each containing five, nine, 15, 13 and two isolates. The clustering clearly revealed the presence of high degrees of variation among *R. solani* isolates. Cluster II and III dominated all clusters in sclerotia number. Cluster I (five isolates) were having minimum growth rate, however, Cluster V contained isolates with minimum number of sclerotia. During preliminary studies, pathological characterization was done with representative isolates selected from each cluster on PMH 4 hybrid during *Kharif* 2017. Five isolates (Rs-4, Rs1, Rs-12, Rs-2 and Rs-7) multiplied on maize sand media were inoculated after 30-40 days of sowing by sheath inoculation method. Relative lesion lengths (RLL), percent disease index (PDI) and virulence index were recorded at regular intervals. Data revealed that two isolates (Rs-12 and Rs-9) in cluster III were most virulent; Rs-12 having mean RLL (39.0), PDI (38.2) and virulence index (19.1) followed by isolate Rs-9 with RLL (32.0), PDI (36.4) and virulence index (18.2). However, isolate Rs-7 present in cluster V was found least virulent with minimum RLL (18.0), PDI (18.2) and virulence index (9.1). Preliminary studies revealed that colony growth rate and sclerotial numbers are directly linked to the aggressiveness of pathogen.

TS6-94: Relative Tolerance of Maize Genotypes to Maize Stem Borer (*Chilo Partellus* Swinhoe) at Chitwan, Nepal

Saraswati Neupane[1]*, Subash Subedi[1], Ghanashyam Bhandari[1], Sheela Sharma[2] and Surendra Yadav[3]

[1]National Maize Research Program, Rampur, Chitwan, Nepal; [2] Entomology Division, NARC, Khumaltar, Lalitpur, Nepal; [3] Regional Agriculture Research Station, Tarahara, Nepal.
*Corresponding author Email: sarusanu2017@gmail.com

Maize stem borer *Chilo partellus* Swinhoe, Lepidopteran in *Pyralidae* family is the major insect pest of maize in Nepal. Host plant resistance is the most cost-effective, eco-friendly and sustainable method to reduce stem borer damage in the field. Forty maize genotypes were screened for relative tolerance against maize stem borer at the research field of National Maize Research Program, Rampur. Those genotypes were planted on two rows of five-meter long in alpha lattice design, with three replications during spring seasons (March to June) of two consecutive years 2015 and 2016. Data was collected on percent damage, tunnel length measurement and number of exit holes made by the borer. Among screened maize genotypes, lower percent damage by borer was found on varieties: RampurS03F04 (9.7) RML-32/RML-17 (7.8), RML-95/RML-96 (5.3) and RML-86/RML-96 (7.2) in 2015. Similarly, lower percentage damage of maize stem borer was recorded on varieties: Arun-2 (9.98), Arun-3 (11.79), Arun-4 (11.26) and Rampur Hybrid-2 (13.04) in 2016. Varieties RampurS03F04, RML-95/RML-96, RML-86/RML-96 had less damage in both years, so they can be used as sources of relative host tolerance against *Chilo partellus* for future breeding purposes.

TS6-95: Analysis of Combining Ability for Heterotic Grouping of Medium Maturing Maize (*Zea mays* L.) Germplasm

Sawan Kumar, S.K. Guleria* and Rakesh Devlash

CSK Himachal Pradesh Krishi Vishvavidylaya, Hill Agricultural Research & Extension Center Bajaura 175125 Distt Kullu Himachal Pradesh, India.
*Corresponding author Email: skg0612@rediffmail.com

Hybrid oriented source germplasm with established heterotic pattern is essential for initiating hybrid development. The objective of this study is to classify the maize germplasm into different heterotic groups. Thirty maize inbred lines developed from diverse sources were crossed with two tester lines, one each from Baj Pool 95 and Baj pool 98. Mean grain yield for crosses ranged from 13.82 t/ha to 6.28 t/ha. General combining ability (GCA) and specific combining ability (SCA) for grain yield were calculated by line x tester analysis. Of the 30 lines tested, eleven lines had positive GCA effects for yield. Significant differences were observed for SCA effects for yield in the different crosses. Several crosses were identified having yields of 10 t/ha or more and possessing significant SCA effects. The maize germplasm was categorized in two different heterotic groups; fifteen lines were included in group A and fifteen lines in group B. However, eight lines *viz.,* BAJIM-15-09, BAJIM-15-10, BML-6, CML-44, CML-269, CML-292, CML-465-B-B and TNAU/CBE-83 which showed positive GCA effects and positive SCA effects with T_2, and negative SCA effects with T_1, were considered more productive in the heterotic group A. Meanwhile the eight lines *viz.,* BAJIM-13-02, BML-7, CML-141, CML-269-1, CML-294, HKI-1040-7, HKI-1105 and MRCQPM-16 which showed positive GCA effects and positive SCA effects with T_1 (BAJIM-08-26), and negative SCA effects with T_2 (BAJIM-08-27) were more productive in heterotic group B. Two heterotic pools MMYPool A and MMYPool B were constituted from these materials using the test cross data.

TS6-96: Combining Ability and Test Cross Performance of New Maize Inbred Lines

S.C. Talekar*, R.M. Kachapur, S.I. Harlapur and S.R. Salakinkop

All-India Coordinated Maize Improvement Project, MARS, University of Agricultural Sciences, Dharwad-580005 Karnataka, India.
*Corresponding author Email: siddu.talekar@gmail.com; talekarsc@uasd.in

The estimates of GCA affects identification of superior parents to be utilized for production of heterotic hybrids. The objective of this study was to estimate the general combining ability of maize S3 lines and specific combining ability test crosses developed using these lines. Twenty-four test crosses developed using six S3 lines (L1 to L6) and four testers *viz*., CM 111, CML 451, CML 472 and CML 02450 were evaluated during *Rabi* 2017/ 2018 using randomized complete block design with two replications. The observations were recorded for days to 50% pollen shed and silking, ASI, cob weight, shelling percentage, 100 seed weight and seed yield. The variance due to lines was significant for seed yield and variance due to testers was significant for shelling percentage and 100 seed weight, whereas variance due to l x t interaction was significant for days to 50% pollen shed, cob weight, shelling percentage and seed yield. Further, additive and dominance variance indicated prevalence of dominance variance for days to 50% pollen shed, cob weight per plot, shelling percentage and seed yield. The GCA effects of lines indicated that no single line was a good combiner for all traits studied. However, the line L2 exhibited significant GCA effects for cob weight and seed yield, indicating that this is a good general combiner which can be utilized in development of heterotic hybrids. The cross involving L2 as female parent exhibited higher SCA effect for most traits and figured top ranking hybrid among the test crosses.

TS6-97: Current Status of Insect Pests on Maize

Sekhar J.C.[1*], Lakshmi Soujanya P.[1], Suby S.B.[2], Reddy M.L.K[3], Jawala Jindal[4] and Sujay Rakshit[5]

[1]Winter Nursery Centre, ICAR-Indian Institute of Maize Research, Rajendranagar, Hyderabad - 500 030, India; [2]ICAR-Indian Institute of Maize Research, Pusa Campus, New Delhi-110 012, India; [3]Maize Research Centre, Professor Jaya Shankar Telangana State Agricultural University, Hyderabad, Telangana 500030, India; [4]Maize Section, Punjab Agricultural University, Ludhiana, Punjab 141001, India; [5]ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana - 141001, Punjab, India.
*Corresponding author Email: javajics@gmail.com

About 130 insect pests are known to attack maize at different stages of the crop cycle but few are reported to cause damage at multiple stages, from seedling to maturity. Stem borers, *Chilo partellus* and *Sesamia inferens*; and shoot fly, *Atherigona* sp, are common pests of maize in rainy, post rainy and spring season respectively in India. Chafer beetle, *Chiloloba acuta*; cut worm, *Agrotis ipsilon*; army worm, *Mythimna* sp.; cob borers, *Spodoptera* spp. and *Helicoverpa armigera*; and aphid, *Rhopalosiphum maidis,* are occasional pests depending on weather conditions during the cropping season. Stem borers, cob borers, chafer beetles and aphids have widely distributed in India while shoot fly, cut worms and army worms are prevalent in North India. Pink stem borer, *S. inferens*, is a regular pest in winter and spring maize in peninsular India, as well as on winter maize in North east plain zone (NEPZ) and North west plain zone (NWPZ). During *kharif* 2017, sporadic outbreak of army worm was noticed in maize growing areas of Karnataka due to prolonged period of drought followed by long spells of rainfall and migration from smaller millets. The infestation of this pest causes

complete defoliation in affected areas. Also, the incidence of sugarcane leaf hopper, *Pyrilla perpusilla* (Hemiptera: *Fulgoridae*), was observed during reproductive stages of maize in spring 2018 at various villages in Jalandhar district, Punjab. The pest migrated from sugarcane fields after harvesting. The population dynamics of *Helicoverpa armigera*, a potential cob borer in maize, has been monitored since 2015. Out of all locations, peninsular India recorded least activity of the pest, while spring maize in Punjab recorded the most activity.

TS6-98: Genetic Studies for Drought Related Root Traits in Maize Inbred Lines

Shazia Gulzar[1]*, Z.A. Dar[2], P.A. Sofi[1], A.A. Lone[2], M.A Bhat[1], M.A. Ahangar[3] and N. Yousuf[1]

[1]Division of Genetics & Plant Breeding, FOA Wadura, SKUAST-K, (J&K, India; [2]Dryland (*Karewa*) Agriculture Research Station, Budgam, SKUAST-K, J&K, India; [3]Mountain Crop Research Station, Sagam, SKUAST-K, J&K, India.
*Corresponding author Email: shaziagulzar08@gmail.com

The productivity of maize is usually limited by various biotic and abiotic stress factors, such as drought. Drought affects yield through various mechanisms across the whole life cycle of the maize plant (Leach et al., 2011). Drought tolerance is a complex trait (Quarrie, 1996) involving several morpho-physiological traits, including root characters (Ludlow and Muchow, 1990; Tuberosa et al., 2002). Plant roots play an important role in drought tolerance, thus the present study was conducted for 12 inbred lines of maize under drought and irrigated conditions in pipe like structures in the green house facility at the Division of Genetics and Plant Breeding, Faculty of Agriculture, SKUAST-K, Wadura. Significant genetic variability in drought tolerance traits was revealed among the maize inbred lines. Also, root length exhibited positive correlation with root volume. Root length under drought conditions varied between 46.5cm (KDM-914A) to 116.0cm (KDM-914A), root volume ranged from 9.0ml (V-351 and KDM-895A) to 39.0ml (KDM-916A), and root biomass ranged from 4.58 (KDM-926B) to 17.25 (KDM-439) g/plant. The promising lines identified, such as KDM-914A (116.00 cm) for root length, KDM-916A for root volume (39.0ml) and KDM-439 for root weight (17.25g/plant), can be used as trait donor lines to transfer specific traits into a recipient genotype for drought tolerance in maize.

TS6-99: National Maize Germplasm Collection at ICAR-NBPGR- the unmined treasure

Sherry Rachel Jacob*, Vandana Tyagi, Jyoti Kumari, Ashok Kumar and Kuldeep Singh

ICAR- National Bureau of Plant Genetic Resources, New Delhi-110012.
*Corresponding author Email: sherry.jacob@icar.gov.in

The National Genebank (NGB) at ICAR-NBPGR conserves one of the largest collections of maize germplasm in Asia. The base collection of NGB has 11,179 germplasm accessions, 8712 of which are of indigenous origin (collected from all maize growing states of India, over a period of four decades) and the remaining 2467 are of exotic origin (received from 16 countries). The collection includes 2523 landraces primarily collected from the North Eastern region (1430 landrace accessions) and the Western Himalayan region (614 accessions). The ICAR-NBPGR has, since its inception, also facilitated the import of around 298000 accessions of maize germplasm, thereby contributing to the augmentation of maize genetic resources within our country. However, our maize improvement program is catered to by genetic

resources having very limited diversity, which restricts its potential adaptation to environmental challenges and expansion of its product utility. The narrow use of genetic resources is more apparent in the public research sector, compared to private sector counterparts. The data on maize germplasm flow in our country during the previous decade clearly indicates this skewed trend, wherein out of the total demand for exotic germplasm (93456 samples), only 9.5% was from the public sector. It may be argued that the germplasm flow between multinational companies and their subsidiaries in India is a major cause for this imbalance, but domestic demand for diverse germplasm by public sector research organizations in India - as indicated by indents received at NBPGR - was a meager average of 150 accessions per year (none being landraces). There is a positive shift in global maize research towards unraveling the genetic potential of unique landraces and wild relatives for better utilization. The germplasm collection at National Genebank will be the ideal resource for such efforts in India because it is the safety deposit where alleles that are already extinct in nature are still conserved.

TS6-100: Integrated Management of Turcicum Blight of Maize Caused by *Exserohilum Turcicum*

Shikha Sharma[1*], Bhupendra Thakre[1], Raksha Viswakarma[1] and V.K. Paradkar[2]

[1]Jawaharlal Nehru Krishi Vishva Vidyalaya, Zonal Agricultural Research Station, Chhindwara, Madhya Pradesh-480001, India; [2]AICRP on maize, Zonal Agricultural Research Station, JNKVV, Chhindwara-480001, India.
*Corresponding author Email: agri.shikha2oct@gmail.com

Maize is an important cereal crop that is affected by several fungal diseases including leaf blight - also known as northern corn leaf blight or turcicum leaf blight - which affects photosynthesis, causing severe reduction in grain yield (ranging from 28 to 91%). Disease symptoms appear on the leaves at any stage of plant growth, but usually at or after anthesis. Therefore, an experiment on Integrated Disease management of turcicum blight of maize caused by *Exserohilum Turcicum* was conducted at Zonal Agriculture Research Station, Chandangoan, Chhindwara during *Kharif* 2017. This was done with eight treatment combinations of seed treatment with fungicide, spray of fungicides, bacterial, fungal bioagents and recommended dose of fertilizers. Seed treatment with carbendazim 3gm/kg of seed and three sprays of SAAF 0.3% recorded minimum percent disease index of 20.63%, 54.44 % PEDC and highest yield of 65 qn/ha; whereas seed treatment with carbendazin 3gm/kg of seed with three sprays of carbendazim 0.25% recorded 26% PDI, 48.24% PEDC and seed yield of 63qn /ha, compared to control which recorded maximum PDI 65.88% and seed yield of 44qn/ha.

TS6-101: Phenotyping of Hybrid Maize at Seedling Stage under Drought Condition

Shirin Akter[1*], N. Hossain[2], M.A. Latif[1], M. Billah[1], S.A. Bagum[3] and M.S. Uddin[3]

[1]Patuakhali Science and Technology University, Patuakhali, Bangladesh; [2]Hajee Mohammad Danesh Science & Technology University, Dinajpur, Bangladesh; [3]Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh.
*Corresponding author Email: aktershirin1992@yahoo.com

Drought is viewed as one of the greatest destructive phenomena, responsible for extensive sterile agronomic land across the globe. This experiment intends to identify drought enduring

maize genotypes in Bangladesh. Consequently, a pot study of 49 hybrid maize genotypes was conducted under water stress conditions with treatment (control and drought), and two replications under Split Plot RCBD method. The data was received 35 days after sowing using appropriate procedures. Descriptive statistics of traits like percentage of SPAD, leaf rolling, maximum root length, maximum shoot length, root dry matter, shoot dry matter, stomata length, stomata width, thickness of stomata, total dry matter and ANOVA for control and drought conditions individually showed significant ($P<0.05$) variations among the germplasm for their genotypes, treatment and interaction. Cluster analysis placed the 49 hybrids into six main groups, five of which showed the maximum number mean value of traits. By forming genotype and traits bi-plot of 11 traits of 49 genotypes, the highest positive relationship was found among TS, WS, RTDM, STDM and TDM traits. After analysis, it was clear that (CML-80×IPB911-16) and (CZI-04×IPB911-16) were the most tolerant hybrid maize genotypes, while (P-12×CML487), (CML-32×PB911-16) and (P-33×CML487) proved susceptible. It is expected that the higher expression of considered traits might be obligate for better yield under drought stress.

TS6-102: Integrated Management of Major Maize Diseases

S.I. Harlapur

All-India Coordinated Maize Improvement Project, University of Agricultural Sciences, Dharwad-580005 Karnataka, India.
Email: harlapursi@gmail.com

Maize production and productivity is severely constrained by an array of factors. Out of various stresses responsible for lowering productivity in Karnataka state, diseases are priority. Turcicum leaf blight, common rust and charcoal stalk rot are widespread and destructive – the magnitude and dynamics of which are rapidly increasing under climate change. The filed experiments on integrated management of major diseases of maize were conducted at University of Agricultural sciences, Dharwad, from 2015 to 2017. Integration of tolerant hybrid GH-0727 and seed treatment with Carboxin power at 2g/kg seed, or combined seed treatment with Azospirillum sp. at 25 g/kg seed and Trichoderma harzianum at 6g/kg seed followed by three sprays with Mancozeb at 0.25%, or two sprays of Tebuconozole at 0.1%, was found to be the most effective IDM package for the management of foliar diseases of maize. Pseudomonas fluorescens at 0.5% as seed treatment, bioagennt-fortified FYM (1:50) and spray at 0.5% were found effective in suppressing charcoal stalk rot. This treatment recorded significantly lower disease severity (36.22%) and maximum grain yield (60.25 q/ha). The treatment recorded 47.66% disease control efficacy and resulted in 21.32% increase in grain yield over untreated check. Nevertheless, the treatment viz., local strains of fungal antagonists *Tricholderma harzianum* Dharwad 1 (Local strain) at 0.5% as seed treatment, bioagent-fortified and incubated FYM (1:50) and spray at 0.5%; and TH-3 at 0.5% as seed treatment and incubated FYM (1.50) and spray at 0.5% were also equally effective.

TS6-103: SRAP Markers-Based Genotyping and its Relationships with Heterosis and Combining Ability in Maize

Sitar Singh Verma* and N.K. Singh

Department of Genetics and Plant Breeding, GBPUAT, Pantnagar 263145.
*Corresponding author Email: sitarsinghverma@gmail.com

Heterosis is theoretically based on allelic diversity and directional dominance. In maize, the phenomenon of heterosis has been widely exploited with great impact on vertical increase in productivity. Despite the significant advancement in both quantitative and molecular science, including presence-absence variation (PAV) theory, the determination of heterosis remains yet unanswered. In the present investigation, 30 sequence-related amplified polymorphisms (SRAP) markers were used - which target genetic variation in the open reading frames (ORFs) of the genome - to determine genetic diversity (GD) among 24 inbred lines and further investigate relationships of SRAP marker diversity among pairs of inbred lines, with respective heterosis and combining ability. A total of 184 alleles were amplified in twenty-four genotypes, which gave an average of 6.13 alleles per SRAP marker. The PIC values of SRAP markers ranged from 0.076 (M5E2, M5E3 and M5E4) to 0.91 (M3E2) with mean value of 0.51 which indicates the efficiency of markers in discriminating different inbred lines. These markers data categorized 24 genotypes in four clusters with inter-cluster similarity coefficient of less than 0.85. The GD among pairs of inbred lines indicated significant and positive associations with grain yield of hybrids indicating role of SRAP based diversity in optimizing yield in maize. Based on the significant positive correlations, the MPH, BPH and SCA were noted to have better prediction efficiency of maize hybrid yield. The GD, however, showed non-significant association with MPH, BPH and specific combining ability.

TS6-104: Induced Systemic Resistance Against Banded Leaf and Sheath Blight (*Rhizoctonia Solani*) of Maize through *Trichoderma viride*

S.K. Singh*, M.B. Patel, P.K. Parmar, B.N. Thakker and K.H. Patel

Main Maize Research Station, Anand Agricultural University, Godhra-389 001, Gujarat, India.
*Corresponding author Email: singh.sk30@gmail.com, singh.sk30@aau.in

Trichoderma viride is a biocontrol agent used in agriculture to antagonize pathogens of crop plants. In addition to direct mycoparasitism of soil-borne fungal pathogens, *T. viride* interacts with roots. This interaction induces systemic resistance (ISR), which reduces disease in aboveground parts of the plant. In the molecular dialog between fungus and plant leading to ISR, proteins secreted by *T. viride* provide signals. Although studies delineating biocontrol activity of *Trichoderma* against fungal pathogens are documented, there is need for divulging the biochemical basis of disease resistance being induced by *Trichoderma.* Therefore, investigations pertaining to induction of such systemic resistance and associated biochemical responses is essential to understand the mechanism of biological control by *Trichoderma viride*. The study was designed to understand the role of *T. viride* in inducing defense enzymes (Peroxidase, Polyphenol Oxidase and Phenyl Alanine ammonia Lyase) and total phenolic content in maize against *Rhizoctonia solani.* It was found that the biocontrol agent, *T. viride,* induced higher levels of defense enzymes in maize during pathogenesis by *Rhizoctonia solani*. The result showed that glucanase activity and total phenol content in maize plants treated with *Trichoderma viride* (1587 µg/g) significantly increased. In addition, *T. viride* enhanced induced

systemic resistance on maize plant and obtained grain yield (4477 kg/ha). It was concluded that plant defense enzymes play a vital role in mitigating pathogen-induced stress in *Zea mays* during biological control by *T. viride.*

TS6-105: Differential Behaviour of Teosinte (*Zea mays* ssp. *parviglumis*) under Excess Water Stress Condition

Sneha Adhikari*, Anjali Joshi and N.K. Singh

GBPUAT, Pantnagar, India.
*Corresponding author Email: snehaadhikari24@gmail.com

Teosinte (*Zea mays* ssp. *parviglumis*) also known as Balsas teosinte is the most probable progenitor of modern maize. Due to its growing habit and adaptability, teosinte can be a potential germplasm in maize improvement program for abiotic stresses including excess soil moisture tolerance. Reports are scanty on the adaptation of teosinte-*parviglumis* in excess soil moisture conditions. Thus, an experiment was conducted to assess behavior of teosinte-*parviglumis* for 13 quantitative and three morphological characters in the field under normal and excess soil moisture conditions during the *kharif* 2017. The data was validated statistically using R software. Of the 13 quantitative characters, behavior of six parameters were noted to be significantly different. Characters with differential behavior were plant height, flag leaf length, flag leaf width, ears/plant, time of silk emergence and anthesis. Adventitious roots, one of the important excess moisture adaptive traits were noted to be absent in teosinte under excess soil moisture condition. Excess soil moisture condition also affected branching/tillering, tassel volume and density whereas the same were profuse and bulky under normal grown condition. Thus, the investigation indicates that there is significant reduction in many parameters in teosinte when exposed to excess soil moisture. Teosinte-*parviglumis*, therefore, did not possess adaptive traits against excess soil moisture stress conditions.

TS6-106: On-Farm Trials for Pre-commercial Field Corn Hybrids on Farmers' Field

Sodsai Changsaluk[1*], Sumran Srichomporn[1], Chadamas Jittlekha[1], Sarawut Rungmekharat[2], Naroon Waramitr[3], Waraporn Bunkoed[1], Paweena Thongluang[1], Kittisak Srichomporn[1], Suripat Thaithed[4] and Somchai Limaroon[1]

[1]National Corn and Sorghum Research Center, Faculty of Agriculture, Pak Chong, Nakhon Ratchasima 30320, Thailand; [2]Department of Agronomy, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand; [3]Department of Agronomy, Faculty of Agriculture, Kasetsart University, Kamphaengsan Campus, Nakhonpathom 73200, Thailand; [4]Nakhon Sawan Field Crop Research Research Center, Takfha, Nakhonsawan 60190, Thailand.
*Corresponding author Email: ijsssc@ku.ac.th

Trial on pre-commercial field corn hybrid was conducted in farmers' fields in six provinces of Thailand, namely Lopburi, Nakhon Ratchasima, Saraburi, Sa Kaew, Nakhon Sawan and Tak. The trial was conducted from May-November 2016, with the objective to identify the high potential pre-commercial field corn hybrids before they were recommended as commercial hybrid to farmers. The trial composed of 33 entries in 21 locations. The experimental design was RCBD with three replications. The result of combined analysis data from all 21 locations revealed that ST7124 gave the highest yield of 9,175 kg/ha, which was 13% higher than the yield of SW4452. However, it was not significantly different from SH161208, KSX5908,

KSX5924, KSX5911, KSX5603, KSX5927, KSX5720, KSX5912, STG286, KSX5819, KSX5934 and KSX5903, whose mean grain yield ranged between 8,531 to 9,119 kg/ha. SW4452, as check hybrid in the trial, gave yield of 8,144 kg/ha. The grand mean yield of the trial was 8,300 kg/ha. KSX5927, KSX5720 and KSX5924 showed the best stability.

TS6-107: Early Generation Testing of Maize (*Zea Mays* L.) F_4 Inbred Lines for General Combining Ability

Sowmya H.H., E. Gangappa* and S. Ramesh

Department of Genetics and Plant Breeding, College of Agriculture, UAS, GKVK, Bengaluru-560065, India.
*Corresponding author Email: egangu@gmail.com

Testing of early stage inbred lines for general combining ability (GCA) enables plant breeders to discard undesirable ones and identify desirable lines for production of superior hybrids. In this context, 15 F4 inbred lines selected based on narrow anthesis-silking interval (ASI) and high grain yield potential were evaluated for their GCA using testcrosses for days to anthesis, days to silking, ASI, cob weight plant^{-1}, grain yield plant^{-1} and shelling percentage during *kharif* 2017, at the University of Agricultural Sciences, Bengaluru. The analysis of variance for combining ability revealed significant differences among the test crosses for all the traits. The F4 inbred lines varied widely for their GCA and suggested good ability of testers to discriminate the inbred lines for GCA. Five F4 inbred lines were identified as good general combiners for cob weight^{-1} and grain yield^{-1}. Significant positive, and fairly high, magnitude of correlation coefficient between per se performance of hybrids and sum of parental GCA effects indicated good predictability of hybrids per se performance based on their parental GCA effects for all the six traits investigated. Further, significant positive and high magnitude of correlation coefficient between parental difference and mid-parent heterosis suggested the need for using diverse parents for maximizing the probability of recovering heterotic hybrids for grain yield.

TS6-108: Sustainable Approach for Management of Southern Corn Leaf Blight Disease of Maize in the Lower Gangetic Plains of India

Srabani Debnath[1*], Sonali Biswas[2] and Anirban Maji[3]

[1]AICRP on Maize, Bidhan Chandra Krishi Viswavidyalaya (BCKV), Kalyani, West Bengal, India; [2]AICRP on Maize, BCKV, West Bengal, India; [3]AICRP on Wheat & Barley Improvement, BCKV, Kalyani, WB, India.
*Corresponding author Email: srabanidebnath72@gmail.com

Maize (*Zea mays* L.) is the third most important cereal crop after rice and wheat, having wider adaptability to different agro-ecological and climatic conditions. Maize production and productivity is increasing in West Bengal, the lower Gangetic plain zone of India, where paddy dominates as the main crop. During *kharif* season, maize cultivation faces severe constraint from heavy rainfall and biotic stresses/diseases. One of the most prevalent diseases of maize crop in the lower Gangetic plain zone of India is Maydis leaf blight (MLB) / Southern corn leaf blight (SCLB) caused by the ascomycete fungi *Bipolaris maydis,* causing infection by conidia and resulting in yield loss of up to 70%. There are three races of this fungus - Race O, Race T and Race C - but most corn types are vulnerable to Race O which produce small, diamond shaped lesions of tan color, with buff to brown borders that remain within the leaves of the

maize plant. To avoid the devastating effect of SCLB in maize production an experiment was conducted at Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal for two consecutive years (2016 and 2017) with some bioextracts/ natural products for the purpose of management of this disease in a sustainable way. Experimental design was RBD with twelve treatments replicated thrice. The treatments are T_1, *Azadirachta indica* leaves at 10%; T_2, *Pongamia pinnata* (Kranj) at 10% extract; T_3, *Calotropis* sp. at 10%; T_4, *Datura stramonium* (Datura) at 10%; T_5, *Parthenium hysterophorus* at 10%; T_6, *Lantana camara;* T_7, *Polyalthia longifolia* (false Ashoka) at 10%; T_8, *Ocimum sanctum* (Tulsi) at 10%; T_9, *Allium sativum* (garlic) bulb at 10%; T_{10}, Cow urine at 50%; T_{11}, Hexaconazole (recommended dose); T_{12}, Water. From the pooled data of two years' results, the lowest disease score (1-9 scale) and Percent Disease Index (PDI) (28.4) was found in case of T_9 (score=2.56), followed by T_{10} (PDI= 29.8) (disease score= 2.68) and T_4 (PDI= 30.1) (disease score= 2.7) with no significant difference among them. Highest disease control percentage (61.13%) was obtained in T_9, followed by T_{10} (59.28%) and T_4 (58.82). Maximum yield was also gained in T_9 (25.8 q/ha), followed by T_{10} (24.7 q/ha) and T_4 (22.45 q/ha) with no significant difference among them. Garlic bulb extract at 10% rich in volatile antimicrobial substance allicin (diallylthiosulphinate), performed best against SCLB of maize. The result obtained by applying cow urine at 50% - which has antimicrobial & plant growth promoting properties - is at per with T_9. However, application of cow urine at 50% is more cost effective and easy to apply than garlic bulb extract at 10%.

TS6-109: KNMH-4010131: A High Yielding, Late-Wilt Resistant Single Cross Maize Hybrid Suitable for Telangana State of India

Sravani D. [1*], Sumalini K.[1], Usharani G.[2], Manjulatha G.[2], Rajanikanth E.[2], Nagesh Kumar M.V.[2], Sobha Rani T.[2], Pradeep T.[2] and Swarna Latha V.[2]

[1]Agricultural Research Station, Karimnagar, India; [2]Professor Jaya Shankar Telangana State Agricultural University, Hyderabad, India.
*Corresponding author Email: dsravanireddy@gmail.com

Late wilt poses a moderate to severe threat to maize production in India, especially in Telangana state where it is the most severe and destructive disease, and yield losses range from 10-40% and can be as high as 100% in some areas. In Telangana, maize was cultivated in 8.01 lakh ha both in *kharif* and *rabi* season (2016/ 2017). KNMH-4010131 is a high yielding medium maturity single cross maize hybrid with resistance to late wilt, a PFSR disease developed from ARS, Karimnagar, PJTSAU. KNMH-4010131 recorded a highest mean grain yield of 9542 kg/ha against the tested check hybrid 30v92(7173 kg/ha) under minikit trials in different districts of Telangana and Andhrapradesh in 2011, 2012 and 2013. The hybrid was also tested in Tr. No. 62 (IVT-Medium maturity) of All India Coordinated Maize Improvement Project trails during *Kharif* 2013 at twenty-six locations along with check BIO 9637. It recorded grain yield of 9580 kg/ha against check BIO9637 (9413 kg/ha), showed an average shelling out-turn of 80-82 % and was found resistant to the Post-Flowering stalk rot, compared to the check varieties under field screening in wilt sick plots of famer fields in Karimnagar district of Telangana state. Based on the superior yield performance and resistance to late-wilt disease, KNMH 4010131 was released in 2016 for general cultivation in the *kharif* and *Rabi* in maize growing areas of Telangana state.

TS6-110: *In Vitro* Evaluation of Botanicals and Fungicides against *Exserohilum turcicum* Causing Leaf Blight of Maize

Subash Subedi[1*], Surendra B.K.[2], Saraswati Neupane[1], Lokendra Oli[1] and Mina Karki[1]

[1]National Maize Research Program, Rampur, Chitwan, Nepal; [2]Nepal Polytechnic Institute, Purbanchal University, Bharatpur, Chitwan, Nepal.
*Corresponding author Email: subedi.subash1@gmail.com

Maize is the principal staple cereal diet of most Nepalese people, who mainly live in hilly regions. The maize yield level at present is far below potential yield in Nepal. There are various biotic and abiotic stresses that limit maize yield, with diseases and poor crop management being chief ones. Maize plants are affected by a wide range of fungal pathogens, and incidence of turcicum leaf blight caused due to *Exserohilum turcicum* at the pre-harvest stage has been a major hindrance to increasing production. A total of six botanicals and four fungicides, including systemic and non-systemic, were evaluated *in vitro* in different concentrations against *E. turcicum*. All the tested botanicals and fungicides showed fungicidal action and significantly inhibited mycelial growth of the test pathogen over untreated control. Among botanicals, extract of *Acorus calamus* L. at 1% W/V checked the pathogen growth completely *in-vitro*. The mycelial growth inhibition percent of *Lantana camera* L., *Artimisia indica* Willd., *Xanthoxylum armatum* DC., *Allium sativum* L. and *Azadirachta indica* A. Juss. at the concentration of 2.5 % W/V on PDA was 68.36 %, 65.95%, 50.13%, 40.75% and 29.76 % respectively. Among systemic fungicides, SAAF (Carbendazim 12% + Mancozeb 63% WP) at 1000 ppm concentration was found best (71.32% mean inhibition) while ACME-COP (Copper oxychloride 50% WP) and Dithane M-45 (Mancozeb 75% WP) among non-systemic was found prominent (71.96% and 60.72% mean inhibition) in inhibiting the mycelial growth of *E. turcicum*.

TS6-111: Sources of Resistance in Maize Genotypes against Post Flowering Stalk Rot Disease Under Subtropical Regime of Nepal

Subash Subedi*, Saraswati Neupane, Tirtha Rijal, JB Adhikari, Teknath Ghimire and Mina Karki

Nepal Agricultural Research Council, National Maize Research Program, Rampur, Chitwan, Nepal.
*Corresponding author Email: subedi.subash1@gmail.com

The inadequate source of resistance material in maize against major biotic stresses is one of the main reasons for its low yield in Nepal. During summer, the post flowering stalk rot caused by *Fusarium moniliforme* is a serious disease with high incidence during grain filling stage of maize in subtropical region, resulting in premature wilting of the plants. With the objective of identifying resistance/tolerance in maize genotypes, thirty genotypes were tested for maize stalk rot resistance during summer season of 2016 and 2017 at National Maize Research Program, Rampur, Chitwan. The experiment was carried out under natural epiphytotic condition at hot spot of disease following randomized complete block design with two replications. The plot size was 5m long with 75cm row to row spacing. The recommended fertilizers at 120:60:40 kg ha-1 (N:P:K) were applied. Agronomic practices were followed as recommended. The summer seasons of 2016 and 2017 were affable for post flowering stalk rot of maize at NMRP, Rampur. In two consecutive years, out of 30 genotypes, most of the tested entries showed susceptible reaction. However, RML-95/RML-96, Across 9942/Across 9944,

ZM 401, BGBYPOP, Rampur 34, RamS03F08, TLBRS07F16, Rampur 24, Rampur Composite and Arun 2 showed resistance against post flowering stalk rot with higher yield at Rampur Chitwan. Resistance against post flowering stalk rot is a considerable factor to be included in maize breeding program to develop disease resistant high yielding maize varieties.

TS6-112: Studies on Feasibility of Hybrid Seed Production of Public Bred Single Cross Maize Hybrids under Different Temperature Regimes

Sudipta Basu[1]*, Reza Joudaki[1], Viswanath Sharma[1], Monika A. Joshi[1], Anjali Anand[2] and Archana Singh[3]

[1]Division of Seed Science and Technology; [2]Division of Plant Physiology; [3]Division of Biochemistry, ICAR-Indian Agricultural Research Institute, New Delhi 110012, India.
*Corresponding author Email: sudipta_basu@yahoo.com

The climate change regime especially the variations in temperature have immense effect on seed production potential of maize. The present study was undertaken to evaluate the performance of parental lines under different sowing dates and assess the feasibility of parental line multiplication and hybrid seed production of single cross hybrids under different temperature regimes. Parental lines of four public bred single cross maize hybrids; BML6, BML7, VQL1, VQL2, HKI193-1, HKI163, CM150, CM151 were sown on six planting dates in monsoon, winter and spring summer season. The temperature and RH had significant effect on field emergence, early vegetative growth, flowering traits, synchronization behavior, seed yield and quality of the parental lines under different planting dates. Non-synchronization of flowering in parental was least in monsoon (1.75days) followed by spring summer (4.25days) and maximum in winter (6.25 days) season. Among parental lines, performance related to seed production traits were least influenced in CM150 and CM151; moderately in VQL-1 and VQL-2, HKI193-1, HKI 163 and most affected in BML6 and BML7 under different sowing dates. Seed quality was better in monsoon than spring-summer and winter produce. The study concluded that parental line multiplication and hybrid seed production was feasible both in monsoon and spring-summer season but not in winter season of above parental lines under Delhi conditions. In spring summer season, staggered sowing (five days) of the parental lines with pre-sowing hydro priming (17h), followed by dry dressing with thiram at 2.5g/kg of seed was recommended for achieving perfect nicking during commercial seed production.

TS6-113: Comparative Performance and Stability of Single and Multiple Crosses of Maize (*Zea mays* L.) across Environments

Sumalini Katragadda[1], Pradeep Tekale[2] and Sravani Dinasarapu[3]

[1]Agricultural Research Station, PJTSAU, Kampasagar, Telangana, India; [2]Professor Jaya Shankar Telangana State Agricultural University, Hyderabad, Telangana, India; [3]Agricultural Research Station, Karimnagar, India.
*Corresponding author Email: sumalinikatragadda@gmail.com

A set of 256 entries involving seven parents and their single, three-way and double crosses derived through half diallel mating design were evaluated, along with private/public hybrids, for grain yield in a balanced lattice design at three environments during *kharif* 2015. ANOVA revealed that TWC × Parents, DC × TWC, DC × SC, DC × Parents, and SC × Parents interaction were significant at all locations. Data was also obtained on the variety × environment interaction patterns for the three types of crosses. Significant interaction deviates

were higher for double crosses, followed by three-way crosses and finally single crosses. Average yield of double crosses was 37 kg ha^{-1} greater than that for single crosses, and the average for single crosses was 143 kg ha^{-1} greater than for three-way crosses. The range of single crosses was 483 kg ha^{-1} less than that of three-way crosses and 30 kg ha^{-1} greater than that of double crosses. There were no differences in yield stability among single and three-way crosses. Stability analysis for grain yield showed significant genotype × environment interaction in all the three classes of hybrids. Three-way cross (BML-51 × BML-10) × (BML-6) and double crosses (BML-51 × BML-32) × (BML-13 × BML-6) and (BML-13 × BML-7) × (BML-10 × BML-6) were found to be stable with unit b value, small deviation from mean square and high mean grain yield. These need to be exploited in future to combat biotic and abiotic stresses arising from climate change.

TS6-114: Studies on Standard Heterosis in Maize Single Crosses for Grain Yield and Yield Contributing Traits

Swarnalatha Devi, I.* and Nusrath

Professor Jayashankar Telangana State University, Rajendranagar, Hyderabad.
*Corresponding author Email: inapanuri.72@gmail.com

Maize *(Zea mays* L.) is an important cereal crop in global agriculture after wheat and rice. A line x tester analysis involving twenty-four crosses - generated by crossing eight elite maize inbred lines with three testers and two standard checks - was conducted for agronomic traits such as days to 50% tasseling, days to 50% silking, days to maturity, plant height, cob placement, ear length, ear girth, number of kernel rows per ear, number of kernels per row, hundred seed weight and grain yield per plant, during 2015/ 2016 cropping season at Seed Research and Technology Centre, Rajendranagar, Hyderabad. The objective of the study was to estimate the amount of standard heterosis of the hybrids for grain yield and yield related traits. The genotypes were evaluated in randomized block design, replicated thrice. The standard heterosis ranged from -21.92 to 24.39% and the highest standard heterosis was recorded for BML 6 x EC 15 (24.39%), followed by BML 6 x EC 14 (20.58%) over the standard check DHM 121 for grain yield per plant. Presence of substantial heterotic potential was observed that could be exploited in maize breeding programs and develop desirable cross combinations and synthetic varieties through crossing of inbred lines with desirable traits.

TS6-115: Genetic Enhancement for Increasing Yield Gains in Maize Breeding Programs

Swarna Latha V.*, Sravani D., Sumalini K, Badru D., Sreelatha D. and Narsimha Reddy V.

Maize Research Centre, ARI, Rajendranagar, Professor Jaya Shankar Telangana State Agricultural University.
*Corresponding author Email: vswarnalatha1980@rediffmail.com

Inbred line stagnation for productivity and stability is reflected in the *per se* productivity of lines below 50% in comparison to single crosses, and the inability to predict hybrid performance. Breeding of a maize source population is an effective way to enhance the development of superior inbred lines and improve genetic gain through enhancing potential and closing the yield gaps. Seeking elite lines began with the basic material of 187 crosses (105 three-way crosses and 82 double crosses). S_1 families with a mean yield corresponding to 15% of the original hybrids were selected and the mean yield improved

to 46% for S_5. Low inbreeding depression, positive general combining ability and negative specific combining ability were found to be criteria for best promising starting material. The best S_5 fixed potential inbred lines yielded from 30 to 40% higher than the yield of the inbreds used in creating double and three-way cross hybrids. These inbred lines were developed from the (BML-51×BML-32) × (BML-13×BML-6), (BML-51×BML-7) × (BML-32×BML-14), (BML-32 × BML-6) × (BML-13 × BML-10) and (BML-32×BML-14) × BML-51 via controlled selfing and selection without any previous population improvement. The fixed lines D-1, D-3, D-4 and TWC-2 were of high yielding inbreds with good *per se* due to the accumulation of favorable additive genes. It can be concluded that these fixed potential inbreds can be used in breeding programs to obtain superior hybrids with predicted genetic gains.

TS6-116: Photosynthetic Performance of Inbred Lines under Water Stress in Thailand

Thadsanee Budthong*, S. Thaitad and J. Chanthavorn

Nakhon Sawan Field Crops Research Center, Nakhon Sawan, 60190, Thailand.
*Corresponding author Email: tchuajad@hotmail.com

Study on photosynthetic rate of 10 inbred lines was done during the dry season, 2017. They were evaluated in separate trials under well-watered and water stress conditions at Nakhon Sawan Field Crops Research Center. A randomized complete block design was used with three replications. Individual plot consisted of four rows of five meters long with a row spacing of 0.75m and 0.20m between plants. Observations were made on grain yield, yield components, physiological traits and photosynthetic rate. The experiment showed grain yield ranging from 0.98-3.91 t ha^{-1} under well-watered conditions and 0-1.23 t ha^{-1} under water stress. Across two conditions, yield loss ranging from 66-100% and drought index ranging from 0.00-2.74 was observed. Grain yield across two conditions showed that Nei462013 and Nei542017 are drought tolerant because they were high yielding and had drought index of more than one. Consideration on photosynthetic rate, and sun and sky response under water stress, showed that photosynthetic rate and transpiration rate started at 6.00 a.m. increased or decreased depending on photosynthetically active radiation (PAR). At noon, the highest photosynthetically active radiation and leaf temperature was experienced, and inbred lines showed water stress and started to wilt. Three lines (Nei462013, Nei402011 and Nei542017) were classified as drought tolerant because they were still photosynthesizing, consistent with grain yield. Correlation analysis between photosynthetic rate and physiological traits under water stress showed that photosynthetic rate correlated positively with stomatal conductance, transpiration rate, leaf temperature and photosynthetically active radiation but correlated negatively with leaf vapor pressure deficit.

TS6-117: Evaluating the Agronomic Characteristics and Analysis Genetic Diversity, Heterosis of 24 DH Lines for Breeding Program in Vietnam

Thanh Nguyen Duc*, Ha Dang Ngoc and Hung Nguyen Huu

[1]National Maize Research Institute, Hanoi, Vietnam.
*Corresponding author Email: thanhkhvn2010@gmail.com

In recent years, haploids and doubled haploid lines have been widely applied in advanced maize breeding. With CIMMYT's help, the National Maize Research Institute of Vietnam (NMRI)

has successfully applied in vivo doubled haploid technique with 217 DH lines developed from diversified germplasm, from which 24 selected DH lines were evaluated on agronomic characteristics, genetic diversity and classified into heterotic groups in the spring seasons of 2016 and 2017. The promising DH lines of heterotic groups were identified and used as parents for developing hybrids in the future. To have evaluated genetic diversity of 24 DH maize lines in this study, 23 SSR markers announced at website http://www.maizegdb.org were used. The results showed that six DH lines were selected based on high uniformity and good physio-agronomic traits. Evaluating genetic diversity and classifying heterotic groups of 24 DH lines with SSR markers showed that most of these lines were of high homozygosity (over 90%) and could be divided into two groups. Six selected DH lines with good agronomic characteristics and different major heterotic groups were selected and may be evaluated for combining ability later.

TS6-118: Evaluation of Inbreds for Grain Yield and Its Contributing Characters Under Rainfed Conditions

Usharani G.*, Sravani D., Sumalini K., Swarnalatha V., Rajanikanth E., Manjulatha G. and Vijayabhaskar B.

Agricultural Research Station, Karimnagar, Professor Jayashankar Telangana State Agricultural University.
*Corresponding author Email: ushagenetics@gmail.com

Moisture stress during critical stages of crop growth and development is one of the most limiting factors for maize production and productivity in large areas of the tropics. Maize is particularly sensitive to water stress one week before flowering and two weeks after flowering, causing severe losses when exposed to drought conditions during flowering due to increased anthesis silking interval. Prolonged drought spells at flowering during *kharif* in maize crop is a recurring phenomenon in the state of Telangana. In this context, a trial was conducted at Agricultural Research Station, Karimnagar, during *kharif* 2017 involving sixty genotypes against the check KDTML-3 (Drought tolerant line registered with NBPGR) under rainfed conditions to identify drought tolerant inbreds. Grain yield of superior inbred lines was in the range of 101 to 125 g per plant under rainfed conditions. Three inbred lines *viz.,* KNMDL 14-11, KNMDL 14-69 and KNMDL 14-98 were found to be suitable for rainfed conditions as these lines expressed a yield advantage of >13% over the check KDTML-3, and had a grain yield of more than 115 g plant^{-1} that could be exploited in future for development of climate resilient hybrids.

TS6-119: Evaluation and Selection of Newly Developed Maize Inbreds for Genetic Enhancement of Yellow Maize

Uttam Chandel[1*], S.K. Guleria[2], R. Devlash[2], D. Kumar[1] and G. Katana[3]

[1]CSKHPKV, SAREC, Kangra, India; [2]CSKHPKV, and Himachal Pradesh, HAREC Bajaura District, Kullu, Himachal Pradesh, India; [3]CSKHPKV, Palampur, India.
*Corresponding author Email: uttam_chandel@yahoo.co.in

Yellow maize is usually preferred over white maize for human consumption in North-Western hills of India. Since elite parental material is a pre-requisite for the genetic enhancement of any crop, forty newly developed yellow inbreds along with three checks (HKI-1040, HKI-1105 and

CM-212) were evaluated in a randomized complete block design with two replications at Experimental Farm of Shivalik Agricultural Research and Extension Centre, Kangra during *Kharif* 2016. Inbreds were kept open for random mating. Data was collected on days to anthesis and silking, anthesis-silking interval (ASI), yield and its contributing traits. The analysis of variance revealed significant differences among genotypes for all the considered traits. Genotypes of high yielding ability with less ASI were selected at 5% LSD over best check CM-212. A total of nine inbreds viz., KI-3B-I, KI-7B, KI-17, KI-28-A, KI-28B-2, KI-29A-I, KI-29A-2, KI-29C-I and KI-35B with high yield (2183-2661kg/ha) were selected. These inbreds had less ASI (1 to 4 days) and recorded (>25 %) higher yield than the best check. These selected inbreds, therefore, could be effectively used for hybrid development and enhancing yellow maize yield in North Western Himalayas Ecology.

TS6-120: Comparison of Estimators Used to Identify Inbred Donors with New Favorable Alleles

Vaibhav P. Chaudhary[1*], N. Sarma Barua[2], Ramendra N. Sarma[2], Purna K. Barua[2], Ranjan Das[3] and S.N. Phukan[4]

[1]ICRISAT, Patancheru, India; [2]Plant Breeding and Genetics, AAU, Jorhat, India; [3]Crop Physiology, AAU, Jorhat, India; [4]Agricultural Statistics, AAU, Jorhat, India.
*Corresponding author Email: vpcmaize@gmail.com

The estimators viz., the estimate of relative number of favorable dominant alleles present in a donor but not in the hybrid to be improved (μG'), upper bound statistic (UBND), predicted three-way performance (PTC), net improvement (NI) and probability of net gain of favorable dominant alleles (PNG_g) were used to identify inbreds with favorable alleles, compared for their efficiency in ranking donors using data on single crosses, parents and donor inbreds. Eight inbred lines of maize (V341, V351, VQL12, VQL16, LQPM42, CLQ47, I-07-57-5 and I-07-8-6) were crossed in a half-diallel fashion at AAU, Jorhat, Assam, India. Grain yield and three agronomic traits were reported. The donor inbred line VQL12 was found to be the best potential inbred donor for the target cross LQPM24 × I-07-8-6 as estimated by most of the estimators used for identification of new favorable alleles. Among the estimators used, μG', PTC, UBND and NI in general showed significant *inter se* correlations indicating similar efficiency in identifying the donors with new favorable alleles.

TS6-121: Morphological and Molecular Diversity Studies in Maize (*Zea mays* L.) Inbreds for Yield and Yield Related Traits.

Varsha Gayatonde*, J.P. Shahi, Prudhvi Raj Vennela and K. Srivastava

Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P, India.
*Corresponding author Email: varshapanchu@gmail.com

Presence of diversity among inbreds is an important strategy for developing hybrids with varied and desirable characters that play a vital role in increasing the acreage and productivity of maize. Therefore, information on diverse inbreds at genotypic level is essential. The present investigation was carried out in the maize research laboratory, Department of Genetics and Plant Breeding, using 20 inbreds collected from AICRP on Maize Centre, BHU, Varanasi. The morphological diversity studies resulted in formation of five clusters. Cluster I consisted of mid-altitude and highland inbreds, while the mid-altitude inbred lines from CIMMYT were

grouped in cluster II with two sub-divisions. Cluster III contained highland and mid-altitude inbreds. Cluster IV, the largest group, with highland adapted maize inbred lines. This group was further divided into two subgroups, based on pedigree relatedness. Cluster V consisted of a mixed group of mid-altitude and highland inbreds. For molecular diversity analysis a total of 145 markers were used, out of which 93 were found informative and polymorphic. A total of 223 alleles were obtained with an average of 2.34 alleles per locus. Mean polymorphic information content (PIC) value ranged from 0.76-0.20 with an average of 0.34. The dendrogram generated by hierarchical unweighted pair group method with arithmetic mean (UPGMA) cluster analysis resulted in four major clusters with 0.59 similarity coefficient. Among the inbreds used, HUZM 53 was found to be most diverse from the lines like HKI 193-1, HUZM-152 and other HKI series inbreds. The information generated in this study will be useful in developing heterotic pools.

TS6-122: QTL Mapping for Resistance to Fusarium Stalk Rot in Asian Maize Germplasm

Veerendra Babu*, Pradeep Kumar Singh, Zerka Rashid and Sudha K. Nair

Asia Regional Maize Program, International Maize and Wheat Improvement Centre (CIMMYT), ICRISAT, Patancheru, Hyderabad-502324, Telangana, India.
*Corresponding author Email: V.Babu@cgiar.org

In India, maize production is severely affected by Post flowering stalk rot (PFSR), caused by multiple soil-borne pathogens. *Fusarium moniliforme* is among the pathogens that cause Fusarium stalk rot (FSR) and is prevalent in most maize growing areas of India where water stress occurs after flowering stage of the crop. Resistance to FSR is reported to be a multi-genic trait, with predominance of additive gene action. We carried out a QTL mapping study to identify QTLs controlling resistance to FSR. For QTL analysis, we used two F2:3 bi-parental mapping populations, with a common susceptible parent, CML474. The first population (FSR-P-1) had 166 families genotyped with 112 Polymorphic SNPs and the second population (FSR-P-2) had 256 families genotyped with 156 polymorphic SNPs. Phenotyping was carried out under artificial inoculation conditions in Hyderabad, India, with a heritability of 0.58 for FSR-P-1 and 0.39 respectively. Inclusive composite interval mapping (ICIM) identified three QTLs in FSR-P-1 located on chromosome 2 and chromosome 9. The proportion of phenotypic variation explained by these QTLs ranged from 6.78% to 18.08% and two of them were derived from the resistant parent CML329/MBRc2amF14-2-B*9. In FSR-P-2, two QTLs were identified located on chromosome 1 and chromosome 7. The proportion of phenotypic variation explained by these QTLs was 5.12% to 5.65% respectively. The moderately large effect QTL identified from resistant parent, CML329/MBRc2amF14-2-B*9 will be studied further in breeding populations to strategize possible use of this QTL in marker assisted selection.

TS6-123: Evaluation of Maize Genotypes for Turcicum Leaf Blight (*Exserohilum turcicum*) in Telangana State

Vijaya Bhaskar A.*, B. Mallaiah, G. Manjulatha, G. Usharani, D. Sravani and E. Rajanikanth

Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana, India.
*Corresponding author Email: av_bhaskar12@yahoo.co.in

Maize (*Zea mays* L.) is the third most important staple food crop in Telangana in terms of area and production, after rice and cotton. Both abiotic and biotic stresses contribute to lower maize yields in Telangana. The most devastating diseases of maize in the context of Telangana are leaf blights (northern and southern), stalk rot, ear rot, rust and downy mildews, etc. Turcicum leaf blight (TLB) of maize caused by *Exserohilum turcicum* (Pass.) K.J. Leonard and E.G. Suggs (teleomorph *Setosphaeria turcica* Luttrell) has been reported in all maize growing areas of Telangana wherever maize is cultivated. TLB, also known as Northern corn leaf blight (NCLB), is prevalent in *Kharif* and *Rabi* in Telangana, and occurs in maize from the seedling to maturity stages. The spread of the disease is steadily increasing because of intensive maize cultivation and harvesting of maize from the same land year in and year out. One hundred twenty maize genotypes were evaluated for resistance to Turcicum leaf blight (*Exserohilum turcicum*) in 2017/ 2018 at Agricultural Research Station, Karimnagar, under natural field conditions. The 1-9 scale for disease score was used based on the proportionate leaf area affected by the disease. Of the 124 genotypes evaluated, 25 (IB-63, 70, 77, 78, 82, 99, 118, 125, 131, 145, 147, 149, 152, 154, WNC-8, 35, 42, 259, IJINA004, P72CIX(BASIL), EC5298462, EC672848AAAA, BGS337, ACC52093 and WLSF-73 were resistant (1.0 scale) and 52 genotypes IB-55, 62, 64, 65, 66, 68, 69, 71, 74, 75, 76, 80, 81, 86, 87, 90, 93, 94, 95, 96, 97, 98, 103, 104, 105, 106, 111, 112, 113, 126, 127, 131, 132, 133, 146, 322, WNC-52, 54, 55, 126, 150, 412, 494, Separate, EC6729809, BLS42050,CIM3-2-1,S99-LYQX-32,PFSR-3 and CLQ-RCY) were moderately resistant (2.0 scale), but all entries were susceptible to Turcicum leaf blight disease. The 25 genotypes were identified as promising sources of resistance against *Exserohilum turcicum* and can be used to develop disease resistant and high yielding varieties to enhance maize productivity in Telangana State.

TS6-124: Identification and Expression Profiling of Phosphate Stress Responsive Genes in Maize

Vikram Dayaman[1], Krishan Kumar[1*], Ishwar Singh[1] and Pranjal Yadava[1,2]

[1]ICAR-Indian Institute of Maize Research, Delhi Office, Pusa Campus, New Delhi, India; [2]Department of Biology, Stanford University, 385 Serra Mall, Stanford, CA, 94305, USA.
*Corresponding author Email: krishaniimr@gmail.com

Modern agriculture is based on generous application of fertilizers and high-yielding genotypes. Maize cannot utilize more than 10% of the applied inorganic phosphate (Pi) which is a non-renewable fertilizer resource. Owing its emergence as an industrial, feed and food crop, improvement in phosphorus use efficiency (PUE) is essential in maize for sustainable use of fertilizers containing phosphate. Therefore, there is need to identify key regulatory genes playing pivotal roles in acquisition, transportation and utilization of Pi in maize. The present study was undertaken to identify Pi-responsive genes in maize through whole-genome analysis and expression profiling. The twelve Pi-responsive genes (five having regulatory role, four encoding for secretory proteins and two encoding for Pi transporters) were identified through Hidden Markov Model-based homology search. The expression of identified genes in root and shoot tissues of hydroponically grown maize inbred line HKI-163 under Pi sufficient (1mM KH2PO4) and deficient (5µM KH2PO4) condition was analyzed using quantitative and semi-quantitative RT-PCR. Expression analysis revealed that 11 out of 12 genes were significantly up or down regulated under Pi-deficient condition. To comment upon the mechanism of observed differential expression of Pi-responsive genes under phosphate deprived condition, cis-regulatory elements present in the upstream promoter region of these genes were analyzed and phosphate responsive elements were found in two genes. In other genes, the differential

expression may be indirectly linked to phosphate deprivation. We believe that the identified Pi-responsive genes can be employed for engineering high PUE in maize after functional validation.

TS6-125: All heats are not same: Maize to beat various heat stress regimes in Asian tropics

Vinayan M.T.[1*], Salahuddin Ahmad[2], Prakash Kuchanur[3], S.S. Mandal[4], Ramesh Chaurasia[5], K. Seetharam[1], Reshmi Rani Das[1], S. Vishwanadh[1] and P.H. Zaidi[1]

[1]CIMMYT Asia Maize Program, ICRISAT Campus, Hyderabad, India; [2] Division of Plant Breeding, Bangladesh Agricultural Research Institute, Jodebpur, Gazipur, Bangladesh; [3] University of Agricultural Sciences, Raichur, Karnataka, India; [4] Bihar Agriculture University, Sabor, Bihar, India; [5] Kaveri Seeds Ltd., Hyderabad, India.
*Corresponding author Email: v.madhumalthayil@cgiar.org

Due to unprecedented increase in maize demand, post-rainy spring season maize cultivation has gained popularity across regions of South Asia. The scope of maize production in this season however, is often limited due to heat stress (prolonged daily Tmax >35oC). Varying environmental factors across these growing regions, coupled with high genotype × environment interaction (GEI), often limits the opportunity of identifying potential heat resilient cultivars for deployment. The objective of this study was to assess the magnitude of GEI observed during the spring season across regions of South Asia and identify suitable cultivars for deployment within a specific agro-ecology or across the region. Two sets of trials comprising 30 and 70 hybrids respectively were evaluated for heat stress tolerance during spring season of 2017 across 11 locations of South Asia (India, Pakistan and Bangladesh). Performance of hybrids varied across locations in response to heat stress. The locations clustered into two major groups based on Wards minimum variance method. The first group comprised trial locations in South India (Bejjanki, Raichur, Hyderabad, Bheemarayangudi) and the second group comprised locations in Northern India, Pakistan and Bangladesh. The locations in Group-I were generally more dry (low average relative humidity) compared to the second group during spring season. Additive main effects and multiplicative interactions (AMMI) analysis revealed that the yield variation was explained largely due to environments (35 to 72%) followed by the GEI (14 to 37%) across the two major location clusters. The first three factors from AMMI were able to explain 70-100 percent of the interaction observed across the two major groups and trials. Hybrids ZH16963, ZH1764 and CAH1725 were identified as the most suitable entries for cultivation across region during the spring season.

TS6-126: Elevated Temperature Promotes Pink Stem Borer Growth Performance on Maize and Antagonizes the Effects of Elevated CO_2

Viswajyothi K.[1*], Naveen Aggarwal[2] and Jawala Jindal[3]

[1]Department of Agricultural Entomology, College of Agriculture, Vellayani, Trivandrum, Kerala, India; [2]Department of Entomology, Punjab Agricultural University, Ludhiana, Punjab, India; [3]Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana, Punjab, India.
*Corresponding author Email: viswajyothi14@gmail.com

The effect of climate change on the growth and development of Pink stem borer (PSB), *Sesamia inferens* Walker (Lepidoptera: *Noctuidae*), was studied on maize crop (*Zea mays* L.) (*Poaceae*) by controlled temperature and CO_2 experiments. The experiments were carried out in a

controlled environmental chamber (PGW-40, M/s Percival Scientific, Inc., USA), at the Department of Entomology, College of Agriculture, Punjab Agricultural University (PAU), Ludhiana, India, using factorial CRD design. The insects reared at four combinations of alternating temperature (27:22 and 32:26°C), and CO_2 (375 and 450 ppm) on maize plants revealed that elevated temperature has predominant effect over CO_2. The growth of egg, larval and pupal stages was faster at elevated temperature condition. The total developmental period reduced by 30.9% and fecundity increased by 10.8% at elevated temperature. The reverse effect was observed at elevated CO_2. Larval and pupal development got delayed with increase in CO_2. There was a 5.7% increase in total developmental period and 14.4% reduction in fecundity at elevated CO_2. Both temperature and CO_2 individually and in combination significantly influenced adult longevity. It reduced 24.9% in males and 21.74% in females at elevated temperature and increased 7.6% in males and 6.8% in females at elevated CO_2. Adult longevity increased 44.4% from 32:26°C & 375 ppm combination to 27:22°C & 450 ppm in male, while in female it increased by 38.8%. The temperature and CO_2 were seen to antagonise, with temperature being predominant in influencing the biology of *S. inferens.* It can be concluded that the elevated temperature has positive effect and elevated CO_2 has negative effect on the growth and development of PSB on maize. So, the present study provides evidence that the improved insect performance in the warm climate might be slightly mitigated by the indirect adverse effect of elevated CO_2 on the growth and development of PSB on maize. Its overall effect on PSB population over several generations and its net effect on maize productivity need to be further investigated.

TS6-127: Affordable, Accessible, Asian (AAA) Drought Tolerant Maize: A Successful Example of a Public-Private Partnership

Vivek B.S.[1*], P. Nagesh[1], N. Sharma[2], H. Thieblemont[3], I. Barker[3], S. A. Takalkar[1], P. Dasgupta[3], A.M. Rao[3] and M. Robinson[3]

[1]CIMMYT Asia Regional Maize Program, ICRISAT, Patancheru, Hyderabad-502324, India; [2]Syngenta India Limited, My Home Hub, Sy.No.64P&79P, Block-1, 9th Floor, Madhapur, Hi-Tech City, Hyderabad, Telangana, India; [3] Syngenta Foundation for Sustainable Agriculture (SFSA), Schwarzwaldallee 215, CH-4058 Basel, Switzerland.
*Corresponding author Email: b.vivek@cgiar.org

For smallholder farmers in developing countries, access to, availability and affordability of new crop varieties that are robust, drought tolerant and high yielding were recognized as urgent and lasting needs. Although the public sector has a mandate to develop sustainable solutions for niche requirements, delivery remains a challenge due to the low presence of the private seed sector in stress prone and outlying regions. This project targeted drought prone and tribal areas in Central Western India where maize covers 1.7 million hectares with an untapped market potential of about 34,000 metric tons of seed required by over two million households that could benefit from improved low-cost seed. This erratic environment with other dynamics makes seed marketing risky, unpredictable and unattractive, and is often overlooked by the private seed sector. Therefore, a PPP model that could generate wins for the private sector while at the same time increase access of resource-poor farmers to affordable seed of high quality, was conceived. The AAA project, with support of the Syngenta Foundation for Sustainable Agriculture (SFSA), was operationalized in November 2010 as a collaboration between CIMMYT, Syngenta and the National Agricultural Research Systems (NARS) [National Maize Research Institute (NMRI), Vietnam, and the Indonesian Cereals Research Institute (ICeRI)]. Through further partnership with seed companies, the project has begun

deploying TA5084, a joint hybrid by Syngenta and CIMMYT. A new wave of products is in the pipeline. The AAA concept will be expanded to other regions of India and other Asian countries.

TS6-128: Identification of Stable Sources of Resistance Against Turcicum Leaf Blight of Maize under Temperate Conditions

Z.A. Dar[1*], A.A. Lone, M.A. Ahangar., B.A. Alie, Hooda K.S.[3], R.K. Khulbe, S. Nair[2], Z. Rashid, Gulzaffar, S. Naseer, I. Abidi, G. Ali, B. Ahmed, K. Rehman and S.L. Sharma

[1]DARS-Budgam, SKUAST-K, Kashmir, India; [2]CIMMYT-Asia, Hyderabad, India; [3]ICAR-IIMR, Ludhiana, India.
*Corresponding author Email: zahoorpbg@gmail.com

Turcicum leaf blight, also known as Northern leaf blight, in maize is incited by the fungus anamorph *Exserohilum turcicum* (Pass.) Leonard and Suggs. It is the most economically important disease affecting maize in the world, and frequently occurs in mountain agro-ecologies of Kashmir valley. A set of 125 germplasm lines of maize belonging to CIMMYT, SKUAST-K, ICAR-VPKAS, Almora and ICAR-IIMR, Ludhiana, were initially screened under artificially inoculated field conditions. The experiment was carried out at Mountain Crop Research Station, Larnoo, located at latitude 33° 37' N, longitude 75° 22' E and an altitude of 2286 metres above mean sea level. The experiment was established during *Kharif* 2015 to 2017. Test lines were planted in two row plots of 3m length with plant spacing of 60 X 20 cm. The plot was bordered by susceptible disease spreader rows on each side. The mixed inoculum of twenty-day old cultures of four isolates of *E. turcicum* from Larnoo and Khudwani locations. The genotypes *viz*., VL1018641, VL108665, VL062606, VL05614, VL102, VL109545, showed resistant reaction with disease grade 1 against *E. turcicum*, while the remaining genotypes showed moderate resistance to susceptible reaction. The genotypes Pahalgam local and SMI154 were found highly susceptible. To validate resistance, the genotypes need further evaluation under controlled conditions against all the available isolates of *E. turcicum.*

TS6-129: Phenomics Based Differentiation of Tissue Water Status in Susceptible and Tolerant Maize Inbred Lines to Moisture Stress

Z.A. Dar[1]*, J.S. Rane[1], J.A. Khan[1], R. Giri[1], A.A. Lone[1], R.K. Khulbe[3], S. Naseer[1], P.A. Sofi[1], B.A. Alie[1], I. Abidi[1], B. Ahmed[1], K. Rehman[1] and N.P. Singh[2]

[1]SKUAST, Kashmir, India; [2]ICAR-NIASM, Baramati, India; [3]ICAR-VPKAS, Almora, India.
*Corresponding author Email: zahoorpbg@gmail.com

Phenomics is an emerging science aimed at non-destructive methods that allow large scale screening of genotypes, thereby complementing genomic efforts to identify genes relevant for crop improvement under both favorable and unfavorable environments. Thirty maize inbred lines from different sources (exotic and indigenous) maintained at Dryland Agriculture Research Station (SKUAST- Kashmir) were chosen for the study. In the automated conveyer for plant transport and imaging systems (the ICAR-NIASM LemnaTec Scanalyzer system for large plants), top and side view images were taken of the VIS and NIR range of the light spectrum. The Lemnagrid Integrated Analysis software for high-throughput plant image analyses was used for image-based plant feature extraction. Image processing is divided into

two major parts: image segmentation and feature extraction. All thermal images were obtained with a thermal imager (Vario CAM hr Inspect 575, Jenoptic, Germany). The results introduced a dataset of 30 maize inbred lines. Images were collected daily for 11 days. Imaging started one day after shifting the pots from the greenhouse. Different surrogates were estimated in the study such as area, plant aspect ratio, convex hull ratio, caliper length, e.t.c. A strong association was found between canopy temperature and above ground biomass under stress conditions. Lines showing promise in different surrogates should be crossed with locally adapted lines to develop mapping populations for traits of interest related to drought resilience, in terms of improved tissue water status and map genes/QTLs of interest.

TS6-130: Additive Main Effects and Multiplicative Interaction (AMMI) Analysis to Identify Stable Resistant Maize Genotypes for Charcoal Rot

Zerka Rashid[1], Pradeep. K. Singh[1*], Harleen Kaur[2], Sharanappa Harlapur[3], M.T Vinayan[1], K.S Hooda[4] and Sudha. K. Nair[1]

[1]CIMMYT Asia Regional Maize Program, ICRISAT, Patancheru, Hyderabad-502324, Telangana, India; [2]Punjab Agricultural University (PAU), Ludhiana-141004, Punjab, India; [3]University of Agricultural Sciences (UAS), Dharwad-580005, Karnataka, India; [4]ICAR-Indian Institute of Maize Research (IIMR), PAU Campus, Ludhiana-141004, Punjab, India.
*Corresponding author Email: s.pradeep@cgiar.org

Charcoal rot caused by *Macrophomina phaseolina* is one of the post flowering stalk rots occurring in maize, which is more prevalent when crop is under water stress and accompanied with high temperature and low humidity. In Asia, this disease is reported in Bhutan, South China, India, Nepal, Pakistan, Philippines and Thailand. Breeding programs require close surveillance of virulence changes in existing pathogens and development of durable resistant sources to all virulent strains. In this experiment 75 tropical adapted maize inbred lines were evaluated across four locations over a period of two years to identify stable resistance for the charcoal rot. Lines were evaluated in two replications under artificial inoculation and the heritability estimate of the trials across environments were 0.61. Variation among genotypes (G), environments (E) and genotype-environment interaction (GEI) were highly significant. GEI explained 38.8% variance of the total sum of squares. Additive main effects and multiplicative interaction (AMMI) analysis revealed that the first two interaction principle component axes (IPCAs) explained 36.5% and 22.7% of the interaction effect, respectively. AMMI selections across environment showed the genotype VL109582 as one of the top four genotypes, followed by VL1018680 and SNL142288. AMMI analysis and bi-plot gave information about the reaction of genotypes in different environments which will be useful for breeders to develop location specific hybrids.

TS6-131: Identification of Genomic Regions for Fusarium Stalk Rot Resistance in Tropical Maize (*Zea mays* L.) Using Genome Wide Association Study

Zerka Rashid[1*], Pradeep K. Singh[1], S.S. Sharma[2], K.S. Hooda[3] and Sudha K. Nair[1]

[1]CIMMYT Asia Regional Maize Program, ICRISAT, Patancheru, Hyderabad-502324, Telangana, India; [2]Maharana Pratap University of Agriculture & Technology (MPUAT), Udaipur- 313001, Rajasthan, India; [3]ICAR-Indian Institute of Maize Research (IIMR), PAU Campus, Ludhiana-141004, Punjab India.
*Corresponding author Email: m.zerka@cgiar.org

Among post flowering stalk rots of maize, Fusarium stalk rot (FSR) is one of the most destructive diseases throughout the world. In Asia, *Fusarium moniliforme* is the main pathogen causing FSR of maize and is prevalent in countries like China, India, Indonesia, Nepal, Pakistan, Philippines, Thailand and Vietnam. Resistance to FSR is a complex polygenic trait, hence difficult to incorporate the resistance in elite germplasm. Identification of genomic regions contributing to resistance will be useful in enhancing FSR resistance in elite breeding germplasm. A genome wide association study (GWAS) was conducted for FSR resistance in 409 CIMMYT Asia tropical adapted inbred lines. Trials were conducted for three years at Hyderabad, India, under artificial inoculation conditions. Heritability estimate of the phenotypic trials across three years was 0.52 and BLUP estimates were generated. GWAS was carried out using high density genotyping by sequencing (GBS) SNPs using single locus mixed model analysis which corrects for population structure and kinship. Results revealed 10 highly significant SNPs ($P \leq 2.38 \times 10^{-5}$) on chromosomes 1, 2, 4 and 6 associated with FSR resistance. Minor alleles were favorable for resistance in all the identified SNPs observed in the panel. In GWAS, a narrow sense heritability of 0.46 was estimated with a standard error of 0.90. Haplotype trend regression analysis done using 22 genetic variants which includes four haplotype blocks and 18 independent SNPs, identified SNP S1_21686758 which explained 17.08% of phenotypic variance. Genomic regions identified need to be further validated through linkage mapping for further deployment in the breeding program.

TS7: Socioeconomics and Policies

TS7-1: Agronomic Performance of Quality Protein Maize in Pakistan

Akhter Ali*

CIMMYT, Islamabad, Pakistan.
*Corresponding author Email: akhter.ali@cgiar.org

Quality protein maize (QPM) was recently introduced in Pakistan through the Agricultural Innovation program for Pakistan. QPM seed was first distributed in Punjab, KPK and AJK to a limited number of stakeholders, that is, only 17 farmers and seed companies in total. The main objective of the current paper is to document the agronomic performance of QPM, compared to traditional maize. For that, data was collected from all 17 stakeholders using a comprehensive questionnaire. The detailed results indicated that QPM is at par with traditional maize in terms of germination, plant height, cob size, yield and fodder quality. QPM can help overcome the ever-increasing malnutrition and stunting problem in Pakistan. However, lack of awareness about QPM maize, and inadequate skills about QPM maize production technology, are major constraints to its wider adoption and uptake in Pakistan. For that the agricultural extension department needs to play an effective role regarding awareness and capacity building of QPM production technology. At policy level, improved market prices for QPM maize can speed up the adoption process.

TS7-2: Maize in Vietnam: Current Status and Challenges

Cuong Bui Manh*

National Maize Research Institute (NMRI), HaNoi, Vietnam.
*Corresponding author Email: bmcuongcnsh@gmail.com

Maize is one of the most important cereal crops in Vietnam, after paddy rice, and has been used as food for hundreds of years. In recent decades, however, less than 10% of maize produced has been used as food; instead it is used for animal feed and processing industries. Even with about 1.1 million hectares, grain yield of 4.5 tons/ha-1 and production of 5.5 million tons, demand for maize has been growing rapidly in the last few years. Vietnam still imports about 7-8 million tons of maize annually to meet domestic demand. Although expanding maize area may be considered as a solution, improving productivity, lowering production costs and ultimately increasing economic efficiency are more important for Vietnam's maize production and industry today.

TS7-3: Analysis of Adoption of Modern Maize Varieties Among Farmers in Nepal

Namdev Upadhyay*, Bimala Sharma, Yogendra Acharya, Samaya Gairhe and Sudha Spakota

Nepal Agricultural Research Council, Nepal.
*Corresponding author Email: namdevupadhyay@gmail.com

This study examines the status of adoption of improved maize varieties in Nepal. A total of 682 households were sampled from six districts, namely Sindhupalchowk, Lalitpur, Khotang, Dang, Chitwan and Dadeldhura. Data was analyzed through descriptive statistics. Results indicated that the slow growth rate of area, production and yield was around 2.7% p.a. and growth rate was also at a stagnant rate from 1990 to 2015. Adoption of a modern variety was found to be at 75% of household. Mean area of maize cultivation in Nepal is 0.431 ha/HH. Only seven improved varieties were adopted in large scale, and in 70.6% of maize cultivating areas. Improved varieties Rampur composite, Mankamana-3 and Deuti and Hybrid CP 808 were found to be highly adopted. CP 808, Shrestha and Rajkumar were the dominating hybrids. Age of household head, caste, migration, credit accessibility, cooperative involvement, extension visits, training, formal sector seed availability and knowledge about agricultural insurance were found to be major factors affecting adoption of modern maize varieties. However, education and livestock numbers were found to negatively contribute to adoption.

TS7-4: Policy Innovations for Market Development of Hybrid Maize: Case of Nepal

Narayan P. Khanal*, Mina Devkota, Gokul Paudel, Andrew Mcdonald, Dilli K.C., Shriniwas Gautam and Dyutiman Choudhary

CIMMYT, South Asia Regional Office, Kathmandu, Nepal.
*Corresponding author Email: n.khanal@cgiar.org

Maize is the second most important cereal crop of Nepal, grown on 0.79 million hectares of land with average productivity of 2.5t/ha. Flourishing poultry business and increasing demand for feed has maize emerging as a cash crop near the road corridors. About 90% of the annual 594,000 tons demand, valued at USD 100 million, is met through imports. This presents an

opportunity to increase domestic maize production through the promotion of improved maize technologies, including hybrids. Officially, Nepal imports 1000 tons of hybrid maize seed annually which are registered for cultivation in central Terai (East of Narayani river), resulting in unmet demand in other potential areas. Considering this challenge, the International Maize and Wheat Improvement Centre (CIMMYT) carried out participatory variety selection (PVS) trials for registered hybrids across western, mid-western and far-western regions of Nepal, in partnership with Nepal Agricultural Research Council (NARC), during the spring and summer seasons of 2014 and 2015. Of the 20 hybrids tested, four (TX 369, Nutan, Bioseed 9220 and Rajkumar) were considered for their yield and stress tolerance, and were expanded across the country (up to 700m above sea level) by the Seed Quality Control Centre (SQCC). Since then SQCC has recommended or released crop varieties with a focus on altitudinal characteristics, leading to increased maize production in Nepal. This paper discusses the process innovations made towards policy change and market development as per the government priority highlighted in the Agriculture Development Strategy (2015-2025).

TS7-5: Maize in Bhutan: Status and Future Prospects

Passang Wangmo*, Lhap Dorji and T.B. Katwal

National Maize Program, Agriculture Research and Development Centre, Wengkhar, Mongar, Department of Agriculture, Bhutan.
*Corresponding author Email: passangw9@gmail.com

Maize is one of the most widely cultivated food crops in Bhutan. More than 69% of rural households across the country grow maize on 22,908 hectares of land. The total maize production in 2016 was 74,370 metric tons (MT), with national average yield of 1.224 MT per acre. The National Maize Program has released five OPVs between 1992 and 2012. In 2015, as part of crop intensification and to enhance productivity, the Department of Agriculture explored the potential of hybrid maize as a spring crop, mainly as pre-rice in fallow paddy fields. A total of five hybrid maize varieties were introduced from Pioneer Seeds, Hyderabad. The seed production of maize in Bhutan is carried out by Community Based Seed Production (CBSP) groups; there are currently nine functioning groups. It has been four years since Bhutan joined the Heat Tolerant Maize for Asia (HTMA) project to access germplasm and evaluate the maize lines under Bhutanese conditions, in order to prepare against any possible heat stress on maize in future. Crop damage by wild animals, lack of proper marketing mechanisms, poor processing and seed degeneration are some of the key issues that have emerged in recent times. As the 12th Five Year Plan is put in place, we look forward to the development and release of climate resilient hybrid varieties, and strengthened seed production through the establishment of new CBSP groups. The concept of Market Driven Maize Commercialization will also be brought into action to ensure higher productivity and enhanced income.

TS7-6: Value Chain Agriculture and Debt Relations

Rajesh Verma*

Star Agrotech Pvt. Ltd., India.
Email: vermadrrajesh402@gmail.com

In the context of the world food crisis, 'value-chain agriculture' is emerging as a new frontier of publicly subsidized corporate investment, incorporating smallholder farmers into commercial relations to redress apparent food shortages. This paper conceptualizes value-chains as technologies of economic and ecological power, using cross-regional case studies to explore the impact of debt relations in existing value-chain relations. While the value-chain project envisioned by the development industry in partnership with the private sector is geared towards 'feeding the world', the likely outcome is smallholders serving corporate markets at the expense of local food security. I argue that developmentalists seek to resolve the crisis through a 'spatio-temporal fix', enclosing smallholders in value-chain technologies financed through debt relations that appropriate value from smallholder communities. At the same time some farmers are seeking to avoid the debt trap by developing strategies to decommodify farming practices to preserve and revitalize their farms as creators of ecological value, rather than simply as converters of economic value.

TS7-7: Hybrid Maize Seed Production System in Central Sulawesi, Indonesia

Syuryawati* and Bahtiar

Indonesian Cereal Research Institute (ICERI), Maros, Indonesia.
*Corresponding author Email: syurya_wati@yahoo.co.id

Agricultural research agencies, in this case the Indonesian Cereal Research Institute (ICERI), have major control over the release of superior varieties - both hybrid and composite maize. Seed production technologies need to be passed on to seed growers, fostered by the Central Sulawesi Assessment Institute for Agricultural Technology (AIAT), to meet the growing demand for seed, and ensure affordability. Research involving seed growers to determine their performance in hybrid maize seed production was conducted in September 2016, at the seed growers' location in Mekar Bersatu, Palolo Sub District, under guidance from AIAT central Sulawesi. Purposive sampling was done by selecting active and successful maize seed growers. The results showed growers that had applied good hybrid maize seed production processes (Bima-20 URI. Technology and seed production) yielded 2.0 t/ha of seed. Revenue earned from the sale of seed amounted to 50 million Rupees with the sale of seed at 25.000 Rupees per kilogram. Production of maize seed is profitable and feasible as shown by the value of R/C 3.34 and B/C 2.34. The maize seed was purchased by Sigi Agricultural Service Office and Company Parties in East Java. With proper guidance, maize seed growers can successfully evolve into commercial growers with support from parties such as ICERI, AIAT, Local Agricultural and other companies.

TS9: Specialty Maize, Processing and Value Chains

TS9-1: Heterosis and Association Studies of Kernel Sugar Composition in Sweet Corn

Anima Mahato, Jai Prakash Shahi* and Pawan Kumar Singh

Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India.
*Corresponding author Email: jpshahi1@gmail.com

Thirty polymorphic microsatellite markers, already reported to be associated with QTLs affecting kernel chemical composition, were used to assess the genetic diversity among 39 sweet corn inbred lines. The 30 SSR markers generated three clusters with ten, nine and 20 inbreds in cluster I, II and III, respectively. A total of 12 inbred lines, from different clusters, were chosen for making crosses in half diallel fashion. Parents and their F_1s along with two checks *viz.,* Sugar 75 and Madhuri, were evaluated in randomized block design with three replications at two environments. Standard heterosis of all 66 hybrids was estimated for two quality traits *viz.,* TSS and reducing sugar. The hybrids, SCF x Dulce Amanillo, su2su2o2o2comp (Red)-BBB-40-BBB x Dulce Amanillo, DMSC 4 x Dulce Amanillo and DMSC 6 x Dulce Amanillo showed heterosis for TSS over both checks irrespective of environment. Likewise, promising heterotic combinations for reducing sugar were SC Female x WNCDMRSC08R686(A), DMSC 35 x DMSC 2, DMSC 27 x DMSC 35 and SCF x DMSC 4. Even though there is no significant association between the two quality traits, few hybrids *viz.,* SC Female x Dulce Amanillo, SCF x Dulce Amanillo, and su2su2o2o2comp (Red)-BBB-40-BBB x Dulce Amanillo, were found to have significant heterosis for both traits. The analysis also revealed that both quality parameters had negative association with yield and its component traits, indicating the scope of genetic improvement of kernel sugar composition is independent of yield.

TS9-2: Production, Marketing and Value Chain Mapping of Maize Seed Sector: A Case Study on an SME in Bihar

Atul P. Kulkarni[1*], D.B. Rahut[2] and P.H. Zaidi[1]

[1]CIMMYT Asia Regional Maize Program, ICRISAT Campus, Patancheru, Hyderabad, India; [2]CIMMYT, 56130 Texcoco, Mexico.
*Corresponding author Email: A.Kulkarni@cgiar.org; kulkarniatulp@gmail.com

Bihar has emerged as the third most important maize producing state in India as it is cultivated in all three seasons viz. rainy, post-rainy and summer season. The study was conducted in Samastipur district (an excess moisture prone area) of Bihar in 2017-18. The study was based on a survey of maize seed growers in potato intercropping system of Messina Bioseed Pvt. Ltd. company and seed dealers to understand the maize delivery system in the state. A total of 64 farmers contracted by maize seed growers – 32 growing single cross hybrids and 32 growing double cross hybrids - were selected randomly for interview. One public sector research institution viz. Rajendra Agriculture Central University (RACU) Pusa, Samastipur, was also selected for comparison. It was observed that paid-out cost for single cross, double cross hybrid and overall was Rs. 1,05,457.65/ha, Rs. 99,060.66/ha and Rs. 1,02,259.16/ha respectively in a

potato intercropping system. Net income from single cross hybrid with potato intercropping system was Rs. 95,540.02/ha, for double cross hybrid was Rs. 48,016.39/ha and overall was Rs. 73,067.56/ha. Sources of financial services used by the farmers for seed production were kisan credit card (91 percent), loans from friends and relatives (33 percent), money lender (19 percent) and only (3 percent) from input dealers. The study mapped the value chain of public and private seed systems. Company had distributed 64% of its maize seed through dealers, 32% sales to other companies, 3% to co-operative societies and only 1% direct sale to farmers. The study concluded that public-private partnership would be an innovative model for developing abiotic stress resilient maize cultivars for the benefit of the farming community. The relative advantage of the private sector in commercialization and marketing may be combined with the often-longer research and development experience of the public sector in developing products for marginal environments.

TS9-3: Enrichment of *shrunken2*-Based Sweet Corn Hybrid ASKH-4 for Amino Acids and Provitamin-A Through Molecular Breeding

Bhavna Singh[1*], Rajkumar U. Zunjare[1], Smriti Shrivastava[2], Gulab Chand[1], Vinay Bhatt[1], Vignesh Muthusamy[1] and Firoz Hossain[1]

[1]ICAR-Indian Agricultural Research Institute, New Delhi, India; [2]Amity Institute of Biotechnology, Amity University, Noida, India.
*Corresponding author Email: bhavna.135@gmail.com

Shrunken2 (sh2)-based sweet corn has gained popularity in the last decade due to its diversified usage. However, the sweet corn hybrids are generally low in lysine, tryptophan and vitamin A. While the essential amino acids serve as building blocks in protein synthesis and neuro-transmitters, vitamin A is essential for proper vision in humans. Recessive *opaque2 (o2)* gene significantly increases the content of lysine and tryptophan twofold, and a variant of *crtRB1* gene enhances provitamin-A in the kernel tenfold. In the present study, ASKH-4 a *sh2*-based sweet corn hybrid recently identified in national system for commercial release, was targeted for enhancement of essential amino acids and vitamin by marker-assisted introgression of *o2* and *crtRB1* genes. The parental inbreds (SWT-19 and SWT-20) were crossed with a donor line having *o2* and *crtRB1* developed at IARI. F1s tested for hybridity were backcrossed to recurrent parents. 120-130 individuals in BC1F1 were successfully genotyped using gene-based markers, umc1066 (*o2*) and 3'TE-InDel (*crtRB1*). Heterozygotes were backcrossed with recurrent parent to develop BC2F1 populations. *O2* and *crtRB1* showed severe segregation distortion. More than 100 SSRs were used for background selection, and segregants with >80% recurrent parent genome recovery were advanced. Nutritionally enriched genotype being developed here would increase the acceptability of sweet corn.

TS9-4: Viability and Effectiveness of Biodecomposer for Maize Stover Decomposition

Faesal Nurasia Djaenuddin* and Syafruddin

Indonesian Cereal Research Institute (ICERI), Maros, Indonesia.
*Corresponding author E-mail: f_patefaesal@yahoo.co.id

Research was conducted to find out the viability and effectiveness of combining bacteria and fungi for decomposting maize stover. The treatments were five carrier combinations; BAGM

(rice flour, charcoal flour, peat soil, and molasses), AAM (charcoal flour, seaweed, and molasses), SAM (husk, seaweed, and molasses), BKM (rice flour, coconut water, and molasses), SGM (husk, peat soil, and molasses), and commercial bio decomposer Promi and EM4 as check. Isolate combinations were bacteria+fungi BO(B7.1+O5) and EP(E7.7+P7). The results indicated that common carrier composition formulas tested were more effective than Promi and EM4 in maize waste composting. Carrier formula that consistently produced the better compost after being stored 12 and 24 weeks after production was a combination of SAMEP, BAGMBO, SGMBEP and AAMEP. This presents an opportunity for expansion and mass production.

TS9-5: Agronomic Evaluation of Baby Corn *(Zea mays)* Hybrids under Temperate Conditions

Fayaz Ahmed Bahar*, Ajaz. A. Lone, Z.A. Dar and M.I. Makhdoomi

High Mountain Arid Agriculture Research Institute (HMAARI), Leh, Ladakh, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, J&K, India.
*Corresponding author Email: baharfayaz@rediffmail.com

The field experiment to study the response of maize hybrids under altered crop geometry and nutrients was conducted during *kharif* season of 2016 at Dryland (*Karewa*) Agriculture Research Station (DARS), Budgam, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir. The experiment was laid out in a split plot design with four combinations of hybrids ('HM 4' and 'Golden Baby') and crop geometry levels (60cm x 25cm and 60cm x 20cm) in main plots and four nutrient levels (control, $N_{110.5}P_{17.6}K_{37.5}$, $N_{150}P_{24.2}K_{45.5}$ and $N_{187.5}P_{29.75}K_{59.5}$ kg/ha) in sub plots. Significantly taller plants were recorded with 'HM 4' along with more leaf area index (LAI), dry matter accumulation (DMA) and SPAD score than with 'Golden Baby'. The root volume and dry weight were also more with 'HM 4' compared to 'Golden Baby'. Decrease in spacing from 60cm x 25cm to 60cm x 20cm improved the plant height, whereas dry matter accumulation, leaf area index at all the growth stages and root dry weight and root volume showed the reverse trend with decreasing spacing. Growth parameters *viz.* plant height, dry matter accumulation and leaf area index increased with increasing nutrient levels from control to $N_{187.5}P_{29.75}K_{59.5}$. Similarly, the highest values of SPAD and LCC score were found with highest dose of $N_{187.5}P_{29.75}K_{59.5}$. 'HM 4' recorded earlier coblet initiation, more coblets/plant with higher coblet girth over 'Golden Baby'. Decreased spacing declined the coblet length, coblet girth, coblets/plant and coblet weight. While, application of $N_{187.5}P_{29.75}K_{59.5}$ and $N_{150}P_{24.2}K_{45.5}$ had more coblet length, coblet girth and coblets/plant compared to control. Coblet weight improved with increase in each NPK level up to the highest level. 'HM 4' recorded significant differences of 9.6%, 10.8% and 5.2% more baby corn yield with husk, baby corn yield without husk and green fodder yield over 'Golden Baby' respectively. Similarly, the spacing of 60cm x 20cm recorded 8.8%, 7.8% and 13.5 % significantly more baby corn yield with husk, baby corn yield without husk and fodder yield over 60cm x 25cm spacing, respectively. In general, there was improvement in baby corn yield with husk and without husk at 43.3%, 59.7% and 73.2%; and 45.3%, 59.2% and 70.3% due to application of $N_{110.5}P_{17.6}K_{37.5}$, $N_{150}P_{24.2}K_{45.5}$ and $N_{187.5}P_{29.75}K_{59.5}$ levels over control, respectively. Fodder yield showed increased nutrient level up to $N_{150}P_{24.2}K_{45.5}$. Soil fertility parameters (*viz.* Organic carbon, available N, Zn and K) and coblet quality parameters (*viz.* protein content) were not significantly affected by the difference in hybrid. However, brix value remained higher with 'HM 4' compared to 'Golden Baby'. There was considerable reduction in soil fertility parameters with decreasing spacing from 60cm x 25cm to 60cm x 20cm.

Significant improvement in the contents of organic carbon and available N, P, K and Zn in soil - and protein in coblet - were found with this increasing dose up to $N_{187.5}P_{29.75}K_{59.5}$. The uptake of N, P and K by the crop parts was enhanced as nutrient and plant population levels increased. The gross and net returns and benefit to cost ratio remained higher with 'HM 4' variety and less spacing of 60cm x 20cm. Based on this experiment, it may be concluded that to get more yield and profit, 'HM 4' hybrid should be raised with a spacing of 60cm x 20cm and fertilized with $N_{187.5}P_{29.75}K_{59.5}$.

TS9-6: The Effect of the Interaction of Purple Corn Genotipa (*Zea mays* L.) on Two Growing Environments

Harli A. Karim[1*], M. Yasin HG[2] and Syamsuddin[1]

[1]Agroteknologi Departemen Al Asyariah Mandar University, Indonesia; [2]Balitsreal, Maros, Indonesia.
*Corresponding author Email: harlipertanian@gmail.com

The global demand for corn is huge and increasing every year. Corn is the most important carbohydrate produced after rice. Currently, yellow corn is being developed at national level for feed, food and industry. The special corn variety of purple seeds is still unknown to the community and farmers. Corn production is strongly influenced by the appropriate growing environment. Faithful types of corn have different growing differentiation. The purpose of this study was to examine the effect of several purple corn genotypes from the check genotype, to distinguish a number of purple corn genotypes in two growing environments and to find out if any interaction exists between the genotype and the growing environment against a number of variables of purple corn. This research was conducted in two villages of Duampanua, Anreapi Sub-district, Polewali Mandar Regency, West Sulawesi and Experimental Garden of Cereals Plant of Maros Regency of South Sulawesi, from July to September 2016. Randomized block design consisting of three replications was used. The results showed that genotypes that had a better and significantly different effect on the two growing environments were the 15% yield of seeds of moisture content, the number of harvested cobs, the weight of the wet peeled tuna, the weight of the five-tuna peel, and the number of harvest crops shown from the genotype of Pulut Manado Ungu PMU (S1) synth.F.C1. There is no interaction effect between growing environment and genotype from all observed variables, so it can be interpreted that the evaluated genotype has the same productivity and character in two well-grown environments.

TS9-7: Adaptation of Top Crosses of Anthocyanins Corn in Lowland Zone of Palu, Indonesia

I. Ketut Suwitra[1*], Andi Baso Lompengeng Ishak[1] and M. Yasin H.G[2]

[1]BPTP, Sulteng, Indonesia; [2]ICERI, Maros, Indonesia.
*Corresponding author Email: iketutsuwitra@ymail.com

An experiment was conducted to study characters of some families of anthocyanin corn as top crosses, where the interactions of genotypes (G), and season (S) in the valley of Palu in Indonesia were analyzed. The experiment was conducted by randomized complete block design with three replications in experimental farm of Sidondo Palu, Indonesia, under two seasons, rainy and dry. The ecology of Sidondo is lowland (<10 m above the sea) zone and climate was dry (rainfall less 500 mm per year). Ten top crosses such as anthocyanin corn were

identified and evaluated in two seasons (rainy and dry) in 2017. The top cross populations were subjected to intra-population improvement. The objective of this experiment was to study genotype characteristics and determine which ones are stable and high yielding, and present a promising candidate for F1 top cross varieties. Genotypes were planted in four rows of 5.0 m long, spaced at 75x20 cm, one plant per hill, and Urea fertilizer was applied, Ponska (300-200) kg/ha. The first analysis was of one factor (G) and continuing by interaction effect of GxS, S: season. Genotypes would be selected by LSD test. The results showed that there were significant interactions with GxS and that the promising F1 candidate genotype was PMU(S1)Synt.F.C1-2-3xtester:PPH(S2)C2. Its yield potential was be found to be 6.0-7.0 t/ha, and characteristics of the candidate were scored; one of plant aspect, ear and husk cover, position of ear height is middle of plant height, and there are 45 days for anthesis. The released variety would be developed for indigenous farmers with the aim to increase income, health and nutrition.

TS9-8: Evaluation of Maize Hybrids in Respect to Baby Corn and Fodder Yield

M.C. Kamboj*, Preeti Sharma and Narender Singh

CCSHAU Regional Research Station, Karnal, Haryana.
*Corresponding author Email: karnalmaize@gmail.com

Due to change in food habits, demand for baby corn is steadily increasing particularly in metropolitan cities of India. Baby corn are young, finger-like unfertilized cobs of maize with one to three centimeters emerged silk, usually harvested within 24 hours of silk emergence depending on the growing season. It is consumed as salad and in many value-added products such as murraba, pickles, laddu, pizza, e.t.c. After harvesting baby corn, the left-over plant is used as cattle fodder. Baby corn cultivation provides the advantage of nutrition, crop diversification, providing quality fodder for cattle throughout the year, and may ultimately help farmers to double their income. The present study was undertaken to evaluate 91 maize hybrids for yield and quality parameters, with a view to determine potential of parental stocks in developing high yielding hybrids. The experimental material was grown at a research farm of CCS Haryana Agricultural University, Regional Research Station, Karnal, and evaluated in randomized block design for five consecutive years in large scale trial. Each year during rabi season, crosses were attempted and evaluated during *Kharif* season for baby corn and fodder yield traits along with check hybrid HM 4. Observations were recorded for plant stand, days to silking, days to first picking and last picking of baby corn, plant height, baby corn yield, baby corn girth, length, appearance & taste, and fodder yield. Results from the study revealed that three out of the 24 crosses evaluated showed potential for both baby corn yield (q/ha) and fodder yield (q/ha) over check *viz*., HKI 1344 x HKI 1354-2 (18.2, 230.4), HKI 288-2 x HKI x HKI 161 (16.9, 260.4) and HKI 323 x HKI 161 (15.6, 215.9) in 2013; three crosses viz., HKI 288-2 x HKI 161 (18.6, 235.9), HKI 1344 x HKI 1354-2 (20.5, 255.8) and HKI 1040-4 x HKI 1105 (14.8, 195.4) out of total 10 crosses evaluated in 2014; two crosses viz., HKI 1344 x HKI 1354-2 (18.4, 225.4) and HKI 1040-7 x HKI L 287 (16.2, 204.8) out of total 22 crosses evaluated in 2015; two crosses viz., HKI 1344 x HKI 1354-2 (21.9, 238.9) and HKI 1348-6-2 x HKI 1378 (20.7, 195.7) out of total 18 crosses evaluated in 2016; two crosses viz., HKI 1344 x HKI 1354-2 (20.7, 217.3) and HKI 327T x HKI L 287 (21.9, 228.9) out of total 17 crosses evaluated during 2017 were found promising for baby corn characteristics in terms of both baby corn yield and fodder yield. From the results it was also concluded among the twelve crosses which showed potential for baby corn, two hybrids *viz*., HKI 1344 x HKI 1354-2 and

HKI 288-2 x HKI 161 were found best among them from the consecutive studies, and these hybrids may be commercially exploited after multi-location testing.

TS9-9: Adapop 9d Prevalence and Kurtosis Values in Two Different Characteristics of Super Sweet Corn Population

M. Cavit Sezer*, Rahime Cengiz, Mesut Esmeray, Niyazi Akarken and Ahmet Duman

Maize Research Institute, Sakarya, Turkey.
*Corresponding author Email: mehmetcavit.sezer@tarim.gov.tr

This study was carried out using the S1 recurrent selection method in the Adapop 9d population which has different characteristics - such as grain structure, grain color, and maturity group - to provide source material for the variety development studies carried out in 2012. The obtained data are the values of the progeny control test. When written sources are examined, prevalence indicates that the resulting data set is a measure of symmetry. If data set shows the same distribution from a central point to the right and to the left, this data set is defined symmetrically. While the prevalence for a normal distribution is zero, the prevalence of a symmetric data set is close to zero. Positive skewness indicates that data are common to the right, while negative skewness indicates that data are common to the left. In our study, the skewness coefficient for the whole population was determined as 0.584. Kurtosis is the measure of the dataset being more frequent in near values and forming a peak or spreading to a wider range away from nearest values. A dataset with a high kurtosis tends to have near average values, whereas a dataset with a low kurtosis tends to have wider values than average. In our study, the kurtosis coefficient for the entire population was 0.059. The obtained data is important in knowing the properties of the material studied in breeding. This is also important in terms of how we will shape our material in the future.

TS9-10: Adapop 11a Silage Maize Population

M. Cavit Sezer*, Ahmet Duman, Rahime Cengiz, Mesut Esmeray, Niyazi Akarken and Cem Serdar Cerit

Maize Research Institute, Sakarya, Turkey.
*Corresponding author Email: mehmetcavit.sezer@tarim.gov.tr

This study was carried out using the S1 recurrent selection method in the Adapop 11a population, which has different characteristics such as grain structure, grain color and morphology, to provide source material for the type development studies carried out in the Maize Research Institute between the years 2014-2017. The method involves a four-year process. Literature indicates that the most important stage of the hybrid maize development programs, when viewed, is the obtained inbred line, derived from developed populations based on self-contained lines (F2 generations of exposed open fertilization material, synthetic, composite and hybrid varieties). The Adapop 11a silage population is a population of F2 materials planted together with three silage corn sold in the market. At the beginning of silage populations, the green plant yield was determined as 74.6 t/ha in Adapop 11a C0 and 88.95 t/ha in Adapop 11a (S1) C1 at the end of a cycle. Dry matter quantities were 31.76 t/ha in Adapop 11a C0 and 36.75 t/ha in Adapop 11a (S1) C1 respectively. As a result, 19.2%

improvement in green plant yield was obtained from Adapop 11a C0 to Adapop 11a (S1) C1. At the same time 18 families of Adapop 11a (S1) C1 were transferred to the silage maize breeding program. These results were evaluated positively, and it was decided that the material should be continued one more cycle.

TS9-11: Harnessing the Ratooning and Tillering Ability of Teosinte ssp. *parviglumis* for Animal Fodder

Mukesh Choudhary[1*], Pardeep Kumar[1], Vishal Singh[1], Mamta Gupta[1], Bhupender Kumar[1], Sandeep Kaswan[2], M.M. Das[3] and Sujay Rakshit[1]

[1]ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana, India; [2]Livestock Production Management, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India; [3]ICAR-Indian Grassland and Fodder Research Institute, Jhansi, India.
*Corresponding author Email: mukesh.choudhary1@yahoo.com

Maize has diverse uses in the form of food, feed and fodder. In India, a green fodder deficit of 61.1 percent has been reported. Under this scenario, maize - with its wide adaptability - has enormous potential to serve as nutritious fodder. The annual teosinte, *Zea mays* ssp. *parviglumis,* the closest ancestor of modern maize has ratooning and tillering ability. In an experiment on *parviglumis*, the effect of 30 kg higher nitrogen than recommended dose showed 10% and 15-20% improvement in ratooning ability and green fodder yield, respectively. In a pilot trial, unratooned (at first cut) and ratooned (at second cut) whole/unchaffed fodder samples of *parviglumis* were offered to adult goats and grower kids (approximately nine months old) of Beetal breed. Ratooned fodder samples were fed completely (no leftover) by adult goats as well as grower kids while unratooned fodder samples had negligible leftover for adult goats, but 32% leftover for grower kids. The ratooned leaves exhibited higher softness and significant decline in the sharpness of leaf edges. Goats being selective in feeding habits tend to eat soft and leafy parts of fodders and avoid eating thick or stemmed parts of fodder plants, hence leftover might be lesser if fed to large ruminants. To exploit these traits, *parviglumis* was crossed to fodder variety, J-1006. The F_1 generation exhibited good amount of tillering with several tillers ranging from 1 to 4. Further advancement of promising crosses would help to harness the fodder yield enhancing traits of *parviglumis*.

TS9-12: Factors Affecting Popping Expansion Volume and Flake Size of Popcorn (*Zea mays* var. *everta*)

Munnesh Kumar*, J.P. Shahi, Ashok Singamsetti and Pavan Devesh

Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P.–221005, India.
*Corresponding author Email: muneshbhu94@gmail.com

Popcorn is a snack food with significant commercial popularity. Popcorn popping mechanics can be described by a series of polymeric transformations. The most important quality traits for popcorn are flake volume, expansion volume and “eatability” factors, including unpopped kernels, hull dispersion, and color, texture and flavor of popped flakes. Popcorn quality depends on both intrinsic factors *viz.,* hybrid selection, kernel conditioning, and kernel physiochemical attributes and extrinsic variables including popping method and ingredient additives. Selection of hybrid, growing environment, and kernel conditioning are critical

factors affecting end-use quality. Physical characteristics of kernels such as kernel size, shape, density, and pericarp damage and thickness have been shown to affect popping performance, as have innate compositional factors, including kernel moisture, protein, and fatty acid content. In addition, the end-use quality of popcorn is influenced by extrinsic variables, including the popping method and ingredient additives. The most important attributes of high-quality popcorn are high expansion volume, low occurrence of unpopped kernels, good hull dispersion, desirable appearance, crisp and tender texture and delicate flavor. The significance of investigating and characterizing new quality attributes for popcorn is that it might inspire innovation and lead to renewed growth of popcorn consumption.

TS9-13: Phenotypic Evaluation and Molecular Diversity Analysis of "*Mimban*" (sticky) Maize Landrace from Mizoram

Nenavath Krishna Kumar Rathod[1], Jyoti Kumari[2]*, Firoz Hossain[1], Rashmi Chhabra[1], Somnath Roy[3,4], Ganjalagatta Dasaiah Harish[3], Anup Kumar Mishra[3], Satish Kumar Guleria[5], Rakesh Bhardwaj[2], Sherry Rachel Jacob[2] and Ashok Kumar[2]

[1]ICAR-Indian Agricultural Research Institute, New Delhi, India; [2]ICAR-National Bureau of Plant Genetic Resources, New Delhi; [3]ICAR–National Bureau of Plant Genetic Resources, Regional Station, Shillong, India; [4]Present address: ICAR-National Rice Research Institute, Hazaribag, India; [5]CSKHPKV, HAREC, Bajaura, HP, India.
*Corresponding author Email: jyoti.kumari@icar.gov.in

The NEH region of India is the reservoir of rich genetic resources of maize. *Mimban* landrace of Mizoram state is a popular food among locals due to its sticky nature. The focus of the present study was on the phenotypic evaluation and molecular diversity analysis of 24 *Mimban* maize accessions and identification of promising sticky accessions with superior agronomic performance. 334 alleles were detected using 93 SSR markers. Polymorphism information content varied from 0.117 to 0.829 with an average of 0.528. Thirteen accessions have 20 unique alleles providing an excellent possibility for clear cut differentiation of the accessions. These accessions were grouped into three major clusters each having two, 14 and nine accessions. Clustering pattern was largely congruent with the geographical relationship. Significant variability was recorded for most of the agronomic and biochemical traits based on multi-location evaluation at Shillong, Bajaura and Delhi. The seed size (100 seed weight) varied from 10.1g (TR-205/IR625131) to 33.6g (TR-72/ IC623978). The amylopectin content in seed varied from 80.2% (IC538910) to 93.7% (TR-133). The promising accessions identified for grain yield per plant were TR-27(IC623962), TR-72(IC623978), TR-164(IC624033), TR-2(IC623948) and TR-125(IC624010). TR-27 and TR-164 were identified with high amylopectin content and early maturity, and can show high adaptability across different agro-ecologies. The information generated here possesses great potential in their utilization as rich genetic resource in the waxy corn breeding program. This is the first report of characterization and genetic diversity analysis of *Mimban* landrace accessions from NEH region.

TS9-14: Grouping of Indian Maize Inbred Lines Based on the Fertility Response

Pardeep Kumar*, Mukesh Choudhary, Vishal Singh, and Sujay Rakshit

ICAR-Indian Institute of Maize Research, Ludhiana, India.
*Corresponding author Email: pardeepkumar656@gmail.com

Baby corn plays a significant role in ensuring livelihood security and augmenting income level of farmers in peri-urban areas allowing diversification of the maize production system. The cost of cultivation of traditional male fertile baby corn is high because of the need for detasseling. This problem can be addressed by developing cytoplasmic male sterility (CMS) based baby corn hybrids. For nearly two decades, in the 1950s and 1960s, CMS-T was extensively used in hybrid seed production of maize in the USA. However, in 1970, epidemic of Southern corn leaf blight caused by *Bipolaris maydis* race T across the CMS-T based hybrids in the USA led to discontinuation of the CMS system in maize hybrid seed production. It is felt that CMS based cultivars will be important in addressing manual labor concerns for detasseling fertile male baby corn hybrids. The use of CMS based male sterile hybrid grouping of lines into maintainer (B) and restorer (R) is essential. A total of 99 Indian maize lines were test crossed with CMS based commercial hybrids (G-5414 and G-5417). Based on the tassel morphology, seed setting upon selfing and pollen viability test, 27 test crosses were found to be sterile, 23 were semi-fertile and 49 lines were totally fertile. The 27 lines producing sterile test crosses were grouped as B line while 49 lines giving fertile test crosses were grouped as R line. Hence, with respect to baby corn traits, CMS lines will be used in commercial baby corn hybrid production.

TS9-15: Increasing of Protein and Oil Ratio in Corn

Rahime Cengiz*, Bülent Cengiz, Mesut Esmeray, M. Cavit Sezer, Niyazi Akarken, Ahmet Duman and A. Eşref Özbey

Maize Research Institute, Sakarya, Turkey.
*Corresponding author Email: rahime.cengiz@tarim.gov.tr

Corn protein and oil are crucial to both human and animal nutrition. Maize oil is high in energy value for livestock feeding and is a valuable by-product of the starch industry. Protein is a necessary constituent of both food and feed. Kernel protein, oil and starch content were determined on 56 selected inbred lines, and these lines used as starting material. Six inbred lines with high oil content (5-6%) were made to half diallel crosses. Seven inbred lines with high protein content (15.04% to 17.09%) were still made half diallel crosses. Diallel hybrids were planted according to a randomized complete block experimental design in 2010. Half diallel hybrids were evaluated considering grain moisture, yield and some morphological characteristics, protein, oil, and starch content in kernel at harvest. Initial population was created with half diallel crosses which were selected by considering grain quality and yield values based on their performance, then applied to a cycle of population breeding. Each family of protein and oil synthetic populations was established to progeny yield trials in 2013. Selected high protein families ranged from 12.1% to 15.8% of protein content. Selected high oil families ranged from 5.94% to 7.53% of oil content. The first cycle of population breeding was completed to recombination of selected families. ADAHPSYN S1 (C1) and ADAHOSYN S1 (C1) were improved in 2014. The synthetic populations were used as donors for obtaining doubled haploid lines with high oil and high protein.

TS9-16: Development of Waxy (*Zea mays ceratina*) Corn Hybrids

Rahime Cengiz*, Bülent Cengiz, Mesut Esmeray, M. Cavit Sezer, Niyazi Akarken and Ahmet Duman[1]

Maize Research Institute, Sakarya,Turkey.
*Corresponding author Email: rahime.cengiz@tarim.gov.tr

Waxy corn, which has a different structure than normal maize, was discovered in China in 1908. Normal maize includes 75% amylopectin while waxy maize includes 100% amylopectin. Amylopectin is a form of starch and consists of glucose subunits. The separation of amylose is composed of glucose molecules to subunits, while the waxy characteristic is controlled by a double recessive gene (wx). Waxy corn is used in production of snacks and amylopectin starch. There are no waxy maize varieties registered in our country, which prompted the Maize Research Institute to obtain waxy germplasm and hybrid varieties from abroad and start a breeding program of waxy corn in 2011. In vivo technique was used to obtain the maternal haploid maize lines focus in a short period of time, and waxy lines were developed using doubled haploid (DH) technique. Starch analysis and iodine tests were done on the resulting DH waxy maize lines and hybrids. Hybrid waxy varieties were developed from crossbreeding waxy maize lines and thereafter studied in three locations for two years, where they demonstrated 6.3-10.24 t/ha average grain yield. Grain from candidate waxy varieties were tested for production of snacks by private sector companies.

TS9-17: Development and Validation of *sugary1*- and *shrunken2*-based Markers for Utilization in Sweet Corn Breeding Program

Rashmi Chhabra*, Rajkumar U. Zunjare, Aanchal Baveja, Brijesh Mehta, Vignesh Muthusamy and Firoz Hossain

ICAR-Indian Agricultural Research Institute, New Delhi, India.
*Corresponding author Email: reshu0428@rediffmail.com

Recessive *sugary1* (*su1*) and *shrunken2* (*sh2*) genes have been extensively used in sweet corn cultivar development. Sugary variety having threefold more sugar over ordinary maize is preferred due to glossy and attractive kernels. *sh2*-based sweet corn accumulates six times more sugar and possesses higher shelf-life. Though linked markers are available, suitable gene-based markers that differentiate wild- and mutant- allele of *su1* and *sh2* have not been reported yet. In the present study, five diverse inbreds each of wild-, sugary- and shrunken-type were selected for identifying the polymorphism in the *su1* and *sh2* genes. 27 and 13 overlapping primers covering 11.8 kb and 7.3 kb of *su1* and *sh2*, respectively were designed. Several SNPs and InDels were identified in 5'UTR, exon, intron and 3'UTR of *su1*, from which InDels of ~35bp in 5'UTR and 6bp in intronic region were used to develop gene-based co-dominant markers. They were validated in five F2 populations and 173 diverse inbreds of normal and sugary type. Of the total seven SNPs identified in *sh2*, two were in 5'UTR and five located in intronic regions. The markers developed using these variations were validated in six F2 populations and a set of 197 inbreds with both wild and mutant *sh2* allele. These gene-based markers provide immense advantage over the linked markers in avoiding the selection of false positives caused due to crossing over between gene and marker, and can be efficiently used in genomics-assisted breeding of sweet corn.

TS9-18: Suitability of Maize Semolina for The Preparation of Ready-to-Cook (RTC) Breakfast Mixes

Shobha D.*, Puttaramanaik, N. Mallikarjuna and G. Jadesha

[1]AICRP (Maize), Zonal Agricultural Research Station. V. C. Farm, Mandya-571405, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka.
*Corresponding author Email: shobhafsn@gmail.com

Suitability of maize (*Zea mays* L.) semolina or soji for the preparation of various breakfast mixes combined with pulses and spice mix was studied. Maize soji Besibele bath (MSBB) mix and maize soji Pongal (MSP) mix were standardized using maize soji (14BS mesh) in combination with different ratios of redgram dhal (50:50, 60:40, 70:30 and 80:20) for MSBB and maize soji with greengram dhal (100:50,100:40,100:30 and100:20) for MSP mix. Sensory acceptability scores on nine-point hedonic scale revealed that 50:50 ratio of maize soji:bengal gram dhal and 100:50 ratio of maize soji:green gram dhal scored better for appearance (8.3 and 8.5), color (8.0 and 8.4), texture (8.2 and 8.4), flavor (8.2 and 8.6), taste (8.3 and 8.5) and overall acceptability (8.5 and 8.6) respectively. The MSBB mix and MSP mix had excellent functional qualities such as solubility (0.77 and 0.73 %), swelling power (4.11 and 4.01 %), water (2.12, 2.11g/ml) and oil absorption capacity. (1.89 and 1.87 g/ml). The nutritional composition of the developed mixes revealed that MSBB and MSP mixes contained protein in the range of 17.05 and 13.60 g/ 100 g of mix, carbohydrate (60.70 and 67.70 g/ 100 g), dietary fiber (8.30 and 8.50 g/ 100 g), iron (3.40 and 7.20 mg/ 100 g) and calcium (51.40 and 10.20 mg/ 100 g). The increase of peroxide value and free fatty acids of MSBB and MSP mixes for six months' storage period was found to be well within the limits for stored mixes. The study revealed that the maize semolina was suitable for the preparation of RTC breakfast mixes like any other cereal.

TS9-19: Comparative Assessment of Maize and Rice *idli* Prepared from Maize and Rice Semolina

Shobha D.[1]*, Neena Joshi[2], K.G. Vijayalakshmi[2] and K.V. Jamuna[2]

[1]AICRP (Maize), Zonal Agricultural Research Station, V.C. Farm, Mandya, Karnataka, India; [2]Department of Food Science and Nutrition, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India.
*Corresponding author Email: shobhafsn@gmail.com

Human consumption of maize is limited due to unavailability of food products of acceptable quality. Nutritional quality of maize can be improved by suitable combination of good quality pulses along with the application of several food processing methods such as fermentation. *Idli* with maize semolina and black gram dhal in different ratios viz., 2:1, 3:1 and 4:1 were prepared by natural fermentation and compared with rice *idli* in 3:1 ratio (control). The cooked *idlies* were analyzed for sensory acceptability on 9-point hedonic scale followed by color, texture and nutritional quality. The values for lightness (L*) redness (a*) and yellowness (b*) indicated higher yellowness (37.03) and redness (8.16) in maize *idli* and lightness in rice *idli* (78.48). In different combinations of maize semolina and blackgram dhal, 3:1 ratio was found to be superior for taste (8.60), texture (8.80) and overall acceptability scores (8.30). However, color scores were more for rice *idli* (8.40) prepared in the same ratio of 3:1. The textural profile of maize *idli* was comparable to rice *idli* except in hardness. The protein and fat contents increased from raw to fermented stage but decreased marginally in cooked stage. There was an

increase in the iron and calcium contents in both maize and rice *idli* from raw to fermented stage. This increase in protein, fat and minerals indicated beneficial effect of fermentation on the sensory, nutritional and textural properties of maize *idli*. The present study also revealed suitability of maize in the preparation of highly popular breakfast item *idli* and is expected to add value, which in turn increases consumption of maize.

TS9-20: Role of Kernel Composition on Seed Vigor, Physiological and Biochemical Activities and Storage Behavior of Specialty Maize

Sudipta Basu[1*], Viswanath Sharma[1], Mohammad Athar[1], Firoz Hossain[1], Anjali Anand[1], Ashwani Kumar[2] and Chitra Srivatava[1]

[1]ICAR-Indian Agricultural Research Institute, New Delhi 110012, India; [2]IARI, Regional Station Karnal. India.
*Corresponding author Email: sudipta_basu@yahoo.com

An investigation was undertaken to study the association of kernel composition in specialty maize genotypes with seed vigor, physiological and biochemical activities and storage behavior. Seeds of different compositional groups i.e. dent, flint, QPM, popcorn, waxy and sweet corn [sugary, shrunken, double recessive] were used for the study. Specialty maize genotypes showed variation in chemical composition with respect to kernel carbohydrate, starch, sugar, protein and oil content. The grain compactness studies revealed popcorn and sweet corn as having the highest and lowest grain toughness respectively. X-ray radiograms and scanning electron microscopy showed variations in internal morphology and starch granules (size, distribution, structure) among compositional groups. Seed germination studies (under 15°C, 20°C and 25°C) showed that all groups failed to germinate under 15°C but showed moderate and high germination respectively under 20°C and 25°C. Field emergence under suboptimum conditions (December sowing) exhibited poor performance in sweet corn and QPM types, and good emergence in waxy and popcorn varieties. Among maize compositional groups, popcorn genotypes had high germination, vigor, better membrane integrity, enzymatic activities, free radical quenching mechanism and storability of up to 12 months under ambient conditions. Sweet corn and QPM types exhibited low germination, vigor, poor membrane integrity, antioxidant enzyme activities, storability (up to six months) and susceptibility to stored grain pest (*Sitophilus oryzae*). Decline in seed quality was more pronounced in parental lines as compared to their hybrids, whereas male lines showed poor storability as compared their female counterparts. The study concluded that seed composition had influence on seed quality, physiological and biochemical performance and storage behavior of specialty maize.

TS10: Nutritionally Enriched Maize

TS10-1: Development of Nutritionally-Enriched Sweet Corn Genotypes with High Lysine, Tryptophan and Provitamin-A through Molecular Breeding

Aanchal Baveja[1*], Vignesh Muthusamy[1], Kusuma K. Panda[2], Rajkumar U. Zunjare[1], Abhijit K. Das[1], Rashmi Chhabra[1] and Firoz Hossain[1]

[1]ICAR-Indian Agricultural Research Institute, New Delhi, India; [2]Amity Institute of Biotechnology, Amity University, Noida, India.
*Corresponding author Email: aanchalbaveja@gmail.com

Sweet corn is consumed either fresh or as a processed vegetable worldwide. Recessive shrunken2 (sh2) has been extensively used for sweet corn cultivar development. In India, very few sweet corn hybrids have been commercialized, as they do not possess high levels of micronutrients such as lysine tryptophan and provitamin-A. These essential amino acids play a vital role in protein synthesis, besides serving as neurotransmitters in the human body. Provitamin-A is also essential for eye sight and vision. In the present study, parental lines of provitamin-A rich versions of four QPM hybrids, viz., HQPM1, HQPM4, HQPM5 and HQPM7, developed earlier at IARI were targeted for introgression of sh2 allele using marker-assisted backcross breeding. Gene-based markers (umc1066 and phi057) for o2, (3'TE InDel of crtRB1) for β-carotene and gene linked markers (umc2276, umc1320 and bnlg1257) for sh2 were used for foreground selection. BC1F1, BC2F1 and BC2F2 populations in the genetic background of parental inbreds (HKI161, HKI163, HKI193-1 and HKI193-2) were successfully genotyped. crtRB1 showed segregation distortion. More than 100 genome-wide SSRs were used for background selection. The selected introgressed progenies possess >90% recurrent parent genome. The newly developed progenies possessing sh2, o2 and crtRB1 could be used for the development of nutritionally enriched hybrids, besides serving as the rich genetic resource in sweet corn breeding program.

TS10-2: Assessment of Agronomic Performance of Kernel Zinc Fortified Maize Genotypes in Pakistan

AbduRahman Beshir[1*], Muhammad Amir Maqbool[2], Ehtisham Shakeel Khohkar[2], Muhammad Waheed Anwar[3] and Muhammad Imtiaz[2]

[1]CIMMYT, South Asia Regional Office, Nepal; [2]CIMMYT, Islamabad, Pakistan; [3]UN-Food and Agricultural Organization, Islamabad, Pakistan.
*Corresponding author Email: a.issa@cgiar.org

According to the National Nutrition Survey-2011, 47.6% of pregnant women, 41.3% of non-pregnant women and 39.2% of children are zinc deficient in Pakistan. Zinc fortified maize is an alternative approach to enhancing dietary quality of vulnerable communities. However, the agronomic performance of these varieties should be better than, or at par with, widely cultivated varieties for rapid adoption by farmers. CIMMYT, under the Agricultural Innovation Program (AIP) for Pakistan, evaluated ten zinc enriched genotypes against two commercial checks for agronomic performance at three different locations i.e. Arifwala, Islamabad and Sahiwal in spring 2016. Genotypic and phenotypic correlations of grain yield with different

agronomic traits varied across the locations, which dictated that different selection criteria be followed across diverse locations. Heritability of the grain yield was 0.798, 0.684 and 0.612 respectively at Sahiwal, Arifwala and Islamabad. The minimum average yield was recorded at Arifwala (2.5 t/ha) and maximum yield was recorded at Sahiwal (8.3 t/ha). Genotypes 10, 1 and 8 were significantly high yielding, having 8.3, 6.9 and 6.4 t/ha respectively at Sahiwal location. Genotypes 4, 6 and 10 were statistically high yielding genotypes at Islamabad, having 7.4, 7.4 and 7.2 t/ha respectively as compared to checks. However, genotype 3 (5 t/ha) and 10 (4.5 t/ha) were at par with the check (genotype 11, 5 t/ha) though results were statistically insignificant at Arifwala station. The results from this study indicate the selection potential of Zinc enriched maize for further testing and seed scale up in Pakistan.

TS10-3: Genetic Variability of Kernel-Tocopherols and Utilization of Novel *ZmVTE4* Allele for Vitamin-E Enrichment in Maize

Abhijit K. Das[1*], Vignesh Muthusamy[1], Rajkumar U. Zunjare[1], Hema S. Chauhan[1], Sunil Jaiswal[1], Rashmi Chhabra[1], Aanchal Baveja[1], Gulab Chand[1], Pawan K. Sharma[1], Jayant S. Bhat[1], Satish K. Guleria[2], Supradip Saha[1] and Firoz Hossain[1]

[1]ICAR-Indian Agricultural Research Institute, New Delhi, India; [2]CSK-Himachal Pradesh Krishi Vishwavidyalaya, Bajaura, India.
*Corresponding author Email: das.myself@gmail.com

Tocopherols are important for cardiovascular and neurological functions in humans. α-tocopherol possesses the highest vitamin-E activity over other fractions. In the present study, 54 maize inbreds representing four haplotypes of ZmVTE4 out of >450 diverse inbreds were selected and evaluated at Bajaura, Delhi and Dharwad. Wide variations in α- (3.2-28.6 ppm), γ- (3.5-52.4 ppm), δ- (1.3-9.6 ppm) and total-tocopherol (16.4-87.7 ppm) were observed. The mean α-tocopherol was 16.2 ppm in the most- and 7.6 ppm in the least favorable haplotypes. HKI-1378, DQL-784-5-1 and CML-218 were identified as the most promising stable inbreds using AMMI model. 24 inbreds having favorable haplotypes were also characterized using 80 SSRs. Line (9) × tester (4) analysis revealed the importance of both non-additive and additive gene action for accumulation of tocopherols. Novel InDels in the desired haplotype of ZmVTE4 were identified. The most favorable allele of ZmVTE4 was introgressed into provitamin-A rich versions of four QPM hybrids by marker-assisted backcross breeding. Original inbreds viz. HKI161, HKI163, HKI193-1 and HKI193-2 possessed a mean of 8.0 ppm of α-tocopherol, compared to 15.2 ppm in the introgressed progenies. These new inbreds also possessed high lysine, tryptophan and provitamin-A. The multi-nutrient rich maize inbreds developed here assume significance in alleviating malnutrition through sustainable and cost-effective approach.

TS10-4: Development and Validation of Gene-Based Markers for *lpa1-1* and *lpa2-1* Genes Conferring Low Phytic Acid in Maize Kernel

Abhijith P. Krishnan Nair, Vignesh Muthusamy, Rashmi Chhabra, Vinay Bhatt, Sweta Dosad, Sunil K. Jaiswal, Rajkumar U. Zunjare and Firoz Hossain

ICAR-Indian Agricultural Research Institute, New Delhi, India.
*Corresponding author Email: abhijithnair.777@gmail.com

Considering the growing significance of maize as food and feed, enhancement of micronutrients such as iron and zinc in grain assumes great importance for nutritional security. Phytic acid/ phytate is a major anti-nutritional factor that affects the bioavailability of these micronutrients. Although low phytic acid (lpa) mutants are available, no lpa-based maize hybrids are available in India. Quantification of phytic acid being destructive in nature, non-availability of gene-based markers for selection of lpa1 and lpa2 genes pose limitations in the breeding program. Here, we developed and validated gene-based markers for lpa1-1 and lpa2-1 genes in diverse crosses among normal and low phytate inbreds. The lpa1-1 and lpa2-1 genes mapped on chromosome 1, hold a size of 5.1 kb and 2.2 kb, respectively. The lpa1-1 mutation is due to a C to T transition and, based on this sequence information, mutant-specific and wild-specific markers were developed; and were validated across 8 F¬2 populations segregating for lpa1-1 allele. The lpa2-1 gene was sequenced in mutant and wild type using 7 overlapping primers. Nucleotide polymorphisms that distinguished mutant from wild type allele were selected and used for designing CAPS marker. This co-dominant CAPS marker has been validated across five F2 populations segregating for lpa2-1 allele. The information generated here will help in precise introgression of lpa1-1 and lpa2-1 genes in the desired maize genetic background.

TS10-5: Analysis of *opaque2* Transcription System for Regulation of Zein Protein Expression

Alla Singh*, D.P. Chaudhary and Sujay Rakshit

ICAR-Indian Institute of Maize Research, P.A.U. campus, Ludhiana -141004.
*Corresponding author Email: alla.singh@icar.gov.in and allasingh.panesar@gmail.com

Quality Protein Maize (QPM) rich in lysine and tryptophan has prospects for human health and higher farmer remuneration. Maize opaque mutants have been used to develop current quality protein varieties. Many rounds of breeding efforts are required for sufficient endosperm modification to improve protein and grain quality simultaneously. This is because, while the amount of lysine and tryptophan increases, the maize grain texture is adversely affected. This makes the grain prone to post-harvest losses. Zein proteins are responsible for grain hardness. However, they are poor in lysine and tryptophan content and are primarily responsible for low nutritional value of maize grain. Precision genome editing can be used to accelerate improvement of nutritional quality in local germplasm without detrimental effects on grain quality. A computational model of *opaque2* (*02*) basic leucine zipper domain interacting with its cognate DNA sequence 5' GATGACGTGA 3' was prepared. Amino acid residues in the *o2* transcription factor protein that interact with nucleobases in DNA have been deciphered. Such interacting residues are potential targets for gene editing of *o2* protein to regulate transcription of zein proteins. Since many types and isoforms of zeins are present in maize germplasm, engineering of *o2* transcription factor will affect all the genes it regulates. On the other hand, specific type and/or isoform of zeins can be targeted if the promoter regions are engineered instead. The present work describes analysis of interaction of amino acids with nucleobases in the target sequence.

TS10-6: Enrichment of Nutritional Quality in Maize Through Molecular Breeding

Amandeep Kaur[1*], Yogesh Vikal[1], Jagveer Singh[1], Sunita Sharma[1], Gurjit Kaur Gill[1], Pawan K. Malhotra[1], Firoz Hossain[2] and H.S. Gupta[3]

[1]School of Agricultural Biotechnology, Punjab Agricultural University, Ludhiana, India; [2]ICAR-Indian Agricultural Research Institute, New Delhi; [3]Previous address: Borlaug Institute for South Asia, New Delhi, India.
*Corresponding author Email: aulakhaman95@gmail.com

Maize (*Zea mays* L.) is the queen of cereals deficient in Vitamin A, which causes malnutrition and major health problems. Quality protein maize has enhanced levels of the amino acids, lysine and tryptophan over normal maize varieties. However, QPM varieties are low in provitamin-A, a precursor of vitamin A, which can lead to vitamin A deficiency in humans. In the present investigation the grain quality of QPM inbred is further enriched for β- carotene by introgressing of *crtRB1* and *LcyE* gene through marker assisted backcross breeding. Rare natural genetic variation of *crtRB1* and *LcyE* gene enhance β-carotene in the kernel by blocking its conversion to further components. Traditional yellow maize contains high kernel carotenoids, but the concentration of provitamin-A is quite low (<2µg/g) compared to the recommended level (15µg/g). Development of biofortified maize enriched in provitamin-A, lysine and tryptophan thus holds significant potential in alleviation of micronutrients. Marker assisted stacking of *crtRB1*, *LcyE* and *o2* was undertaken in the genetic background of QLM13 and QLM14, inbreds of PMH1 hybrid. Foreground selection was carried out using gene specific primers on BC_2F_1 population of QLM 13 and QLM 14 and background selection was carried out using SSR markers to check the recovery of recurrent parent genome. The plants of favorable alleles (*crtRB1* and *LcyE*) and 90% recurrent parent genome recovery were selected and selfed to generate BC_2F_2 population. Foreground selection was carried out on BC_2F_2 population using *crtRB1* and *LcyE* gene specific markers and plant carrying homozygous allele were selfed to generate BC_2F_3 progenies. Quality analysis for determination of β-carotene and tryptophan analysis was carried out on BC_2F_3 progenies. The introgressed BC_2F_3 progenies possessed high concentration of provitamin-A (4.28–11.75 µg/g) as compared to recurrent parent QLM13 (4.6906 µg/g). The selected lines of high beta carotene and tryptophan content were crossed to reconstitute PMH1 hybrid. Introgressed inbred having contrast for pigmentation in glume base and silk with respect to recurrent parents possess great utility for registration and unambiguous identification in the field.

TS10-7: Study of Population Structure and Genetic Variation for Kernel Iron and Zinc in Subtropical Maize

Bhupender Kumar[1*], Shankar Lal Jat[1], Vishal Singh[1], Firoz Hossain[2], Vignesh Muthusamy[2], Satish Kumar Guleria[3], Ajay Kumar[4], Raman Gami[5], M.C. Kamboj[6], S.B. Singh[1], Sonu Kumar[1], Hem Raj[1], Meenakshi[1], Harpreet Kaur[1], Hans Raj[1] and Sujay Rakshit[1]

[1]ICAR-Indian Institute of Maize Research, Ludhiana, India; [2]ICAR-Indian Agricultural Research Institute, New Delhi, India; [3]CSKHPKV, HAREC Bajaura, India; [4]RAU, Pusa, Samastipur, India; [5]SDAU, Regional Center Bhiloda, India; [6]HAU, Regional Research Station Karnal, India.
*Corresponding author Email: bhupender.iimr@gmail.com

Two billion people suffer from malnutrition across the globe. Maize assumes great significance as a human food and livestock feed. The important micronutrients *viz*., iron (Fe) and zinc (Zn) are deficient in maize kernels. In this context, biofortification of maize with Fe and Zn is a practical and sustainable solution to micronutrient malnutrition. Towards this endeavor, the

population structure study and genetic diversity analysis for Fe and Zn content in Indian maize germplasm - comprising a set of 350 inbred lines and 51 hybrids - were carried out. The materials were planted at three and five locations for Fe and Zn evaluation, respectively. Plants were selfed and bulks of kernels were grounded using zirconium balls in a Teflon chamber for Fe and Zn analysis. High genetic variation was observed for Fe and Zn content among inbreds (Fe: 8.1-63.5 ppm; Zn: 5.7-45.5 ppm) and hybrids (Fe: 25-44 ppm; Zn 15.0-36.5 ppm). Genotypes also exhibited significant G × E interaction for Fe and Zn content. However, non-significant correlation among Fe and Zn was observed. Inbreds were genotyped using 150 SSRs, of which 79 were polymorphic. The population structure was studied using STRUCTURE software following population admixture model. The hypothetical subpopulations were considered as K= 2-15, with three independent runs for each K. Six sub-populations in total were identified. The partial differentiation of sub-structure was found with respect to dent and flint type kernels. The sufficient genetic variation observed at molecular and micronutrient level can be effectively exploited for high genetic gains in Fe and Zn biofortification program.

TS10-8: Diversity and Combining Ability Analysis in Quality Protein Maize Through Half-Diallel Evaluation

Devraj Lenka*, D. Swain and A.P. Dash

Orissa University of Agriculture and Technology, Bhubaneshwar, India.
*Corresponding author Email: devraj_lenka@yahoo.com

An experiment was conducted to evaluate 49 inbreds of maize, 12 of which - comprising six QPM and six non-QPM - were selected as parents based on per se performance, genetic diversity using morpho-economic traits, seed storage protein and molecular analysis; and seed protein quality (lysine and tryptophan) to develop all possible 66 single cross hybrids (12 x 12 half diallel) at the EB-II, Department of Plant Breeding and Genetics, OUAT, Bhubaneswar, India. The hybrids were evaluated along with parents and a standard check (Vivek QPM 9) in a Randomized Block Design (RBD) with three replications based on different morpho-economic traits. Analysis of variance revealed significant differences among parents, hybrids and the standard check for all the morpho-economic traits, indicating presence of wide genetic variability in the materials used for the study. The ANOVA for combining ability revealed high magnitude of SCA variance to GCA variance for almost all characters, indicating more dominance variance than additive variance. BQPM 7-4 was the best general combiner for all traits except ear height, cob diameter and grains per row. BQPM 3-10 was found to be a good general combiner for seed yield and important cob characteristics. Frequency of hybrids with High x Low GCA parental combination was higher for heterotic yield performance than those with High x High or Low x Low combinations. The crosses i.e., BQPM 5-2/B1110-7-2 and BQPM 3-7/BQPM 9-2 were identified as good specific combiner for both grain yield per plant and seed yield/ha along with important agro-economic traits, which also exhibited the status for QPM.

TS10-9: Biochemical Characterization of Maize Populations for Protein Quality

Dharam Paul Chaudhary[1]*, Alla Singh[1], Shambhavi Yadav[1], Mahak Tufchi[1] and Mehak Sethi[2]

[1]ICAR-Indian Institute of Maize Research, Ludhiana, India; [2]Punjab Agricultural University, Ludhiana, India.
*Corresponding author Email: chaudharydp@gmail.com

Maize, being a staple food crop in many parts of the world and commonly used in different snack preparations, is the most suitable cereal for nutritional enhancement. The nutritional quality of maize is poor due to deficiency of essential amino acids such as lysine and tryptophan. However, the identification of *opaque* mutants opened vistas in nutritional enhancement of maize and subsequently, the quality protein maize (QPM) was developed. Similarly, 100 kernel weight (HKW) positively influences test weight of maize, a parameter important to the yield of large flaking grits. A meta study of twenty maize populations comprising 441 genotypes was conducted to identify suitable populations required for development of maize with better protein quality and kernel hardness. Results showed that mean value of tryptophan and HKW was 0.50% and 22%, respectively, amongst all the tested genotypes. Populations CML 161-165, G33QC20 and S99SIYQ have high amounts of both protein as well as tryptophan. Five out of the twenty populations showed moderate to strong correlation between tryptophan and protein content. Hence, the negative correlation between protein and tryptophan contents is not universal and presumably depends on gene action. Interestingly, in one population (S99TLWQ-HGB), strong positive correlation is found between protein and tryptophan contents. This population can be assessed for gene action and development of novel combinations. No significant correlation was observed between tryptophan and 100 kernels, but population high in tryptophan showed lower 100 kernel weight in some populations.

TS10-10: Marker-Assisted Introgression of *opaque2* and *opaque16* into Parental Inbreds of Popular White Maize Hybrids

Gulab Chand[1*], Vignesh Muthusamy[1], Tanu Allen[2], Bhavna Singh[1], Konsam Sarika[1], Rajkumar U. Zunjare[1] and Firoz Hossain[1]

[1]ICAR-Indian Agricultural Research Institute, New Delhi, India; [2]Amity Institute of Biotechnology, Amity University, Noida, India.
*Corresponding author Email: gulab.biotech@yahoo.com

Traditional maize is deficient in lysine and tryptophan. Recessive *opaque2* (*o2*) mutant enhances these essential amino acids almost two-fold. Recently discovered *opaque-16* (*o16*) - a recessive mutant when present with *o2* - enhances lysine and tryptophan by 49% and 60% respectively over *o2o2*. White maize is a popular choice in some parts of India, especially for domestic consumption. Although popular yellow maize hybrids are improved for protein quality using both *o2* and *o16*, no white maize hybrids have been targeted for introgression by both mutants. In the present study, parental inbreds of white endosperm-based hybrids viz., HM5 (HKI1344 × HKI1348-6-2) and HM12 (HKI1344 × HKI1378) were targeted for marker-assisted introgression by *o2* and *o16*, using a yellow maize donor (*o2o2/o16o16*) developed at IARI. 107-140 plants in BC1F1 across crosses were successfully genotyped using *o2*-specific umc1066 and phi057, and *o16*-linked umc1141 and umc1149. Both genes segregated as per Mendel's law of 1:1. Heterozygous progenies for both *o2* and *o16* were crossed with respective recurrent parents to raise BC2F1 populations. More than 102 SSRs were used for background selection. Segregants with >80% recurrent parent genome and having similarity for plant-, ear- and grain- characteristics were selected. Genotypes with *o2* and *o16* would serve as rich genetic resources, besides serving as parents for development of white maize hybrids with high protein quality.

TS10-11: Enrichment of Sweet Corn Genotypes for Provitamin-A and Vitamin E through Accelerated Breeding

Hema S. Chauhan[1*], Rajkumar U. Zunjare[1], Tuhin Rashmi[2], Abhijit K. Das[1], Brijesh Mehta[1], Vignesh Muthusamy[1] and Firoz Hossain[1]

[1]ICAR-Indian Agricultural Research Institute, New Delhi, India; [2]Amity Institute of Biotechnology, Amity University, Noida, India.
*Corresponding author Email: hsc18.90@gmail.com

Demand for sweet corn has increased significantly in the last decade. Recessive shrunken2 (sh2) gene enhances sweetness six-fold over ordinary maize. The germplasm base of sweet corn is narrow, and hybrids released so far are not rich in vitamins. Vitamin A and vitamin E play vital roles in human metabolism. Vitamin A deficiency causes night blindness, while deficiency in vitamin E leads to cardiovascular and neurological disorders. In this program, two promising sh2-based sweet corn hybrids, ASKH-1 (SWT16 × SWT17) and ASKH-2 (SWT16 × SWT18) developed at IARI were targeted for enrichment of vitamins. Marker-assisted backcross breeding was followed to introgress favorable alleles of crtRB1 and VTE4 for enhancing provitamin-A and vitamin E, respectively. A HarvestPlus derived line was used as donor. BC1F1 and BC2F1 populations, each having 120-124 plants, were successfully genotyped. Promising BC2F2 segregants having homozygosity at sh2, crtRB1 and VTE4 were selected. 130-142 SSRs distributed throughout the genome were used for background selection, and recovery of recurrent parent genome was as high as 98%. The newly derived progenies resembled their recurrent parents for plant, ear and grain characteristics. These introgressed progenies would be used for reconstitution of hybrids, besides serving as valuable donors. The improved sweet corn genotypes with high vitamin A and E would further increase their acceptability.

TS10-12: Exploration of Novel *opaque16* Mutant for Its Utilization in QPM Breeding Program

Konsam Sarika*, Firoz Hossain, Vignesh Muthusamy, Rajkumar U. Zunjare, Aanchal Baveja, Rajat Goswami, Jayant S. Bhat, Supradip Saha, Sunil K. Jha and Hari S. Gupta

ICAR-Indian Agricultural Research Institute, New Delhi, India.
*Corresponding author Email: konsams@gmail.com

The recessive *opaque2* (*o2*) mutant has been successfully utilized for improvement of protein quality in maize. In the present study, a recently discovered recessive *opaque16* (*o16*) mutant was explored for its possible utilization in QPM (quality protein maize) breeding program. *o16o16* segregants in F2 populations possessed similar grain hardness of normal maize and QPM. Some of the *o16o16* segregants possessed comparable lysine and tryptophan as observed in *o2o2* genotypes. Microscopic packaging of starch granules and protein matrix, and zein profiling in *o16o16* was similar to hard endosperm of normal and QPM genotypes. The influence of *o16* on *o2* was further investigated by marker-assisted introgression of *o16* into *o2*-based parental inbreds (HKI161, HKI193-1, HKI193-2 and HKI163) of four commercial QPM hybrids (HQPM-1, HQPM-4, HQPM-5 and HQPM-7) in India. Inbred having *o16,* developed in China, was used as the donor. The introgressed progenies had 81-96% recurrent parent genome with high phenotypic resemblance. Reconstituted hybrids showed an average enhancement of 49% and 60% in lysine and tryptophan respectively over the original hybrids.

Multi-location evaluation revealed similar grain yield potential of their original hybrids. This is the first report of enhancing nutritional quality by *o16* in sub-tropical maize. The study signified the role of *o16* as supplementary to *o2* for nutritional quality enhancement in maize biofortification program.

TS10-13: Zincing and Ironing of Maize Kernels for Better Nutrition: Insights from Genetics and Genomics Studies

Mallikarjuna M.G.[1*], Rinku Sharma[1], Kaliyugam Shiriga[1], Nepolean Thirunavukkarasu[1], Firoz Hossain[1], Jayant S. Bhat[2], Anju Mahendru Singh[3], Soma Sunder Marla[4], S. V. Amitha CR Mithra[5], Kanchikeri Math Manjaiah[6] and Hari Shanker Gupta[7]

[1]Maize Research Lab, Division of Genetics, ICAR-Indian Agricultural Research Institute (ICAR-IARI), New Delhi, India; [2]ICAR-IARI, Regional Research Centre, Dharwad, India; [3]Grain Quality Laboratory, Division of Genetics, ICAR-IARI, New Delhi, India; [4]ICAR-National Bureau of Plant Genetic Resources, New Delhi, India; [5]ICAR-National Research Centre on Plant Biotechnology, New Delhi, India; [6]Division of Soil Science and Agricultural Chemistry, ICAR-IARI, New Delhi, India; [7]Formerly with ICAR-IARI, New Delhi, India.
*Corresponding author Email: MG.Mallikarjuna@icar.gov.in

One third of the global population is affected by iron (Fe) and zinc (Zn) deficiency. The problem of Fe and Zn deficiency is especially severe in developing and underdeveloped countries, where cereal-based diets are predominant. Among several approaches, genetic biofortification has emerged as a sustainable and cost-effective way to address micronutrient-malnutrition. Maize is one of the major sources of food and feed in sub-Saharan Africa, South Asia and Latin America. Hence, biofortification of maize with high kernel Fe and Zn could help to combat Fe and Zn malnutrition. An extensive phenotyping of maize inbreds for kernel Fe and Zn at six diverse locations revealed significant variability (Fe: 18.88-47.65 mg/kg; Zn: 5.41-30.85 mg/kg) and positive correlation between kernel Fe and Zn (r = 0.37-0.52). The components of variance revealed higher contribution of genotype main effects to kernel Fe (39.6%) and environment main effects to both kernel Zn (40.5%) and grain yield (37.0%). Genome-wide expression test was performed using SKV-616 in response to Fe and Zn stresses (+Fe–Zn, –Fe+Zn, –Fe–Zn). Fe and Zn stresses triggered expression of several genes related to mugineic acid pathway, metal transporters, and phyto-hormone metabolism. Co-mapping of differentially expressed genes with previously known QTLs for kernel Fe and Zn concentration revealed candidate genes such as *OPT, metal binding protein, nramp3* and *NAS*. *In-silico* analysis of Fe and Zn transporter gene families revealed synteny among the *Poaceae* members. The identified genes and genotypes in the present investigation could be used in development of high kernel Fe and Zn maize hybrids.

TS10-14: Prolamins and Glutelins as Protein Markers to Distinguish Normal from QPM Germplasm

Mehak Sethi[1], Alla Singh[2] and Dharam Paul Chaudhary[2]*

[1]Punjab Agricultural University, Ludhiana, India; [2]ICAR-Indian Institute of Maize Research, Ludhiana, India.
*Corresponding author Email: chaudharydp@gmail.com

Maize is an important cereal, ranked third after rice and wheat. However, maize endosperm is nutritionally poor due to high content of zeins which are deficient in essential amino acids lysine and tryptophan. *Opaque2* mutants are rich in lysine and tryptophan due to reduced zein

and higher non-zein proteins. However, it carries certain pleotropic effects which were overcome by development of quality protein maize (QPM). On the basis of solubility, endosperm protein can be fractionated into albumin, globulin, prolamin, prolamin-like, glutelin-like and glutelin. Present study was planned to establish protein markers to distinguish normal lines from QPM. Kernels were harvested from selfed ears of 16 normal and seven QPM lines. Total protein and protein fractions were estimated from extracted endosperm. Results revealed that average albumin in QPM (11.1%) is double as in normal lines (5.62%). Globulin is more in QPM (7.92%) than normal (6.14%) lines. Prolamin is highest in normal (44.9%) and least in QPM (8.94%) lines. Prolamin-like is high in normal (12.3%), somewhat less in QPM (11.52%) lines. Glutelin-like is maximum in QPM (21.6%) whereas normal lines retain about half of the amount (10.9%). Glutelin fraction shows drastic difference in QPM (32.9%) compared to normal lines (17.6%). Overall, non-zein proteins are abundant in QPM while zein protein is more in normal lines, with prolamin and glutelin showing significant variation. Out of all protein fractions, prolamin and glutelin can be used as precise and cost-effective protein markers to differentiate normal lines from QPM.

TS10-15: The Interaction (GxE) Effect of OPV-QPM Population Under Lowland Tropical Zone in Indonesia

M. Yasin H.G.*, Faesal and Fachdiana Tabri

Indonesian Cereal Research Institute (ICERI), Indonesia.
*Corresponding author Email: hg_yasin@yahoo.co.id

In Indonesia, maize is the second most important staple food after rice, but in some areas like the eastern part (NTT, NTB, and Maluku) maize is the main food for local and indigenous farmers. QPM (quality protein maize) is a specialty maize with high levels of lysine and tryptophan - two essential amino acids for the human body – that has better nutritional properties for improving deficiency diseases *(kwashiorkor)* common among children and could be used in balancing diets. The experiment in 2014/15 was conducted to evaluate GxE (genotype x environment) interaction in two seasons (dry and rainy) in lowland tropical zones. There were nine populations of QPM vs normal maize included. The objective of the experiment was to find the best QPM population candidate for new QPM open pollinated varieties in Indonesia. The environments (Ei) were in South Sulawesi (e1: Maros experiment farm and e2: Bajeng), West Sulawesi (e3: Polman), Central Sulawesi (e4: Donggala), North Sulawesi (e5: Pandu), NTB (e6: East Lombok), East Java (e7: Muneng) and Riau (e8: Pakanbaru). The experiment was conducted in CRD with three replications. The test entries were compared statistically to the check Srikandi Yellow 1 (S99TLYQ-AB). Each of the populations were planted in four rows 5.0m length, with a spacing of 75x20 cm, one plant per hill, and the fertilizer Urea, Ponska (300-200) kg/ha was applied. Nutritional quality was analyzed in the Nutrition Lab in Bogor, West Java. The results showed that genotypes G1. Q. Com.C0(SK2) and G2. Q. Syn(S1)C1.F(SK3) had the highest yields across the eight environments. The potential yield was found to be 8.73-8.92 t/ha in e3: Polman and e4: Donggala, with 20-35 % yield advantage over the check. The ASI (anthesis silking interval) were three days, with the plant aspect and husk cover scores one. The G1 and G2 populations were found promising as OPV-QPM.

TS10-16: Carotenoid Retention in Provitamin A Biofortified Maize (*Zea mays* L.) after Indian Methods of Processing and Cooking

Nivedita Dube[1*], Purna Chandra Mashurabad[2], Firoz Hossain, Raghu Pullakhanda[2], Longvah Thingnganing [4] and Dinesh Bhartraj[1]

[1]Food and Drug Toxicology Research Center, National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, Telangana, India; [2]Micronutrient Division, National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, Telangana, India; [3]Department of Genetics, Indian Agriculture Research Institute, Indian Council of Agriculture Research, New Delhi, India; [4]Food Chemistry Division, National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, Telangana, India.
*Corresponding author Email: dube.nivedita@gmail.com

Provitamin-A (proV-A) biofortified maize hybrids have been developed to target vitamin A deficient populations in India. The purpose of this study was to evaluate the degradation of carotenoids after household processing and cooking in biofortified maize hybrids [normal maize, quality protein maize (QPM) maize, proV-A carotenoid and double biofortified QPM + proV-A maize hybrids] developed by IARI, New Delhi. In general, the total proV-A carotenoid (BCX+AC+BC) content of biofortified maize was 2–10 fold higher compared to normal maize. The average ratio of non-proV-A to proV-A carotenoids was higher in normal maize (2.01) compared to that in biofortified maize (0.3). The consumption of 200g/day of biofortified maize hybrids, Pusa-PV-16-3 (BC=1036µg/100g; AC=1084µg/100g) and PUSA-APQH8 (BC=414µg/100g; AC=2046µg/100g; BCX=752µg/100g) individually, would contribute to the 67% and 76% of RDAs for adult men after adjusting for conversion factors. There was virtually no degradation due to household processing methods. Cooking of maize flour during the preparation of porridge led to 0–24% loss of carotenoids, the greater loss being for AC and BC. Furthermore, the loss of LUT (0–12%), ZEA (2–15%), BCX (0–13%), AC (0–23%) and BC (0–24%) varied among different maize hybrids. The carotenoid retention from maize hybrids during other household cooking methods (roasting, boiling, microwaving) is currently under evaluation. In conclusion, the retention of non-proV-A carotenoids was higher as compared to the proV-A carotenoids from normal and biofortified maize hybrids, but the magnitude of this effect varied among hybrids.

TS10-17: Marker-Assisted Selection for *crtRB1* for the Development of Locally Adapted Provitamin-A Rich Maize Inbreds

Rajat Goswami[2*], Rajkumar U. Zunjare[1], Suphiya Khan[2], Vignesh Muthusamy[1], Aanchal Baveja[1], Abhijit K. Das[1], Sunil K. Jaiswal[1], Jayant S. Bhat[1], Satish K. Guleria[3] and Firoz Hossain[1]

[1]ICAR-Indian Agricultural Research Institute, New Delhi, India; [2]Banasthali Vidyapith, Rajasthan, India; [3]CSK-Himachal Pradesh Krishi Vishwavidyalaya, Bajaura, India.
*Corresponding author Email: rajatgoswami13@gmail.com

Traditional yellow maize possesses low (1-2 ppm) provitamin-A (proV-A) but contains higher non- proV-A carotenoids. Mutant version of *crtRB1* increases proV-A by two- to 10-fold. In India, only few inbreds with high proV-A are available. To develop diverse proV-A rich genotypes, 10 elite but normal inbreds (1-2 ppm proV-A, good combiner) were crossed with proV-A rich donor, HP704-22 (15-20 ppm proV-A, poor adaptation). Marker-assisted selection (MAS) for *crtRB1* among F2 segregants led to development of 75 proV-A rich inbreds with desirable phenotype. The elite but normal inbreds had 92% of non-proV-A and only 8% proV-

A carotenoids. In the introgressed inbreds, β-carotene and β-cryptoxanthin constituted 52% and 21% (83% proV-A), respectively, while lutein and zeaxanthin together had 27% of total carotenoids. ProV-A among the normal inbreds varied from 1.2-2.2 ppm, while the F2-derived lines possessed high mean proV-A (15.9 ppm) with a range of 9.4-21.5 ppm. Further, HKI1128Q - a parental inbred of three popular hybrids (HM9, HM10 and HM11) - was improved for proV-A through backcross breeding. Segregation distortion for *crtRB1* was observed in BC1F1, BC2F1 and BC2F2 populations. Background selection achieved 88-93% recovery of recipient parent genome. ProV-A among backcross-derived HKI1128Q progenies ranged from 9.97-12.18 ppm. These newly developed locally adapted, agronomically superior and proV-A rich maize inbreds possess great significance in maize biofortification program.

TS10-18: Genetic Analyses of *crtRB1* and *lcyE* Genes and Enhancement of Provitamin-A in QPM Hybrids

Rajkumar U. Zunjare*, Firoz Hossain, Vignesh Muthusamy, Rashmi Chhabra, Aanchal Baveja, Hema S. Chauhan, Jayant S. Bhat, Supradip Sahaand and Hari S. Gupta

ICAR-Indian Agricultural Research Institute, New Delhi, India.
*Corresponding author Email: raj_gpb@yahoo.com

Biofortification of maize for provitamin-A (proV-A) holds great potential in alleviating vitamin-A deficiency. Analyses of various allelic classes of *crtRB1* and *lcyE* revealed large effect of mutant allele of *crtRB1* (5.5-fold) and *lcyE* (two-fold) over unfavorable class. Double recessive homozygote had the highest proV-A (14.82 ppm) over all other classes. Molecular analysis of 5'TE region of *lcyE* identified seven SNPs, four of which differentiated the low proV-A and high proV-A genotypes. Novel multiplex-PCR assay developed for both genes showed potential saving of 43% cost and 50% time, compared to uniplex-PCR assays. Four popular quality protein maize hybrids (HQPM1, HQPM4, HQPM5 and HQPM7) were also proV-A-biofortified by marker-assisted introgression of favorable alleles of *crtRB1* and *lcyE*. HP704-22 and HP704-23 (CIMMYT inbreds) were used as donors, while QPM inbreds viz., HKI161, HKI163, HKI193-1 and HKI193-2 were the recipients. 5-9-fold increase of proV-A was recorded with high recipient parent genome recovery (89-93%) in introgressed lines. Lysine (0.330%) and tryptophan (0.077%) was high among introgressed lines. The reconstituted hybrids showed mean 4.5-fold proA increase (10.58 ppm). Mean lysine (0.334%) and tryptophan (0.080%) of the improved hybrids were at par with original hybrids. Multi-location evaluation showed similar yield potential of the improved hybrids (7320 kg/ha) with their original version (7295 kg/ha).

TS10-19: Genetic-Variability of Provitamin-A Under Storage and Influence of *CCD1* and *LOX* Genes Affecting their Retention

Suman Dutta[1*], Vignesh Muthusamy[1], Rashmi Chhabra[1], Aanchal Baveja[1], Rajkumar U. Zunjare[1], Tapan K. Mondal[2], Manigopa Chakraborti[3], Sunil K. Jha[1] and Firoz Hossain[1]

[1]ICAR-Indian Agricultural Research Institute, New Delhi, India; [2]ICAR-National Research Centre for Plant Biotechnology, New Delhi, India; [3]Birsa Agricultural University, Ranchi, India.
*Corresponding author Email: duttasumansiliguri@gmail.com

Vitamin A deficiency is a major health problem worldwide. In recent years several provitamin-A (proV-A) rich maize hybrids and OPVs have been commercially released. However, loss in proV-A is encountered during storage due to various physical and genetic factors. To sustain the increased proV-A level, there is need to identify stable genotypes during storage and the genetic factors governing higher retention. Here, a set of 22 (>8.0 ppm) and 11 (1-2 ppm) maize inbreds were evaluated for kernel proV-A during six months of storage. The study revealed significant genetic variation for retention of proV-A (10 to 70%) among genotypes. Mean proV-A at harvest and six months after storage was 9.4 ppm and 2.7 ppm respectively. Maize inbreds with contrasting retention potential for proV-A have also been identified. Differential expression of carotenoid cleavage dioxygenase-1 (CCD1; chromosome-9) and lipoxygenase (LOX3; chromosome-1) genes affecting retention of proV-A were observed in contrasting inbreds. Besides, copy number of CCD1 gene also had influence on the degradation of proV-A. These genes can be explored to improve the retention of proV-A in maize during storage. The genotypes with contrasting retention potential would also pave way for identifying novel loci responsible for high retention of kernel carotenoids in maize.

TS10-20: Genetic Variability and Validation of QTLs Linked to Accumulation of Iron and Zinc in Maize

Sunil K. Jaiswal[1*], Firoz Hossain[1], Vignesh Muthusamy[1], Rajkumar U. Zunjare[1], Rajat Goswami, Rashmi Chhabra[1], Gulab Chand[1], Sweta Dosad[1], Rakesh Bhowmick[2], Satish K. Guleria[3], Arunava Pattanayak[2] and Hari S. Gupta[1]

[1]ICAR-Indian Agricultural Research Institute, New Delhi, India; [2]ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, India; [3]CSK-Himachal Pradesh Krishi Vishwavidyalaya, Bajaura, India.
*Corresponding author Email: jaiswal1982@gmail.com

The consequences of iron (Fe) and zinc (Zn) deficiencies in human diet are dire across the world. Humans need Fe for basic cellular functions and proper functioning of the brain, red blood cells and muscles, while Zn is important for >300 enzymes in humans for synthesis and degradation of biomolecules. Breeding maize varieties rich in kernel-Fe and -Zn provides a sustainable and cost-effective solution to malnutrition. In the present study, 20 diverse maize inbreds varying for Fe (30.0-46.13 ppm) and Zn (18.68-39.56 ppm) were analyzed using 25 and 35 SSRs linked to QTLs for Fe and Zn respectively. Moderate positive association was also observed between kernel-Fe and -Zn. Diversity analysis identified 58 and 86 alleles for Fe and Zn respectively. A unique allele for Fe and three unique alleles for Zn were identified. PIC for Fe ranged from 0.20-0.66 (mean 0.40) and PIC for Zn varied from 0.10-0.59 with mean 0.40. A mean dissimilarity coefficient for Fe was 0.58 (range: 0.25-0.91), while mean for Zn was 0.57 (range: 0.27-0.88). PCoA revealed a diverse genetic nature of the inbreds. Three major clusters were observed for the inbreds for both kernel-Fe and -Zn. The study identified selected cross combinations to produce heterotic hybrids higher in Fe and Zn, and to develop novel inbreds using transgressive segregants. The information generated here would be helpful for developing maize hybrids rich in kernel-Fe and -Zn.

TS10-21: Introgression of *opaque2* Gene through Marker-Assisted Backcross Breeding in Elite Maize Inbred Lines

Swaran Lata[1*], S.K. Guleria[1], Kalpna Thakur[1], Reena Kumari[1], Maneet Rana[2] and Waseem Hussain[3]

[1]Department of Crop Improvement, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur-176 062, Himachal Pradesh, India; [2]Department of Crop Improvement, ICAR-Indian Grassland and Fodder Research Institute, Jhansi-284 003, Uttar Pradesh, India; [3]Department of Agronomy and Horticulture, University of Nebraska, Lincoln- 68583-0915, USA.
*Corresponding author Email: slatasharma@gmail.com

Quality protein maize (QPM) lines with two copies of recessive *o2* allele mutation have substantially higher lysine and tryptophan content in grain endosperm compared to normal lines. The QPM maize lines have been used as excellent sources for conversion of normal maize lines into QPM lines. To this end, we employed the marker-assisted backcrossing breeding for the conversion of normal maize inbred lines into QPM lines using *opaque2* gene-specific markers viz., phi057 and umc1066. The two parental lines, BAJIM-08-26 and BAJIM-08-27, were selected as recipient parents for introgression of *opaque2* gene using CML 169 and CML 193 as donor lines. A separate conversion program was used for each normal parent using cross combination BAJIM-08-26 x CML 169 and BAJIM-08-27 x CML 193. At earlier backcross generations (BC1 to BC2), foreground (using markers phi057 and umc1066) and background selection combined with phenotypic selection were carried out for rapid recovery of recurrent parent genomes. The heterozygous offspring of BC2F1 were self-pollinated to produce the BC2F2 generations for both cross combinations. Plants based on 25% opaqueness were selected and selfed to develop BC2F3 and BC2F4 generations to enable the selection of homozygous lines (*o2o2*). Tryptophan content of BC2F4 generation ranged from 0.75 to 0.93% and 0.66 to 0.85% in BAJIM-08-26×CML169 and BAJIM-08-27×CML193 respectively. The total protein in endosperm was found to range from 7.0 to 9.6%. The newly converted QPM lines hold significant promise for improving nutritional quality in maize.

TS10-22: Enhancement of Bioavailability of Micronutrients in Maize through Genetic Manipulation: An Avenue to Alleviate Malnutrition

Vignesh Muthusamy*, Firoz Hossain and Rajkumar U. Zunjare

ICAR-Indian Agricultural Research Institute, New Delhi, India.
*Corresponding author Email: pmvignesh@yahoo.co.in

Micronutrient malnutrition is an alarming problem worldwide. Development of micronutrient dense staples provide a sustainable and cost-effective solution to malnutrition. Several maize genotypes rich in one or more micronutrients viz. lysine, tryptophan, provitamin-A, vitamin E, iron and zinc are now developed. However, bioavailability of these micronutrients to achieve the recommended dietary allowance for humans remains a major concern. Higher concentration of lysine and provitamin-A increase the bioavailability of zinc. Elite QPM hybrids (HQPM1, HQPM4, HQPM5 and HQPM7) that possess higher zinc have been now been improved for provitamin-A using *crtRB1* and *lcyE* genes. Keeping in mind that vitamin E enhances bioavailability of provitamin-A, mutant VTE4 gene has been introgressed into elite QPM and provitamin-A rich inbreds (HKI161, HKI163, HKI193-1, HKI193-2, HKI323, HKI1105 and HKI1128). Owing to the effect of high oil in increasing the bio-availability of provitamin-A, we target to increase the oil content in provitamin-A rich maize hybrids. Phytate

chelates iron and zinc, decreasing their bioavailability. In our program, provitamin-A rich QPM hybrids (HQPM1, HQPM4, HQPM5 and HQPM7) have been targeted for reduction of phytate by introgressing lpa1 and lpa2 genes. These efforts seek to develop nutritious maize with enhanced bioavailability towards nutritional security.

TS10-23: Development of Low Phytic Acid Maize Through Marker Assisted Introgression of *lpa1-1* and *lpa2-1* Genes

Vinay Bhatt[1*], Vignesh Muthusamy[1], Shipra Jha[2], Rajkumar U. Zunjare[1], Aanchal Baveja[1], Sweta Dosad[1] and Firoz Hossain[1]

[1]ICAR-Indian Agricultural Research Institute, New Delhi, India; [2]Amity Institute of Biotechnology, Amity University, Noida, India.
*Corresponding author Email: vinaybhatt024@gmail.com

Nearly 80% of the total phosphorous in the maize grain is present as phytic acid, which significantly reduces the bioavailability of kernel -iron and -zinc. Hence, reduction of phytic acid in maize possesses immense nutritional significance. So far, no low phytate maize hybrid is available for commercial cultivation in India. Here, four elite inbreds (HKI161-ProA, HKI163-ProA, HKI193-1-ProA and HKI193-2-ProA) that are parents of four provitamin-A rich versions of QPM hybrids (HQPM1, HQPM4, HQPM5 and HQPM7) were targeted for marker-assisted introgression of lpa1-1 and lpa2-1 genes from separate donors of exotic origin. Nearly 120 progenies in BC1F1, BC2F1 and BC2F2 were genotyped for lpa1-1, lpa2-1, *crtRB1* and *opaque2* genes using associated markers. The lpa1-1, lpa2-1 and *opaque2* genes showed Mendelian segregation pattern, but *crtRB1* revealed segregation distortion. Background selection using >100 SSRs has led to recovery of recurrent parent genome as high as 94%. Selected segregants resembled their respective recurrent parents and were superior in agronomic performance. Introgressed progenies with (i) *o2*, *crtRB1* and lpa1-1, and (ii) *o2*, *crtRB1* and lpa2-1 would serve as rich genetic resources in the maize biofortification program and development of multi-nutrient maize hybrids with enhanced bioavailability of mineral elements.

PLATINUM SPONSOR:

USAID
FROM THE AMERICAN PEOPLE

GOLD SPONSORS:

BIOSEED

IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

CORTEVA™
agriscience
Agriculture Division of DowDuPont™

DEKALB

syngenta

SILVER SPONSORS:

syngenta foundation
for sustainable
agriculture

JK seeds®

BRONZE SPONSORS:

METAHELIX
Germinating Hope
Metahelix Life Sciences Limited
A TATA Enterprise

VNR

HYTECH™

CRYSTAL

Ajeet
Seeds Pvt. Ltd.

STAR Beej

TRIMURTI
Plant Sciences

HDFC BANK

PREFERRED
POPCORN
Picked to be the Best