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ICAR-Indian Institute of Maize Research

P.A.U. Campus, Ludhiana-141004, India

Nurturing diversity, resilience, livelihood & industrial inputs

भाकृ अनुप
ICAR

भाम अनुसं
IIMR

Annual Report 2017-18

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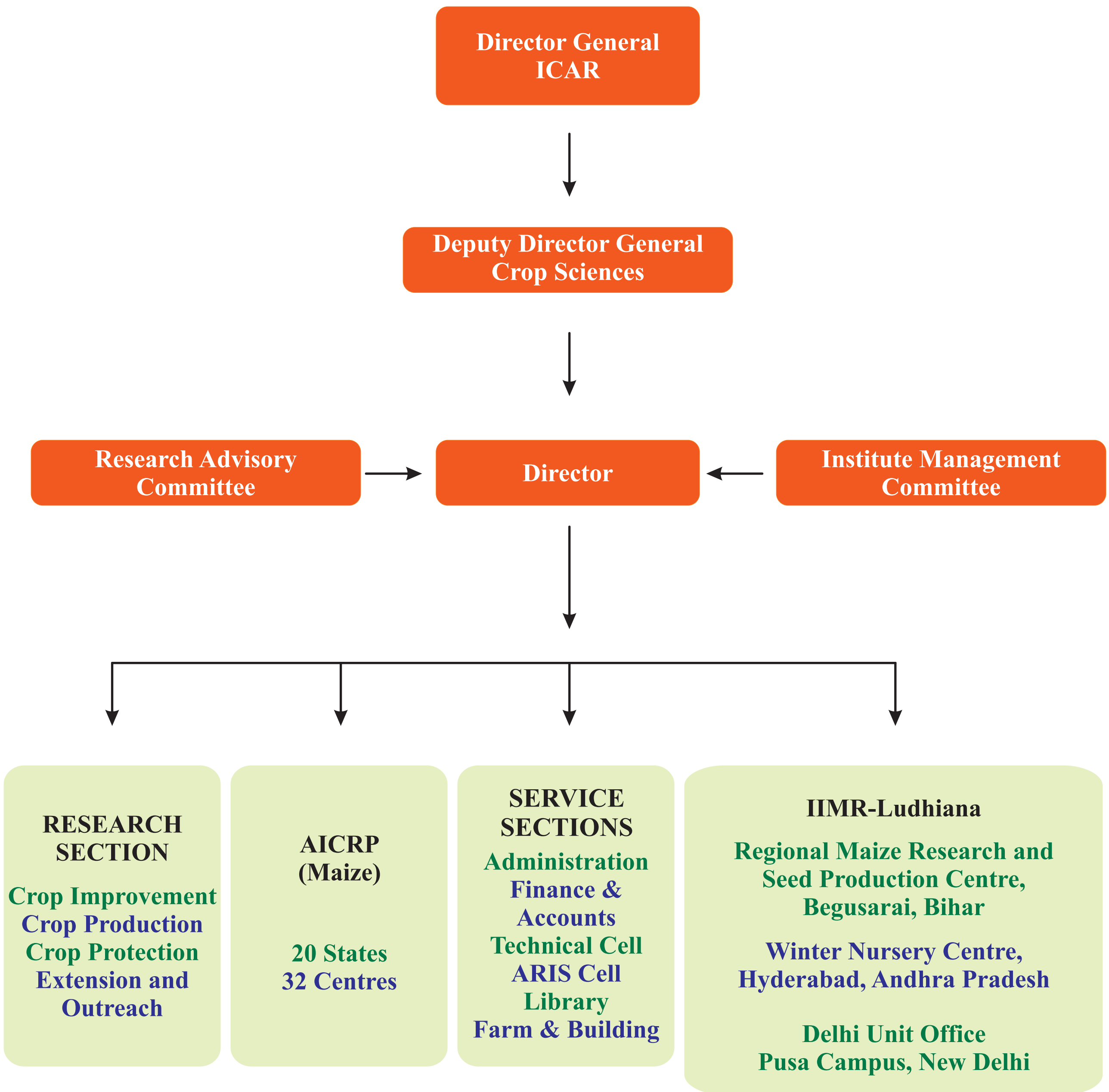
Organogram of ICAR-IIMR



Preface

ICAR-Indian Institute of Maize Research (ICAR-IIMR), with its coordinating centres under All India Coordinated Research Project (AICRP) is the nodal institute for maize research and development) in India. First to be conceptualized in 1957, the program has been instrumental in generating maize technologies for progress and sustainability of maize production in the country. Over last six decades, maize has experienced monumental rise in production from 1.73 million metric tonnes (mt) during 1950-51 to as high as 26.88 mt during 2016-17, which demonstrates the strides achieved in maize research during these years. Increase in area of cultivation and overall productivity have contributed almost equally to the mentioned increase in production. The adoption of Single Cross Hybrid technology has remained a game changer in the process. With the release of 151 hybrids and 137 composite varieties of maize over this period, maize researchers have exhibited its commitment to research and development for the betterment of farmers of the country.

This year, Annual Maize Workshop marked Diamond Jubilee by completing 60 years of service to maize R&D. A major achievement during the reporting year has been the introduction of Maize Automation System, developed in collaboration with ICAR-NAARM, Hyderabad and ICAR-IASRI, New Delhi for online management and analysis of AICRP trials. ICAR-IIMR has been involved in improvement and sharing of maize germplasm. This year, 546 accessions were distributed to 34 centres. Three hybrids developed by the institute have been released by Central Variety Release Committee. IIMR with its AICRP partners has been registering genetic stocks with NBPGR, hybrids and composites with PPV&FRA. This year two hybrids have been registered with NBPGR. Emphasis has been placed on dissemination of developed technologies to beneficiaries through Front Line Demonstrations (FLDs), exhibitions and training programmes. For propagation of technologies to tribal areas, the platform of 'Tribal Sub-Plan' has been effectively utilized.

Under changing climate, both biotic and abiotic stresses cause singnificant loss ot maize production and as it is predominantly grown under rainfed conditions, unpredictable weather causes much losses. Management of both biotic and abiotic stresses is being attempted through broadening of genetic base of breeding material, improved agronomic practices and eco-friendly management of pests and diseases. The use of maize for replacement of environmentally demanding cropping systems at some locations like Indo-Gangetic Plain is very significant for preservation of agro-ecologies. Efforts are being made to determine economically potential cropping and intercropping systems involving maize. Due attention has been paid to specialty corn and fodder maize, considering the changing market dynamics.

The demand for maize is ever increasing and estimated to touch around 50 mt maize grain by 2025. More than 60% of maize would be consumed in the feed sector, nearly 30% would be required for the industrial sector, four percent as food, and two percent for seed and miscellaneous purposes. Depending on the present productivity, a yearly growth rate of 7-8% would raise the production to desired levels. This requires location-specific recommendations for optimizing maize technologies with respect to available resources. Farmer remuneration, consumer benefit and environmental concern need to be taken into account for sustainable development of the maize-based agricultural systems. The institute is making all efforts to meet these demands.

I express sincere thanks and gratitude to Dr. T. Mohapatra, Secretary, DARE and DG, ICAR for his immense support in promoting maize research in India and guiding us. I am also deeply thankful to Dr. A.K. Singh, DDG (Horticulture and Crop Sciences) and Dr. I.S. Solanki, ADG (FFC) for their consistent suggestions, encouragement and support for strengthening maize research in India. I thank editorial team and all staff of IIMR and AICRP-Maize for their active participation and dedication.

(Sujay Rakshit)

MISSION

Enhancing the productivity, profitability and competitiveness of maize and maize-based farming systems with economic and environmental sustainability

VISION

Rapid growth in the food, feed and industrial application of maize and maize-based products, for generation of wealth and employment in farming and industrial sectors, and for all those who are directly or indirectly associated with maize cultivation and utilization

Mandate

Basic and strategic research aimed at enhancement of productivity and production of maize, including specialty corn.

Coordination ofmulti-disciplinary and multi-location research to identify appropriate technologies for varied agro - climatic conditions.

Dissemination of improved technologies, capacity building and developing linkages.

Executive Summary

ICAR- Indian Institute of Maize Research (IIMR) is mandated to carry out basic, strategic and applied research aimed at enhancing production, productivity and sustainability of maize. The institute carries its research activities under four broad themes: Crop Improvement, Crop Production and Protection. Besides, the institute coordinates the All Indian Coordinated Research Project (AICRP) on Maize and undertakes extension and outreach activities. During 2017-18, important achievements were made in various aspects of maize research.

CROP IMPROVEMENT

ICAR-IIMR is solely committed to boost the production and productivity of maize crop in the country. Genetic enhancement of maize germplasm continued to be the major focus of the institute in this regard. The major activities under crop improvement programme are germplasm procurement and characterization; development of resistant germplasm for existing biotic and abiotic stresses; quality improvement; and development of new hybrids for different agro-ecologies of the country. The institute also coordinates the All India Coordinated Research Project (AICRP) on Maize to address the regional as well as national issues related to maize. During the period, the institute made significant research achievements under the crop improvement programme which are mentioned below.

Strengthening of germplasm base

The success of breeding programme of any crop is dependent on the richness of available germplasm. Introduction of exotic germplasm and development of novel genetic resources is a continuous process. To strengthen the Indian maize breeding programme, 66 tropical maize inbred lines, two brown midrib mutants, 252 white CML inbred lines and 468 baby corn germplasm were procured from different national and international sources. Germplasm characterization serves the purpose of identification of special germplasm for specific use. Three hundred germplasm under CRP on Agro-biodiversity, 111 lines for baby corn, 341 germplasm for fodder and 33 inbred lines for high protein and tryptophan were characterized. Two inbred lines, *viz.*, DQL 2032 and DQL 2060 were exceptionally well for both protein (11.25%) and tryptophan content (1.08%). The web based Decision Support System for Maize Germplasm (URL: https://krishi.icar.gov.in/wnciimr) was also updated with addition of information on 150 inbred lines, which will help to select genotypes of choice. Efforts were made toward heterotic grouping of available fixed lines (1394 normal lines and 248 QPM lines) by growing together and crossing these lines with two heterotic testers, *viz.,* LM13 and LM14 at WNC, Hyderabad. For recycling of inbred lines in QPM breeding programme pedigree crosses were attempted within heterotic group (A & B) and 1055 F_3 families were advanced.

Under the diversification programme of QPM germplasm, a set of 25 new QPM inbred lines were derived from pedigrees crosses between normal and QPM germplasm and promising inbred lines with desirable tryptophan content (> 0.6%) were selected. Wild species of maize are being used to introgress the desirable trait from wild germplasm into active breeding material. Three wild species are being maintained and crossed to elite inbred lines. Similarly, to exploit the tillering traits, *Zea parviglumis* accession was crossed to fodder variety J-1006 and tillering pattern of F_1 generation was recorded.

Hybrid development programme

A common set of 1500 experimental hybrids including three checks was evaluated in α-lattice design and promising hybrids were identified for contribution in AICRP trial. Thirty four early and 247 QPM experimental hybrids were evaluated in two separate trials using α-lattice design. Two QPM hybrids, *viz.,* DQL 2234 × DQL 2184 and DQL 2299 × DQL 2018-1 and two early hybrids, *viz.,* IC656136-1-6-2-1-1× CML425 and (13045/V373)-1-1-1-2-1-1 × CML425 were found superior over the check.

Three single cross maize hybrids DMRH 1301 (normal maize), DMRH 1308 (normal maize) and DMRHP 1402 (popcorn) were released in 78th meeting of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops held on 9th and 10th July, 2017 held at CIARI, Port Blair.

Winter nursery facility and germplasm distribution

Sharing of germplasm among public institutions is one of the mandates of IIMR, for which 546 maize accessions were provided to 34 different AICRP and cooperating centres during 2017-18. *Further, the seeds of Teosinte* were also shared with TNAU, Coimbatore and PAU, Ludhiana. The institute has also provided off-season nursery facility at Hyderabad to two of ICAR Institutes and four state agricultural universities for maintenance and hybrid seed production of maize.

Germplasm for combating biotic stresses

Three sets of 138, 320 and 134 germplasm lines were screened against maydis leaf blight (MLB), banded leaf & sheath blight (BLSB) and charcoal rot (ChR), respectively under artificially created epiphytotics. Out of these, 17, 12 and 49 lines exhibited resistant reaction against MLB, BLSB and ChR, respectively. A multi-location phenotyping trial of 98 genotypes was also evaluated for resistance against post flowering stalk rot (PFSR) in which 13 lines were found to be resistant, while 24 were moderatrely resistant. One genotype, MF2-46-9 out of 78 tested against spotted stem borer (*Chilo partellus); two and six lines (out of* 6 and 53 genotypes, *respectively)* screened under artificial infestation against pink stem borer (*Sesamia inferens), recorded resistant response.*

Host-pathogen interaction

Thermal longevity of Post-flowering stalk rot (PFSR) causal inoculum of *M. phaseolina* was tested at temperature range from 35°C to 70°C. Significant colour variation observed after raising 5°C temperature in every incubation. Maize plants exhibited significant changes in visual symptoms when inoculated with treated pathogen. The present investigation suggests adaptability of the pathogen up to 65°C.

Germplasm screening for combating abiotic stresses

A set of 100 inbred lines were evaluated under water logging as well as drought stresses in glasshouse. The two lines, *viz.,* DML 221 and DQL 593-4, were identified as highly tolerant to water logging stress whereas two lines *viz*., DML 221 and DQL 574-2 showed tolerance to drought stress. It is interesting to note that DML221 showed tolerance against both excess and low moisture stresses. The RNA from root and shoot samples of water and drought tolerant and susceptible genotype were isolated and sequenced to understand the molecular basis of drought and water logging stresses tolerance in maize. Further, towards development of trait specific germplasm should be targeted for development of abiotic stress tolerant cultivars, inbred lines with high temperature stress adaptive traits, *viz*., tassel blasting, leaf firing, leaf rolling and leaf senescence were identified and used to develop F2:3 populations. To test any harmful effect of high temperature on spring season grown maize embryo viability, 14 inbred lines were grown at both Begusarai and Ludhiana during *rabi* and spring seasons of 2017, respectively. Seed lots from Ludhiana harvest showed lower 33% viability and 58% germination compared to seed lots harvested from Begusarai which indicates existence of harmful effects of high temperature at embryo development stage during *spring* season.

CROP PRODUCTION

Along with crop improvement, management of the crop plays an important role in ensuring overall productivity. The crop production programme of the institute is focused on management of nutrient application and cropping systems.

Nutrient and cropping system management

On the basis of 5-year experimentation, it was concluded that for getting the maximum net returns in maize-mustard-mungbean (MMMb) system, crops should be grown with residue retention using sulphur coated urea, while maize-wheat-mungbean (MWMb) should be grown with residue and neem coated urea application under conservation agriculture. Adoption of conservation tillage (Zero Tillage/Permanent Bed) practices with improved nutrient management (Site-Specific Nutrient Management/Ad-hoc) could be a viable option for achieving higher productivity, water and energy-use efficiency, profitability and soil organic carbon in MWMb system of north-west India. The green seeker (GS) based application of nitrogen had a wide yield range (122 to 190 kg/ha) in various cropping systems and residue management scenarios that showed that the calibration curve developed by IIMR in collaboration with CIMMYT and IIFSR had capacity to give precision N recommendations in various field situations. Under conventionally tilled system, the GS based N application was 13 to 40 kg lesser than the recommended N (150 kg/ha) in maize for North Western Plain zone. It was also found that cropping system also had significant influence on the productivity of *kharif* maize where MWMb was better than MMMb cropping system.

CROP PROTECTION

Entomology division in the institute focused on Host Plant Resistance based approaches for the management of insect pests. Germplasm screening against stem borers of maize, *viz*., *spotted stem borer and pink stem borer* resulted in identification of valuable sources of resistance, which would help in developing new cultivars with in-built resistance. Towards understanding the role of metabolome in resistance response against spotted stem borer, about 100 differentiallly expressed metabolites were detected from susceptible inbred line (BML 6), tolerant inbred line (BML 7), and their hybrid (DHM 117), of which 35 were significant. Majority of the compounds belonged to flavonoid glucosides, which were down-regulated 48 hrs after infestation by the pest. The highly downregulated metabolites were dihydrocaffeic acid 3-O-glucuronide (Log_2 fold change -2.67) in BML 7 and epicatechin 3'-O-glucuronide (Log_2 fold change -2.43) in DHM 117.

Among newer fungicides, foliar application of trifloxystrobin 25% + tebuconazole 50% @ 0.05% effectively controlled TLB and common rust. Seed treatment with *Pseudomonas fluorescens* @ 0.5% + bioagent-fortified FYM (1:50) + spray @ 0.5% and application of fungal antagonist TV-3 (*Trichoderma viride*) @ 0.5% as seed treatment + bioagent-fortified FYM (1:50) + spray @ 0.5% were found effective in suppressing the PFSR and RDM, respectively. Aqueous extracts of garlic cloves and neem leaf @ 10 per cent controlled MLB disease whereas cultural practices like leaf stripping of lower leaves inhibited severity of BLSB.

AICRP ON MAIZE

During *Rabi* 2016-17, total 99 entries were received for multi-location evaluation in AICRP trials. Of 99 entries, 95 were received in normal maize group, and remaining four were in quality protein maize (QPM). Total seven different breeding trials were constituted and evaluated at 20 test centers across country. There were 90 entries available for promotion from first and second year of testing, out of which only 33 entries got promoted to their advance stages of testing.

During *Kharif* 2017, total 375 maize entries were evaluated in all India coordinated trials. Out of these, 303 were normal maize and remaining 72 belonged to specialty corns. Seventeen breeding trials were constituted and evaluated at 57 centers across the country. Total 352 entries were available for promotion, of which only 97 entries got promoted from *Kharif* 2017 to *Kharif* 2018 in different maturity groups.

To identify elite germplasm resistant to major diseases, 21 trials including 444 hybrids and 3758 inbred lines in both *Kharif* and *Rabi* were screened against maydis leaf blight (MLB), turcicum leaf blight (TLB), banded leaf and sheath blight (BLSB), sorghum downy mildew (SDM), Rajasthan downy mildew (RDM), curvularia leaf spot (CLS), post-flowering stalk rots (PFSR) - charcoal rot (ChR) & fusarium stalk rot (FSR), common rust (CR), polysora rust (PR) and bacterial stalk rot (BSR) in artificially created epiphytotics at hot spot locations. Out of these, 407 hybrids were promising exhibiting multiple disease resistance. Based on three years disease reactions, 12 promising entries were identified by Variety Identification Committee (VIC). Beside this, during *Kharif* 2017, 345 maize hybrids of different maturity groups were examined against cyst nematode (*Heterodera zeae*) at Udaipur centre and out of them, 21 entries exhibited moderate resistant reaction. In addition to these, disease surveys and surveillance were conducted at farmer's fields in 210 locations of maize growing states to assess overall disease scenario during the crop season. MLB, BLSB, TLB and ChR were the most important diseases in all the zones whereas CLS and BSR is gaining importance in Himachal Pradesh, Punjab, Uttarakhand, Dharwad, Mandya, Gujarat, Telangana and Haryana with low to moderate intensities. Trap nursery trial for disease occurrence was conducted at Almora, Dhaulakuan, Delhi, Karnal, Ludhiana, Pantnagar, Dholi, Kalyani, Udaipur, Coimbatore, Dharwad, Hyderabad and Mandya centres. Yield losses were reported up to 18.49-22.01, 19.82, 21.20, 89.10, 41.52 and 16.91 per cent due to MLB, TLB, ChR, SDM, RDM and CLS, respectively in experimental plots.

The major component in entomology programme is to identify germplasm with HPR against major pests of maize, *viz.*, spotted stem borer (*Chilo partellus*) mainly in *Kharif*, pink stem borer (*Sesamia inferens*) in *rabi* and shoot fly (*Atherigona* spp.) in spring. During *Kharif* 2017, a total of 161 hybrids and 34 inbred lines were evaluated against spotted stem borer under artificial infestation. Among these, DMRH 1305 (in NEPZ), DQH 111 and AHB 6005 (in CWZ) were resistant. In *Rabi* 2016-17, out of 36 entries tested; KMH 3981, DKC 9175 (IP8514), NMH 1290, Buland (late maturity); BLH 101, DMH 117, BIO 9544 (medium maturity) and MMH QPM-6-12-13 (QPM) were found resistant against spotted *stem borer* at Kolhapur.

During spring 2017, WNCDMR11R5881, G18QC8-36, P63C2BBB17B, PFSR/51016-1, SO1SIYQBBB13B were found to be resistant out of 49 maize inbred lines screened under natural infestation against shoot fly at Delhi centre. Two inbred lines, *viz.,* CM 13 and CML 43 (out of 40 lines evaluated) were resistant at both Ludhiana and Delhi centres.

The population of cob borer was monitored from tasseling till harvesting stage by installing pheromone traps during spring and *Kharif* 2017. Maximum catch of 289 moths/acre was recorded during last week of April in spring sown maize at Ludhiana whereas No moth was recorded in Kolhapur in *Kharif* maize. Presence of the pest was fairly high in Bajaura (42), Karnal (43) and Delhi (34), while low in Udaipur (10) and Hyderabad (4). Incidence of *C. partellus* was monitored in two genotypes during *kharif* 2017 at five different locations. Maximum number of larvae (4.25/plant) was recorded in susceptible genotype in fourth week of July at Karnal.

EXTENSION AND OUTREACH

During 2017-18, the frontline demonstrations under National Food Security Mission were conducted on 178.2 ha by IIMR and AICRP stations in 15 states, which benefitted 468 farmers. The yield gaps compared to farmer practices varied respectively, across the seasons and the states from 41 (15 to 98), 22 (10 to 59) and 41 (20 to 65) per cent during *kharif* 2017, *rabi* 2016-17 and spring 2017 seasons. Tribal Sub Plan (TSP) trainings were also conducted for farmers by AICRP maize centers benefiting 865 farmers and in demonstrations under TSP, yield improvement over existing farmer practices of 22-36% at Jhabua (MP) and 42-133% at Banswara (RJ) was recorded. In NEH programme, 8 trainings were conducted in Manipur in collaboration with ICAR Manipur centre benefiting 562 farmers towards promotion of improved maize cultivation region. Under this programme, Inputs were also distributed to 379 farmers for conduct of 178.5 ha FLDs in 9 districts of Manipur.

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CROP IMPROVEMENT

The mandate of ICAR-Indian Institute of Maize Research (IIMR) is to carry out basic, strategic and applied research to enhance the production, productivity and sustainability of maize in India. Crop Improvement and Crop Management are the two major thematic areas of research of the institute. The institute coordinates the All India Coordinated Research Project on Maize in collaboration with many agricultural universities and volunteer centres, and also carries out extension and outreach programmes to deliver promising technologies to farmers. The institute made significant achievements in different areas of maize research during 2017-18.

Maize Genetic Resource Management

Introduction of germplasm

During the reporting period, to enrich the existing maize germplasm available in the institute 66 tropical maize inbred lines (Import Permit No. 271/2017) in July 2017 and two trait specific germplasm, *viz.*, brown midrib lines (Import Permit No. 272/2017) in August 2017, were procured from CIMMYT, Mexico and Genetics Stock Centre, USA, respectively through standard material transfer agreement (SMTA). The procured germplasm was assigned exotic collection (EC) number *i.e.* EC926982 to EC927049 to maintain the germplasm identity. Similarly to strengthen the white maize breeding programme, 252 white CML inbred lines with EC number EC938318 to EC938569 were procured from CIMMYT, Mexico through SMTA. In order to strengthen the baby corn germplasm, CMS sources have been imported from USA.

Characterization of germplasm

Under CRP on Agro-biodiversity, 300 maize germplasm lines from the GeneBank of NBPGR were characterized for 31 maize descriptors during the period at Winter Nursery Centre, Hyderabad. In total, 1200 germplasm were characterized in a collaborative mode under this programme along with PAU, Ludhiana; HPKV HAREC, Bajaura and NBPGR, New Delhi.

Documentation of information on germaplam

The web based Decision Support System for Maize Germplasm was updated with addition of information on 150 inbred lines during 2017-18. The database is hosted on ICAR server and is available on KRISHI Server as well with URL: https://krishi.icar.gov.in/wnciimr.

Sharing of germplasm

Sharing of germplasm and breeding programme among public sector researchers is a continuous process. In the previous year during Maize Germplasm Field Day a total of 1401 maize accessions were displayed to breeders, pathologists, agronomists and entomologists from 27 AICRP centres from SAUs and ICAR institutes for assessment and selections. Based on the indent received, a total of 546 maize accessions (2128 seed packets) were supplied to 34 different AICRP and cooperating centres during 2017-18 **(Table1.1)**.

Table 1.1: Germplasm distributed to different centres during 2017-2018

Sl. No.	Centre	Accessions
1.	ALMORA	40
2.	ASSAM	36
3.	AMBIKAPUR	90
4.	BAJAURA	47
5.	BENGALURU UAS	31
6.	BHILODA	42
7.	BHUBANESWAR	68
8.	CHHINDWARA	59
9.	COIMBATORE	41
10.	DHARWAD IARI RS	51
11.	HANUMANMATTI,UAS DHARWAD	73
12.	DHOLI	196
13.	DELHI	54
14.	GODHRA	82
15.	HYDERABAD	96
16.	CRIDA HYDERABAD	25
17.	IMPHAL	42
18.	KANGRA	15
19.	KARNAL	11
20.	KARIMNAGAR	62
21.	KOLHAPUR	81
22.	LUDHIANA	175
23.	MANDYA	33
24.	COLLEGE OF AGRL NAGPUR	87
25.	PANTNAGAR	33
26.	RANCHI	158
27.	RAHURI	90
28.	RAHURI AICRP FORAGE	74
29.	SRINAGAR	124
30.	VAGARA	22
31.	VARANASI	15
32.	UDHAMPUR	23
33.	UDAIPUR	6
34.	IIMR	46
	Total	**2128**

Further, the seeds of Teosinte (Zea mays ssp. *parviglumis*, *Zea mexicana* and *Zea luxurians)* were also shared with two AICRP centres of maize (TNAU, Coimbatore and PAU, Ludhiana) to facilitate their germplasm diversification programm (**Table 1.2**)

Table 1.2: Wild accessions of maize supplied to AICRP centres

Sl. No.	Centre	Wild species supplied
1.	PAU, Ludhiana	*Zea mays* subsp. *parviglumis*
2.	TNAU, Coimbatore	*Zea mays* subsp. *parviglumis* and *Zea mexicana*

Development, recycling and maintenance of genetic resources

Development of new germplasm is a continuous process. During the period, around 1652 segregating genetic material of normal maize was advanced from $F_{2\text{-}4\text{-}5\text{-}6}$ to $F_{4\text{-}6\text{-}7\text{-}9}$ through self-pollination. Out of these 347 inbred lines with morphological uniformity were selected (Fig. 1.1). In addition, a set of 310 QPM lines of F_3 stage were advanced.

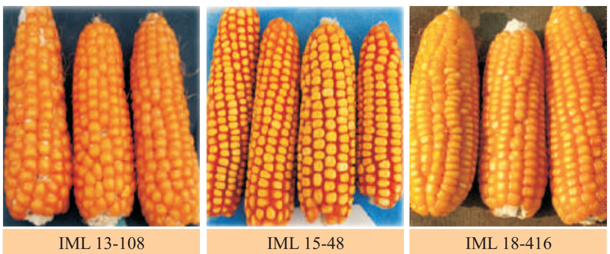

Figure 1.1: Promising inbred lines developed at IIMR

Development of trait specific germplasm is one of the priority area especially in the breeding programmes aimed at developing abiotic stress tolerant cultivars. Thirty seven maize germplasm were screened for drought (low moisture) tolerance and ten of the lines were identified having stress adaptive traits. The inbred lines with different stress adoptive traits were used to generate biparental populations for trait specific germplasm development and QTL mapping. Biparental crosses were generated for traits, *viz.*, tassel blasting, leaf firing, leaf rolling and leaf senescence (**Table 1.3**). The crosses attempted were advanced to F_3 stage and phenotyping for $F_{2:3}$ are under process.

Table 1.3: Crosses attempted to understand genetics of various drought adaptive traits

Sl. No.	Drought adaptive traits	Crosses
1	Tassel blasting	DML 1276 × DML 1343, DML 1276 × S04YLWL 172-B-1-1-B-1-B*-6-B, DML 1860 × S04YLWL 172-B-1-1-B-1-B*-6-B, DML, 1860 × DML 1373
2	Leaf firing	DML 1276 × LM 11, DML 1860 × LM 11, DML 1276 × DML 1363, DML 1860 × DML 1363
3	Leaf rolling	DML 1860 × DML 1363, DML 1213 × DML 1363
4	Leaf senescence	DML 1610 × DML 1213

Recycling of inbred lines by making elite × elite pedigree crosses within heterotic groups was initiated in QPM breeding programme. Within heterotic group A three pedigree crosses (DQL 2024 × DQL 2208, DQL 2024 × DQL 2184, DQL 2248 × DQL 2208) were attempted, while four crosses (DQL 2180 × DQL 2274, DQL 2080-1 × DQL 2065, DQL 2057-1 × DQL 2164, DQL 2230 × DQL 2192) were attempted within heterotic group B. A total of 1055 F_3 families of the above crosses were raised during 2017-18 and further advanced after selecting the desirable plants from these crosses for development of new inbred lines.

Further, 236 normal inbred lines are being maintained through self-pollination. In addition, two different RILs mapping populations for MLB of size 283 and 288, respectively along with a diverse panel of 416 fixed inbred lines are also maintained through hand pollination.

Diversification of maize germplasm

QPM hybrids need to be made as competitive as normal maize hybrids in term of grain yield. In this regard, an effort was made to develop new QPM inbred lines through diversification of QPM germplasm. A new set of 25 QPM inbred lines derived from pedigrees crosses between normal and QPM lines are now available to develop QPM hybrids with diverse genetic background. The promising inbred lines derived from normal × QPM pedigree crosses with desirable tryptophan content (> 0.6%) are given below (Table 1.4). The lines derived from BML 6-1 × HKI 193-1- 8-1-1-1, HKI 1105 × CML

Table 1.4: The list of promising inbred lines derived from normal × QPM germplasm

Sl. No.	Pedigree	Protein (%)	Trp. (%)
1.	BML 6-1 × HKI 193-1-5-1-1-1	9.16	1.02
2.	BML 6-1 × HKI 193-1-8-1-1-1	10.24	0.62
3.	BML 6-1 × HKI 193-1-10-1-1-1	9.26	0.78
4.	BML 6-1 × HKI 198-1-14-1-1-1	10.70	0.58
5.	BML 6-1 × HKI 198-1-14-2-1-1-1	8.70	0.68
6.	HKI 1105 × CML 161-3-1-1-1-1	9.27	0.72
7.	HKI 1105 × CML 161-3-2-1-1	9.55	0.62
8.	HKI 1105 × CML 161-4-2-1-1-1	9.20	0.64
9.	HKI 1105 × CML 161-7-2-1-1-1	8.82	0.74
10.	HKI 1105 × CML 161-8-2-1-1-1-1	9.02	0.52
11.	HKI 1105 × CML 161-11-1-1-1	9.00	0.59
12.	HKI 1105 × CML 161-12-4-1-1-1	9.06	0.61
13.	HKI 1105 × CML 161-15-1-1-1-1	9.28	0.60
14.	HKI 1105 × CML 161-18-2-1-1-1	10.26	0.60
15.	HKI 1105 × CML 161-21-3-1-1-1	9.73	0.67
16.	HKI 1105 × CML 161-25-1-1-1-1	10.77	0.65
17.	HKI 1105 × CML 161-29-1-1-1-1	8.87	0.69
18.	HKI 1105 × CML 161-30-1-1-1-1	8.67	0.84
19.	HKI 1105 × CML 161-36-1-1-1	9.22	0.72
20.	BML 6-1 × CML 161(22)-7-1-1-1	9.47	0.61

161-18-2-1-1-1 and HKI 1105 × CML 161-25-1-1-1-1 had shown protein content more than 10% and tryptophan content beyond threshold level.

Table 1.5: Wild species are being maintained at WNC, Hyderabad

Sl. No.	Species	No. of accessions
1.	*Zea luxurians*	1
2.	*Zea mexicana*	2
3.	*Zea mays* subsp. *parviglumis*	2

Towards introgression of desirable traits from wild germplasm into active breeding material wide crosses were attempted as part of diversification of maize germplasm. A total of three wild species are being maintained (Table 1.5). A set of 46 F_2 single plant selections derived out of cross between BML 6 and *Zea mexicana* was selfed in *rabi* 2017-18 to obtain the F_3 families. Similarly, another set of 20 F_2 selections of cross between BML 7 and *Zea mexicana* were selfed to derive $F_{2:3}$ populations. Further, one hundred and ten fixed inbred lines were crossed with *Zea mexicana* in *kharif* 2016 and all the F_1s were characterized and evaluated during *rabi* 2017-18.

Further, to exploit the ratooning and tillering traits, *Zea parviglumis* (**EC 804456**) accession was crossed to fodder variety J-1006. The F_1 generation exhibited good amount of tillering with tiller number ranging from 1 to 4. The promising crosses will be advanced further to exploit the fodder yield contributing traits of *Zea parviglumis*.

Hybrid development programme

Heterotic grouping of inbred lines

Information on the combining ability among different inbred lines is the first step of systematic hybrid development programme. Grouping of inbred lines into different heterotic groups is important to increase the efficiency of breeding programme and also probability of getting productive hybrids. The field experiment was conducted to generate the information on combining ability and heterotic pattern of 61 newly developed maize inbred lines by using two heterotic testers, BML6 and BML7. The 122 F_1 hybrids generated by following line × tester mating design were evaluated during 2016 and 2017 at Regional Maize Research and Seed Production Centre, Begusarai. Out of 61 inbred lines, 29 had positive GCA with maximum GCA effect. The 29 lines showing positive GCA for grain yield were classified into two heterotic groups 'A' (12 inbred lines) and 'B' (17 inbred lines) based on SCA effects with testers, BML 6 and BML 7, respectively. Four lines with positive and significant SCA for grain yield were equally distributed in heterotic group A and B (**Table 1.6**). Further to expand the dimension of heterotic grouping, available fixed lines at the institute which includes 1394 normal lines and 248 QPM lines were pooled and was grown at WNC, Hyderabad. These were crossed to two heterotic testers, LM13 and LM14 in line tester fashion

Table 1.13:Heterotic grouping of inbred lines based on the positive GCA and SCA

Sl. No.	Inbred Lines	Yield		GCA	SCA		Heterotic Groups
		BML 6	BML 7		BML 6 (A group)	BML 7 (B group)	
1.	IMLSB 23-2	74.12	81.20	-15.62***	-3.29	3.29	-
2.	IMLSB 43-2	81.16	77.94	-13.72***	1.84	-1.84	-
3.	IMLSB 49-2	77.29	101.60	-3.83	-11.92***	11.92***	-
4.	IMLSB 54-2	80.51	78.02	-14.02***	1.48	-1.48	-
5.	IMLSB 55-2	100.14	105.57	9.57***	-2.47	2.47	A
6.	IMLSB 58-1	82.55	81.53	-11.23***	0.74	-0.74	-
7.	IMLSB 81-1	82.54	83.56	-10.23***	-0.27	0.27	-
8.	IMLSB 83-1	82.49	96.51	-3.77	-6.77*	6.77*	-
9.	IMLSB 86-2	79.63	80.30	-13.32***	-0.09	0.09	-
10.	IMLSB 91-2	80.87	86.40	-9.64***	-2.52	2.52	-
11.	IMLSB 93-2	83.91	71.00	-15.82***	6.69*	-6.69*	-
12.	IMLSB 100-1	106.72	86.55	3.35	10.32**	-10.32**	B
13.	IMLSB 107-2	89.56	86.11	-5.44*	1.96	-1.96	-
14.	IMLSB 114-1	85.48	115.41	7.16**	-14.72***	14.72***	A
15.	IMLSB 119-1	92.02	92.60	-0.97	-0.04	0.04	-
16.	IMLSB 126-2	104.53	89.15	3.55	7.92*	-7.92*	B
17.	IMLSB 128-1	78.83	93.91	-6.91**	-7.30*	7.30*	-
18.	IMLSB 156-2	86.41	103.14	1.49	-8.12*	8.12*	A
19.	IMLSB 162-1	80.03	91.72	-7.40**	-5.60	5.60	-
20.	IMLSB 164-1	86.75	95.56	-2.12	-4.16	4.16	-
21.	IMLSB 166-2	101.30	96.47	5.60*	2.65	-2.65	B
22.	IMLSB 171-2	99.00	92.79	2.61	3.34	-3.34	B
23.	IMLSB 173-2	63.71	101.98	-10.43***	-18.89***	18.89***	-
24.	IMLSB 181-2	87.81	106.60	3.92	-9.15**	9.15**	A
25.	IMLSB 190-1	84.85	79.83	-10.94***	2.74	-2.74	-
26.	IMLSB 219-2	123.95	77.68	7.52**	23.37***	-23.37***	B
27.	IMLSB 231-1	114.54	98.49	13.23***	8.26*	-8.26*	B
28.	IMLSB 254-1	95.15	106.11	7.34**	-5.24	5.24	A
29.	IMLSB 274-1	92.07	98.66	2.08	-3.05	3.05	A
30.	IMLSB 285-1	96.99	118.44	14.43***	-10.48**	10.48**	A
31.	IMLSB 301-2	111.72	91.03	8.09***	10.58**	-10.58**	B
32.	IMLSB 306-1	103.60	77.36	-2.80	13.35***	-13.35***	-
33.	IMLSB 334B-2	115.27	116.24	22.46***	-0.24	0.24	A
34.	IMLSB 342-1	108.18	95.91	8.76***	6.37	-6.37	B
35.	IMLSB 343-3	79.00	112.13	2.28	-16.32***	16.32***	A
36.	IMLSB 406-2	127.20	109.93	25.28***	8.87**	-8.87**	B

37.	IMLSB 428-2	100.22	76.38	-4.98*	12.15***	-12.15***	-
38.	IMLSB 457-2	88.96	87.74	-4.93*	0.85	-0.85	-
39.	IMLSB 507-1	69.37	92.34	-12.42***	-11.24***	11.24***	-
40.	IMLSB 508-1	80.56	100.41	-2.79	-9.69**	9.69**	-
41.	IMLSB 561-1	70.68	87.45	-14.22***	-8.14*	8.14*	-
42.	IMLSB 571-2	92.55	90.02	-1.99	1.50	-1.50	-
43.	IMLSB 592-2	98.79	91.13	1.67	4.07	-4.07	B
44.	IMLSB 617-1	95.71	80.82	-5.01*	7.68*	-7.68*	-
45.	IMLSB 719-1	79.82	90.18	-8.28***	-4.94	4.94	-
46.	IMLSB 758-1	83.54	90.58	-6.22**	-3.28	3.28	-
47.	IMLSB 763-1	97.17	77.20	-6.09**	10.22**	-10.22**	-
48.	IMLSB 800-1	101.03	100.11	7.29**	0.69	-0.69	B
49.	IMLSB 814-2	115.45	111.55	20.21***	2.19	-2.19	B
50.	IMLSB 883-1	91.64	91.13	-1.89	0.49	-0.49	-
51.	IMLSB 975-2	110.52	97.92	10.93***	6.53*	-6.53*	B
52.	IMLSB 976-2	84.53	99.49	-1.27	-7.23*	7.23*	-
53.	IMLSB 1043-1-1	92.04	101.15	3.31	-4.32	4.32	A
54.	IMLSB 1047-1-1	99.02	90.98	1.72	4.25	-4.25	B
55.	IMLSB 1062-2-2	97.77	108.40	9.80***	-5.07	5.07	A
56.	IMLSB 1299-2	99.22	83.29	-2.02	8.20*	-8.20*	-
57.	IMLSB 1299-5	117.54	120.30	25.63***	-1.13	1.13	A
58.	IMLSB 2028	105.30	96.09	7.41**	4.84	-4.84	B
59.	IMLSB 2039	101.83	90.07	2.66	6.11	-6.11	B
60.	IMLSB 2083	105.84	85.53	2.39	10.39**	-10.39**	B
61.	IMLSB 2166	76.70	87.06	-11.40***	-4.94	4.94	-

*,**, ***, Significant at P=0.05, 0.01 and 0.00, respectively

Hybrids released/notified

Three single cross maize hybrids DMRH 1301, DMRH 1308 and DMRHP 1402 were released 78th meeting of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops held on 9th and 10th July, 2017 held at CIARI, Port Blair. DMRH 1301, a normal maize hybrid was released and notified for NEPZ & CWZ in medium maturity for *rabi* season. DMRH 1308 hybrid, a normal maize hybrid was released and notified for CWZ in late maturity for *rabi* season and DMRH 1402, a popcorn hybrid was released for NWPZ & CWZ in early group in *kharif* season **(Table 1.7)**. The glimpses of promising hybrids released and under testing in AICRP trials have been given in **Figure 1.2**.

Table 1.7: Notified and Release of Varieties of maize from IIMR, Ludhiana during 2017

Sl. No.	Hybrid	Type	Zone	Maturity	Season
1.	DMRH 1301	Field corn	NEPZ & CWZ	Medium	Rabi
2.	DMRH 1308	Field corn	CWZ	Late	Rabi
3.	DMRH 1402	Popcorn	NWPZ & CWZ	Early	Kharif

Figure 1.5: Glimpses of promising maize hybrids released (DMRH1 301, DMRH1308) and under testing (DMRH1410) in AICRP trials

Hybrids promoted under AICRP

During 2017-18, total 85 maize hybrids from ICAR-IIMR were contributed and tested in AICRP trials of *kharif* (71) and *rabi* (14). Of total 85 hybrids, 60 were tested in first years (of which 8 were promoted) and 17 in second years (of which 2 were promoted). Further, 8 hybrids has completed three years of testing in AICRP trials (Table 1.8). Besides three hybrids were contributed to AICRP fodder trials of which two, *viz.*, DMRH 1410 and IMH 1527 were promoted to second year of testing.

Common station trial

A common set of 1500 experimental hybrids including three checks [DKC 7074 & Vivek hybrid-45 (early), Bio 9544 (Medium) and CMH-08-282 (Late)] was evaluated in α-lattice design at ICAR-IIMR, Ludhiana. The entries were compared with their respective checks based on maturity. Most promising entries with superiority percent from each maturity group were identified (**Table 1.9, 1.10 & 1.11**).

Table 1 8 .Details of ICAR -IIMR hybrids promoted and has completed three years of testing in AICRP trials of kharif and rabi during 2017 -18

Sl. No.	Hybrids Name	Type of corn	Yield (kg/ha)	Ecology	%SUP	Days to anthesis	Maturity	Season
Entries promoted to second year testing								
1	IMHBG-17K-15	Field corn	9040	Normal	14.3	55.9	Medium	Kharif
2	IMHBG-17K-22	Field corn	9483	Normal	6.3	53.0	Medium	Kharif
3	IMHBG-17K-6	Field corn	9296	Normal	4.2	54.4	Medium	Kharif
4	IMHBG-17K-17	Field corn	9274	Normal	3.9	54.3	Medium	Kharif
5	DMRH1417	Field corn	4518	Rainfed	22.6	48.6	Early	Kharif
6	IMHBG16R-6	Field corn	8375	Normal	0.97	95.8	Medium	Rabi
7	IIMRQPMH 1708	QPM	7031	Normal	0.2	50.9	Medium	Kharif
8	IIMRQPMH 1705	QPM	6310	Normal	4.5	53.5	Medium	Kharif
Entries promoted to third year of testing								
9	IMHQPM 1530	QPM	9341	Normal	16.3	49.6	Early	Kharif
10	IIMRQPMH 1601	QPM	7127	Normal	1.6	52.2	Medium	Kharif
Entries completed three years of testing								
11	DMRH 1305	Field corn	6450	Normal	4.9	54.7	Early (Zone-I)	Kharif
12	IMHP-1535	Popcorn	3357	Normal	9.3	50.5	Early	Kharif
13	IMHP-1540	Popcorn	3422	Normal	11.4	48.8	Early	Kharif
14	DMRHB 1305	Baby corn	1554	Normal	21.2	NA	Early	Kharif
15	IMHB 1529	Baby corn	1496	Normal	16.7	NA	Early	Kharif
16	IMHB 1532	Baby corn	1391	Normal	8.5	NA	Medium	Kharif
17	IMHB 1538	Baby corn	1543	Normal	20.4	NA	Medium	Kharif
18	IMHB 1539	Baby corn	1289	Normal	0.5	NA	Medium	Kharif

Table1.9: Promising early maturing hybrids under station trial

Sl. No.	Hybrids	Days to Tassel anthesis	Days to silking	Yield (q/ha)	Sup. (%)
1.	IMLSB-1058-2-2 × BML-6	51	52	97.0	20.9
2.	DML 1105 × VL 109126	50	50	96.6	20.4
3.	DML 1849 × VL 109126	49	50	93.9	17.0
4.	DML 1819 × VL 109126	50	50	92.1	14.8
5.	IMLSB-1072-1-1 × IMLSB-310-1	49	50	92.1	14.8
6.	DML 1440 × DML 1873	47	49	86.2	7.5
7.	IMLSB-406-1 × HKI-1128	48	50	86.2	7.5
8.	DML 2029 × DML 2062	49	50	85.8	6.9
9.	IMLSB-43-2 × HKI-1128	50	51	85.1	6.2
10.	IMLSB-2019 × IMLSB-310-1	49	50	84.8	5.8
11.	DKC 7074	49	50	80.1	-

CD value at 5%=1.33; DKC 7074 (Check)

Table 1.10: Promising medium maturing hybrids under station trial

Sl. No.	Hybrids	Days to Tassel anthesis	Days to silk	Yield (q/ha)	Sup. (%)
1.	IMLSB-1252 × BML-6	52	54	154.7	39.5
2.	IMLSB-119-1 × BML-7	55	57	129.5	16.8
3.	DML 1653 × DML 1820	50	51	119.5	7.7
4.	IMLSB-976-2 × BML-7	52	54	118.7	7.1
5.	CMG-471 × BML-7	53	53	117.1	5.6
6.	IMLSB-593-1 × BML-7	53	54	116.7	5.2
7.	IMLSB-1050-2-2 × BML-7	51	52	115.0	3.7
8.	IMLSB-975-2 × BML-6	51	52	113.9	2.7
9.	DML 1924 × CML 451	52	52	111.4	0.5
10.	WNC-32199 × BML-6	53	57	111.1	0.2
11.	Bio-9544	53	55	110.9	-

CD value at 5%=1.33; Bio-9544 (Check)

Table 1.11: Promising late maturing hybrids under station trial

Sl. No.	Hybrids	Days to Tassel anthesis	Days to	Yield silk	Sup. (q/ha)(%)
1.	IMLSB-1044-5-2 × BML-7	55	57	117.9	26.6
2.	IMLSB-173-2 × BML-7	53	55	115.4	23.9
3.	IMLSB-722-1 × BML-7	55	56	110.9	19.1

Sl. No.	Hybrids	Days to Tassel anthesis	Days to silking	Yield (q/ha)	Sup. (%)
4.	IMLSB-114-2 × BML-6	55	56	105.5	13.3
5.	IMLSB-365-1 × BML-7	54	56	105.1	12.9
6.	CMG-101 × BML-6	57	59	102.7	10.3
7.	IMLSB-1298-8 × BML-7	55	56	101.1	8.6
8.	DML 1906 × CML 451	55	56	98.8	6.1
9.	DML 1278 × DML 1818	55	55	97.1	4.2
10.	IMLSB-568-1 × BML-7	55	57	95.6	2.7
11.	DML 1923 × CML 451	55	55	94.9	1.9
12.	IMLSB-343-3 × BML-7	57	56	94.5	1.5
13.	IMLSB-571-1 × BML-7	54	55	94.3	1.3
14.	IMLSB-164-1 × BML-7	57	57	93.7	0.6
15	CMH-80-282	53	54	93.1	-

CD value at 5%=1.33; CMH-08-282 (Check)

A separate trial of 34 early experimental hybrids along with check Vivek Hybrid 47 was conducted under randomized block design in *kharif* 2017 at Ludhiana. Two hybrids, *viz.*, IC656136-1-6-2-1-1× CML425 (27.5%) and (13045/V373)-1-1-1-2-1-1 × CML425 (6.6%) were found superior over the check (**Table 1.12**).

Table 1.12: Promising early hybrids conducted at IIMR, Ludhiana

Sl. No.	Hybrids	Yield (q/ha)	Sup. (%)
1.	IC656136-1-6-2-1-1× CML425	84.0	28.0
2.	(13045/V373)-1-1-1-2-1-1 × CML425	70.3	7.0
3.	Vivek hybrid-47	65.89	-

CD value at 5%≤4.89; Vivek hybrid-47 (check)

QPM hybrid trial

In QPM Hybrid trial a total of 247 experimental hybrids including thee QPM checks (HQPM 1, HQPM 4 & HQPM 7) and one Normal check (Bio 9544) were evaluated in α-lattice design at ICAR-IIMR, Ludhiana. Only two hybrids were found superior than the best QPM check HQPM 4 and none of the hybrid was found superior to normal maize hybrid check (**Table 1.13**).

Table 1.13: Promising QPM hybrids under station trial

Sl. No.	Hybrids	Days to Tassel anthesis	Days to Silk	Yield (q/ha)	Sup. (%)
1	DQL 2234 × DQL 2184	50	51	99.9	4.1
2	DQL 2299 × DQL 2018-1	52	54	99.2	3.4
	HQPM-4	53	54	96.0	-

CD value at 5% 1.764; HQPM-4 (Check)

Specialty corn breeding

Baby corn breeding

During the period 468 germplasm comprising inbred lines and hybrids were collected from different sources and were evaluated in *kharif* 2017 for prolificacy, which is one of the important traits for development of baby corn germplasm. Among the total 468 germplasm, 111 lines were selected for further baby corn improvement programme. Out of these 111 lines, 92 lines produced 2 to 4 baby corns per plant. To decipher fertility restoration response of these lines 99 crosses were made with a CMS source.

Sweet corn breeding

During the period 44 inbred lines were procured from Winter Nursery Centre, Hyderabad, out of which 23 inbred lines were maintained and ten lines, *viz.*, DMSC 24, MRCSC-37-3, MRCSC11, MRCSC2, MRCSC4, MRCSC6, MRCSC9-TYPE1, MRCSC9-TYPE2, SC Selection 1-1, and SC Selection 1-2 were selected for making experimental crosses. Totally 25 experimental crosses were generated between selected sweet corn inbred lines, which will be evaluated during *kharif* 2018 for yield as well as sweetness. In order to develop new inbred lines, crosses have been attempted between normal maize inbred lines and sweet corn inbred lines, which will be advance to F_2 during *kharif* 2018. In addition 6 commercial single cross hybrids of sweet corn were also selfed to generate new inbred lines of sweet corn as well as to diversify the inbred lines genetic base.

Fodder maize breeding

A total of 341 germplasm including landraces and inbreds were evaluated and 45 promising land races and 144 inbred lines for fodder yield were identified on the basis of morphological traits during *rabi* 2016-17. Six crosses were attempted among the released three composites of fodder maize, *viz.*, J 1006, AfricanTall and PMC 6.

Table 1.14: Promising early maturing inbred lines showing resistance to post flowering stalk rot

Sl. No.	Genotypes	Disease score
1.	PFSR (Y)-C1-A-A1 ⊗-3-2-1-1-1-1-2	1.0
2.	PFSR (Y)-C1-A-A1.⊗-3-2-1-1-1-1-1	1.4
3.	North east 4-1 (N)-2-⊗-1-1-1	1.8
4.	V338 -1(x)-1-1-1 -1-⊗-1-1-1 -2	2.0
5.	CML 433-2-1-⊗-1-2	2.0
6.	North east 4-1 (N)-2-⊗-1-1-2	2.1
7.	V338 -1⊗-1-1-1 -1-⊗-2-1-1-2	2.1
8.	North east 4-1 (N)-1-⊗-1-1-1	2.2
9.	CML 433-2-1-⊗-1-3	2.3
10.	CML 370-1-2-1-1-1-1-Ä-1-1-1-2	2.3
11.	V338-1⊗-1-1-1 -1-⊗-1 -1-1-1	2.5
12.	V 338-1⊗-1-1-1 -1-⊗-2-1-1-1	2.5
13.	HEY Pool (Extra Early) ⊗-1-3-⊗-2-1	2.5
14.	PFSR (White)-⊗-3-2	2.8
15.	V338-1⊗-1-1-1 -1-⊗-2 -1-1-1	2.8
16.	HEY Pool (Extra Early) ⊗-1-1-⊗-2-1	2.8
17.	PFSR (White) ⊗-1-2-⊗-1-1-2	3.0
18.	V338-1⊗-1-1-1 -1-⊗-1-1-1 -1	3.0
19.	HEY Pool (Extra Early) ⊗-1-1-1-⊗-2-1	3.0

Evaluation of maize germplasm for biotic stress response

Post flowering stalk rot (PFSR)

A total of 150 genotypes were evaluated during *kharif* 2017, among them 19 recorded disease rating ≤ 3.0 and were considered as resistant. The most promising genotypes are given in Table 1.14.

Maydis leaf blight (MLB)

Twenty nine genotypes were evaluated for resistance against MLB in two locations, *viz.*, Karnal (spring 2017) and Ludhiana (spring and *kharif* 2017). Among these, one line, [(E13118/CML 474) PMH1]-5-2-1-1-1 exhibited resistance at both the locations during spring and another line, 141143-PP-7-1-1 exhibited resistance at Ludhiana in both the seasons (Table 1.15).

Multiple Disease [Turcicum leaf blight (TLB), common rust and charcoal rot]

A diverse panel of 350 inbred lines were evaluated for multiple diseases, *viz.*, TLB, charcoal rot and common rust under artificial inoculation at single or multiple hot-spots over three years. The lines which have shown resistance/tolerance to single disease like TLB and multiple diseases like TLB & common rust, charcoal rot & common rust are given in Table 1.16a, 1.16b and 1.16c, respectively.

Spotted Stemborer, Chilo partellus (Swinhoe)

Seventy eight genotypes along with resistant (CM 500) and susceptible (BML6) checks were evaluated under artificial infestation against *Chilo partellus* during *kharif* 2017 (Table 1.17). The resistant, moderately resistant and susceptible lines were defined based on LIR rating 1-3, >3-6 and >6-9, respectively. The following five genotypes, *viz.*, CML 73 (4.8), VQPM 9-1-1-1-1 (3.3), HEY Pool 2011-12-1-1-3-4-1 (4.5), HEY Pool 2011-25-6-1-3-1-1 (4.5) and HEY Pool 2011-25-6-2-1-5-1 (4.5) recorded LIR ≤ resistant check CM 500 (4.8).

Table 1.15: List of inbred lines with TLB resistance/ tolerance identified after testing across hot-spot sites and/or over years

Sl. No.	Inbred line	Ludhiana				Karnal		Avg. of Locations		Avg. of Seasons	
		Spring 2017		*Kharif* 2017		*Spring* 2017		*Spring* 2017		Ludhiana	
		DS	Reaction	DS	Reaction	DS	Reaction	DS	Reaction	DS	Reaction
1	141140-2PP-4-2-4	7.5	S	4	MR	5.5	MS	6.5	MS	3.9	MR
2	141139-1PP-1-1-1	7.0	MS	4.2	MR	7	MS	7	MS	3	R
3	141140-1-PP-3-3-1	9.0	S	5.8	MS	7.5	S	8.3	S	4.4	MR
4	141140-1-PP-3-5-2	8.0	S	4.2	MR	7	MS	7.5	S	4.5	MR
5	141140-1-PP-3-3-2	8.5	S	4.3	MR	6	MS	7.3	S	4.4	MR
6	141167-2-PP-25-4-3	3.5	MR	2.9	R	7	MS	5.3	MS	3.1	R
7	141167-2-PP-25-3-3	3.5	MR	2.6	R	6	MS	4.8	MR	3.5	MR
8	141143-PP-7-1-1	2.5	R	3	R	7.5	S	5	MR	2.9	R
9	[(E13068/V373)VH43]-2-1-2-1-1	3.0	R	4.1	MR	7	MS	5	MR	4.6	MR
10	[(VQH9/VQH9)BIO9544]-6-1-3-1-1	7.0	MS	3.3	MR	7	MS	7	MS	4.1	MR
11	DML1343-3-2-1-1-2	5.0	MR	4.1	MR	4	MR	4.5	MR	3.8	MR
12	HEY Pool 2011-5-5-1-2-1-2	7.0	MS	3.5	MR	4.5	MR	5.8	MS	4.4	MR
13	IC656136-1-6-2-1-1	7.5	S	4.8	MR	5.5	MS	6.5	MS	4.6	MR
14	HEY Pool 2011-15-6-1-1-2-2	8.0	S	5	MR	7.5	S	7.8	S	3.8	MR
15	EC639397-2-2-1-1	5.5	MS	3	R	5	MR	5.3	MS	2.9	R
16	[(E13086/CML474)VH43]-1-2-3-1	9.0	S	3.5	MR	5.5	MS	7.3	S	3.7	MR
17	HEY Pool 2011-42-1-3-1-3-1-1	9.0	S	4.0	MR	5.0	MR	7.0	MS	4.6	MR
18	[(E13118/CML474)PMH1]-5-2-1-1-1	3.0	R	3.5	MR	2.0	R	2.5	R	3.6	MR
19	HEY Pool 2011-42-1-3-3-2-2-3	4.5	MR	3.7	MR	6.5	MS	5.5	MS	4.5	MR
20	(E13045/V373)-1-1-1-2-1-1	5.0	MR	4.5	MR	4.5	MR	4.8	MR	4.8	MR
21	EC639328-2-1-1-1-1	6.0	MS	3.6	MR	5.5	MS	5.8	MS	4.3	MR
22	EC639328-2-3-1-2-1	9.0	S	3.6	MR	3.0	R	6.0	MS	3.6	MR
23	[(ELPJB10/NS76B) BIO9544]-1-2-1-1-1	8.0	S	3.2	MR	6.5	MS	7.3	S	4.0	MR
24	[(ELPJB10/E121022) BIO9544]-2-1-1-1-1	4.0	MR	2.1	R	5.0	MR	4.5	MR	3.1	R
25	[(E13031/CML474) BIO9544]-2-1-3-2-1	6.0	MS	4.3	MR	4.5	MR	5.3	MS	4.2	MR
26	HEY Pool 2011-19-1-1-2-1-2	7.5	S	6.6	MS	7.0	MS	7.3	S	5.1	MR
27	HEY Pool 2011-12-1-1-2-8-3-1	7.0	MS	2.7	R	3.5	MR	5.3	MS	3.0	R
28	HEY Pool 2011-37-2-1-3-1-2-1	8.0	S	4.2	MR	5.5	MS	6.8	MS	4.7	MR
29	Check (CM 600)	8.6	S	4.9	MR	8.5	S	6.5	MS	5.4	MS

(DS: Disease Score)

Table 1.16a: List of inbred lines with TLB resistance/ tolerance identified after testing across hot-spot sites and/or over years

Sl. No.	TLB Genotype	*Kharif* 2015 (1-5) Bajaura	Mandya	Dharwad	*Kharif* 2016 (1-9) Bajaura	Mandya	*Kharif* 2017 (1-9) Bajaura	Mandya
1	IML16-17	1.5	3.0	2.0	3.0	1.0	4.0	1.0
2	IML12-133	2.0	3.5	2.0	2.0	1.0	2.0	-
3	IML12-135	2.0	3.0	2.0	3.0	1.0	2.0	1.0
4	IML15-244	2.5	3.0	2.0	2.0	2.0	3.0	1.0
5	IML12-116	1.5	4.0	2.0	3.0	1.0	3.0	1.0
6	IML16-134	2.5	4.0	2.0	2.0	1.0	3.0	1.0
7	IML16-108	2.0	3.5	3.0	2.0	1.0	2.0	1.0
8	IML12-10	2.0	3.0	3.0	2.0	2.0	4.0	1.0
9	IML12-74	2.0	4.0	2.0	2.0	2.0	3.0	1.0
10	IML16-27	2.0	4.0	3.0	2.0	1.0	3.0	1.0
11	IML15-112	2.5	4.0	2.0	3.0	1.0	5.0	1.0
12	IML13-62	2.5	4.0	2.0	2.0	2.0	3.0	3.0
13	Sus. Check	5.0	5.0	5.0	8.0	8.5	8.0	8.5

(Susceptible Check for TLB: NB 3 at Bajaura and CM 202 at Dharwad and Mandya)

Table 1.16b: List of inbred lines with TLB and common rust resistance/ tolerance identified after multiple year of testing

Sl. No.	Genotype	*Kharif* 2015 TLB (1-5) BAJ	TLB (1-5) DHR	C. Rust (1-9) DHR	*Kharif* 2016 (1-9 scaling) TLB BAJ	TLB MND	TLB DHR	C. Rust DHR	*Kharif* 2017 (1-9 Scaling) TLB BAJ	TLB DHR	TLB MND	C. Rust DHR
1	IML15-244	2.5	2	3	2	2	2	4	3	4	1	3
2	IML15-112	2.5	2	2	3	1	3	3	5	2	1	2
3	IML 15-65	2.5	2	3	3	2	4	2	4	6	1	4
4	IML12-180	2	3	1	4	2	4	2	5	4	2	2
5	IML12-10	2	3	3	2	2	4	2	4	3	1	2
6	IML13-62	2.5	2	1	2	2	5	2	3	4	3	8
7	Sus. Check	5	5	4	8	8.5	9	8	8	7.5	8.5	8.5

[Susceptible Check for TLB: NB 3 at Bajaura (BAJ) and CM 202 at Dharwad (DHR) and Mandya (MND); for common rust (C. Rust), CM 202 at Dharwad (DHR)]

Table 1.16c: List of inbred lines with charcoal rot and common rust resistance/ tolerance identified after testing across hot-spot sites and/or over years

Genotype	*Kharif* 2015 (1-9) C. Rot LDH	C. Rot DEL	C. Rust DHR	*Kharif* 2016 (1-9) C. Rot LDH	C. Rot DEL	C. Rot HYD	C. Rust DHR	*Kharif* 2017 (1-9) C. Rot LDH	C. Rot HYD	C. Rust DHR
IML12-74	3.4	1.8	2.0	5.0	1.0	3.0	2.0	5.0	7.7	8.0
IML15-10	5.0	2.0	3.0	4.5	1.0	2.8	4.0	4.0	NG	9.0
IML15-280	4.0	3.0	1.0	3.7	1.0	2.4	4.0	3.0	5.4	4.0
Sus. Check	7.6	-	4.0	8.0	-		8.0 -	7.0	7.2	8.5

Susceptible Check for C. Rot: CM 501 at Hyderabad (HYD); CM 600 (*kharif* 2015 and 2016) and 7157-1-2 (*kharif* 2017) at Ludhiana (LDH); CM 600 at Delhi; for C. Rust, CM 202 at Dharwad (DHR)

Table 1.17: Leaf Injury Rating Scale of most promising genotypes screened against Chilo partellus

Sl.No	Pedigree	Mean LIR (1-9 Scale)
1.	DMRE63/CML 287-2-46-9	2.7
2.	CML-73	4.8
3.	VQPM9-1-1-1-1	3.3
4.	HEY Pool -2011-12-1-1-3-4-1	4.5
5.	HEY Pool -2011-25-6-1-3-1-1	4.5
6.	HEY Pool -2011-25-6-2-1-5-1	4.5
7.	CM500 (Resistant Check)	4.8
8.	BML6 (Susceptible Check)	7.5

CD value at 5%=0.5

Shoot fly

Forty inbred lines were evaluated during *spring* 2017 for reaction to shoot fly infestation at Ludhiana for *Atherigona naqvii* Steyskal and at Delhi for *Atherigona soccatta* Rondani. The lines were evaluated using fish meal technique. Based on the results, five line in Ludhiana (CM 13, CML50, HEY Pool 2011-30-4-1-2-2-1, HEY Pool 2011-15-1-3-2-1-1 and HEY POOL 2011-12-5SC-3-1-1) and two lines in Delhi (CM 13 and CML **43**) were found resistant to shoot fly (**Table 1.18**).

Table 1.11: Reaction of inbred lines against maize shoot fly at Ludhiana (*Atherigona naqvii* Steyskal) and Delhi (*Atherigona soccatta* Rondani) using fish meal technique during spring 2017

Sl. No.	Pedigree	Ludhiana				Delhi
		Avg. LIR 21DAG	Avg. DH (%) 21DAG	Avg. SI	Reaction based on SI	Avg. DH (%)
1	CM 140⊗⊗	22.32	43.75	2.07	MR	33.75
2	CM 137⊗⊗	15.56	37.22	1.82	MR	32.83
3	CM 13⊗⊗	30	18.33	1.16	R	0
4	CM 212⊗⊗	40.38	36.22	1.6	MR	14.29
5	CML 292⊗⊗	16.11	41.67	1.74	MR	16.67
6	CML 9⊗⊗	36.54	34.13	1.58	MR	16.67
7	CML 224⊗⊗	10.8	38.64	1.94	MR	20.83
8	CML 238⊗⊗	15	65	2.06	MR	25
9	CML 06⊗⊗	27.5	37.5	1.65	MR	16.67
10	CML 342⊗⊗	23.72	44.55	2.45	S	80
11	CML 425⊗⊗	23.3	38.64	1.68	MR	50
12	CML 43⊗⊗	16.78	29.72	1.76	MR	0
13	CML 482⊗⊗	40.38	31.54	1.5	MR	22.22
14	CML 50⊗⊗	28.21	28.21	1.49	R	23.75
15	CML 73⊗⊗	33.4	43.2	1.8	MR	33.9
16	HEY Pool 2011-12-1-1-3-3-1⊗⊗	21.9	56.8	2.4	S	53.6
17	HEY Pool 2011-12-3-3-3-1-1⊗⊗	21.3	54.2	2.2	S	56.3
18	HEY Pool 2011-15-1-3-2-1-1⊗⊗	25.8	22.3	1.3	R	14.1

Sl. No	Pedigree	Ludhiana Avg. LIR 21DAG	Ludhiana Avg. DH (%) 21DAG	Ludhiana Avg. SI	Ludhiana Reaction based on SI	Delhi Avg. DH (%)
19	HEY Pool 2011-15-3-7-3-1-1⊗⊗	33.6	41.3	2.0	MR	29.3
20	HEY Pool 2011-19-1-1-1-1-1⊗⊗	23.6	42.7	2.0	MR	30.0
21	HEY Pool 2011-21-2-3-3-1-1⊗⊗	25.8	51.9	2.0	MR	37.8
22	HEY Pool 2011-25-6-1-3-1-1⊗⊗	24.0	36.2	2.0	MR	46.4
23	HEY Pool 2011-30-4-1-2-2-1⊗⊗	22.3	18.4	1.2	R	11.1
24	HEY Pool 2011-37-2-1-3-1-1⊗⊗	45.8	38.1	1.7	MR	14.6
25	HEY Pool 2011-5-4-1-1-2-1⊗⊗	26.1	33.0	1.6	MR	17.0
26	HEY Pool 2011-5-6-1-2-1⊗⊗	17.4	47.4	2.3	S	17.9
27	HEY POOL 2011-12-5SC-3-1-1⊗⊗	24.5	20.7	1.3	R	3.9
28	HEY Pool 2011-5-2-3-2-1-1⊗⊗	29.2	39.2	1.8	MR	14.0
29	IC-639445⊗⊗	17.2	45.1	2.2	S	27.7
30	IC-656142⊗⊗	28.6	32.1	1.6	MR	25.2
31	NAI-147⊗⊗	22.0	40.7	1.9	MR	4.6
32	NAI-175⊗⊗	32.0	32.1	1.6	MR	9.1
33	PFSR-10109⊗⊗	23.7	52.2	2.1	MR	24.2
34	PFSR 10116⊗⊗	42.9	39.3	1.7	MR	9.1
35	V 341⊗⊗	23.4	39.7	2.8	-	31.0
36	VH 9-1-2-1-1⊗⊗	22.0	48.1	2.3	S	24.2
37	VH 9-2-1-1-1⊗⊗	35.9	43.9	2.0	MR	8.3
38	VH 9-3-2-1⊗⊗	29.7	38.1	1.8	MR	32.7
39	VQPM 9-1-2-1⊗⊗	28.6	32.1	1.6	MR	23.6
40	VQPM 9-2-1-3-1⊗⊗	25.0	35.7	1.7	MR	12.1
	Mean	19.1	**Mean SI**	1.8	NS	-

SD: 0.35; Range: 1.5-2.19; Resistant: < 1.50; MR: 1.50-2.18; Susceptible: > 2.18

Pink Stemborer, Sesamia inferens (Walker)

Six genotypes along with resistant and susceptible checks were screened in a replicated trial under artificial infestation against *Sesamia inferens* during *rabi* 2017-18. Among the lines screened, HEY Pool 2011-30-4-1-2-2-1 (2.20), HEY Pool 2011-41-2-1-1-1-1 (2.23) were found to be resistant, while HEY Pool 2011-41-2-1-1-2-1(3.23), DMRE63 (3.53), HEY Pool 2011-21-2-3-3-1-1 (4.30) and VQPM 9-2-1-2-1 (5.43) were moderately resistant to *S. inferens* (2.47) *(Table 1.19)*.

Table1 1.19: Evaluation of maize genotypes gainst Pink borer , *S.inferens*

Sl. No.	Pedigree	Mean LIR (1-9 Scale)
1.	HEY Pool -2011-30-4-1-2-2-1	2.20
2.	HEY Pool -2011-41-2-1-1-1-1	2.33
3.	HEY Pool -2011-41-2-1-1-2-1	3.23
4.	HEY Pool -2011-21-2-3-3-1-1	4.30
5.	VQPM9-2-1-2-1	5.43
6.	DMRE63	3.53
7.	CM500	2.47
8.	BML6	6.10

SEM: 0.70 ; CD: 2.14

Evaluation of maize germplasm for abiotic stress response

Water-logging and drought

A set of 100 inbred lines were evaluated for water logging as well as drought stresses in glass house. The water-logging stress was given by maintaining 4 cm water level in the pots after germination and continued till 15 days. The data were recorded on percent mortality (%), SPAD value, root length (cm), adventitious roots (Nos.), root volume (cm3), root weight (gm/plant), shoot length (cm), and shoot weight (gm/plant). The two lines, *viz.*, DML 221, and DQL 593-4, were identified as highly tolerant to water logging stress (Fig. 1.3).

The same sets of lines were also screened for drought (low moisture) stress. The low moisture stress was applied at seedling stage (6-8 leaves stage) and sustained for 20 days in pot under glass house conditions. The data was recorded on chlorophyll content (%), leaf senescence (% leaves), leaf rolling (% leaves), root and shoot length (cm) and weight (gm), and root volume (cm^3). Two lines, *viz*., DML 221 and DQL 574-2 showed tolerance to drought stress. It is interesting to note that DML 221 showed tolerance against both excess and low moisture stress. Figure 1.3 shows the root imaging of tolerant and susceptible lines under drought stress (Fig. 1.4a) and water logging (Fig. 1.4b). The RNA samples of root and shoot samples of extremely tolerant and susceptible genotype were isolated and sequenced to understand the molecular basis of drought and water logging stresses tolerance in maize.

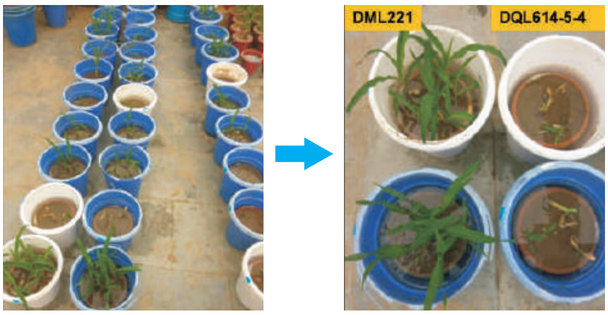

Figure 1.3: Inbred line, DML221 showing high tolerance to water logging stress against susceptible ones (DQL614-5-4).

Viability and germinability of seeds grown under different climatic conditions

Germination is an important physiological process which gets affected by several factors like temperature, moisture etc. during seed maturation. To test any harmful effect of high temperature during spring season on embryo viability, a preliminary experiment was conducted at Ludhiana. A set of 14 inbred lines were grown at Begusarai and Ludhiana during *rabi* and spring season of 2017, respectively. The viability and germination test was conducted using seeds of the 14 inbred lines, using both Tetrazolium (TZ) assay and germination test. The results showed highly significant difference in both seed viability and germination percentage between seeds harvested at two locations with seed lots from Ludhiana harvest having lower

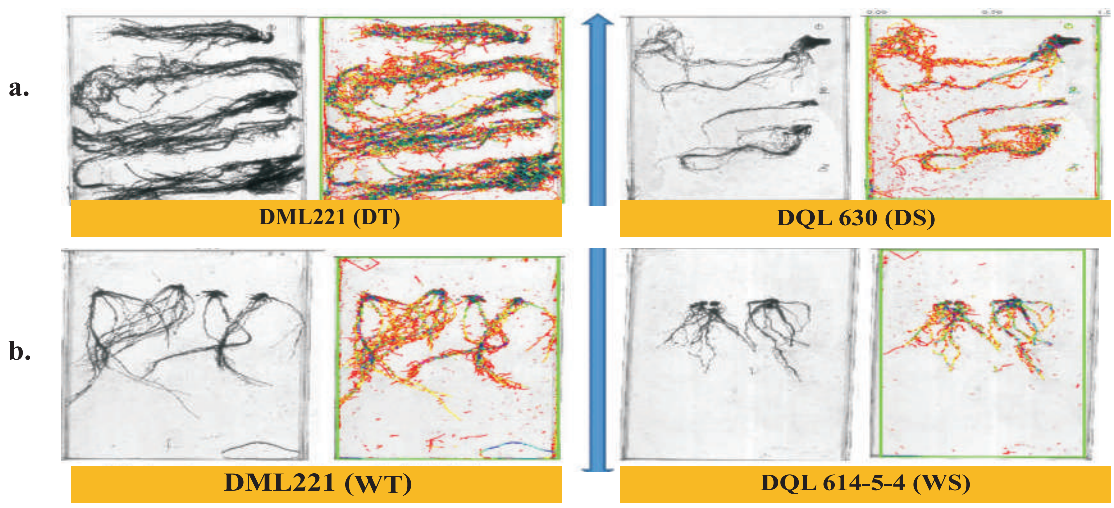

Figure 1.4: Root imaging of tolerant and susceptible lines under drought (a) and water logging (b) (DT: Drought tolerant, DS: Drought susceptible,WT: Water logging tolerant and WS: Water logging susceptible)

viability (33%) and germination (58%), respectively. This supports the hypothesis of harmful effects of high temperature at embryo development stage during spring season. Details study in this regard is required for conclusive establishment and reason behind it.

Screening of maize genotypes for natural variation in Nitrogen Use Efficiency (NUE)

Forty maize inbred lines were screened under N sufficient (residual N+180 Kg/ha) and N deficient (residual N+0 Kg/ha) conditions during *kharif* 2017 under net house condition (**Fig. 1.5**). The plants were extensively phenotyped for plant height, stem girth, LAI, CGR, RGR, root length, root biomass, root proliferation, cob position, ASI, chlorophyll content, dry matter partitioning, grain yield and its attributes (cob weight, cob length, cob girth, Number of rows per cob, number of grains per row, 100 grain weight). Prominent natural genetic variation in terms of NUE was observed among the genotypes in the first year of screening

Figure 1.5: Representative cobs of few inbred lines screened for natural variation in NUE

(required to be repeated for 2nd year for conclusion).

Evaluation of maize germplasm for quality traits

Protein and Tryptophan

During the period, biochemical analysis of QPM germplasm and inbred lines was carried out in term of protein and tryptophan (Trp) content. Based on the protein and tryptophan content, the list of most promising QPM inbred lines is given below (**Table 1. 20**). Two inbred lines, *viz*., DQL 2032 and DQL 2060 were exceptionally well for both protein content (11.25%) and tryptophan content (1.08%). In fact all other also showed good ratio for protein and tryptophan content.

WINTER NURSERY FACILITY

The institute has provided off-season nursery facility at Hyderabad to three ICAR Institutes, *viz*., VPKAS, Almora; IARI, New Delhi (Maize Genetic Unit, Division of Genetics and Division of Maize Pathology) and NBPGR, New Delhi. In addition five AICRP Centres of maize, *viz*., HPKV HAREC, Bajaura; HPKV, SAREC, Kangra; GBPUA&T, Pantnagar; PAU, Ludhiana; SKUA&T, Srinagar during *rabi* 2017-18 were also supported for generation advancement and maintenance of breeding material and hybrid seed production of entries under AICRP testing.

Table 1.20:The list of most promising QPM inbred lines identified during 2017-18.

Sl. No.	Inbred line	Protein (%)	Trp. (%)	Sl. No.	Inbred line	Protein (%)	Trp. (%)
1.	DQL 2060	7.89	1.08	34	DQL 2182	10.21	0.72
2.	DQL 2063	8.36	1.00	35	DQL2010	9.37	0.71
3.	DQL 2308	9.44	1.00	36	DQL 2055	9.25	0.70
4.	DQL 2018-6	8.69	0.96	37	DQL 2191-3	9.23	0.70
5.	DQL 2042	9.30	0.92	38	DQL 2209	8.05	0.7
6.	WNCQPM 10058-1	8.44	0.90	39	DQL 2281	10.94	0.70
7.	DQL 2097	8.15	0.88	40	DQL 2292	8.20	0.70
8.	DQL 2098	7.51	0.87	41	DQL 644-3-2-1	8.96	0.70
9.	DQL 2104-1	9.55	0.85	42	DML 1806	10.88	0.70
10.	DQL 2191-1-1	9.97	0.85	43	DQL 2017-3	7.78	0.69
11.	DQL 2071	8.16	0.84	44	DQL 2072	9.17	0.69
12.	DQL 721-3-1	9.49	0.84	45	DQL 2104	9.64	0.69
13.	DQL 2207	8.79	0.79	46	DQL 2124-1	7.85	0.69
14.	DQL 727-1-1	9.59	0.79	47	DQL 2310	8.53	0.69
15.	DQL 394-1-4-13-5	9.63	0.79	48	DQL 2013	9.17	0.68
16.	DQL 2105-1	8.57	0.78	49	DQL 2062	8.64	0.68
17.	DQL 2053	7.00	0.77	50	DQL 2081	9.22	0.68
18.	DQL 2080	8.23	0.77	51	DQL 2295	9.86	0.68
19.	DQL 2306	8.92	0.77	52	DQL 720-10-5-1-7	8.03	0.68
20.	DQL 2064-1-1	9.11	0.76	53	DML 1823	8.01	0.68
21.	DQL 2004-2	9.15	0.75	54	DQL 2049	8.70	0.67
22.	DQL 2191-1	8.49	0.75	55	DQL 2167	8.06	0.67
23.	DML 1278	8.09	0.75	56	DQL 2169-1	7.10	0.67
24.	DQL 2032	11.25	0.74	57	DQL 2192-1	7.86	0.67
25.	DQL 2113-2	9.08	0.74	58	DQL 2293	8.05	0.67
26.	DQL 644-4-6-2	8.89	0.74	59	DQL 817-2-1	9.08	0.67
27.	DQL 2307	8.77	0.74	60	DQL 2003	10.14	0.66
28.	DQL 2266	7.01	0.73	61	DQL 2230-1	8.83	0.66
29.	DQL 817-4-1-1	8.64	0.73	62	DQL 2059	9.00	0.65
30.	DQL 366-1-1A	8.93	0.73	63	DQL 2124	9.46	0.65
31.	DQL 2311	9.11	0.73	64	DQL 2178	8.82	0.65
32.	DQL 2082	9.32	0.72	65	DQL 565-3-1	11.19	0.65
33.	DQL 2018-1	9.46	0.72				

2

BASIC SCIENCES

The basic sciences division of the institute is involved in carrying research activities to standardize and optimize various platforms for advanced maize technologies in accordance with mandate of the institute. It plays an important role in exploring new avenues for addressing the challenges being faced in maize.

Biochemistry

Biochemical analysis of various nutritional maize programme includes QPM, bio-fortification, starch profiling, high oil etc. The biochemistry laboratory facilitates the identification of nutritionally superior germplasm for various quality traits such as protein quality, starch profile, oil content and pro-vitamin A components.

During the period of 2017–2018, a large number of samples were received under quality programme of AICRP as well as of the institute. These were analysed for protein quality and other quality parameters as requested by the breeders. In the first set of experiment, a total of 299 inbreds were analysed for protein quality. The kernels were screened on the basis of opaqueness to select the representative sample of QPM. Outcrossed as well as non-uniform kernels were discarded. The endosperm was separated, defatted and processed for protein quality. The range of protein was from 7% to 13.11% being exhibited by the genotypes DQL 781-1-8-1-6-10 and DQL 781-1-3-2-3-4, respectively. The range of tryptophan was from 0.31% (DQL 779-5-11-1-1) to 0.83% (DQL 644-2-1-1-6-7). Out of this stock, only 27 lines **(Table 2.1a)** were found to possess the threshold concentrations of tryptophan (≥0.6% of endosperm protein) required for QPM breeding.

Table 2.1a: Promising lines identified for protein quality

Sl. No.	Inbred	Protein (%)	Tryptophan (% of endosperm protein)
1.	DQL 779-5-6-1-4	9.52	0.60
2.	DQL 779-5-6-7-5	10.19	0.60
3.	DQL 779-5-11-2-6	11.09	0.60
4.	DQL 779-13-5-1-6-2	8.80	0.60
5.	DQL 781-1-8-1-6-10	7.00	0.60
6.	DQL 781-1-8-3-1-4	10.27	0.60
7.	DQL 783-5-3-1-6-3	9.44	0.60
8.	DQL 614-1-1-1-6-5	10.46	0.60
9.	DQL 634-4-3-11-4	8.60	0.60
10.	DQL 771-8-14-6-1	8.97	0.61
11.	DQL 771-8-14-6-12	9.65	0.61
12.	DQL 772-1-4A-1-10-5	10.42	0.61
13.	DQL 773-1-2-1-1-7	10.24	0.61
14.	DQL 772-1-4A-1-9-3	8.89	0.62
15.	DQL 626-2-2-2-1-2	8.92	0.62
16.	DQL 644-2-1-1-7-7	8.02	0.63
17.	DQL 779-5-6-2-2	9.42	0.63
18.	DQL 787-5-3-1-4-6	10.13	0.63
19.	DQL 74-1-1B-4-5	7.05	0.64
20.	DQL 644-2-1-1-7-2	11.58	0.65
21.	DQL 779-5-6-5-5	8.95	0.65
22.	DQL 774-18-2-1-2-4	8.64	0.66
23.	DQL 626-2-2-1-1-2	9.73	0.66
24.	DQL 614-1-1-1-4-7	7.53	0.72
25.	DQL 721-1-2-2-1-7	11.65	0.76
26.	DQL 783-31-15-10-2-7	9.37	0.77
27.	DQL 644-2-1-1-6-7	12.08	0.83
Mean value		**9.50**	**0.64**
CD (5%)		**0.427**	**0.43**

In another set of experiment, a total of 319 inbreds were analysed for protein quality following the process described earlier. The range of protein was 6.69% to 13.89 % with lowest and highest values being exhibited by the genotypes DQL 2272 and DQL 708-8-1-3, respectively. The tryptophan ranged between 0.32% (DQL 506-4-1-4) and 1.08% (DQL 2064). A total of158 lines out of this stock found to possess the threshold concentrations of tryptophan (≥0.6% of endosperm protein) required for QPM breeding, are given in **Table 2.1b**.

Table 2.1b: Promising lines identified for protein quality

Sl. No.	Pedigree	Protein (%)	Tryptophan (% of endosperm protein)
1.	DQL 2002	10.27	0.6
2.	DQL 2027	10.22	0.6
3.	DQL 2030	8.82	0.6
4.	DQL 2034	8.23	0.6
5.	DQL 2039-2	8.78	0.6
6.	DQL 2043	9.82	0.6
7.	DQL 2057-1	8.98	0.6
8.	DQL 2063-1	9.23	0.6
9.	DQL 2068	9.18	0.6
10.	DQL 2157	7.83	0.6
11.	DQL 2018-5	8.76	0.6
12.	DQL 2165	9.5	0.6
13.	DQL 2169	8.78	0.6
14.	DQL 2189	8.23	0.6
15.	DQL 2192	8.6	0.6
16.	DQL 2193-1	9.23	0.6
17.	DQL 2216	8.73	0.6
18.	DQL 2221	9.01	0.6
19.	DQL 2245	8.86	0.6
20.	DQL 2256	8.43	0.6
21.	DQL 2272	6.69	0.6
22.	DQL 2280-1	8.58	0.6
23.	DQL 2297	9.52	0.6
24.	DQL 2299	8.01	0.6
25.	DQL 297-1-1	8.29	0.6
26.	DQL 295-1-1-1	9.11	0.6
27.	DQL 708-8-1-3	13.89	0.6
28.	DQL 600-1-7-5-1	9.23	0.6
29.	DQL 205-1-3-5	8.84	0.6
30.	DQL 817-2-3	11.35	0.6
31.	DMRQPM-102-10-2-1	8.11	0.6
32.	DML 1435	10.09	0.6
33.	DQL 2064-1	8.79	0.6
34.	DQL 393-1-3	8.8	0.6
35.	DQL 2002-1	9.03	0.61
36.	DQL 2032-1	12.27	0.61
37.	DQL 2037	10.32	0.61
38.	DQL 2080-1	10	0.61
39.	DQL 2085	7.83	0.61
40.	DQL 2105	10.04	0.61
41.	DQL 2111	7.41	0.61
42.	DQL 2164	9.89	0.61
43.	DQL 2167-2	8.23	0.61
44.	DQL 2188	7.42	0.61
45.	DQL 2221-1-1	8.43	0.61
46.	DQL 2230-2	10.06	0.61
47.	DQL 2258	10.13	0.61
48.	DQL 2289-2	8.8	0.61
49.	DQL 2304	8.86	0.61
50.	DQL 644-3-1	9.25	0.61
51.	DQL 2312	10.24	0.61
52.	DQL 2024	8.84	0.62
53.	DQL 2029-1	8.17	0.62
54.	DQL 2031-1	8.54	0.62
55.	DQL 2046	9.69	0.62
56.	DQL 2113-1	9.13	0.62
57.	DQL 2124-2	10.08	0.62
58.	DQL 2173	8.57	0.62
59.	DQL 2192-1-1	8.58	0.62
60.	DQL 2217	8.82	0.62
61.	DQL 2283	8.59	0.62
62.	DQL 2289-1	8.18	0.62
63.	DQL 2300	9.56	0.62
64.	DQL 2305	9.85	0.62
65.	DQL 644-2-1-1-1	9.69	0.62
66.	DML 1851	8.29	0.62
67.	DQL 2007	8.4	0.63
68.	DQL 2035	8.2	0.63
69.	DQL 2144	7.39	0.63
70.	DQL 2158	8.78	0.63
71.	DQL 2161	9.8	0.63
72.	DQL 2166	9.7	0.63
73.	DQL 2167-1-1	6.86	0.63
74.	DQL 2177	9.3	0.63
75.	DQL 2180	8.71	0.63
76.	DQL 2181	8.68	0.63
77.	DQL 2186	10.22	0.63
78.	DQL 2225	8.48	0.63
79.	DQL 110-1-1-1	9.22	0.63
80.	DQL 772-1-4-1-2	9.81	0.63
81.	DQL 184-3-2A-1-4	8.16	0.63
82.	DQL 2186	8.11	0.63
83.	DQL 2017-2	9.47	0.64
84.	DQL 2028	8.23	0.64
85.	DQL 2048	10.36	0.64
86.	DQL 2052	7.85	0.64

Sl. No.	Pedigree	Protein (%)	Tryptophan (% of endosperm protein)
87.	DQL 2058-1	10.72	0.64
88.	DQL 2096	8.09	0.64
89.	DQL 2160	8.74	0.64
90.	DQL 2262	9.03	0.64
91.	DMRQPM-102-11-1-1	8.17	0.64
92.	DQL 2059	9	0.65
93.	DQL 2124	9.46	0.65
94.	DQL 2178	8.82	0.65
95.	DQL 565-3-1	11.19	0.65
96.	DQL 2003	10.14	0.66
97.	DQL 2230-1	8.83	0.66
98.	DQL 2049	8.7	0.67
99.	DQL 2167	8.06	0.67
100.	DQL 2169-1	7.1	0.67
101.	DQL 2192-1	7.86	0.67
102.	DQL 2293	8.05	0.67
103.	DQL 817-2-1	9.08	0.67
104.	DQL 2013	9.17	0.68
105.	DQL 2062	8.64	0.68
106.	DQL 2081	9.22	0.68
107.	DQL 2295	9.86	0.68
108.	DQL 720-10-5-1-7	8.03	0.68
109.	DML 1823	8.01	0.68
110.	DQL 2017-3	7.78	0.69
111.	DQL 2072	9.17	0.69
112.	DQL 2104	9.64	0.69
113.	DQL 2124-1	7.85	0.69
114.	DQL 2310	8.53	0.69
115.	DQL 2055	9.25	0.7
116.	DQL 2191-3	9.23	0.7
117.	DQL 2209	8.05	0.7
118.	DQL 2281	10.94	0.7
119.	DQL 2292	8.2	0.7
120.	DQL 644-3-2-1	8.96	0.7
121.	DML 1806	10.88	0.7
122.	DQL2010	9.37	0.71
123.	DQL 2082	9.32	0.72

Sl. No.	Pedigree	Protein (%)	Tryptophan (% of endosperm protein)
124.	DQL 2018-1	9.46	0.72
125.	DQL 2182	10.21	0.72
126.	DQL 2266	7.01	0.73
127.	DQL 817-4-1-1	8.64	0.73
128.	DQL 366-1-1A	8.93	0.73
129.	DQL 2311	9.11	0.73
130.	DQL 2032	11.25	0.74
131.	DQL 2113-2	9.08	0.74
132.	DQL 644-4-6-2	8.89	0.74
133.	DQL 2307	8.77	0.74
134.	DQL 2004-2	9.15	0.75
135.	DQL 2191-1	8.49	0.75
136.	DML 1278	8.09	0.75
137.	DQL 2064-1-1	9.11	0.76
138.	DQL 2053	7	0.77
139.	DQL 2080	8.23	0.77
140.	DQL 2306	8.92	0.77
141.	DQL 2105-1	8.57	0.78
142.	DQL 2207	8.79	0.79
143.	DQL 727-1-1	9.59	0.79
144.	DQL 394-1-4-13-5	9.63	0.79
145.	DQL 2071	8.16	0.84
146.	DQL 721-3-1	9.49	0.84
147.	DQL 2104-1	9.55	0.85
148.	DQL 2191-1-1	9.97	0.85
149.	DQL 2098	7.51	0.87
150.	DQL 2097	8.15	0.88
151.	WNCQPM 10058-1	8.44	0.9
152.	DQL 2042	9.3	0.92
153.	DQL 2018-6	8.69	0.96
154.	DQL 2063	8.36	1
155.	DQL 2308	9.44	1.00
156.	DQL 2309	8.74	1.04
157.	DQL 2060	7.89	1.08
158.	DQL 2064	8.56	1.08
Mean vaue		**8.97**	**0.67**
CD (5%)		**0.45**	**0.66**

Another set of 29 elite inbreds received from IIMR, Ludhiana was analysed for protein quality as per the set procedure discussed earlier. The range of protein was from 8.67-11.37 % with lowest and highest values being exhibited by (HKI 1105×CML 161 COB 30C1) and (HKI 1105× CML 161 COB 12C2), respectively. The range of tryptophan was 0.36% (HKI 1105×CML 161 COB 12C2) to 1.02% (BML 6-1× HKI 193-1-COB 5). Most of lines (17) out of this stock were found to possess the threshold concentrations of tryptophan (≥0.6% of endosperm protein) required for QPM breeding, and are given in **Table 2.1c**.

Table 2.1c: Promising lines identified for protein quality

Sl. No	Pedigree	Protein (%)	Tryptophan (% of end. protein)
1.	HK 1 1105×CML 161 COB 15C1	9.28	0.60
2.	HK 1 1105×CML 161 COB 18C2	10.26	0.60
3.	HK 1 1105×CML 161 COB 12C4	9.06	0.61
4.	BML 6-1×CML-161(22)COB 7C1	9.47	0.61
5.	BML 6-1×HK1-193-1-COB 8C1	10.24	0.62
6.	HK 1 1105×CML 161 COB 3C2	9.55	0.62
7.	HK 1 1105×CML 161 COB 4C2	9.20	0.64
8.	HK 1 1105×CML 161 COB 25C1	10.77	0.65
9.	HK 1 1105×CML 161 COB 21C3	9.73	0.67
10.	BML 6-1×HK1-198-1-COB 14C2	8.70	0.68
11.	HK 1 1105×CML 161 COB 29C1	8.87	0.69
12.	HK 1 1105×CML 161 COB 3C1	9.27	0.72
13.	HK 1 1105×CML 161 COB 36C1	9.22	0.72
14.	HK 1 1105×CML 161 COB 7C2	8.82	0.74
15.	BML 6-1×HK1-193-1-COB 10C1	9.26	0.78
16.	HK 1 1105×CML 161 COB 30C1	8.67	0.84
17.	BML 6-1×HK1-193-1-COB 5	9.16	1.02
Mean value		**9.41**	**0.69**
CD(5%)		**0.600**	**0.94**

Physiology

Differential expression of heat shock proteins (HSPs) genes during flowering stage heat stress in contrasting maize genotypes

Heat stress at flowering stage significantly affects grain yield. Earlier studies identified LM 17 as heat stress tolerant and HKI 1015WG8 as heat stress susceptible. Expression profiling of four selected HSP genes (*ZmHsp 22, ZmHsp 70, ZmHSp 82 and ZmHsp 101*) was studied in these two field grown contrasting maize inbred lines at flowering stage. The plants were sown in micro-plots at the net-house facility on 1st March, 2017 and leaf samples were collected from these plants at weekly interval from the day of tasselling, which coincided with high atmospheric temperature in the range of 38 - 44°C. Total RNA was isolated by using ambion PureLink RNA isolation kit as per the manufacturer's instructions. First strand cDNA was synthesized using 1 µg of total RNA using Affinity Script qRT-PCR cDNA synthesis kit. Gene specific primers for qRT-PCR were synthesized. Expression analysis was done by qRT-PCR. All the four genes showed significantly higher up-regulation in LM 17

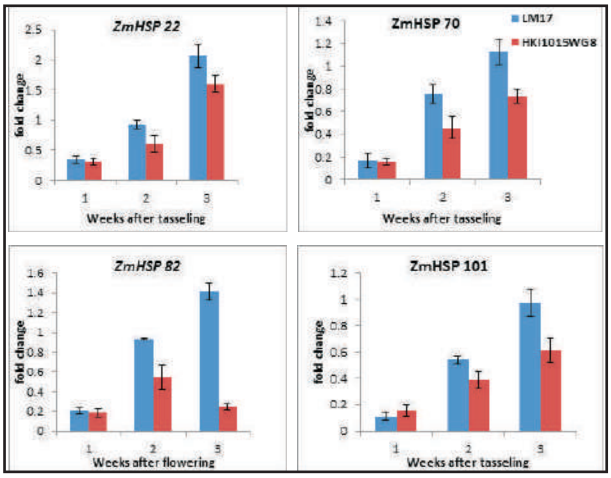

Figure 2.1: Differential expression of 4 HSP genes (*ZmHsp* 22, *ZmHsp* 70 and *ZmHSp* 82 and *ZmHsp*-101) during flowering stage heat- stress in two contrasting maize genotypes

at flowering stage **(Fig. 2.1)**, confirming role of these HSP genes in imparting tolerance against high temperature.

Biotechnology

Evaluation of maize genotpes for callus induction using mature embryo as explants

At present, in most of the tropical maize tissue culture and transformation protocols, immature zygotic embryos is being used as explants. However, the immature embryos are available seasonally and have strictly limited durability for culturing which results in major constrain in continuous availability of explants throughout the year. Besides, the use of immature embryos as explants is laborious as well as time consuming. A regeneration system based on mature embryos may overcome these limitations. Keeping this in mind, evaluation of tropical maize inbreds for *in vitro* callus induction for mature embryo was taken up.

Twenty five different tropical maize genotypes, comprised of 22 inbred lines (DQL1017-2, HKI 161, LM 13, CML420, UMI 1210, IML418-1, DMPRE6-1, HKI42050, BML 5, V373, IML 15-268, HKI 193-2, CML152, IML16-194, BML10, HKI 323, BML 7, VQL2, CML409, HKI1128, BML6 and IML12-9) and three hybrids (DHM 117, Vivek Hybrid 33 and Vivek Hybrid 25) were evaluated for *in vitro* callus induction using nodal explant. Seeds were sterilized and inoculated on germination medium for the development of conspicuous node (bulging). The nodes and hypocotyl-epicotyl axis (tigellum or left over region of embryo) were split longitudinally into two halves. The split nodes and split embryo region were placed on the callusing medium and incubated under dark at 26°C ± 2°C. A total of 5419 and 4844 split embryo and nodes, respectively were taken from 25 genotypes for callus induction. There was no success in callus induction with use of split embryo as explants. However, with split node as explants, of total 25 genotypes, the promising results were obtained in three genotypes namely BML 6 (35.0%), DMRPE 6-1 (9.0%) and CML 409 (5.6%) for callus induction (**Figure 2.2**). Out of these three genotypes, regeneration was obtained in BML 6 (11%) and CML 409 (16%), while no regeneration was observed in DMRPE 6-1. However, the regeneration percentage needs to be improved. With these initial results, we are pursuing this activity across different media compositions in BML 6 to validate the reproducibility and improve upon the efficiency of regeneration process.

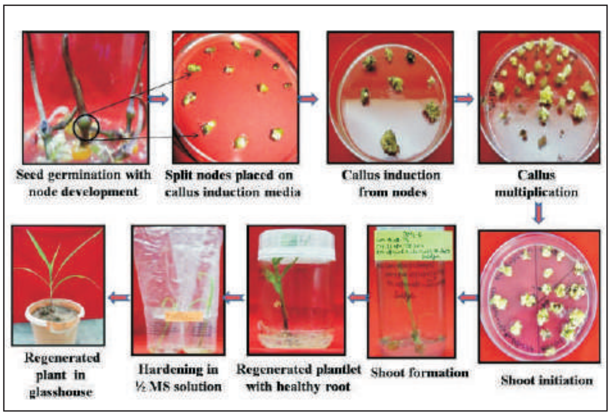

Figure 2.2: Callusing and regeneration of plantlet from mature embryos of BML 6 line

Developing plant transformation construct capable of imparting glyphosate herbicide tolerance

A new construct (for glyphosate tolerance) harbouring maize ubiquitin promoter, maize chloroplast transit peptide, mutated version of maize 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase gene, and maize ubiquitin terminator was developed. In this construct, the mutated maize EPSPS gene (for glyphosate tolerance) is driven by maize ubiquitin promoter. The construct was inserted in pCAMBIA2300 backbone. The final vector is suitable to use for *Agrobacterium* mediated transformation (**Figure 2.3**). The final vector was named as "pCAM-ZmUbiPro-CTP-EPSPS-UbiTer" elements. This construct is being validated in the model plant such as tobacco. This construct can be utilized later as a universal construct for functional characterization of any stress (mainly abiotic) responsive gene(s) by replacing the CTP-EPSPS fragment with gene of interest by restriction digestion & ligation reaction. This is the first construct designed and developed at our institute for imparting glyphosate tolerance.

(A)

LB EcoR1+Avr II – UBipromoter – AatII+BamH1+Sac1 – CTP – Sma1 – EPSPS
Kpn1+ Spe1+ Mlu1 – Ubi Ter – Stu I+HindIII RB

Various restriction enzymes sites (total length-66 bp) used in the construct are as follows-

EcoRI- G*AATTC; AatII - G*ACGTC; BamHI - G*GATCC; SacI - GAGCT*C;

SmaI- CCC*GGG; MluI - A*CGCGT; KpnI - GGTAC*C; SpeI - A*CTAGT;

HindIII - A*AGCTT ;AvrII - C*CTAGG; StuI – AGG*CCT.

Maize Ubiquitin Promoter (ZmUBIp) – 1992 bp; Chloroplast transit peptide (CTP) – 60 bp.

Maize Epsps gene- 1425 bp; Maize Ubiquitin Terminator (UbiTer) - 341bp.

Total construct size- 3884 bp.

LB and RB represents left and right border respectively in pCAMBIA2300 plasmid backbone.

(B)

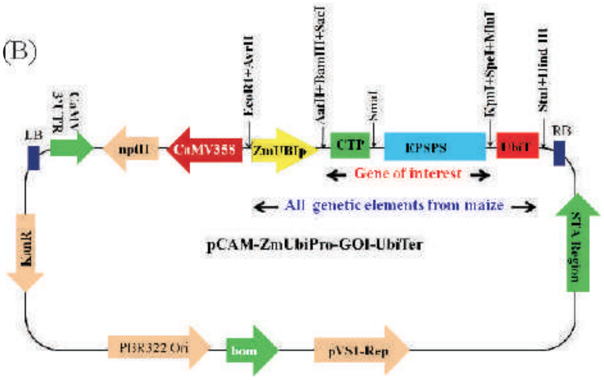

Figure 2.3: Complete vector map of plant transformation construct (pCAM-ZmUbiPro-CTP-EPSPS-UbiTer) inserted under pCAMBIA2300.

Transformation of maize for herbicide tolerance

More than seven thousand immature embryos were harvested from CM300 inbred line and cultured on callus induction media. Type II embryogeniccalliobtained from immature embryo (2757) were regenerated (**Figure 2.4**). The embrogeniccalli were transformed with CRISPR/Cas9 based EPSP gene editing construct through particle bombardment for herbicide tolerance. After biolistic transformation, 379 shoots were regenerated in the regeneration media. Amongst these 379 shoots, only 288 developed roots. Further, out of 288 well developed putative transformants/seedlings, only 196 were able to survive after hardening process (**Figure 2.5**). Morphological abnormalities like, tassel seed formation were observed in 78 tissue culture raised plants. PCR analysis of putative transformants with cas9 gene specific primersindicated that none of the putative transformantswere positive. This calls for further intensification of the efforts in this direction.

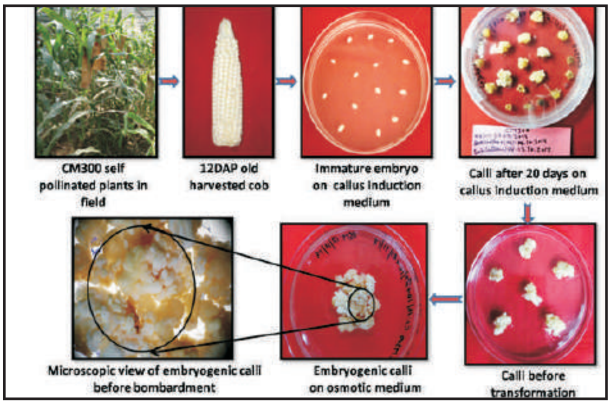

Figure 2.4: A pictorial representation of embryogenic calli formation from CM 300 line

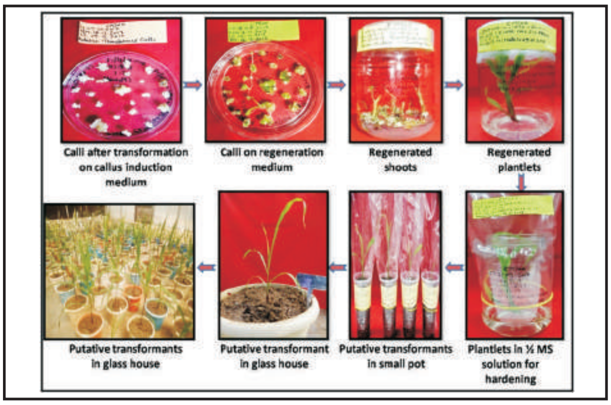

Figure 2.5: A pictorial representation of transformation of maize with CRISPR/Cas 9 construct for herbicide resistant by biolistic method using immature embryo derived type II embryogeniccalli

Computational model of interaction of opaque2 Transcription Factor protein with its target DNA sequence

Protein quality is an important trait that adds to the commercial value of a crop. The current high protein quality maize varieties have been developed from *opaque* maize mutants. In *opaque* mutants, the amount of lysine and tryptophan increases roughly two-fold. In presence of *opaque2* mutation, the maize grain texture is adversely affected. Many rounds of breeding efforts are required for sufficient endosperm modification to improve protein and grain quality simultaneously. On the other hand, precision genome editing has the potential to expedite the enhancement of nutritional quality in locally-adapted germplasm, without detrimental effects on grain quality. The expression of zeins is regulated by *opaque2* (*o*2) Transcription Factor, which binds to specific *o*2 DNA elements in the promoter of zein genes. In some *opaque* mutants, the variant *o*2 Transcription Factor has less affinity to *o*2 DNA elements, resulting in lesser expression of zein proteins. The lesser expression of zein proteins is accompanied by a concomitant increase in the proportion of non-zein proteins, including albumins and globulins. These non-zein proteins are rich in codons for lysine and tryptophan, explaining the enhancement of nutritional quality in QPM. Hence, if the affinity of *o*2 Transcription Factor to DNA is altered, changes in maize protein quality can be brought. A computational model of o2 Transcription Factor protein interacting with its target DNA sequence was prepared, based on homology modelling. The 3-dimensional conformational model, thus generated, has yielded information on orientation of different amino acid residues in the major groove of double-helical DNA. *o*2 Transcription Factor is a basic leucine zipper (bZIP) protein. An amino acid loop KRKESNRES appears important for interaction with DNA owing to its position in the helix. As the opaque mutations are known to result in wide-spread pleiotropic changes in the cellular metabolism, it is important to engineer disruptions in protein-DNA interactions with minimum effect on overall protein stability or function. The computational model shown in **Fig. 2.6** is helpful in this regard.

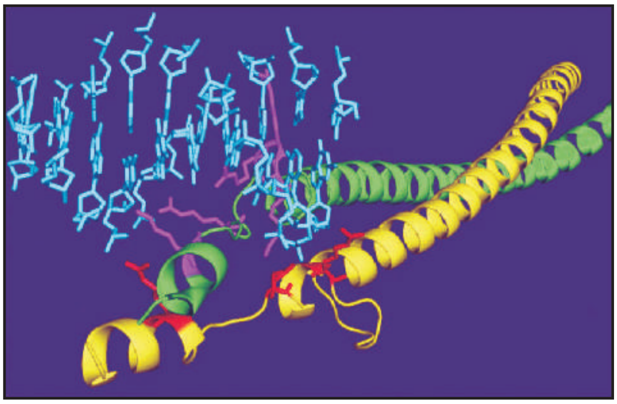

Figure 2.6: Leucine zipper domains of bZIP-containing *opaque2* Transcription Factor protein with nucleobases (coloured in cyan with two strands depcted in white) in its target DNA. The residues in two loops (represented in green and yellow) that proximally interact with nucleobases in DNA are shown in magenta and red, respectively.

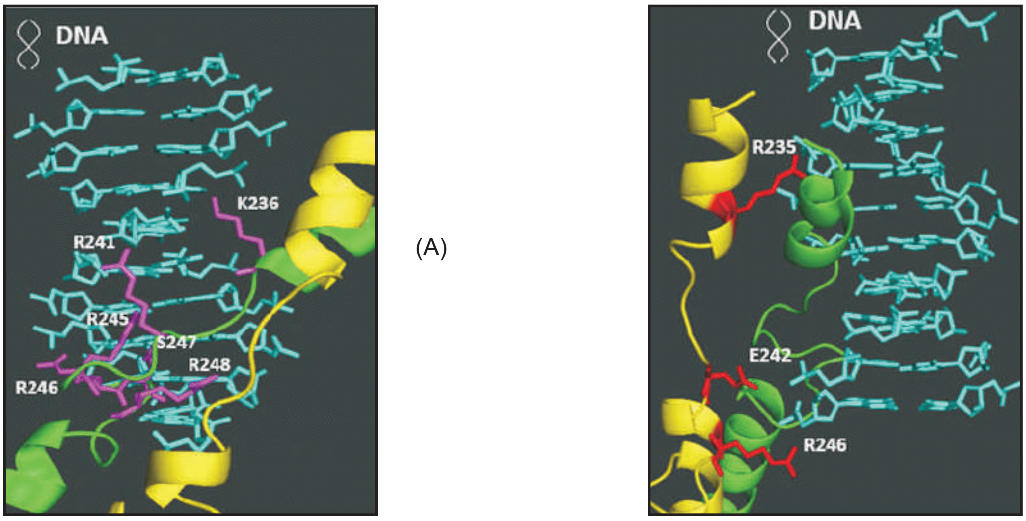

Figure 2.6: Residues in *o2* Transcription Factor protein that interact with nucleobases in the target DNA. A. Close-up of interacting residues (represented in magenta) in loop 1 (green). B. Close-up of interacting residues (represented in magenta) in loop 1 (green).

Figure 2.7: Summary of interaction of *o2* protein amino acids. Amino acids in red represent residues that interact with nucleobases in the target sequence. DNA (top view) is schematically represented in the region responsible for DNA-protein interaction Amino acids interacting in the two domains via polar contacts are represented by lines. Green asterisk denote invariant residues (N240 and R248) in the primary sequence.

Six residues in one loop and three in the second loop are close to nucleobases for possible interaction (**Figure 2.7**. A. and B.). The leucine zipper thus, contact DNA helix asymmetrically. The DNA-protein and intra-protein interactions have been summarized in **Fig. 2.8.**

The important residues elucidated by the computational model can be used to gene editing for precise regulation of the binding affinity of *o2* protein with its target DNA for achieving desired level of kernel hardness along with higher amino acid content in selected maize lines.

PRODUCTION SYSTEM AND TECHNOLOGY

3

Crop management plays an important role in ensuring overall productivity and sustainability of crop production. The crop production programme of the institute is focused on precision nutrient management and development of conservation agriculture practices in maize based cropping systems.

Nitrogen management under conservation agriculture in maize systems

Conservation agriculture (CA) improves soil health and requires a different strategy for nutrient management. The residue retention in CA may interact negatively with urea split application in standing crops as part of nutrient remains on the residue without any soil contact that leads to volatilization and immobilization losses. There is stiff competition for the residue by various sectors like livestock, domestic fuel etc. in India, hence, the residue application cost, and its benefit as soil health and economic profitability in CA needs attention of the researchers. On this background, the application of the coated fertilizer like neem/sulphur coated urea were explored for enhancing the productivity of maize systems under different residue management scenario in CA. The work is a long term study for five years.

An analysis of the five year trends in the systems yield of the maize-mustard-mungbean (MMuMb) system shows that the system productivity increased in the residue retention (WR) plots in all the treatments **(Fig. 3.1)**.

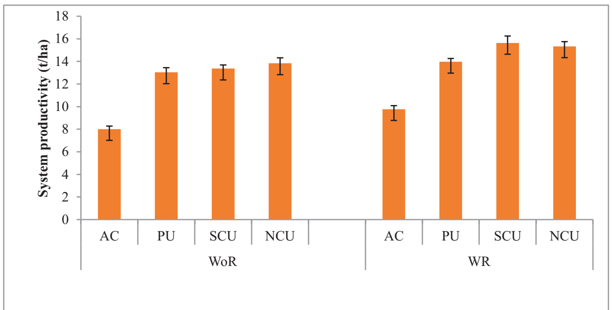

Figure 3.1: Effect of coated fertilizer application on system productivity of maize-mustard-mungbean systems under different residue management scenario (mean of 5-years, 2012-17). AC=Absolute control, PU=Prilled Urea, SCU=Sulphur-coated urea, NCU=Neem-coated urea, WoR=without residue, WR=with residue.

However, in without residue (WoR) treatments, the yield declined over the years in the control treatment, which shows the importance of residue recycling in these intensified cropping system. Over all (mean of 5-years), the residue application increased MMuMb system yield by 13% over WoR treatments. However, the application of sulphur-coated urea (SCU) gave maximum yield that was on par to neem-coated urea where their application increased productivity of the systems by 7% and 8% over prilled urea (PU) application, respectively.

The maize-wheat-mungbean (MWMb) system productivity increased in the residue retention (WR) plots in all the urea application treatments along with control. The observed effect might be due to legume inclusion in intensified cropping system **(Fig. 3.2)**. However, in without residue (WoR) treatments, the yield declined over the years in the control treatment, which shows the importance of residue recycling in these intensified cropping system. When quantified as mean of five years, the residue application increased MWMb system yield by 13.0% over WoR treatments. However, the application of neem-coated urea (NCU) registered maximum productivity of the systems in all the years and as mean of

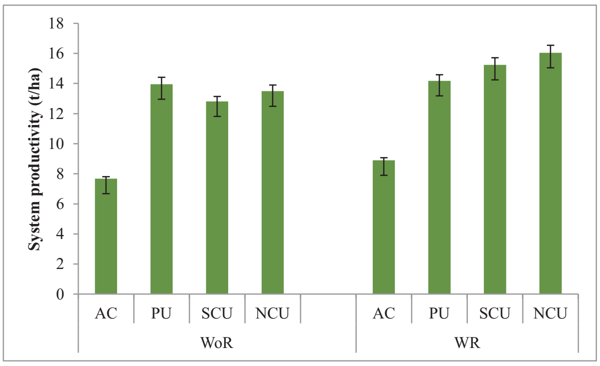

Figure 3.2: Effect of coated fertilizer application on system productivity of maize-wheat-mungbean systems under different residue management scenario (mean of 5-years, 2012-17).

5 years, its application increased productivity of the systems by 5.0% over prilled urea (PU) application.

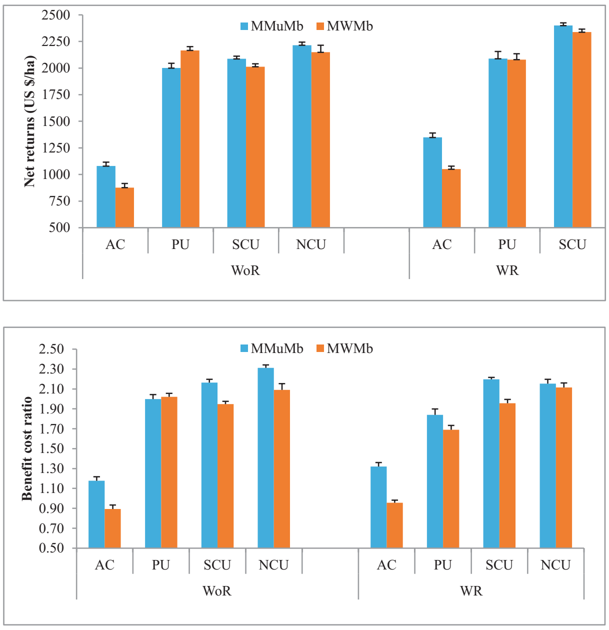

Figure 3.3: Effect of coated fertilizer application on system net returns and benefit cost ration (BCR) in intensified maize systems under different residue management scenario (mean of 5 years, 2012-17).

permanent raised bed (PB) practices enhanced grain yield of maize and wheat by 12.7-14.5% and 7.2-12.3% and reduced the system irrigation water requirement by 140–200 mm/ha and 200–300 mm/ha, respectively, when compared to conventional till (CT) system. This increases water productivity (WP) by 18.4–39.0%. Significantly higher pooled bioenergetic yields (22-35%), net returns (31-38%) and water-use efficiency (30-35%) was observed in SSNM/Ad-hoc plots compared with FFP plots. Combination of PB and SSNM increased maize-wheat (MW) productivity by 23% and 41%, respectively, compared with CT+ RDF and CT+FFP **(Fig. 3.4)**.

Significant interactions between tillage practices and nutrient management strategies were found with respect to water–use, WP and grain yield of MW system. SSNM based nutrient application coupled with CA-based tillage practices (PB) in MW system has potential to attain higher system productivity and WP compared to the use of these crop management practices in isolation.

The concentration of SOC in the CT surface soil (0-0.15 m and 0.15-0.30 m) was lower than in the PB and ZT treatments, which did not differ from each other (Table 3.1). The tillage and nutrient management had significant (P<0.05) interaction effect on SOC content of 0-0.15 m soil layer only. However, the tillage and nutrient management interaction effect on SOC was not observed for 0.15-0.30 and 0.30-0.45 m soil layers. The available N, P, and K content of the PB and ZT treatments at depths of 0-0.30 m were higher than in CT. There were no tillage differences in N, P, or K availability at the 0.30-0.45 m

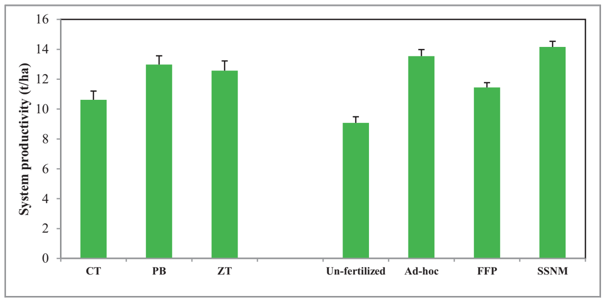

Figure 3.4: Mean system productivity of maize-wheat-mungbean rotation as influenced by different tillage and nutrient management practices during five year of study (2012-17). CT=Conventional tillage, ZT=Zero-tillage, PB=permanent raised bed, Ad-hoc=Recommend application, FFP=farmer fertilization practices SSNM=Site-specific nutrient management.

depths. Nutrient management treatments significantly affect the available N, P and K content at 0-0.30 m soil depth. Thus, adoption of conservation tillage (ZT/PB) practices with improved nutrient management (SSNM/Ad-hoc) could be a viable option for achieving higher biomass productivity, water and energy-use efficiency, profitability and soil organic carbon in MWMb system of north-west India.

Sensor guided nitrogen management in maize based cropping system under conventional and conservation agriculture practices

High Nitrogen (N)-use efficiency can be achieved by replacing blanket fertilizer recommendation by an optical sensor-based nitrogen (N) management strategy consisting of applying moderate amount of fertilizer N at planting and sensor-guided fertilizer N dose for split application. The sensor guided recommendations are already available for rice and wheat in India, but not for maize till date. So, this project was initiated to generate technology in maize based system on sensor guided N management that will help in reducing input and enhancing N-use efficiency under both CA and conventional agriculture in India.

Table 3.1. Effect of tillage and nutrient management practices on total organic carbon content of a sandy loam soil after four years of maize-wheat-mungbean rotation.

Treatments	Total soil organic carbon (g kg-1 of soil)		
	0-0.15 m	0.15-0.30 m	0.30-0.45 m
Tillage practices			
CT	5.21[b]	4.93[b]	3.97
PB	6.28[a]	5.64[a]	4.11
ZT	6.15[a]	5.82[a]	4.20
Nutrient management			
Unfertilized	5.02[b]	4.87[b]	3.88
FFP	5.47[b]	5.03[b]	4.11
Ad-hoc	6.44[a]	5.88[a]	4.17
SSNM	6.60[a]	6.07[a]	4.22

** Means followed by a similar superscript letter within a column are not significantly different (at P≤0.05) between treatments of the same year according to least significant difference test.*

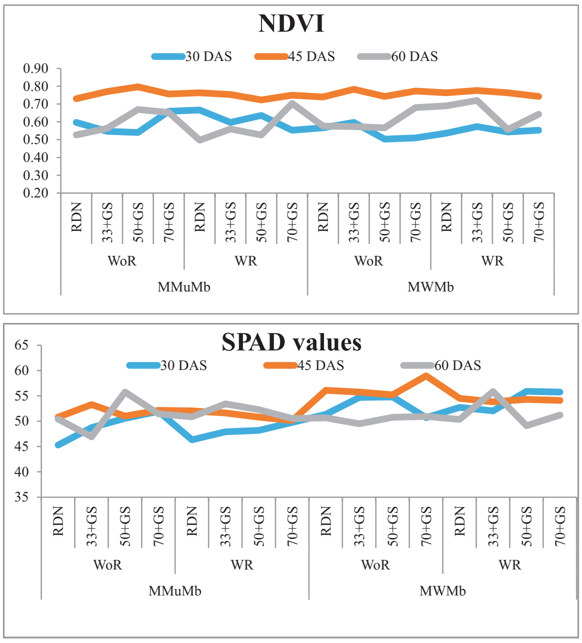

Figure 3.5. NDVI and SPAD values at various crop growth stages of maize under different nutrient and residue management scenario.

The calibration curve for green seeker (GS) guided N management developed by IIMR in collaboration with Indian Institute of Farming Systems Research (IIFSR) and International Maize and Wheat Improvement Centre (CIMMYT) was used for validation towards making recommendation for precision N management in maize systems. It was observed that the normalized differential vegetation indices (NDVI) given by green seeker were more differentiated at various crop growth stages compared to SPAD sensor given values in maize (Fig. 3.5). It was inferred that the NDVI readings could be used for sensing the overall crop growth compared to the SPAD values and hence can be a better sensor for *in-situ* precision N management in maize.

The GS based application of nutrients had wide range (122 to 190 kg/ha) in various cropping systems and residue management scenarios that showed that the calibration curve developed had capacity to give precision N recommendations in various field situations. The application of GS based N by 33% recommended dose of nitrogen (RDN) +GS in maize resulted in significantly higher maize yield over RDN and other treatments. Significantly higher partial factor productivity of applied N (PNP_N) was recorded with 70%RDN+GS which was followed by in 50%RDN+ GS (Fig. 3.6). The *kharif* 2017 was good crop season from point of view of rainfall distribution in maize. Hence, a little gain by residue (4.9%) while higher gain by MWMb cropping system (12.6%) was observed on maize productivity during 6th year of the experimentation.

Under conventional tilled system, the GS based N application had slightly narrow range (109 to 177 kg/ha) compared to conservation agriculture which was 13 to 40 kg lesser than the recommended N (150 kg/ha) in maize for North Western Plain zone. These GS based application gave at par maize grain yield to the RDF.

Development of precision conservation agriculture practices in cereal-based system in Indo-Gangetic Plains

Rice-wheat (RW) cropping system in north-west India,

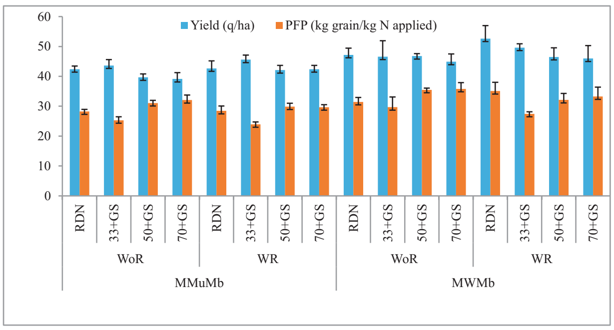

Figure 3.6: Effect of the green seeker (GS) sensor guided nutrient application on the maize yield and partial factor productivity (PFP) of applied N during kharif 2017 under conservation agriculture.

although providing food security in the country, have also led to soil degradation and over exploitation of underground water resources. The diversification of RW systems with maize-based systems, alternate soil and crop management practices could help enhance the system productivity, sustain soil health and environment quality, save irrigation water and labour costs, provide palatable fodder and meet increased demand of maize grains from piggery and poultry industries.

In maize during first year of experimentation, non-significant differences was found amongst different tillage treatments (**Table 3.2**). However, in terms of nutrient management, significantly high maize yield (8.1 t/ha) was obtained with SSNM which remained at par with RDF, followed by green seeker sensor and significant low yield (7.2 t/ha) was obtained by farmers fertilizer practice.

Study of different organic nutrient sources in maize and specialty corn

Presently, there is increased demand of organic product due to their better nutrition value and quality. However, no concrete information is available for organic maize production with special reference to specialty maize that has great potential. Hence, on long term basis one experiment has been initiated during kharif 2018 on fixed site to measure the effect of fertilizer vis-a-vis different organic sources in maize and specialty corn i.e. baby corn and sweet corn (**Table 3.3**). In first year, recommended dose of fertilizer (RDF) produced significantly higher normal maize as compared to different organic practices [Farm Yard Manure (FYM), FYM + Vermicompost combinations]. In baby corn, in baby corn and sweet corn, no significant difference due to fertilization was observed. It showed that the organic nutrient management has more potential in specialty corn production.

Table 3.2. Effect of different tillage and nutrient management practices on maize yield in *kharif* 2017.

Treatments	Maize grain yield (kg/ha)
Tillage practices	
Conventional Tillage (CT)	7996
Conservation Agriculture (CA)	7823
LSD (P=0.05)	N.S.
Nutrient management practices	
Farmers Fertilizer Practice (FFP)	7181
Recommended Dose Fertilizer (RDF)	7527
Green Seeker Sensor (GS)	8073
Site Specific Nutrient Management (SSNM)	8157
LSD (P=0.05)	416.3

Table 3.3. Effect of the different sources of nutrient application on the yield of various maize types in *kharif* 2017.

Treatments	Maize grain yield (kg/ha)	Sweet corn with husk yield (kg/ha)	Baby corn with husk yield (kg/ha)
RDF	6435	9986	7570
100% FYM	4453	9417	6585
50% FYM+ 50% VC	4487	9121	6268
25%FYM+25% VC+1/3 Straw	4518	8635	6598
LSD (P=0.05)	290.1	NS	NS

CROP PROTECTION

4

Insect pests and Diseases are the major biotic constraints in harnessing potential yield of maize. In order to reduce the losses due to insect pests and diseases, while simultaneously increasing the production, various research approaches on management strategies are being carried out. The major thrust is on host plant resistance, where evaluation of maize germplasm against major diseases and insect pests forms its integral part. Development of management tools for integrated pest and disease management is another important aspect in crop protection.

Host plant resistance

Host plant resistance (HPR) is the most vital and integral part of ecofriendly pest and disease management. Under close collaboration crop scientists are working with the breeders towards this direction. Detail outcome of evaluation of germplasm for stress response has already been discussed in chapter 1. Brief outputs are given here.

Resistance against major diseases

To identify resistance sources against maydis leaf blight (MLB), banded leaf & sheath blight (BLSB) and charcoal rot (ChR), three set of germplasm of 138, 320 and 134, respectively were screened under artificially created epiphytotics. Out of these, 17, 12 and 49 lines exhibited resistance reaction against MLB, BLSB and ChR, respectively. Besides, these F_2 mapping populations were also screened against MLB for QTLs identification. A multi-location phenotyping trial of 98 genotypes was evaluated for resistance against charcoal rot at Ludhiana and Delhi, for fusarium stalk rot at Udaipur. Out of them, a total of 13 lines were resistant (< 3.1 score) and 24 were moderately resistant (<5.1 score).

Resistance against major insect pests

Out of 78 genotypes screened under artificial infestation against *Chilo partellus*. Only one genotype MF2-46-9 was found resistant with LIR score of 2.7. Similarly, out of 6 and 53 genotypes, screened against *Sesamia inferens,* two and 6 lines, respectively, recorded resistance response.

Analysis of maize soluble metabolome towards germplasm screening for *Chilo partellus* resistance

To understand the role of metabolome in resistance response, *C. partellus* susceptible inbred line BML 6, tolerant inbred line BML 7, and their hybrid DHM 117 were analyzed for differential expression of soluble metabolome by Ultra Performance Liquid Chromatograph (UPLC), coupled to a Quadrupole-Time of Flight mass spectrometer (QToF-MS). Log_2 fold change value of molecular abundance of each metabolite was calculated and subjected to analysis of variance (ANOVA), followed by Tukey-Kramer test to identify significantly differentially expressed metabolite. About 100 differentiallly expressed metabolites were detected from the infested and control parents and hybrids samples **(Fig. 4.1)**, of which 35 were significant. Majority of the compounds belonged to flavonoid glucosides, which were down-regulated 48 hrs after infestation by the pest. The highly downregulated metabolites were dihydrocaffeic acid 3'-O-glucuronide (Log_2 fold change -2.67) in BML 7 and epicatechin 3'-O-glucuronide (Log_2 fold change -2.43) in DHM 117.

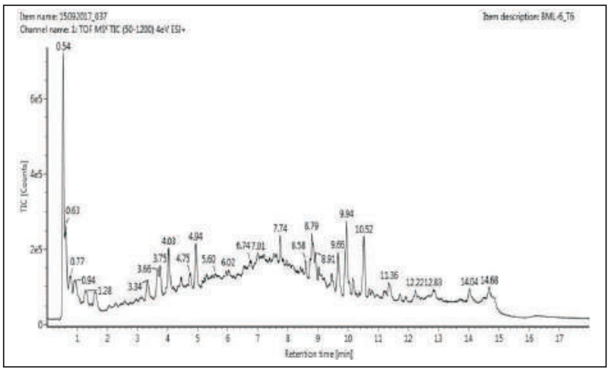

Figure 4.1: Total ion chromatogram of the soluble metabolites of *Sesamia inferens* infested plants of susceptible inbred line BML 6

Disease management

Efficacy of newer fungicides against common rust

Six fungicides, *viz.,* azoxystrobin @ 0.05%, trifloxystrobin 25% + tebuconazole 50% @ 0.05%, propiconazole @ 0.1%, tebuconazole @ 0.05%, hexaconazole @ 0.1% and difenconazole @ 0.1 % were evaluated against common rust as foliar spray (test hybrid: HKI 536 YN). All the fungicides were found effective against common rust. However, trifloxystrobin 25% + tebuconazole 50% @ 0.05% was found the most effective (47.3% disease control) followed by propiconazole @ 0.1% (46.3% disease control) and tebuconazole @ 0.05% (45.3% disease control) with significant increase in yield. Azoxystrobin @ 0.05% was found least effective among the fungicides tested.

Efficacy of newer fungicides against TLB

Foliar application of eight fungicides, *viz.,* difenconazole @ 0.1%,propiconazole @ 0.1%, tebuconazole @ 0.1%, hexaconazole @ 0.1%, azoxystrobin 18.2% + difenconazole 11.4% @ 0.1%, pyraclostrobin @ 0.1%, fluxapyroxad + pyraclostrobin @ 0.2%, trifloxystrobin 25% + tebuconazole 50% @ 0.05% were tested against TLB on 900 M Super hybrid. Among these treatments, trifloxystrobin 25% + tebuconazole 50% recorded 68.8% TLB disease control efficacy and resulted in 40.9% increase in yield over untreated control followed by azoxystrobin 18.2% + difenconazole 11.4% @ 0.1% and tebuconazole @ 0.1%.

Efficacy of bioagents, fungicides and potash in control of post flowering stalk rot (PFSR)

Pseudomonas fluorescens @ 0.5% as seed treatment of test hybrid - 900 M Super, bioagent-fortified FYM (1:50) and spray @ 0.5% was effective in suppressing the PFSR. This treatment recorded significantly lower disease severity (36.2%) and maximum grain yield (60.3 q/ha). The treatment recorded 47.7% disease control and resulted in 21.3% increase in grain yield over untreated check. Nevertheless the treatments, local strains of fungal antagonists: *Trichoderma harzianum* Dharwad 1 (Local strain) and TH-3 (*T. harzianum*) @ 0.5% as seed treatment; incubated FYM (1:50) and spray @ 0.5% was also equally effective.

Efficacy of bio-agents and fungicides in control of RDM

Application of fungal antagonist TV-3 (*Trichoderma viride*) @ 0.5% as seed (Pratap Makka-3) treatment, bioagent-fortified FYM (1:50) and spray @ 0.5% checked RDM up to 63.0% with 78.4% increase in yield as compared to inoculated control whereas azoxystrobin @ 0.2% seed treatment and spray @ 0.15% gave 72.0% disease control with 91.0% yield increase.

Effect of bio-extracts/natural products on the incidence of MLB

Bio-extracts/natural products were evaluated for management of MLB at Delhi (CM 600), Karnal (HKI 1105) and Kalyani (Pan 6010) centres and data revealed that garlic cloves and neem extracts @ 10% were superior in controlling MLB disease up to 61.0% and 41.0%, respectively and provided up to 65.0% and 57.0% yield advantage.

Efficacy of cultural practices (leaf stripping) on severity of BLSB

Effectiveness of cultural practices like leaf stripping of lower leaves was tested at Karnal, Ludhiana, Pantanagar and Godhra centre on different cultivars and it was found that leaf stripping of lower leaves controlled severity of BLSB up to 12.9-55.0% with 8.1-45.3% increase of yield compared to inoculated unstripped checks.

Host-pathogen interaction between post-flowering stalk rot pathogens in maize

Post-flowering stalk rot of maize is an important and destructive disease of the country. The disease caused by soil borne pathogens and disease incidence recorded in India ranged from 10.0 to 42.0%. Following experiments for studying the host resistance were carried out:

Effect of various temperature ranges on inoculum of *Macrophomina phaseolina*

Thermal longevity of inoculum of *M. phaseolina* was tested at temperature ranging from 35^{0}C to 70^{0}C after mixing with soil. Pure cultures obtained from petri-plate of each incubation and maintained in separate petri-plates under normal conditions (28°C). Significant colour variation in Delhi isolate of *M. phaseolina* was observed after raising 5°C temperature in every incubation (**Fig. 4.2**). Virulence of the isolate after giving heat treatment was tested on 15-20 days old maize seedlings maintained in pots.

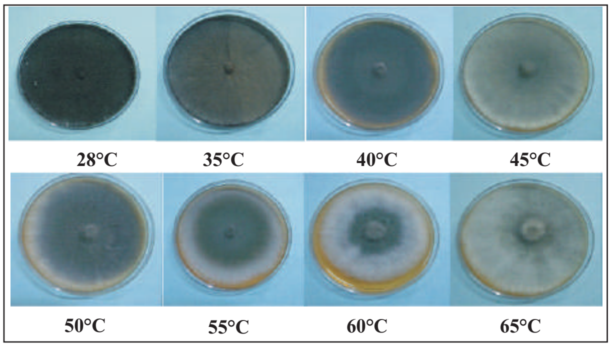

Fig. 4.2: The colour variations in Delhi isolate of *M. phaseolina* at raised temperatures

Virulence test of heat treated isolates of *M. phaseolina*

Maize plants exhibited significant changes in visual symptoms when inoculated with pathogen treated with temperature range of 28^{0}C to 45^{0}C compared to the plant inoculated with temperatures 60^{0}C and 65^{0}C **(Fig.4.3, 4.4,**

Inoculum treated with 30°C | **Inoculum with 35°C** | **Inoculum with 40°C**

Figure 4.3: Virulence test of *M. phaseolina* isolates treated at 30, 35 and 40°C.

Inoculum treated with 45°C | **Inoculum with 50°C** | **Inoculum with 55°C**

Figure 4.4: Virulence test of *M. phaseolina* isolates treated at 45, 59 and 55°C.

Inoculum treated with 60°C | **Inoculum with 65°C** | **Uninoculated healthy plant**

Figure 4.5: Virulence test of *M. phaseolina* isolates treated at 60 and 65°C. The uninoculated check is shown on the right.

and 4.5). However, there is no significant effect on root branching, seedling height, shoot girth of inoculated plants.

The culture growth of *M. phaseolina* was significantly affected by varying temperatures. Further on culturing these heat treated inocula back into normal condition exhibited colour shades differentiation (**Fig. 4.2**). Study revealed that, fungal inoculum can survive up to 65^{0}C in soil, however, the culture growth is reduced with the temperature increases on PDA. Virulent behaviour of pathogen observed at temperatures 35-45^{0}C. Among the temperatures tested, 35^{0}C was the most favorable by exhibiting maximum disease symptoms followed by 40ºC. Above this, fungal growth was suddenly decreased and at 65ºC only single colony was observed at 10^{-1} dilution. As far as virulence is concerned, it is reduced with temperature increases.

Determination of toxicity of culture filtrates of *M. phaseolina* at different dilutions

Thirty days old liquid broth culture of *M. phaseolina* was maintained and diluted to 10, 20 and 30% dilution in distilled water. The soils of experimental pots was inoculated with 100ml of these dilutions separately in triplicate and maintained healthy control separately. The effect on 10 days old seedlings was studied. Observation was recorded on various parameters *viz.*, root branching, plant hight, shoot girth, lemina width, and visual symtoms on plant at 7^{th} days interval. No significant observation was recorded in respect to root branching, plant height and shoot girth, however at 30% dilution significant difference was recorded on lamina width and plant visual symptom **(Fig. 4.6)** compared to untreated control.

At 10% concentration Mild yellowing symptoms at the tip of leaves | At 20% concentration yellowing of leaves and tip burning symptoms | At 30% concentration symptoms of yellowing and leaf drying

Fig 4.6: Visual symptoms rating (1-9 scale)

The present investigation suggests adaptability of the pathogen to wide range of temperature. Maximum temperature tolerance was recorded at 65°C, though at this temperature the pathogenicity is reduced. However, survival of pathogen at this temperature is quite alarming. It implies that the predicted global warming is likely to increase the range and severity of charcoal rot disease caused by *M. phaseolina*.

5

EXTENSION AND OUTREACH

The demonstration of the improved technology at the farmers' field and training is most important for translation of the research into impact. In this endeavour, the improved maize technologies were demonstrated at the farmers' field and trainings were imparted to the farmers on the best crop management and value addition in maize though TSP, NEH and frontline demonstration under NFSM.

Front Line Demonstrations

The institute is providing extension services to the nation through organizing Front Line Demonstrations (FLDs), field days, trainings etc. The institute organized FLDs in collaboration with different AICRP centres spread across the country under National Food Security Mission (NFSM) project of Ministry of Agriculture and Farmers Welfare, Government of India. Under NFSM, 50 ha FLDs in *rabi* 2016-17, 35 ha FLD in spring 2017 and 98.2 ha FLDs in *kharif* 2017 were conducted in maize. These FLDs were conducted by 19 different centres under AICRP on maize including IIMR and its regional stations and the FLDs were spread across 15 states. All promising technologies, *viz.*, single cross hybrids, specialty corn, intercropping, weed management, foliar application of micronutrient etc. were demonstrated at farmer's field benefitting 468 individuals. The yield gaps in FLDs vis-a-vis farmer's practices varied across the seasons and the states **(Table 5.1)**. On an average the yield gaps compared to farmer practices were 41% (15% - 98%), 22% (10% - 59%) and 41% (20% - 65%), respectively, during *kharif* 2017, *rabi* 2016-17 and spring 2017.

Demonstration of the Vivek Hybrid Maize 45 in Uttrakhand during *kharif* 2017

A good crop in demonstration in Kokhrajar at Assam during *rabi* 2016-17.

Table 5.1: Seasonal variation in the yield-gaps observed at farmer's field in maize cultivation in various states during 2016-17.

Sl. No.	Name of the state	Av. Yield kg/ha in FLDs (state-wise)	Av. yield kg/ha in local check (state-wise)	Yield gains (%)
		***Rabi* 2016-17**		
1.	Telengana	5414.5	4250	27.4
2.	Assam	3333	2099	58.8
3.	Bihar	7120	5908	20.5
4.	Karnataka	6398	5318	20.3
		Spring 2017		
5.	Manipur	2401	1451	65.5
6.	Uttar Pradesh	4200	3500	20.0
7.	Meghalaya	2500	1800	38.9
8.	Haryana	6060	3993	51.8
		***Kharif* 2017**		
9.	J&K	5362	3259	64.5
10.	Uttarakhand	5010	3100	61.6
11.	Bihar	4570	3882	17.7
12.	Rajasthan	3707	2041	81.7
13.	Gujarat	3275	2097	56.2
14.	Chhattisgarh	3717	2011	84.8
15.	Uttar Pradesh	4161	3630	14.6
16.	Madhya Pradesh	4150	3238	28.2
17.	Tamil Nadu	7209	5997	20.2

Tribal-Sub Plan

Tribal Sub Plan (TSP) Scheme is a programme funded by Government of India to uplift the economic condition of tribal farmers. The institute implemented TSP programme in maize in various tribal belts across the country through approved expenditure of Rs. 28 lakhs. The various activities performed under TSP scheme were demonstration of latest maize technologies at tribal farmer's field, regional level training for tribal farmers, input distribution, field days etc. The farmers were not only trained on the aspects of good production practices of maize but also on the value addition as well. In TSP demonstrations yield improvements over existing farmer practices of 22-36% at Jhabua (Madhya Pradesh) and 42-133% at Banswara (Rajasthan) were recorded. Twenty-eight demonstrations (0.5 acre plot each) were conducted in TSP programme by selecting 28 ST farmers from Srikrishnapur village, Ashoke Nagar Thana, 24 Parganas (N) district with the help of Assistant Directors of Agriculture. Trainings are important component of TSP

Officer training programme conducted by Srinagar centre

programme. During the reported period, a total of seven training programmes were organized under TSP scheme benefitting 865 farmers **(Table 5.2)**.

Various inputs including hybrid seed, knapsack sprayer, maize sheller, tarpaulin, and power operated sprayer etc. were distributed under TSP programme **(Table 5.3)**.

Table 5.2: Training conducted by AICRP on maize centres under TSP programme.

Sl. No.	Title	State	Date	Beneficiaries
1.	Maize production technology	Srinagar	29.08.2017 30.08.2017	100 100
2.	Maize production technology Maize production technology, popular hybrids and value addition	Vagarai	27.12.2017 24.01.2018	50 50
3.	Maize production technology	Chhindwara	25.02.2018 21.03.2018 29.03.2018	117 129 93
4.	Maize production technology	Ambikapur	20.03.2018	100
5.	Maize production technology	Hyderabad	28.02.2018	26
6.	Crop production, crop protection, specialty corns, seed production	Kalyani	21.02.2018	50
7.	Crop production, crop protection, specialty corns, seed production	Kalyani	13.03.2018	50
		Total		**865**

Five field days were conducted during 2017-18 under TSP by four AICRP centres benefitting 512 farmers **(Table 5.4)**

The TSP programme of IIMR was implemented in collaboration with SKUAST, Srinagar centre. Under this, 113 demonstrations (1.0 acre plot each) were conducted in the fields of 25 ST farmers each from three districts, *viz*. Budgam, Pulwama and Srinagar, and 38 farmers from Ganderbal district. Under this programme seed, fertilizer, tarpaulin were distributed among target beneficiaries (800kg seed of Shalimar Maize Hybrid-2 (SMH-2) and 10 kg of Sugar-75, 5000 kg urea, 4000 kg DAP, 1500 kg MOP, were distributed free of cost among farmers). Beside these, five tarpaulin were issued to tribal farmers on community basis for drying of their maize produce.

Scientists of AICRP centre Srinagar visited the TSP plots to interact with farmers regarding maize production techniques and discussed the maize production technologies particularly for seed production, weed management and introduction of specialty corn. Farmers were highly satisfied with the performance of SMH-2 and maize production technologies developed by SKUAST-Kashmir.

Table 5.3: Inputs distribution under TSP programme.

Sl. No.	Distributed items	Total
1.	Seed	2500 kg
2.	Urea	17030 kg
3.	DAP	11667 kg
4.	MOP	5061 kg
5.	Atrazine	35 kg
6.	HDPE flexible pipe	21 Nos
7.	Fiber bandali	44 Nos
8.	Frying pan + Frying ladle	44 Nos
9.	Tarpaulin	50 Nos
10.	Hand sprayers	3 Nos
11.	Spades	6 Nos
12.	Hand hoe	11 Nos

Table 5.4: Field days conducted by AICRP Maize centres under TSP.

Sl. No.	Centre	Date	Beneficiaries
1.	SKUAST, Srinagar	24th August, 2017 7th September, 2017	102 150
2.	IGKVV, Ambikapur	25th February, 2018	110
3.	TNAU, Vagarai	7th March, 2018	100
4.	BCKV, Kalyani	13th March, 2018	50


Field day and demonstration at Jhabua centre (Madhya Pradesh)

Training programme and seed distribution at Ambikapur (Chhattisgarh)


Training under TSP on value addition at Mandya (Karnataka)

Seed distribution by Hyderabad centre

Training programme at BCKV, Kalyani

Impact of TSP programme: There was a clear impact on production of maize in demonstrated plots (22.7q/acre) with the yield increase 77.03% over check plot (12.8q/acre) by adoption of improved package of practices **(Table 5.5)**.

Maize promotion in North East Hill (NEH) region

The institute implemented a pilot project in collaboration with ICAR Manipur centre under NEH fund of the institute sanctioned by ICAR during 2017-18. Objective of this pilot project was to promote maize cultivation in NEH region. Under this, 8 training programmes were conducted benefitting total 562 farmers of which 333 were female **(Table 5.6)**. Inputs were distributed to 379 farmers in 9 districts of Manipur under this programme for conduct of 178.5 ha FLDs **(Table 5.6)**. QPM technology was demonstrated at various places in NEH, as given in **Table 5.7**.

The seed was given to the farmers @ 20 kg/ha. Total seed distributed was 3550 kg among 379 beneficiaries. Total fertilizers in the form of Agrilime: 500 bags; Vermicompost: 4.0 tonnes; Urea: 150 bags; Single Super Phosphate (SSP): 148 bags; Rock phosphate: 101 bags; Muriate of Potash (MOP): 120 bags; *Azotobacter*: 200 kg;

Table 5.5: Major changes in maize cultivation as impact of TSP programme at J&K.

Before TSP programme	Impact of the TSP programme
Using high seed rate (60 kg/ha)	Use of optimum seed rate (20 kg/ha for hybrid and 30 kg/ha for composites)
Adopted high plant population 1,50,000 plant/ha)	Optimum plant population (80,000 plants/ha) was maintained.
Applied only urea	Awareness was created on use of balanced dose of NPK.
No knowledge about the use of pre-emergence herbicides	Timely pre-emergence and post-emergence herbicides were applied, which helped in reduction of cost of cultivation.
No knowledge about the use of pesticides	Timely management of pest and diseases was done by farmers, particularly stem borer, which helped to achieve good harvest.

Table 5.6: Training programmes and workshops conducted in NEH region

Sl. No.	Title	Venue	No. of participants Male	Female	Total	Date of training
1	Promoting improved technology of maize production in NEH region	Monsangpantha, Chandel district	18	27	45	5-6th February, 2018
2	Promoting improved technology of maize production in NEH region	Pearsonmun village, Churachandpur district	17	31	48	9-10th February, 2018
3	Promoting improved technology of maize production in NEH region	Noney, Tamenglong district	23	63	86	23-24th February, 2018
4	Promoting improved technology of maize production in NEH region	Sinakeithel village, Ukhrul district	3	47	50	12-13th March, 2018
5	Two days training programme on maize production in NEH Region	Ukhongshang, Thoubal district	56	62	118	23-24th March, 2018
6	Promoting improved technology of maize production in NEH region	KanglaSiphai, Imphal East	29	35	64	24-25th March, 2018
7	Promoting improved technology of maize production in NEH region	Luireishimphung, Ukhrul	20	20	40	24-25th March, 2018
8	Maize for North East: emerging trends and technologies transformation to farmers field	ICAR RC for NEH Region, Lamphelpat, Imphal	63	48	111	28th February 2018
		Total	**229**	**333**	**562**	

Azospirillum: 200 kg; Phosphorus Solubilizing Bacteria (PSB): 300 kg; *Metarhizium* bioinsecticide: 450 kg and Neem insecticide: 44 litres, distributed among 379 beneficiaries covered in 9 districts of Manipur. Fertilizers were distributed in participatory mode, with 50% of the recommended dose of fertilizers borne by farmers themselves.

Table 5.7: Demonstration of QPM technology in NEH

District covered	Location covered	No. of beneficiaries	Area demonstrated (ha)
Churachandpur	**24 villages** (Salbung, Hengkot, Maovom, Tuihong, T. Zouzang , Tuibrung, Matalambulane, T. Joujang , Telsing Bazar, L. Khengjang, Gangpijang, K. Hengnmol, B. Vengnom, Siden, Monofenphei, Thongkholni, Yaiphakol, Meralpi, Saehenjang, Nghathal, Tallian village, Sainoujang village, New Lamka, Tuili village, Singngat)	72	41
Chandel	**10 villages** (Pangchai, Palhai, Abungnikhu, Pasana, Riverlane, Chandonpokpi, Prumchubang, Plemchubom, Chandel village, Christian, Duthang)	45	35
Tamenglong	**11 villages** (Longmai I, Longmai II, Longmai III, Longmai IV, Longmai V, Longmai Bazar, Pongailong, Rangkhung, Abungchiang II, Khuniji, Thanagong)	40	20
Bishnupur	**1 village** (Kwasiphai)	2	1
Imphal East	**3 villages** (Nongpok Heirok, Kangla Siphai , Kangla Sangomsang)	15	5.25
Imphal West	**12 villages** (Awang Sekmai, Kanglatongbi, Tispari Kanglatongbi, Kanglatongbi Mantriband, Hatikhuwa Kanglatongbi, Kanglatongbi Hatikhuwa, Kachikhul, Tengdongyang, Maidangpok, Ngairangbam, Heigrujam, Phumlou Mayai)	25	15
Thoubal	**2 villages** (Ukhongshang, Hijamkhunou)	25	12.5
Ukhrul	**2 villages** (Luireishimphung village, Sinakeithei village)	90	32.5
Senapati	1 (Purul village)	65	16.25
	Total	379	178.5


Training programme at Monsangpantha village, Chandel

Training programme at Pearsonmun village, Churachandpur


Training programme at Noney village, Tamenglong


Training programme at Sinakeithei village, Ukhral

Training programme at Ukhongshang village, Thoubal


Training programme at Kangla Siphai village, Imphal East


Training programme at Luireishimphung village, Ukhrul

Regional workshop on "Maize for North East: emerging trends and technology" organized at Manipur Centre, Lamphelpat, Imphal

Media coverage of NEH activities

Need to introduce HQPM in NE underscored

By Our Staff Reporter

IMPHAL, Feb 28: A one-day regional workshop on "Maize for North East: Emerging Trends and Technology" was inaugurated by Dr N Prakash, Director, ICAR Research Complex for NEH Region, Meghalaya; Dr C A Srinivasamurthy, Director Research, CAU, Imphal; Dr I Meghachandra Singh, Joint Director and Dr MA Ansari, Scientist, ICAR Manipur Centre as chief guest, guest of honour, president and organising secretary respectively.

The workshop was jointly organised by ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat and ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana.

Addressing the gathering, Dr Prakash underscored the need to introduce the suitable high yielding varieties of High Quality Protein Maize (HQPM) in the region. He said that the high yielding varieties (HYV) of maize is widely adopted in other parts of country but in the NEH region, most of the farmers are growing low yielding local varieties and they are affected by fluctuation in climatic trends.

Dr Srinivasamurthy said that maize grains are not only important for human consumption but it also provides integral feed for major feed resources in the North East and other parts of the country for poultry and other livestocks.

Dr Meghachandra gave emphasis on HQPM having opaque-2 mutant gene, which is particularly responsible for enhancing lysine and tryptophan content of maize endosperm protein. Quality protein maize looks and tastes like normal maize with same or higher yield potential, but it contains nearly twice the quantity of essential amino acids, lysine and tryptophan, which makes it rich in quality proteins. Other than QPM, traditional cultivars have fewer amounts of these amino acids, he explained.

The dignitaries also highlighted the introduction of baby corn and sweet corn which have high potential in North East States. During the occasion, the dignitaries released a publication on baby corn cultivation, sweet corn cultivation, HQPM cultivation and maize fodder production under hydroponics.

A total 120 participants including progressive farmers, representative from various farmers' clubs and NGOs, officers from ICAR KVKs of Chandel, Churachandpur, Imphal West, Tamenglong and Ukhrul and scientists of ICAR participated in the workshop.

2 days training programme on HYV maize starts

CHANDEL, Feb 5

ICAR Research Complex for NEH Region, Manipur Centre, Imphal and KVK Chandel kisckstarted a two day 'Training cum input injection programme on promoting improved technology of maize production in NEH Region' at Monsangpantha Village, Chandel district.

The training programme organised by ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal and Krishi Vigyan Kendra, Chandel under the sponsorship of ICAR- Indian Institute of Maize Research, PAU Campus, Ludhiana, Punjab will continue till Feb 6.

The inauguration today was graced by the Senior Scientist and Head, KVK Chandel; Principal Investigator of the project Dr MA Ansari, Scientist, Agronomy, ICAR Research Complex for NEH Region, Manipur Centre, Imphal and Er L Kanta Singh, ACTO, KVK Imphal West.

Dr KL Levis Chongloi, ACTO, KVK Chandel delivered the key note address.

Addressing the gathering, the dignitaries at the event emphasized on the introduction of suitable high yielding varieties of maize in the hilly regions.

Successful maize production in the North Eastern Himalayan Region depends on the correct choice of genotypes of maize and applications to sustain the environment as well as agricultural production since the region have complex climatic variability which is different from other parts of the country, said experts at the event.

High yielding varieties (HYV) of maize are widely adopted in other parts of country, but in the NEHR, most of the farmers are growing low yielding local varieties. Maize grains are not only important for human consumption but is also an integral feed for poultry and other livestocks. Farmers in NEH region need to adopt pre kharif maize cropping system which will increase the production as compared to traditional mono-cropping system currently adopted by farmers, stated the experts.

The team of scientists delivered lectures on cultivation practices- fertilizer management, soil management.

During the programme the ICAR, Manipur centre distributed quality seeds of maize (HQPM 1 and 5) for 35 hill areas. More than 50 farmers attended the training programme.

Mera Gaon Mera Gaurav (MGMG)

The institute and its regional stations implemented the MGMG programme in 24 villages adopted in the Sonipat (Haryana), Banswara (Rajasthan), Ranga Reddy (Telengana), Begusarai (Bihar), Hoshiarpur and S.B.S. Nagar (Punjab) districts across the country. Seven team of scientists were in regular touch with the farmers of these villages through visits, phone calls and messages. The farmers were also given information on the best management practices in maize, cultivar selection, lowering of ground water (need of water conservation) and adoption of conservation agriculture to check the decreasing soil fertility and productivity besides government mission on Swatchh Bharat and Crop Insurance and importance of Soil Health Cards. Summary of beneficiaries under MGMG programme is given in **Table 5.8**, details of demonstrations conducted under MGMG by Institute are given in **Table 5.9** and input support by Institute is given in **Table 5.10**.

Distribution of maize seed to farmers of Burjugadda Thanda village, Ranga Reddy district, Telangana under MGMG programme

Table 5.8: Summary of beneficiaries by interface meetings, literature and advisory support to the farmers under MGMG programme.

Name of activity	No. of activities conducted	No. of farmers participated/ benefitted
Visit to village by teams	4	40
Interface meeting/ Goshthies	1	20
Mobile based advisories	121	176
Literature support provided	40	40
Awareness created	7	136
Linkages developed with other agencies	5	161

Scientist-Farmer interaction meeting at Jhundpur, Sonipat (Haryana)

Interaction of MGMG team on the farmer's field having adopted baby corn + fenugreek intercropping at Jhundpur, Sonipat (Haryana)

Table 5.9: Details of demonstrations conducted under MGMG by the Institute

Title of demonstrations	No. of demonstration	Area covered under demonstration (ha)/ number of units, etc.)	No. of farmers benefitted
Single cross hybrid maize (DHM 117)	25	10	25
Single cross hybrid maize (DHM117, COHM (6), P 3396, P 3546)	20	8	20
Single cross hybrid maize (DKC 9108)	25	10	25

Maize farmers and scientists watched live honourable Prime Minister's address

On March 17, 2018 the address of Honorable Prime Minister of India, Shri Narendra Modi Ji in the Krishi Unnati Mela at Pusa, New Delhi, was shown live to 450 maize farmers by IIMR along with research scientists and public representatives at Begusarai and Srinagar.

Farmers watching live address of PM Shri Narendra Modi at Begusarai and Srinagar

Makka Kisaan Mela 2017

ICAR-Indian Institute of Maize Research (IIMR), Ludhiana organized a "Makka Kisaan Mela" at Ladhowal farm on 7th October, 2017. On this occasion, Dr. A.K. Singh, Deputy Director General (Horticulture and Crop Sciences), ICAR was the Chief Guest. Dr. B.S. Dhillon, Vice Chancellor, Punjab Agricultural University also graced the occasion. Among other dignitaries present were Dr. Sujay Rakshit (Director, ICAR-IIMR), Dr. Rajbir Singh (Director, ICAR-ATARI), Dr. N.S. Bains (Director Research, PAU), Dr. K.S. Thind (Additional Director Research, PAU), Dr. G.S. Buttar (Additional Director Extension, PAU), Dr. K.B. Singh (Director, University Seed Farm, Ladhowal), Dr. J.S. Chawla (Senior Maize Breeder, PAU), Dr. Baldev Singh (Chief Agricultural Officer) and Dr. Subhash Chaoudhary (Agricultural Officer, Gadshankar). The event was attended by more than hundred progressive maize farmers, who came from various maize-growing areas across Punjab like Pathankot, Nawashehar, Hoshiarpur, Ludhiana etc. The scientific and technical staff of ICAR-IIMR were also present and interacted with the farmers.

Table 5.10: Details of Input support provided under MGMG by the Institute.

Type of Input Support Provided (Seed, planting material, technology, fertilizers, etc.)	Quantity (Kg/No.)	Area (ha)	No. of farmers benefitted
DHM 117	200 kg	10	25
DHM117, COHM(6), P 3396, P 3546	160 kg	8	20
DKC 9108	200 kg	10	25

Participants during Makka Kisan Mela organized at Ludhiana

Farmer's Field Day

A farmer field day on, "Maize hybrid technology and its seed production" was organized on March 17, 2018 at Regional Maize Research and Seed Production Centre of ICAR-Indian Institute of Maize Research, Kushmahaut, Begusarai. A total 350 farmers attended the programme. Dr. Bhola Singh, Honorable Member of Parliament (Lok Sabha) Begusarai was the chief guest of the programme. He appreciated the progress in maize development and seed production of the centre. Other Government officers, besides the IIMR staff attended the gathering.

Farmer's Field Day at Begusarai.

Tribal Maize Day

A tribal maize day was organized by ICAR-IIMR in collaboration with AICRP Maize Srinagar Centre on March 17, 2018 at ICAR-CITH Srinagar. The programme was chaired by Professor M. Y. Zargar, the Director Research of SKUAST-K along with other 22 scientists and officials of SKUAST-K, ICAR-CITH, regional center of ICAR-NBPGR and ICAR-IGFRI at Srinagar. A total of 100 tribal farmers attended the tribal day. During the programme, inputs were also distributed among the tribal and farmers under TSP programme of ICAR-IIMR.

Important events

5th India Maize Summit 2018

The 5th India Maize Summit was organized at Federation of Indian Chambers of Commerce & Industry (FICCI), New Delhi on March 23, 2018. ICAR-IIMR was co-organizer of the event. The summit was graced by Shri Radha Mohan Singh, the Honorable Union Minister of Agriculture and Farmers Welfare. He emphasized the importance of ICAR-IIMR, Ludhiana to carry out basic, strategic and applied research for enhancing production, productivity and sustainability of the crop and also mentioned the contributions of ICAR-IIMR in technological advancements in maize cultivation. On this occasion the minister also released a report on 'Maize Vision 2022'. The Summit also witnessed the energetic presentations and panel discussions by think tanks of the foreign, government and private sectors. The notable speakers included Dr. Prem Kumar, Minister of Agriculture, Govt. of Bihar; Dr Ashok Dalwai, CEO, National Rainfed Area Authority (NRAA); Mr Kurt Shultz, Senior Director-Global Strategies, US Grains

Council; Dr. Sujay Rakshit, Director, ICAR-IIMR among others.

The focus of the summit was the state of Bihar, where the technological interventions needed to optimize the value chain was discussed. It was emerged that farm-gate driers are the immediate need of the state as the farmer sell the product at 20-25% moisture level, while the commodity exchange need a produce with 14% moisture level or less. The experts were also in the opinion that minimum support price is only a psychological support to the farmer since maize won't be facing a market glut in near future, while optimizing the value chain will fetch a higher price for the commodity.

ICAR-SAU-Line Department Interface Meeting organized in Ludhiana

ICAR-SAU-Line Department Interface Meeting

An ICAR-SAU-Line Department Interface Meeting on 'Maize-based Diversification of Cropping System in Punjab' was held under the chairmanship of Dr. B.S. Dhillon, Vice Chancellor, Punjab Agricultural University, Ludhiana. The meeting was attended by more than 80 State Government officials and scientists of Krishi Vigyan Kendra (KVKs) of Punjab. The participants were addressed by the Director, ICAR-CIPHET & ICAR-ATARI, Zone-I, Director Research, PAU and Director, ICAR-IIMR. It came out the maize is the most suitable candidate crop which can replace rice in selected pockets and efforts should be made to sort out the constraints associated with its proliferation. Fodder maize has immense potential to support the dairy industry in Punjab.

6 AICRP on Maize

An All India Coordinated Research Project (AICRP) on maize was started in 1957. The objectives of the program were focused to development and dissemination of superior cultivars and also enhanced production and protection technologies. The country has been divided into five agro-climatic zones, based on agro-climatic conditions, as shown in **Fig. 6.1**. The AICRP on maize consists of 30 centres for varietal testing. A list of the involved centres with their location and soil characteristics is given in **Table 6.1**.

Figure 6.1: Map showing different agro-climatic zones of India.

Maize Breeding

Rabi 2016-17

During *Rabi* 2016-17, total 99 entries were received for multi-location evaluation in AICRP normal late, normal medium and quality protein maize (QPM) trials. Of 99

Table 6.1: Location and soil characteristics of AICRP on Maize centres.

Zone	States	Centres	Latitude	Longitude	Altitude (masl)	Soil Type
NHZ	Himachal Pradesh	CSK, Himachal Pradesh Krishi Viswavidhyalaya, Bajaura	33°22' N	77°0' E	1090	Grey wooded Podzolic soil
		Himachal Pradesh Krishi Viswavidhyalaya, Dhaulakuan	30 ° 30' N	77 °20' E	468.0	Brown alluvial and grey brown podzolic soil
		CSK, Himachal Pradesh Krishi Viswavidhyalaya, Kangra	32°6' N	76 °16' E	2404	
	Jammu and Kashmir	Sher-e-Kashmir University of Agricultural Science and Technology of Jammu, Udhampur, Jammu	32°56' N	75°8' E	2480	Sandy loam
		Sher-e-Kashmir University of Agricultural Science and Technology, Sringar	34°08'N	74°80E	2743	Alluvial
	Uttarakhand	Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora	29°37' N	79°40' E	1650	Clay loam
	North Eastern States	ICAR Research Complex for NEH region, Barapani	25°70' N	91°97' E	1500	Sandy loam
		Assam Agricultural University (AAU), Gossaigoan, Assam	26°45' N	94°13' E	91.0	Sandy loam
NWPZ	Punjab	Punjab Agricultural University, Ludhiana	30°54' N	75°51' E	247	Sandy,clay loam
	Punjab	Indian Institute of Maize Research, Ludhiana				
	Haryana	Chaudhary Charan Singh, Haryana Agricultural University, Uchani, Karnal	29°41' N	76°59' E	257	Loamy soil
	Delhi	Indian Agricultural Research Institute, Delhi	28°39' N	77°13' E	228	Loam to sandy loam
	Uttar Pradesh	Chandra Shekhar Azad University of Agricultural and Technology, Kanpur	26°28' N	80°21' E	125	Sandy loam
	Uttarakhand	Govind Ballabh Pant University of Agriculture and Technology.	29°6' N	79°30' E	243	Clay loam

NEPZ	Bihar	Rajendra Agricultural University, Dholi	25°54' N	85°36' E	51.8	Sandy loam
	Jharkhand	Birsa Agricultural University, Ranchi	23°21' N	85°20' E	652	Sandy loam
	Orissa	Orissa University of Agriculture and Technology, Bhubaneswar	20°14' N	85°50' E	45	Clay loam
	Eastern Uttar Pradesh	Banaras Hindu University, Varanasi	25°20' N	83°0' E	128.93	Sandy loam
		Narendra Dev University of Agriculture and Technology, Bahraich	27°35' N	81°36' E	130	Sandy loam
	West Bengal	Bidhan Chandra KrishiViswavidhyalaya, Kalyani, West Bengal	22°97'N	88°43'E	16	Alluvial
PZ	Karnataka	University of Agricultural Sciences, Bangalore, Mandya	12°33'N	76°54' E	695	Light red sandy loam
		University of Agricultural Sciences, Dharwad, Arbhavi	16°13' N	74°48' E	640	Black soil; Medium black
	Telangana	Professor Jayshankar Telangana Agricultural University, Hyderabad, Telangana	17°23'N	78°29' E	530	Black Clay loam
		Professor Jayshankar Telangana Agricultural University, Karimnagar, Telangana	18°26'N	79°9' E	869	Red sandy-loamy
	Tamil Nadu	Tamil Nadu Agricultural University, Coimbatore	11°0'N	76°58' E	411.5	Black
		TNAU, Vagarai	10° 35' N	77° 34' E	926	Black
	Maharashtra	Kolhapur	21°0' N	77°52' E	574	Light to medium black
CWZ	Rajasthan	Maharana Pratap University of Agriculture and Technology, Banswara	23°33' N	74°27' E	218	Red loam
		MPUA &T, Udaipur	24°35' N	73°41' E	572	Loam to sandy loam
	Gujarat	Anand Agriculture University, Godhra	22°45' N	73°38' E	119.4	Sandy loam
	Madhya Pradesh	Jawaharlal Nehru Krishi Viswavidhyalaya, Chhindwara	22° 4' N	78° 56' E	682	Medium clay
		Rajmata Vijayaraje Scindia Krishi Viswavidhyalaya, Jhabua	22°46' N	74°36' E	318	Clayey to Sandy
	Chhattisgarh	RMD College of Agriculture and Research Station, Ajirma, Ambikapur	23°7' N	83°12' E	1978	Sandy loam

test entries, 75 entries were evaluated in NIVT, 11 in AVT-I, 9 in AVT-II and 4 entries in QPM trials. Total seven different breeding trials were constituted and put for evaluation at 20 test centres across the four zones. The success rate of each zone was calculated based on trials allotted versus reported and overall it was 93.6% for Rabi 2016-17 breeding trials. The highest success rate of 100% was reported in NEPZ and lowest in NWPZ (75%). The zone wise details of success rate in reporting data is given in **Table 6.2**.

There were 90 entries available for promotion during *rabi* 2016-17, out of which only 33 entries got promoted to their advance stage of testing. The trial wise detail of number of entries promoted from *rabi* 2016-17 to *rabi* 2017-18 is given in **Table 6.3**.

Kharif 2017

During *kharif* 2017, 375 maize entries were evaluated in all India coordinated trials. Of 375 entries, 212 entries were evaluated in national initial varietal trial (NIVT), 47 in advance varietal trial-I (AVT-I), 8 in advance varietal trial-II (AVT-II), 38 entries in (QPM) trial, and 34 in specialty corns trials (10 in baby corn, 11 in sweet corn, and 13 in popcorn trials). Inrainfed trials, 6 entries late, 19 in medium, and 7 in early group were evaluated. Besides these, 4 were also tested in OPVs. Of total entries received, 273 were contributed from public and

Table 6.2: Zone wise details of success rate of AICRP Trials in *rabi* 2016-17

Zone (s)	Centers	Trials allotted	Trial Reported	Percent Success
NWP Z	Ludhiana, Karnal, Kanpur, Pantnagar	28	21	75.0
NEP Z	Dholi,Ranchi, Bhubaneshwar, Bahraich, Varanasi , Sabour, Kalyani	49	49	100.0
PZ	Rahuri, Mandya Dharwad, Karimnagar, Coimbatore, Vagarai, Kolhapur	49	47	95.91
CWZ	Banswara, Godhra	14	14	100.0
Over all		**140**	**131**	**93.57**

Table 6.3: Trial wise details of number of entries promoted from *rabi* 2016-17 to *rabi* 2017-18

Sl. N	Trial	Entries Evaluated	Entries Promoted	Percent Promoted
1	NIVT Late	44	25	61.36
2	NIVT Medium	31	6	19.35
4	AVT I Late	8	Nil	00.0
5	AVT I Medium	3	2	66.6
7	QPM	4	NA	00.0
	Total	**90**	**33**	**36.6**

102 by the private sector. Seventeen breeding trials (three each of NIVT, AVT-I, AVT-II, and specialty corn and one each in QPM, OPV, rainfed late, medium and early) were constituted for evaluation at 57 locations (34 regular and 23 volunteers) across country. The different breeding trials were organized at 11 test locations in NHZ, 7 in NWPZ, 8 in NEPZ, 17 in PZ and 14 test locations in CWZ. All entries were tested under three maturity groups, *viz.*, late, medium, and early (extra early entries were clubbed in early trial). The success rate of NWPZ for reporting of trials was highest (80.9%)

Table 6.4: Zone wise details of success rate of AICRP Trials in *kharif* 2017

Zone (s)	Centers	Trials allotted	Trials Reported	Percent Success
NHZ	Srinagar, Almora, Bajaura, Barapani, Kangra, Gossaingaon, Udhampur, Poonch, Dhaulakuan, Rajauri, Imphal,	64	43	67.2
NWPZ	Ludhiana, Karnal, Delhi, Kanpur, Pantnagar, Aligarh, Kapurthala	47	38	80.9
NEPZ	Dholi, Ranchi, Bhubaneswar, Varanasi, Bahraich, Sabour, Kalyani, Koraput,	52	33	63.5
PZ	Arabhavi, Mandya, Karimnagar, ShegalFou, Hyderabad, Coimbatore, Vagarai, Kolhapur, Dharwad,VRDC KSSC, Devihosur, Almel, Belavatagi, Dhule, Parbhani, Nasik, Rahuri,	128	94	73.4
CWZ	Udaipur, Banswara, Chindwara, Ambikapur, Godhra, Jabhua, Bhiloda, Dahod, Raipur, Jagadalpur, Ujjain, Indore, Kota, chittarkoot,	111	73	65.8
Overall		**402**	**281**	**69.9**

and of NEPZ was lowest(63.5%) with an average of 69.9%. The details success rate of reporting the data from each zone is given in **Table 6.4**.

Out of total 375, 352 entries were available for promotion, of which only 97 entries were got promoted from *kharif* 2017 to *kharif* 2018 in different maturity group. The details of numbers of entries evaluated and promoted during *kharif* 2017 in various trials have been given in **Table 6.5**.

Maize Agronomy

The major agronomic research areas during *kharif* 2017 were

- Optimization of fertilizer dose and planting density for different maturity pre-released and notified maize hybrids,
- Precision nutrient management, site specific nutrient management (SSNM) for maize hybrids and tillage practices,
- Weed management in maize,
- Enhancing water-use efficiency in rainfed maize,
- Long term trial on integrated nutrient management, and
- Ecological intensification for climate resilient maize systems

Table 6.5: Trial wise details of number of entries promoted during *kharif* 2017

Sl. No	Trial	Entries evaluated	Entries Promoted	Percent promoted
1	NIVT-Late Maturity	81	26	32.1
2	NIVT-Medium Maturity	97	24	27.4
3	NIVT-Early Maturity	34	7	20.6
4	AVT-I–Late Maturity	19	4	21.1
5	AVT-I-Medium Maturity	20	6	30.0
6	AVT-I-Early Maturity	8	0	0.0
7	AVT-II-Late Maturity	2	NA	--
8	AVT-II-Medium Maturity	3	NA	--
9	AVT–II Early Maturity	3	NA	--
10	QPM 1-2-3	38	12	31.6
11	Popcorn-1-2-3	13	4	12.9
12	Sweet Corn-1-2-3	11	2	18.2
13	Baby Corn-1	10	2	20.0
14	Rainfed trials-Late	6	2	33.3
15	Rainfed trials-Medium	19	3	17.6
16	Rainfed trials-Early	7	3	42.8
17	OPV	4	2	50.0
	Total	**375**	**97**	**25.9**

Evaluation of pre-release genotypes under varying planting density and nutrient levels

In *kharif* season (2017), a total of 8 pre-release genotypes of different maturity groups were evaluated with 7 national checks under two densities and two nutrient levels (200:65:80, 250:80:100 N:P2O5:K2O kg/ha). The early genotypes DMRH 1305 and FH 3754 responded to higher nutrient level (250:80:100 N: P2O5: K2O kg/ha) with high plant density (1, 00,000) over best check (PMH 5 and Prakash) in NHZ. In Central Western Zone, JKMH 4222 responded to lower nutrient level (200:60:80 N: P2O5: K2O kg/ha) at Jhabua and to higher nutrient level at Udaipur over best checks (PMH 5, Prakash). This shows that there is need for having customized Package of Practice for individual hybrid, rather than going for blanket recommendation.

In *rabi* 2016-17, a total of 9 pre-release late and medium-maturing hybrids were evaluated and response was found with higher dose of 250:95:95 N:P2O5:K2O kg/ha and at high density. Experiments on nutrient management in maize based cropping system under different tillage practices have also shown encouraging results. Adoption of either Zero Tillage (ZT) or Conventional Tillage (CT) along with Site Specific Nutrient Management (SSNM) or Recommended Dose of Fertilizer (RDF) gave highest system productivity of maize-wheat-cowpea sequence, system net returns and Benefit to Cost (B:C) ratio, which shows that ZT and SSNM could be alternative for CT and RDF, respectively.

Weed management in maize systems

In the third consecutive year for finding best post emergence herbicide, it was found that Atrazine @ 1.5 kg/ha pre-emergence followed by Tembotrione (Laudis) @ 120 g/ha Post Emergence at 25 DAS was effective at 17 locations, while Atrazine @ 1.5 kg/ha pre-emegence followed by Halosulfuron 60 g/ha 25 DAS found to be effective for weed management in *kharif* maize at three locations, namely Srinagar, Bahraich and Hyderabad.

Long term trial on integrated nutrient management in maize- wheat cropping system

To explore the possibilities of integrated nutrient management by inclusion of organic sources in maize production, a long term experiment was initiated during *kharif* 2014 at Pantnagar. After completion of four years of experimentation, highest net returns (Rs. 114659) and BC ratio (2.35) of the system was obtained in the Maize + Cowpea with FYM 10 t/ha + *Azotobactor* application in maize-wheat cropping system which is based only on the organic nutrient sources.

Ecological intensification for climate resilient maize systems

This experiment was initiated in *kharif* 2017 with the objective to develop the ecological intensification practice that could improve the current farmer practices in the identified cropping systems, while reducing the climate risk. In first year, by adoption of ecological intensification, yield was significantly increased at all locations in the range of 1.6 % (Karnal) to as high as 131% (Bajaura). Out of 15 locations, at 7 locations (Bajaura, Karnal, Ludhiana, Ranchi, Dharwad, Karimnagar and Chhindwara), lack of nutrient management caused significant yield reduction. At 4 locations (Coimbatore, Ambikapur, Banswara and Udaipur), weed management played most important role, as its lack imparted maximum losses in maize yield. At two locations (Srinagar and Kalyani), plant density played most important role for yield improvement. Tillage practices played important role in yield maximization at Imphal, while water management was significant at Vagarai. The initial results indicate that there is need of location specific component technology at farmer's field in order to improve resilience in maize systems.

Maize Pathology

Coordinated trials

The AICRPM Plant Pathology and Nematology programme consisted of management of major diseases of maize, *viz.*, maydis leaf blight (MLB), turcicum leaf blight (TLB), banded leaf and sheath blight (BLSB), sorghum downy mildew (SDM), Rajasthan downy mildew (RDM), curvularia leaf spot (CLS), post-flowering stalk rots (PFSR) - charcoal rot (ChR) &fusarium stalk rot (FSR), common rust (CR), polysora rust (PR) and bacterial stalk rot (BSR) through host plant resistance (HPR) and by deploying cultural practices, chemicals, botanicals and bio-agents. In HPR, a total of 21 disease screening trials (15 in *kharif* and 6 in *rabi*) were conducted in artificially created epiphytotics at hot spot locations *viz.*, Almora, Bajaura, Dhaulakuan, Larnoo, Barapani (NHZ); Delhi, Karnal, Ludhiana, Pantnagar (NWPZ); Dholi, Kalyani (NEPZ); Coimbatore, Dharwad, Hyderabad, Mandya (PZ) and Udaipur (CWZ). During the reporting period, a total of 444 hybrids (345 in *kharif* and 99 in *rabi*) and 3758 inbred lines (2830 in *kharif* and 928 in *rabi*) were screened. Out of these, 407 hybrids were promising exhibiting multiple disease resistant reactions at one or other locations.

Promising hybrids

After continuous screening for two to three years against major diseases, a total of 146 genotypes found promising in one or other zone showing multiple disease resistance. The promising entries showing resistance against various diseases identified (VIC) are given in **Table 6.6**.

Survey and surveillance of maize diseases

Disease surveys and surveillance were conducted at farmer's fields in a total of 105 maize growing locations of Himachal Pradesh (12) in NHZ; Punjab (6), Haryana (5) and Uttarakhand (2) in NWPZ; North Bihar (14) and West Bengal (5) in NEPZ; Tamil Nadu (4), Northern & Southern Karnataka (20) and Telangana (all maize growing districts) in PZ; Southern Rajasthan (18) and Gujarat (18) in CWZ to assess overall disease scenario during the crop season. MLB, BLSB, TLB and ChR were the most important diseases in all the zones. CLS and BSR is gaining importance in Himachal Pradesh, Punjab, Uttarakhand, Dharwad, Mandya, Gujarat, Telangana and Haryana with low to moderate intensities. In Southern Karnataka SDM and PR were localized, while in Northern Karnataka CR and in Southern Rajasthan RDM were reported in moderate to severe intensities. SDM were also noticed in some districts of Tamil Nadu and Telangana state. Brown spot were reported from some areas of Himachal Pradesh, Punjab and Southern Rajasthan in trace to low intensities.

Table 6.6: List of entries showing resistance against various diseases, as identified by Variety Identification Committee.

Genotype	Group	Resistant	Moderately resistant
ADV 7022	AVT II Late 2017	TLB, BLSB, BSR, CLS, RDM	MLB, ChR, TLB, CR
VAMH 12014	AVT II Medium	TLB, BLSB, MLB, CLS, RDM	BSR, ChR
JH 13347	AVT II Medium	BLSB, MLB, CLS	TLB, BSR, ChR, RDM
DMRH 1305	AVT II Early & E Early	CLS	TLB, BLSB, BSR, ChR, PR
JKMH 4222	AVT II Early & E Early	ChR, CLS, RDM	BLSB, BSR, MLB
FH 3754	AVT II Early & E Early	PR, RDM	TLB, BLSB, MLB, ChR, CLS
GAYMH-1	AVT II Specialty Corn (BC)	BLSB, CLS,	TLB, BSR, MLB, ChR, RDM
IMHB 1532	AVT II Specialty Corn (BC)	BLSB, TLB, CLS, RDM	BSR, MLB, ChR
IMHB 1539	AVT II Specialty Corn (BC)	BLSB	TLB, ChR, CLS, RDM
ASKH-4	AVT II Specialty Corn (SC)	-	BLSB, RDM
FSCH 75	AVT II Specialty Corn (SC)	RDM, CLS	TLB, BLSB, ChR, PR
DKC 9165	AVT II Late 16-17	-	ChR

Trap nursery trials

Trap nursery trial for disease occurrence was conducted at Almora, Dhaulakuan, Delhi, Karnal, Ludhiana, Pantnagar, Dholi, Kalyani, Udaipur, Coimbatore, Dharwad, Hyderabad and Mandya. Occurrence of MLB and CLS diseases in all the zones; TLB in NHZ, NEPZ and PZ; BLSB in NHZ, NWPZ and CWZ; PFSR in all zones except NHZ were reported in low to medium intensities whereas SDM, CR andPR were confined to PZ and RDM in CWZ only in low to moderate intensities. Besides these, brown spot in NHZ, NEPZ, CWZ and bacterial stalk rot in Pantnagar (NWPZ) were also recorded in trace to low intensities.

Assessment of avoidable yield losses

Yield loss assessment trials were conducted at Dhaulakuan and Kalyani for MLB; Dharwad for TLB and ChR; Mandya for SDM; Udaipur for RDM; and Godhra for CLS. Yield losses were reported up to 18.49-22.01% due to MLB, 19.82% for TLB, 21.20% for ChR, 89.10 for SDM, 41.52% for RDM and 16.91% for CLS.

Nematology

Screening of maize hybrids against cyst nematode (Heterodera zeae)

A total of 345 maize hybrids belonging to different maturity groups of IVT, AVT and specialty corn were screened against cyst nematode at hot spot location (Udaipur). Out of these, 21 entries namely OMH 16-3, KMH 150375, DKC 9185 (IR8449), IMHBG-17K-24, CMH 15-005, Rasi-3499, PM17104L, RCRMH3 (CAH156), KH 103, WH-1010, NMH-4053, GIN-03, REH 2013-17, HT 16607, DKC 9178 (IQ8623), LMH 1216, Nuzi 260, ASKH-61, IIMRQPMH 1508, APQH-7 and IIMRQPMH 1602 exhibited moderate resistant reaction

Maize Entomology

Off-Season nursery facilities to north Indian AICRP maize centres during Winter Season (Rabi 2017-18):

The following ICAR centres *viz.* VPKAS, Almora; IARI Maize Genetic Unit and Maize Pathology; NBPGR, New Delhi; and AICRP centres, *viz.*, Bajaura, Kangra, Pantnagar, Ludhiana and Srinagar utilized the off-season nursery at Hyderabad center during *rabi* 2017-18

Germplasm sharing

Maize Germplasm Field Day was organized at its Winter Nursery Centre, Hyderabad on 27th February, 2017. A total of 1401 maize accessions were grown in a compact block for assessment and selections by breeders, pathologists, agronomists and entomologists from 27 AICRP centres from SAUs and ICAR institutes. The material included inbred lines from CIMMYT, NBPGR and large segregating materials with sub-tropical and temperate background from IIMR and seven AICRP centres. Thirty-eight participants from AICRP, SAUs and ICAR institutes participated in the field day. During 2017-18, a total of 546 maize accessions (2128 seed packets) were provided to 34 different AICRP and cooperating centres.

One externally funded project on **Consortium Research Project (CRP) on Agro biodiversity (2013-20)** is in operation at the center with the objective of evaluation, characterization and regeneration of the maize accessions in the National Gene Bank (NGB). Under the project over one thousand accessions were characterized and evaluated for 30 traits. Three hundred accessions (300) were characterized, evaluated and regenerated during 2017.

During *rabi* 2016-17 and *kharif* 2017, trials on different aspects of maize pest management, *viz.*, evaluation of maize genotypes for resistance to major pests of maize, *viz.*, shoot fly *(Atherigona spp.)* and spotted stem borer *(Chilo partellus)* and pink stem borer *(Sesamia inferens);* evaluation of insecticides and biopesticides against stem borers; monitoring of cob borer *(Helicoverpa armigera)* using pheromone trap; monitoring of stem borers to develop pest forecasting model and survey and surveillance of maize growing areas of Himachal Pradesh for the incidence of maize pests were conducted.

Evaluation of AICRP entries against stemborers under artificial infestation

During *kharif* 2017, 65 hybrids of different maturity period; 45 QPM, 14 popcorn, 11 baby corn and 15 sweet corn hybrids; 11 hybrids for rainfed ecology and 34 inbred lines were evaluated at NWPZ (Karnal and Ludhiana), NEPZ (Dholi), PZ (Kolhapur, Hyderabad) and CWZ (Udaipur) against stem borer under artificial infestation. The genotypes with less than 3.0 leaf injury rating (LIR) were considered to be resistant. None of the hybrids of full and medium maturity groups were resistant across the zones, while DMRH 1305 of early maturity group was resistant to stem borers at NEPZ. The QPM hybrid DQH 111 and baby corn hybrid AHB 6005 were resistant at CWZ, but none of the sweet corn and pop corn hybrids were found resistant to the pest across the zones.

In *rabi* 2016-17, out of 16 late maturity entries screened under artificial infestation against spotted stem borer at Kolhapur, KMH 3981, DKC 9175 (IP8514), NMH 1290 and Buland were resistant with less than 3 LIR. Among the 13 medium maturity entries, BLH 101, DMH 117 and BIO 9544 were resistant. The QPM hybrid MMH QPM-6-12-13 was also resistant at Kolhapur.

During *rabi* 2016-17, 16 hybrids of late maturity, 13 medium maturity group hybrids and 7 QPM hybrids were tested for pink borer resistance at Hyderabad. None of the hybrids were found resistant to pink stem borer at Hyderabad.

Evaluation of inbred lines against stem borers

Screening of 38 inbred lines against spotted stem borer in the first year at Kolhapur in *rabi* 2016-17, sixteen entries recorded resistance. The same inbred lines, when screened against pink stem borer, none was resistant at Hyderabad.

Evaluation of inbred lines against shoot fly under natural infestation

During spring 2017, out of 49 maize inbred lines screened under natural infestation against shoot fly at Delhi centre, WNCDMR11R5881, G18QC8-36, P63C2BBB17B, PFSR/51016-1, SO1SIYQBBB13B were resistant with no dead heart formation. On the other hand, out of 40 maize inbred lines screened under natural infestation against shoot fly at Ludhiana centre for the first year, CM 13, CML-50, HEY Pool 2011-15-1-3-2-1-1, HEY Pool 2011-30-4-1-2-2-1 and HEY Pool 2011-12-5SC-3-1-1 were resistant based on susceptibility index. When same inbred lines were evaluated against shoot fly at Delhi, only CM 13 and CML 43 were resistant with no dead heart formation.

Evaluation of bio-pesticides against spotted stem borer

The efficacy of three *Beauveria bassiana* isolates, *viz.*, Bb-5a, Bb-23, Bb-45; *Metarhizium* isolate Ma-35; Bt formulation –Delfin 5G; a neem formulation and Chlorantraniliprole 18.5 SC along with state recommended insecticides were evaluated against spotted stem borer during *kharif* 2017. This was second year of testing. State recommended insecticides followed by Chlorantraniliprole 18.5 SC @ 0.3 ml/ L were most effective across the locations based on LIR while, Chlorantraniliprole 18.5 SC @ 0.3 ml/ L followed by state recommended insecticides resulted in maximum yield.

Monitoring of cob borer by pheromone traps

The population of cob borer was monitored from tasseling till harvesting stage by installing pheromone traps during spring and *kharif* 2017. Maximum catch of 289 moths/acre was recorded during last week of April in spring sown maize at Ludhiana. Presence of the pest was fairly high in Bajaura (42), Karnal (43) and Delhi (34), while low in Udaipur (10) and Hyderabad (4). No moth was recorded in Kolhapur in *kharif* maize.

Incidence of spotted stem borer in relation to plant age and meteorological factors

This experiment aims at developing forecasting models for maize pests based on pest incidence and climatic data over a span of 10-15 years. Incidence of spotted stem borer was monitored in two genotypes during *kharif* 2017 at five different locations. Maximum number of larvae (4.25/plant) was recorded in susceptible genotype in fourth week of July at Karnal.

Survey and surveillance of maize growing areas of Himachal Pradesh for different insects and other pests

Survey was conducted in two districts and five villages in Himachal Pradesh.

Early stage maize was found to be prone to attack of cutworms in Mandi and Kullu districts. Snails attack was common in high rainfall area of Banjar valley of Kullu and Gohar and Maviseri area of Mandi district. Attack of white grubs was recorded in Hamirpur and Bilaspur. No attack of maize stem borer was recorded from any of the place surveyed.

Maize Biochemistry

Evaluation of maize germplasm developed by AICRP centres for protein quality

The biochemistry laboratory of IIMR facilitates the analysis of maize samples received from various AICRP centres for protein quality. Under this programme samples were received from CSK HPKV, HAREC, Bajaura and MRC, PJTSAU, Hyderabad. Out of 131 received from Bajaura, 16 lines were found to possess the desired level of protein quality. Two lines, BML 6 and BML 7, as converted to their QPM counterparts at PJTSAU, Hyderabad, were evaluated for protein quality. Out of these, only BML 7 was found to possess the required concentration of tryptophan. As newly developed entry FQH-106 possessed the required concentration of protein quality.

Evaluation of maize germplasm for nutritional quality

Samples received from SKUAST Srinagar, KVK, Madhya Pradesh, Banswara and IIMR, Ludhiana were analysed for various quality traits. Out of the material received from IIMR, Ludhiana 7 oil rich lines ($\geq$5%) were identified and one line {TLWQ (HO)QPMC15BBB38BBB} exhibited more than 6% of oil.

AICRP on Maize Automation System

AICRP on Maize Automation System was developed in collaboration with ICAR-NAARM, Hyderabad and ICAR-IASRI, New Delhi for online trial management and analysis of AICRP trials. It has the facility to generate the trial, download data book, review of submitted data and analysis of the respective trials data in one go. Under this, respective PIs of different coordinating centres can upload the data and pictures of various trials conducted at respective centres. It will help in better processing and handling of huge data generated from a number of AICRP trials, thus saving time and resources. The site was launched by Hon'ble Dr. Trilochan Mohapatra (Secretary, DARE & DG, ICAR)

Dr. Trilochan Mohapatra, Secretary, DARE & DG, ICAR launches AICRP on Maize Automation System

SIGNIFICANT EVENTS

Diamond Jubilee (60th) Annual Maize Workshop at Udaipur, Rajasthan

ICAR-Indian Institute of Maize Research, Ludhiana organized the Diamond Jubilee 60th Annual Maize Workshop from April 2-4, 2017 at Maharana Pratap University of Agriculture and Technology, Udaipur. The workshop was inaugurated by Dr. J. S. Sandhu, DDG (CS), ICAR. He mentioned that adoption of single cross hybrid technology resulted in phenomenal increase in maize production in the country. He also emphasized on effective weed management, conservation agriculture and precision farming. Tremendous improvement in maize production and productivity over last six decades was acknowledged by the special guest Dr. I. S. Solanki, ADG (FFC), ICAR. Dr. Uma Shankar Sharma, Vice Chancellor, MPUAT, Udaipur highlighted the importance of short duration QPM varieties to overcome the problem of malnutrition for the state of Rajasthan. Former maize Directors, viz., Dr. N. N. Singh, Dr. Sain Dass and Dr. O. P. Yadav were felicitated on the occasion. In his lead talk on "Retrospect of maize research in India", Dr. N. N. Singh gave a brief historical recap of maize research in India and suggested roadmap ahead. Panel discussion on "Challenges in maize under climate change" was organized in which the speakers were Dr. Sain Dass, Dr. P. H. Zaidi, Dr. M. L. Jat, Dr. Bijender Pal and Shri R.J. Aggarwal. In Variety Identification Committee, out of 32 proposals received 22 were identified. Dr. T. Mohapatra, Secretary, DARE & Director General, ICAR addressed the gathering during valedictory session. He commended the progress made in maize production and productivity over the last 60 years. He put forth the way ahead of maize research and development in India.

Release of the book 'Maize Research in India: Retrospect and Prospect' by Dr. T. Mohapatra, Secretary, DARE & Director General, ICAR

Visit of Dignitaries at ICAR-IIMR

Visit of Secretary, DARE & Director General, ICAR to ICAR-IIMR, Ludhiana

Hon'ble Secretary, DARE & DG, ICAR, Dr. Trilochan Mohapatra visited the institute on October 17, 2017. He visited the experimental farm area of IIMR at Ladhowal along with other eminent dignitaries like Dr. B. S. Dhillon (Vice Chancellor, Punjab Agricultural University), Dr. Sujay Rakshit (Director, ICAR-IIMR), Dr. Rajbir Singh (Director, ICAR-ATARI), Dr. Sain Dass (Former Director, ICAR-IIMR) and others. Later, he interacted with the scientists of the institute and provided valuable insights on future maize research necessities.

Tree plantation by Dr. Trilochan Mohapatra, Secretary, DARE & Director General, ICAR during his visit at experimental farm, Ladhowal (Ludhiana).

Dr. Trilochan Mohapatra, Secretary, DARE & DG, ICAR, made his second visit to the institute on December 15, 2017. He appreciated the effort being made by IIMR staff to establish the institute at a new place.

Visit of Dr. Trilochan Mohapatra, Secretary, DARE & Director General, ICAR to ICAR-IIMR, Ludhiana

Visit of Additional Secretary, DARE and Secretary, ICAR to ICAR-IIMR, Ludhiana

Shri Chhabilendra Roul, Additional Secretary, DARE and Secretary, ICAR visited the institute on December 11, 2017. He praised the staff of IIMR for their active effort in institute building and development of research facilities in a very short span of time. He visited the farm at Ladhowal and transit office facilities at PAU campus.

Tree plantation by Shri Chhabilendra Roul, Secretary, ICAR and Additional Secretary, DARE at ICAR-IIMR during his visit at experimental frm, Ladhowal, Ludhiana

Visit of Deputy Director General (Horticulture & Crop Science), ICAR to ICAR-IIMR, Ludhiana

Honorable DDG (Horticulture & Crop Science), ICAR, Dr. A K. Singh visited the experimental farm of IIMR at Ladhowal on October 7, 2017. On this occasion Dr. B. S. Dhillon (Vice Chancellor, Punjab Agricultural University), Dr. N.S. Bains (Director Research, PAU), Dr. Rajbir Singh (Director, ICAR-ATARI) and Dr. K.S. Thind (Additional DR, PAU) were also present. Dr. A. K. Singh motivated the staff of IIMR and encouraged them to work in collaboration with PAU.

Interaction of Dr. A. K. Singh (DDG, Horticulture & Crop Sciences), ICAR with the staff of ICAR-IIMR

Dr. A. K. Singh, DDG (Horticulture & Crop Science), ICAR sharing his views with Dr. B. S. Dhillon (VC, PAU) during visit to experimental farm of ICAR-IIMR at Ladhowal

Visit of Dr. Balraj Singh, Vice Chancellor, University of Jodhpur, Rajasthan and Dr. Tara Satyavathi, Project Coordinator, AICRP on Pearl Millet

Dr. Balraj Singh, Vice Chancellor, University of Jodhpur, Rajasthan visited the institute on April 28, 2017. He shared his experience on conservation technology in agriculture with the scientists of IIMR. On the same day Dr. Tara Satyavathi, Project Coordinator, AICRP on Pearl Millet also visited the institute and shared her experience with scientists.

Dr. Balraj Singh, Vice Chancellor, University of Jodhpur, Rajasthan and Dr. Tara Satyavathi, Project Coordinator, AICRP on Pearl Millet sharing their experience with scientists at ICAR-IIMR, Ludhiana

Important days

International Yoga Day

All the scientists and staff of IIMR participated in the celebration of International Yoga Day for better health and improved work efficiency on 21st June, 2017. The participants promised to practice yoga in their daily life as a routine practice.

International Yoga Day celebration at IIMR, Ludhiana

Soil Health Day

Soil health day was celebrated on 5th December 2017 at V&P-Dhamai, Tehsil-Garh Shankar, Dist. Hoshiarpur (Punjab) which was attended by 25 farmers. The importance of soil health card was discussed with the farmers. Farmers were explained the importance of soil nutrition. On this occasion the Sarpanch of village Sh. Avtar Singh informed that the most of the farmers have received their soil health card and using fertilizers judiciously. It was emphasized during discussion that burning of crop residue should be discouraged and instead use of happy seeder should have to be encouraged for direct sowing of wheat crop after the harvest of paddy.

Sensitization of farmers about importance of soil health card during Soil Health Day

Vigilance Week

To promote morality in public life and to accomplish a corruption free society Vigilance Awareness Week is observed every year. Observation of vigilance week helps to achieve our commitment and goals of promoting honesty and transparency in public life. Vigilance week was observed in ICAR-IIMR and its regional stations from October 30 to November 4, 2017. Integrity Pledge was taken by every staff of the institute. A discussion on sensitization to preventive vigilance was held in IIMR, Ludhiana.

Integrity Pledge being taken by staff at ICAR-IIMR, WNC, Hyderabad

Integrity Pledge being taken by staff at ICAR-IIMR, Delhi Unit

Discussion on Preventive vigilance at IIMR, Ludhiana

Memorandum of Understanding (MoU) Signed

MoU signed between ICAR-IIMR and PJTSAU

A Memorandum of Understanding (MoU) between ICAR-Indian Institute of Maize Research, Ludhiana and Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad was signed by the Director, ICAR-IIMR and the Registrar, PJTSAU on

August 21, 2017. The MoU was exchanged in the presence of IIMR QRT team and Vice-Chancellor of PJTSAU. As per the MoU, training of the students/ post graduate and Ph.D. research work is facilitated between these two institutions. Further, lease deed for providing land and other facilities for Winter Nursery Centre activities were also signed and exchanged between Registrar, PJTSAU and Director, ICAR-IIMR on the same day.

Memorandum of Understanding being exchanged between ICAR-IIMR, Ludhiana and PJTSAU, Hyderabad

MoU signed between ICAR-IIMR and PAU

A Memorandum of Understanding (MoU) was signed between ICAR-Indian Institute of Maize Research, Ludhiana and Punjab Agricultural University (PAU), Ludhiana to promote collaboration in the field of research and teaching on October 16, 2017. The MoU recognized the scientific staff of IIMR, Ludhiana as a faculty member of PAU, Ludhiana. According to the MoU instrument and library facilities of both the organizations will be shared between both the parties. Another MoU was also signed between ICAR-IIMR and PAU on November 20, 2017 regarding breeder seed production of wheat.

MoU exchanged between ICAR-IIMR and PAU on teaching and research

MoU signed between ICAR-IIMR and PAU on breeder seed production

Important Meetings

Institute Research Council (IRC)

The Institute Research Council (IRC) meeting was held at conference room of CIPHET, Ludhiana from 15 to 16 June, 2017 under the Chairmanship of Dr. Sujay Rakshit, Director, ICAR-IIMR. Dr. K. S. Thind, Head Department of Plant Breeding & Genetics, PAU Ludhiana and Dr. J. S. Chawla, Senior Maize Breeder, PAU Ludhiana were invited as external expert. Dr. Ishwar Singh, Member-Secretary-IRC welcomed the participants of the IRC meeting. In his opening remarks Dr. K. S. Thind highlighted the importance of maize crop in doubling farmer's income by 2022. Dr. J. S. Chawla stressed upon the need of concerted efforts for breeding of high yielding single cross maize hybrid resistant to biotic and abiotic stresses. The Director in his remarks highlighted the importance of development of climate resilient hybrids to cope up with the changing global climate. This was followed by individual presentation of progress of 20 ongoing research projects during 2016-17 and a total 11 new project proposals were discussed during the meeting.

Institute Research Council (IRC) meeting held at ICAR-IIMR, Ludhiana

Research Advisory Committee (RAC)

The meeting of the Research Advisory Committee (RAC) of ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana was held from 3 to 4 July, 2017 under the chairmanship of Dr. S.K. Sharma, CSIR-Emeritus Scientist & Former Vice-Chancellor, CSK-HPKVV, Palampur (HP). Other members who attended this meeting included Dr. I. S. Solanki, ADG (FFC), ICAR, Dr. B. L. Jalali, Ex-Director of Research, CCSHAU, Hisar, Dr. R. K. Malik, Senior Agronomist, CIMMYT & Ex-Director of Extension, CCSHAU, Hisar and Dr. Sujay Rakshit, Director, IIMR. Director, IIMR welcomed the Chairman and Members of RAC and other participants. Dr. Ishwar Singh, Member-Secretary, presented the Action Taken Report (ATR) on the recommendations of

Research Advisory Committee (RAC) meeting at IIMR, Ludhiana

previous RAC meeting and major accomplishments of the Institute during 2016-17. Director, IIMR presented the brief achievements. Respective principal investigators made detailed presentation on the achievements of respective disciplines. The Committee appreciated the outstanding work done by IIMR scientists, particularly the quality of publications in refereed journals, submission of new project proposals for external funding and efficient resource generation. The major recommendations of committee was to initiate fodder maize improvement programme in collaboration with IGFRI, to use the registered lines for resistance or tolerance with NBPGR as check in all the future studies, to evaluate all the germplasm at one place to remove duplication and to assess the impact of technologies developed by IIMR. The committee also visited the labs and field facilities

Quinquennial Review Team (QRT)

To maintain a mechanism of transparency and accountability in the system, ICAR has established the practice of independent Quinquennial Reviews (QRs) for every institute which is conducted once in every five years. Quinquennial Review Team (QRT) consisting of

Interaction of QRT team with Dr. Trilochan Mohapatra, Secretary, DARE and DG, ICAR

Dr. Swapan Kumar Datta (Vice Chancellor, Visva Bharati) as chairman, Dr. Sain Dass (former Director, DMR), Dr. I. P. S. Ahlawat (former Head of Division, Agronomy, IARI), Dr. K. Srinivas (Principal Scientist, NAARM), Dr. A. K. Sharma (former Director, NIAIM) as member and Dr. Shankar Lal Jat as Member Secretary reviewed the work done by the Institute and AICRP on Maize during the five-year period from 2011 to 2016. The committee held its meeting at Delhi (June 20, 2017), Godhra (July 19-20, 2017), Santiniketan (August 8-9, 2017), Hyderabad (August 21-22, 2017) and Ludhiana (October 15-17, 2017) during June to October, 2017.

Institutional Biosafety Committee (IBSC)

Every organisation conducting research on genetically modified organisms (GMOs) is responsible to establish an

Table 7.1: List of seminars organized at IIMR, Ludhiana during 2017

Sl. No	Date	Topic	Presenter
2	April 27	Engineering and two-stage evolution of a lignocellulosic hydrolysate tolerant Saccharomyces cereviseae strain for anaerobic fermentation of Xylose from AFEX pretreated corn stover	Dr. Alla Singh (Scientist)
3	May 26	Plant Biosecurity system in Australia	Dr. K.S. Hooda (Principal Scientist)
4	May 26	Bioremediation of contaminated soils through maize cultivation	Dr. Alla Singh (Scientist)
5	August 16	Purple corn : A potential Natural colorant and protective agent against diseases	Dr. Sapna (Scientist)

Table 7.2: List of seminars organized at IIMR, Delhi Centre during 2017

Sl. No.	Date	Topic of Seminar	Name & Designation
2	April 15	Host Pathogen Interactions as affected by dsRNA and Plasmids in *Rhizoctonia* sp.	Dr. Vimla Singh (DST-Woman cientist)
3	May 02	SMARTER De-stressed Cereal Breeding	Dr. Chikkappa G.K (Scientist)
4	May 18	Genetic Transformation of Indian Maize Germplasm	Dr. Alok Abhishek (RA-NASF)
5	June 19	Genome Editing with Engineered Nucleases	Dr. Chetna Aggarwal (SRF-NASF)
6	August 11	MicroRNA Mediated Regulation of Drought Stress Tolerance in Contrasting Maize Lines	Ms. Anuradha Gautam (Ph.D. student)
7	August 23	Embryo Specific Silencing of a Transporter Reduces Phytic Acid Content of Maize	Ms. Shivani Singh Gangoliya (PDF)
8	September 07	Association Mapping: A Sophisticated Highway to Explore QTLs in Plants	Dr. Harpreet Kaur (SRF-CRP, Biofort)
9	September 21	MATRILINEAL, a Sperm-Specific Phospholipase Mediated Haploid Production in Maize	Ms. Thungri Ghoshal (SRF-CRP, MB)
10	October 04	Epigenetic and Chromatin Based Mechanisms in Environmental Stress Adaptation and Stress Memory in Plants	Ms. Avni (Scientist)
11	December 05	Physiological Implications of C4 Genes Transfer into C3 Plants	Ms. Ragini Bhardwaj (Ph. D. Student)

Institutional Biosafety Committee (IBSC) for periodically review of the work to check the biosafety aspects of the research projects. The Institutional Biosafety Committee (IBSC) meeting of IIMR was held on September 7, 2017. The committee was comprised of Dr. Sujay Rakshit, Director, IIMR (Chairman), Dr. Tanushri Kaul (DBT Nominee), Dr. Amrita Srivastava (Medical Officer), Dr. Monika Dalal (External Member), Dr. Chikkappa G. K. (Member), Dr. Bhupender Kumar (Member). Dr. Krishan Kumar (Member Secretary) and everyone attended the meeting. The committee appreciated the new initiative being taken up by the institute.

Scientific Seminars & Invited Talks

Scientific Seminars

With an objective to have regular and active scientific discourse and keep the scientific and research staff updated with the advancements in the field of agricultural research in general and maize research in particular, a series of in-house seminars and invited lectures were planned and successfully executed at the institute **(Table 7.1; Table 7.2 & Table 7.3)**.

Table 7.3: Invited Lectures at IIMR, Ludhiana during 2017

Sl. No	Date	Topic	Presenter
	April 22	Application of Remote Sensing in Indian Agriculture	Dr. Vinay Sehgal (Professor, Agricultural Physics, IARI)
1	May 26	Studies on Decontamination of Heavy Metal Pollutants	Dr Rajeev Sikka (Professor, Soil Science, PAU)
2	November 10	Next Generation Mutagenesis	Dr. Gurmukh S Johal (Professor, Purdue University)

Students Visit at ICAR-IIMR

IIMR celebrated Agriculture Education Day on December 3, 2017 in the memory of birthday of 1st Union Agriculture Minister and Bharat Ratna Dr. Rajender

Students of BVM School visited ICAR-IIMR, Ludhiana to commemorate Agriculture Education Day

Prasad. Students from BVM Senior Secondary School, Ludhiana were invited to give them first-hand information related to agriculture sector and especially about maize research in India and around the world in order to develop their interest. They were taken to different laboratories for on-lab exposure and the maize documentary film highlighting the vision, mandate and the research work was played to give them an exposure of maize and agricultural research. They were also sensitized on *'Swachh Bharat Mission'* of Government of India.

Apart from this, students of B.Sc. Biotechnology of Khalsa College of Women visited IIMR on September 1, 2017. The students interacted with scientists on various aspects of applied sciences.

Students of Khalsa College for Women interacting with scientists of ICAR-IIMR, Ludhiana

Similarly, also visited a group of 20 class XIth Biology students from Salwan Public School, Pusa Road, New Delhi visited ICAR-IIMR Delhi Centre along with their teachers (Dr. Shilpa and Mrs Bhawna) on July 25, 2017. These were part of the institute's outreach program targeting a broad community of students and science enthusiasts to raise awareness and develop interest for agricultural research in general and maize in particular. Also, a batch of 60 B.Sc. (Ag.) final year students from Ramakrishna Mission Vivekananda University (RMVU, Coimbatore, accompanied by 4 faculty members, visited ICAR-IIMR New Delhi Centre in the afternoon of November 30, 2017 as part of their All-India study tour.

Students of Sulvan Public School visited ICAR-IIMR Delhi Unit

Students of RVMU Coimbatore visited ICAR-IIMR Delhi Unit

हिंदी कार्यशाला

भाकृअनुप-भारतीय मक्का अनुसन्धान संस्थान में दिनांक 31 अगस्त, 2017 को राजभाषा के प्रगामी प्रयोग को बढ़ावा देने हेतु हिंदी कार्यशाला का आयोजन पादप प्रजनन एवं अनुवांशिकी विभाग, प. कृ. वि. परिसर, लुधियाना के समिति कक्ष में किया गया । कार्यशाला में सभी अधिकारियों और कर्मचारियों ने भाग लिया। वक्ता के रूप में श्रीमती किरण साहनी, सदस्य सचिव एवं सहायक निदेशक राजभाषा, नगर राजभाषा कार्यान्वयन समिति, लुधियाना को आमंत्रित किया गया । राजभाषा राजभाषा कार्यान्वयन समिति के सदस्य सचिव डॉ. बहादुर सिंह जाट ने सभी का हार्दिक अभिनन्दन किया । डॉ. सुजय रक्षित, निदेशक, भोंअनुप-भारतीय मक्का अनुसन्धान संस्थान ने हिंदी के महत्व एवं उसके दिन-प्रतिदिन कम में लेन पर जोर दिया तथा यह भी कहा कि किस प्रकार हम अपनी जीवन शैली को हिंदी में ला सकते हैं ।

श्रीमती किरण साहनी भाकृअनुप–भामअनुस के कर्मचारीगण को हिन्दी कार्यशाला के दौरान सम्बोधित करते हुए।

हिंदी सप्ताह समारोह

भाकृअनुप-भारतीय मक्का अनुसन्धान संस्थान में 08 से 14 सितम्बर, 2018 हिंदी सप्ताह समारोह का आयोजन किया गया । इसके दोरान कई गतिविधियाँ और प्रतियोगिताएं जैसे वाद-विवाद, काव्यपाठ, श्रुतलेख, निबंध लेखन आदि आयोजित की गयी ।

कार्यक्रम की शुरुआत उद्घाटन समारोह से की गयी जिसमें श्री मुकेश चौधरी, वैज्ञानिक ने राजभाषा के सम्मान को महत्व देते हुए, हिंदी में अधिक से अधिक कार्य करने पर जोर दिया ।

14 सितम्बर, 2018 को "हिंदी दिवस" का आयोजन किया गया जिसमें उपस्थित सभी अधिकारियों/कर्मचारियों ने अपने विचार प्रस्तुत किये तथा हिंदी की प्रतियोगिताओं में बढ़-चढ़ कर भाग लिया । 16 सितम्बर, 2018

को ''हिंदी सप्ताह'' का समापन समारोह और पुरुस्कार वितरण समारोह का आयोजन पादप प्रजनन एवं अनुवांशिकी विभाग, प.कृ.वि. परिसर, लुधियाना के समिति कक्ष में किया गया । समारोह की अध्यक्षता करते हुए डॉ. सुजय रक्षित, निदेशक, भाकृअनुप-भारतीय मक्का अनुसन्धान संस्थान ने हिंदी में कार्य करनें के लिए सभी को उत्साहित किया तथा हिंदी को ऊँचाईयों पर ले जाने के लिए यथासंभव प्रयास करने का आह्वान किया । निदेशक महोदय ने कहा कि जब वो दूसरे देश में जाते है और वह लोग हिंदी में बात करते हैं तो बड़ा गर्व महसूस करते हैं । श्रीमती किरण साहनी, सदस्य सचिव एवं सहायक निदेशक राजभाषा, नगर राजभाषा कार्यान्वयन समिति, लुधियाना को मुख्य अतिथि के रूप में आमंत्रित किया गया तथा उन्होंने कहा कि जिस तरह हम राष्ट्रगान और राष्ट्रध्वज का सम्मान करते हैं उसी तरह हिंदी भाषा का भी सम्मान करना चाहिए । हिंदी को लोग सिर्फ देश में ही नहीं विदेशों में भी सीख रहे हैं । अंत में सभी प्रतिभागियों को पुरुस्कार प्रदान कर सम्मानित किया गया ।

भामअनुस के कर्मचारीगण हिन्दी सप्ताह समारोह में भाग लेते हुए।

Activities undertaken in 'Swachh Bharat Mission' program

In accordance with the initiative by Government of India's 'Swachh Bharat Mission', IIMR has taken keen interest in various activities related to cleanliness in the campus and around public places. Apart from this, sensitization regarding the program has been provided to school and college students during their visits to IIMR. In addition, a one-day program was taken up in a nearby village, Ladhowal, where IIMR employees interacted with villagers on the issue of hygiene and healthcare. A toilet facility was created in a home during the program. A committee, Swachhta Nigrani Committee, has been constituted by Director for supervision of overall cleanliness work in IIMR, Ludhiana. Other regional units also showed keen interest and enthusiasm and have taken active part in promotion of cleanliness at their level in various programs.

Swachhta Pakhwada

'Swachhta Pakhwada' was celebrated in IIMR and its regional units from 16th to 31st May, 2017. Cleanliness of the entire campus was performed. All the employees took active part in the operations. The staff were encouraged to use eco-friendly options and technologies, wherever applicable to ensure safe and clean environment. Importance of Shramdaan was emphasized.

Swachhta Hi Sewa

'Swachhta Hi Sewa' campaign was observed in IIMR and its regional units from 15th September to 2nd October, 2017. Swachhta Pledge was taken by all employees of IIMR. Following specific activities were undertaken during the program:

S. No.	Event	Description	Date
1.	Sewa Diwas	Dedicated cleaning and sweeping of institute premises	17.09.2017
2.	Samagra Swachhta Diwas	Creation of a proper toilet facility at a disadvantaged area	24.09.2017
3.	Sarwatra Swachhta Diwas	Cleaning of public places	25.09.2017
4.	Swachhta of Nearby Tourist Spot	Cleaning of nearby important tourist spot	01.08.2017

Institute Management Committee Meeting

The 8th IMC meeting was held on 10th February, 2018. The meeting was chaired by Director, IIMR. The following members attended the meeting: Dr. S.K. Guleria, CSK HPKV, Bajaura; Dr. Ashok Kumar, ICAR; Mr. K.K. Sharma, NBPGR, New Delhi and Mr. Ashwani Kumar, AO, IIMR. The following Scientists of IIMR also attended the IMC meeting: Dr. S.b. Singh; Dr. A.K. Singh; Dr. K.S. Hooda; Dr. Ramesh Kumar, Dr. Dharam Paul and Mr. Permod Sharma. Total Nine Agenda items were discussed and decided upon which were communicated to ICAR. The 9th IMC meeting was held on 23rd March, 2018, which was chaired by Director, IIMR. The following members attended the meeting: Dr. Ashok Kumar, ICAR; Dr. Seema Jaggi, IASRI, Mr. K.K. Sharma, NBPGR, New Delhi and Mr. Ashwani Kumar, AO, IIMR. Dr. Ishwar Singh IIMR also attended the meeting. Five agenda items were discussed in the meeting and the decisions were communicated to ICAR.

Glimpses of the activities under *Swachhta Hi Sewa* campaign

Tree plantation by Dr. Trilochan Mohapatra, Secretary, DARE & Director General, ICAR during his visit at experimental farm, Ladhowal (Ludhiana).

Pledge of Swachh Bharat Abhiyan

Cleanliness drive by staff on Sewa Diwas

IIMR staff cleaning public park in Inderpuri New Delhi

Cleaning of public place during Sarwatra Swachhta Diwas by IIMR Ludhiana

Cleaning of public place during Sarwatra Swachhta Diwas by IIMR Hyderabad

Creation of toilet facility at a disadvantaged area during Samagra Swachhta Diwas

Cleaning of a nearby tourist place

Cleaning of office premises road in IIMR, New Delhi

AWARDS & HONOURS

8

- Dr.K. S. Hooda received "Distinguished Scientist Award" for Plant Pathology in the International Conference on Global Research Initiatives for Sustainable Agriculture and Allied Sciences held at MPUAT- Udaipur on December 2-4, 2017
- Dr. S.B. Singh received "Excellence in Research Award" for Genetics and Plant Breeding in the International Conference on Global Research Initiatives for Sustainable Agriculture and Allied Sciences held at MPUAT- Udaipur on December 2-4, 2017.
- Dr N. Sunil received the Sipani Anushandhan Award 2017 as the Best Paper for the year 2017 published in Journal Asian Agri-History.
- Dr N. Sunil received "Excellence In Research Award" by Samagra Vikas Welfare Society (SVWS) on the occasion of International Seminar on Agriculture & Food for Inclusive Growth and Development during 14-15th January 2017 at NBRI, Lucknow
- Dr. Suby S. B. received best oral presentation award in International conference on biocontrol and sustainable insect pest management (ICBS 2018), Agricultural College and Research Institute, Tamil Nadu Agricultural University, Killikulam.
- Ms. Sapna received "International Travel Grant" from CSIR for paper presentation at "10th International conference on Agriculture and Horticulture" (Agri-2017) from 02-04 October, 2017 London, UK.

Dr. S.B. Singh receiving award of "Excellence in Research Award"

Annexure 1

List of Cultivars identified during 60th Annual Maize Workshop

On the occasion of 60th Annual Maize Workshop held at Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur during April 2-4, 2017, the Variety Identification Committee Meeting was conveyed under the Chairmanship of Dr. J. S. Sandhu, Deputy Director General (Crop Sciences), Indian Council of Agricultural Research, New Delhi in the Committee Room, Directorate of Research, MPUAT, Udaipur at 14:30 on April 2, 2017.

Cultivar	AICRP Centre/ Pvt. Company	Public/ Private	Average Yield (kg/ha)	Zones	Area of adaptation States	Maturity or Type of Corn	Season
DMRH 1308	ICAR-Indian Institute of Maize Research	Public	8078	CWZ (Z5)	Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Late	*Rabi*
CP 838	Charoen Pokphand Seeds	Private	11209 (Z2), 9203 (Z3), 8739 (Z4), 9200 (Z5)	NWPZ (Z2), NEPZ (Z3), PZ (Z4) and CWZ (Z5)	Delhi, Punjab, Haryana, Western Uttar Pradesh; Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal; Andhra Pradesh,Telangana, Maharashtra, Karnataka, and Tamil Nadu; Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Late	*Rabi*
KMH 1411	Kaveri Seeds	Private	9145	NEPZ (Z3)	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal	Late	*Rabi*
GK 3155	Ganga Kaveri Seeds	Private	9583	NEPZ (Z3)	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal	Late	*Rabi*
CP 999	Charoen Pokphand Seeds	Private	8497	PZ (Z4)	Andhra Pradesh, Telangana, Maharashtra, Karnataka, and Tamil Nadu.	Late	*Rabi*
CP 333	Charoen Pokphand Seeds	Private	9465	CWZ (Z5)	Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Late	*Rabi*
HTMH 5108	Hytech Seed India	Private	8671	PZ (Z4)	Karnataka, Tamil Naidu, , Andhra Pradesh, Telangana, Maharashtra	Late	*Rabi*
GK3150	Ganga Kaveri Seeds	Private	9540	CWZ (Z5)	Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Late	*Rabi*
ADV 0990296 (ADV 756)	Advanta Seeds	Private	9316 (Z4), 7123 (Z5)	PZ (Z4) and CWZ (Z5)	Karnataka, Tamil Naidu, Andhra Pradesh, Telangana, Maharashtra; Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh.	Late	*Kharif*
HT 51412616	Hytech Seeds India	Private	9216	PZ (Z4)	Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Maharashtra	Late	*Kharif*

Cultivar	AICRP Centre/ Pvt. Company	Public/ Private	Average Yield (kg/ha)	Zones	Area of adaptation States	Maturity or Type of Corn	Season
DMH 192	Metahelix Life Sciences	Private	9120	PZ (Z4)	Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Maharashtra	Late	*Kharif*
DKC 9151	Monsanto India	Private	7144	CWZ (Z5)	Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Late	*Kharif*
DMRH 1301	ICAR-Indian Institute of Maize Research	Public	9904 (Z3); 11307 (Z5)	NEPZ (Z3) and CWZ (Z5)	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal; Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Medium	*Rabi*
BL 798	Bisco Bio Sciences	Private	9057	NEPZ (Z3)	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal	Medium	*Rabi*
BL 147	Bisco Bio Sciences	Private	9154	NEPZ (Z3)	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal	Medium	*Rabi*
BL 900	Bisco Bio Sciences	Private	8921 (Z3), 8881 (Z4), 10799 (Z5)	NEPZ (Z3), PZ (Z4) and CWZ (Z5)	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal,; Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra,; Rajasthan, Madhya Pradesh, Chhattisgarh, Gujarat	Medium	*Rabi*
JKMH 4848	JK Seeds	Private	8738	PZ (Z4)	Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, Maharashtra	Medium	*Kharif*
DMRHP 1402	ICAR-Indian Institute of Maize Research	Public	3990 (Z2), 2835 (Z5)	NWPZ (Z2) and CWZ (Z5)	Delhi, Punjab , Haryana , Western Uttar Pradesh; Rajasthan, Madhya Pradesh, Chhattisgarh, Gujarat	Popcorn	*Kharif*
APQH 9	ICAR-Indian Agricultural Research Institute	Public	5588 (Z1), 6015 (Z4)	NHZ (Z1) and PZ (Z4)	Jammu & Kashmir, Himachal Pradesh, Uttarakhand and North-East Hills, Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, Maharashtra	Medium; QPM + Provitamin A	*Kharif*
AQH 9	ICAR-Indian Agricultural Research Institute	Public	5201	NEPZ (Z3)	Bihar, Odisha, Eastern-Uttar Pradesh, Jharkhand, West Bengal	Medium; QPM	*Kharif*
AQH 4	ICAR-Indian Agricultural Research Institute	Public	6419	NWPZ (Z2)	Delhi, Punjab, Haryana, Western-Uttar Pradesh	Medium; QPM	*Kharif*
AQH 8	ICAR-Indian Agricultural Research Institute	Public	6258	PZ (Z4)	Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Maharashtra,	Medium; QPM	*Kharif*

NHZ - Northern Hill Zone; NWPZ - North Western Plain Zone; NEPZ - North Eastern Plain Zone; PZ - Peninsular Zone; CWZ - Central Western Zone.

Annexure 2

List of cultivars notified during 2017-18

Sl.No.	Cultivar	AICRP Centre/Pvt. Company	Public / Private	Notification Date	Notification No.	Maturity	Area of adaptation	Zone	Average Yield (t/ha)	Cropping season	Type
1	Gujarat Anand White Maize Hybrid 2 (GAWMH 2)	Anand Agriculture University	Public	27.03.2018	1379(E)	Early	Gujarat.	CWZ (Z5)	4.7	*Kharif*	Normal
2	Shaktiman 5 (MHQPM 09-08)	Rajendra Prasad Centra Agriculture Univerity	Public	27.03.2018	1379(E)	Late in both season *kharif* & *rabi*	Uttar Pradesh, Bihar, Jharkhand, West Bengal, Orissa and Chhattisgarh in both *Kharif* and Rabi seasons.	NEPZ (Z3)	6.2-6.5 (in *Kharif*) 10.05-10.10 (in *Rabi)*	*Kharif* & *Rabi* both	QPM
3	CP 999	Charo en Pokphand Seeds	Private	27.03.2018	1379(E)	Late	Karnataka, Tamil Nadu, Telangana and Maharashtra	PZ (Z4)	8.497	Rabi	Normal
4	CP 838	Charo en Pokphand Seeds	Private	27.03.2018	1379(E)	Late	Punjab, Haryana, UP, Plain areas of Uttrakhand, Bihar, Jharkhand, West Bengal, Odisha, Karnataka, Tamil Nadu Telangana, Andhra Pradesh, Maharashtra, Rajasthan and Gujarat.	NWPZ (Z2), NEPZ (Z3), PZ (Z4) and CWZ (Z5)	11.2, 9.2, 8.7, 9.2	Rabi	Normal
5	MM 9344 (DMH 192)	Metahelix Life Science	Private	27.03. 2018	1379(E)	Late	Karnataka, Maharashtra, Andhra Pradesh, Tamil Nadu and Telangana.	PZ (Z4)	9.1	Kharif	Normal
6	ADV 756 (ADV 0990296)	Advanta Seeds	Private	27.03.2018	1379(E)	Late	Karnataka, Maharashtra, Andhra Pradesh, Tamil Nadu, Telangana, Rajasthan , Gujarat, Madhya Pradesh and Chhattisgarh.	PZ (Z4) and CWZ (Z5)	9.3, 7.1	Kharif	Normal

Sl. No.	Cultivar	AICRP Centre/Pvt. Company	Public / Private	Notification Date	Notification No.	Maturity	Area of adaptation	Zone	Average Yield (t/ha)	Cropping season	Type
12	LG 34.05 (BL 900)	Bisco Bio Sciences	Private	27.03.2018	1379(E)	Medium	Uttar Pradesh, Bihar, Jharkhand, West Bengal, Odisha, Maharashtra, Telangana, Andhra Pradesh, Karnataka, Tamil Nadu, Madhya Pradesh, Chhattisgarh, Gujarat and Rajasthan.	NEPZ (Z3), PZ (Z4) and CWZ (Z5)	8.921, 8.881, 10.799	Rabi	Normal
13	LG 34.04 (BL 147)	Bisco Bio Sciences	Private	27.03.2018	1379(E)	Medium	Uttar Pradesh, Bihar, Jharkhand, West Bengal and Odisha.	NEPZ (Z3)	9.154	Rabi	Normal
14	JKMH - 4848(IMR 498)	JK Agrigenetics	Private	24.01.2018	399 (E)	Medium	Maharashtra, Karnataka, Andhra Pradesh, Telangana and Tamil Nadu	IV	8.7	*Kharif*	Normal
15	DMRH 1301	IIMR	Public	24.01.2018	399 (E)	Medium	Eastern Uttar Pradesh, Bihar, Jhark hand, Odisha , West Bengal ,Rajasthan, Madhya Pradesh and Chhattisgarh	III & V	9.9	Rabi	Normal
16	DMRHP 1402	IIMR	Public	24.01.2018	399 (E)	Early	Punjab, Haryana, Delhi NCR and Western Uttar Pradesh, Rajasthan, Madhya Pradesh, Chhattisgarh and Gujarat	II & V	3.9	Kharif	Popcorn
17	DMRH 1308	IIMR	Public	24.01.2018	399 (E)	Late	Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	V	9.6	Rabi	Normal

Sl. No.	Cultivar	AICRP Centre/Pvt. Company	Public/ Private	Notification Date	Notification No.	Maturity	Area of adaptation	Zone	Average Yield (t/ha)	Cropping season	Type
18	Bisco Cham -pion 61 (Bisco 2238)	Bisco Bio Sciences	Private	25.08.2017	2805(E)	82 - 85	Jammu & Kashmir, Himachal Pradesh, Hills of Uttarakhand and NEH region and Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu	I & IV	8.2	Kharif	Nor -mal
19	Bisco X 5129	Bisco Bio Sciences	Private	25.08.2017	2805(E)	115 - 120	Maharashtra, A ndhra Pradesh, Karnataka, Tamil N adu	IV	8.5	Rabi	Nor mal
20	Karim nagar Makka (KNM H - 40101 41)	Telangana State Ag. Univ. (PJTSA U)	Public	25.08.2017	2805(E)	90 - 95	Telangana, Andhra Pradesh, Ma harashtra, Karnataka and Tamil Nadu rainfed	IV	7.9	Rain fed Kharif	Nor mal
21	Pusa HM-8 Improved (AQH-8)	ICAR-Indian Agricultural Research Institute	Public	25.08.2017	2805(E)	90 - 95	Maharashtra, Karnataka, Andhra Pradesh, Telangana and Tamil Nadu	IV	6.3	Kharif	Quality Protein Maize (QPM)
22	Pusa HM-9 Improved (AQH-9)	ICAR-Indian Agricultural Research Institute	Public	25.08.2017	2805(E)	85 - 90	Bihar, Jharkhand, Odisha, Uttar Pradesh and West Bengal	III	5.2	Kharif	Quality Protein Maize (QPM)
23	Pusa HM-4 Improved (AQH -4)	ICAR - Indian Agricultural Research Institute	Public	25.08.2017	2805(E)	Medium	Punjab, Haryana, Delhi, Uttarakhand and Uttar Pradesh	II & III	6.4	Kharif	Quality Protein Maize (QPM)
24	PusaVivek QPM -9 Improved (APQH -9)	ICAR - Indian Agricultural Research Institute	Public	25.08.2017	2805(E)	Medium	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Mizoram , Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh, Maharashtra, Andhra Pradesh, Tamil Nadu and Telangana	I & V	5.6	Kharif	Quality Protein Maize (QPM)

Annexure 3

Varietal Registration and DUS Testing

Hybrid / variety registered under PPVFRA during 2017-18

Sl.No.	Name	Centre	Period of protection (Years)
1	Vivek Maize Hubrid 47 (FH 3513)	VPKAS, Almora	Dec 25, 2017 to Dec 24, 2023
2	DHM 121	PJTSAU, Hyderabad	Dec 25, 2017 to Dec 24, 2023

DUS Testing undertaken during 2017-18

Hybrid Entries

Sl. No.	Name of Entry	Testing Year	Category	Type
1	DKC9145	First	New	MPH
2	HTMH 5801	First	Extant VCK	MPH
3	GK3172	First	New	MPH
4	GK 3145	Second	New	MPH
5	MM 7663	Second	New	MPH
6	HTMH 5402	Second	New	MPH
7	DKC 9144	Second	New	MPH
8	AFRICAN TALL		Reference	OPV
9	NARMADA MOTI		Reference	OPV
10	Winorange Sweet Corn		Reference	O P V
11	DKC9141	First	New	SCH
12	DKC8144	First	New	SCH
13	KDMH 755	First	New	SCH
14	MM 9333	First	New	SCH
15	GK3200	First	New	SCH
16	GK3176	First	New	SCH
17	P 3550	First	New	SCH
18	STAR X-14	First	New	SCH
19	STAR X-12	First	New	SCH
20	STAR X-20	First	New	SCH
21	STAR X-18	First	New	SCH
22	STAR X-16	First	New	SCH
23	Palam Sankar Makka 1 (EHL 1625 08)	First	New	SCH
24	P 3355	First	New	SCH
25	P 1866	First	New	SCH
26	P 3535	First	New	SCH

Sl. No.	Name of Entry	Testing Year	Category	Type
27	P 3552	First	New	SCH
28	PMH 10	First	New	SCH
29	P3400	First	Extant VCK	SCH
30	NMH-51	First	Extant VCK	SCH
31	Palam Sankar Makka 2	First	New	SCH
32	MM 7009	Second	New	SCH
33	PMH 8 (JH 31244)	Second	New	SCH
34	PMH 7 (JH 3956)	Second	New	SCH
35	GK 3166	Second	New	SCH
36	AMH-3436	Second	New	SCH
37	GK 3112	Second	New	SCH
38	PMH 9 (JH 9144)	Second	New	SCH
39	P3511	Second	New	SCH
40	P3399	Second	New	SCH
41	PH2RBR	Second	New	SCH
42	P3466	Second	New	SCH
43	P3520	Second	New	SCH
44	DKC9155	Second	New	SCH
45	MZ14S016N	Second	New	SCH
46	TMMH 844	Second	New	SCH
47	D4244	Second	New	SCH
48	D4685	Second	New	SCH
49	SYN-CO-6217	Second	New	SCH
50	SYN-CO-6304	Second	New	SCH
51	SYN-CO-6607	Second	New	SCH
52	SYN-CO-6668	Second	New	SCH
53	SYN-CO-6850	Second	New	SCH
54	SYN-CO-7750	Second	New	SCH
55	SYN-CO-NP-5611	Second	New	SCH
56	DHM 117	--	Reference	SCH
57	HM 8	--	Reference	SCH
58	HQPM-1	--	Reference	SCH
59	HQPM4	--	Reference	SCH
60	HQPM5	--	Reference	SCH
61	PRAKASH	--	Reference	SCH
62	Shaktiman 1	--	Reference	SCH
63	Shaktiman 2	--	Reference	SCH

Sl. No.	Name of Entry	Testing Year	Category	Type
64	Shaktiman 3	--	Reference	SCH
65	Shaktiman 4	--	Reference	SCH
66	Vivek 27	--	Reference	SCH
67	Vivek 33	--	Reference	SCH
68	VIVEK 39	--	Reference	SCH
69	Vivek 43	--	Reference	SCH
70	VIVEK -9	--	Reference	SCH
71	VIVEK25	--	Reference	SCH

Inbred Entries

Sl. No.	Name of Entry	Testing Year	Category	Type
1	PH2A7S	First	New	Inbred
2	PH1RA7	First	New	Inbred
3	MZ14S028N	First	New	Inbred
4	MZ14S022N	First	New	Inbred
5	PH1DVA	First	New	Inbred
6	PH2V73	First	New	Inbred
7	PH1CHO	First	New	Inbred
8	PH2A6G	First	New	Inbred
9	PH2GP6	First	New	Inbred
10	WCV01	First	New	Inbred
11	PH2B00	First	New	Inbred
12	PH2NGW	First	New	Inbred
13	PH23FF	First	New	Inbred
14	SYN-CO-NP 5612	First	New	Inbred
15	SYN-CO-NP 5140	First	New	Inbred
16	SYN-CO-NP FX 7233	First	New	Inbred
17	SYN-CO-NP 5646	First	New	Inbred
18	SYN-CO-NP 5603	First	New	Inbred
19	SYN-CO-NP 5120	First	New	Inbred
20	SYN-CO-NP 5139	First	New	Inbred
21	SYN-CO-NP 5296	First	New	Inbred
22	SYN-CO-NP 5300	First	New	Inbred
23	BS112 12	First	Extant VCK	Inbred
24	WCV02	First	Extant VCK	Inbred
25	KML 5164	Second	New	Inbred
26	PH218V	Second	New	Inbred

Sl. No.	Name of Entry	Testing Year	Category	Type
27	PH1RA9	Second	New	Inbred
28	PH217Z	Second	New	Inbred
29	PH1RA5	Second	New	Inbred
30	PH26WP	Second	New	Inbred
31	PH1B26	Second	New	Inbred
32	PH1CGY	Second	New	Inbred
33	MZ14S020N	Second	New	Inbred
34	TSIH 008	Second	New	Inbred
35	WWV 04	Second	New	Inbred
36	TWV14	Second	New	Inbred
37	MZ14S018N	Second	New	Inbred
38	MZ14S017N	Second	New	Inbred
39	MZ14 S019N	Second	New	Inbred
40	BLI 102	Second	New	Inbred
41	TM 800125	Second	New	Inbred
42	SYN-CO-NP-5104	Second	New	Inbred
43	SYN-CO-NP-5197	Second	New	Inbred
44	SYN-CO-NP-5198	Second	New	Inbred
45	SYN-CO-NP-5219	Second	New	Inbred
46	SYN-CO-NP-5322	Second	New	Inbred
47	SYN-CO-NP-5324	Second	New	Inbred
48	SYN-CO-NP-5610	Second	New	Inbred
49	SYN-CO-NP-5616	Second	New	Inbred
50	CM152	--	Reference	Inbred
51	CM 212	--	Reference	Inbred
52	BML 5	--	Reference	Inbred
53	BML 6	--	Reference	Inbred
54	BML 7	--	Reference	Inbred
55	HKI 1105	--	Reference	Inbred
56	HKI 163	--	Reference	Inbred
57	HKI 193-2	--	Reference	Inbred
58	HKI161	--	Reference	Inbred
59	HKI193-1	--	Reference	Inbred
60	HKI323	--	Reference	Inbred
61	V 335	--	Reference	Inbred
62	V 341	--	Reference	Inbred
63	V 345	--	Reference	Inbred

Sl. No.	Name of Entry	Testing Year	Category	Type
64	V 346	--	Reference	Inbred
65	V 373	--	Reference	Inbred
66	VQL 1	--	Reference	Inbred
67	VQL 2	--	Reference	Inbred

SCH - Single Cross Hybrid
MPH - Multi-parent Hybrid
Extant VCK - Extant Variety Common Knowledge

Annexure 4

Breeder Seed Production

Crop : MAIZE Sl.No.	Variety	Type	Year of Notification	Quantity (in quintals) Allocation BSP-I	Production	Surplus/Deficit over DAC Indent	Producing Institute
1	Pratap Kanchan 2 WC-236(Y)	OPV	2009	0.40	0.45	0.05	MPUAT, Udaipur
2	Praptap Makka 3(EC-3108)	OPV	2005	4.20	2.30	-1.9	
3	Pratap maize Hybrid 3 (Female)	Inbred	2016	4.00	4.00	0	
4	Pratap maize Hybrid 3 (male)	Inbred	2016	2.00	2.00	0	
5	Pratap Makka 5	OPV	2006	12.60	5.10	-7.5	
6	Pratap Makka Chari 6	OPV	2009	10.50	8.70	-1.8	
7	Pusa Composite 3 (Composite 85134)	OPV	2005	4.02	4.50	0.48	IARI
8	Pusa Composite-4(Composite 8551)	OPV	2005	1.20	1.50	0.3	
9	PMH 7 (F)	Inbred	--	0.65		-0.65	PAU, Ludhiana
10	PMH 7 (M)	Inbred	--	0.30		-0.3	
11	CM 139	Inbred	--	0.12	0.30	0.18	
12	CM 140	Inbred	--	0.20	0.20	0	
13	LM 13	Inbred	--	4.00	3.50	-0.5	
14	LM 14	Inbred	--	2.00	2.10	0.1	
15	LM 15	Inbred	--	0.12	0.40	0.28	
16	LM 16	Inbred	--	0.06	0.30	0.24	
17	LM 17	Inbred	--	0.06	0.10	0.04	
18	LM 18	Inbred	--	0.12	0.20	0.08	
19	LM 19	Inbred	--	0.06	0.10	0.04	
20	LM 20	Inbred	--	0.06	0.90	0.84	
21	LM 23	Inbred	--	3.00	3.80	0.8	
22	LM 24	Inbred	--	1.50	1.50	0	
23	J 1006 (FODDER)	OPV	1992	56.20		-56.2	
24	J 1008	OPV	--	0.80		-0.8	
25	HM 10 (HKH 1200) (Female HKI193-2)	Inbred	2008	0.30	0.30	0	CCSHAU, Hisar
26	HM 10 (HKH 1200) (Male HKI 1128)	Inbred	2008	0.15	0.30	0.15	
27	HQPM 7 (HKI 193-1 (F))	Inbred	2008	0.05		-0.05	
28	HQPM 7 (HKI 161 (M))	Inbred	2008	0.02	0.02	0	
29	HQPM 1-Male (HKI 163)	Inbred	2007	0.63	0.55	-0.08	
30	HQPM 1-Female (HKI 193-1 (F))	Inbred	2007	1.70	1.40	-0.3	
31	HQPM 5-Male (HKI-161)	Inbred	2007	0.60	0.60	0	

32	HQPM 5-Female (HKI 163)	Inbred	2007	1.15	1.15	0	
33	HQPM 4 HKI-193-2 (F)	Inbred	2010	0.05	0.10	0.05	
34	HQPM 4 HKI-161 (M)	Inbred	2010	0.02	0.18	0.16	
35	DHM 121 (F) BML 45	Inbred	2014	4.05	3.00	-1.05	PJTSAU, Hyderabad
36	DHM 121 (M) BML 6	Inbred	2014	2.03	2.03	0	
37	DHM 117- BML 6 A LINE	Inbred	2010	4.24	4.24	0	
38	DMH 117 (M)	Inbred	2010	2.07	2.07	0	
39	DHM 117- BML 6 R LINE	Inbred	2010	0.05	0.05	0	
40	DHM 109 (EH 40097)	TWCH	1994	0.50	0.50	0	
41	DHM 107 CM-119xCM-211	TWCH	1993	0.50	0.50	0	
42	RAJASHREE GPM 456	Inbred	--	0.18		-0.18	Kolhapur
43	RAJASHREE GPM 342	Inbred	--	0.09		-0.09	
44	PHULE MAHARISHI (QMH 1025) (F)	Inbred	--	0.05		-0.05	
45	PHULE MAHARISHI (QMH 1025) (M)	Inbred	--	0.02		-0.02	
46	QMHSC 1182 PHULE MADHU (F)	Inbred	--	0.05		-0.05	
47	QMHSC 1182 PHULE MADHU (M)	Inbred	--	0.02		-0.02	
48	AFRICAN TALL COMPOSITE	OPV	1983	45.07		-45.07	
49	CoH(M)8 Female Parent of UMI1201	Inbred	2013	0.05	0.10	0.05	TNAU, Coimbatore
50	CoH(M)8 Male Parent of UMI1230	Inbred	2013	0.03	0.03	0	
51	COHM 9 (F) UMI 1205	Inbred	2014	0.05	0.40	0.35	
52	COHM 9 (M) UMI 1230	Inbred	2014	0.03	0.47	0.44	
53	Malviya Hybrid Makka 2(V 33) (M)	Inbred	2007	0.35	0.00	-0.35	BHU, Varanasi
54	Malviya Hybrid Makka 2(V 33)(F)	Inbred	2007	0.65	0.00	-0.65	
55	Vivek Sankul Makka-31(VL 103)	OPV	2008	1.20	4.00	2.8	VPKAS, Almora
56	VQPM 9 (F)	Inbred	2008	1.40	1.15	-0.25	
57	VQPM 9 (M)			0.60	0.45	-0.15	
58	SHAKTIMAN CML 161(F)	Inbred	2006	0.04	1.50	1.46	RAU, Dholi
59	SHAKTIMAN CML 169(M)	Inbred	2006	0.02	0.50	0.48	

60	Jawahar Vikas Maize - 421 (JVM 421)	OPV	2007	2.00		-2	Chhindawada
61	JAWAHAR MAKAI - 216 (JM 216)	OPV	2004	24.00		-24	
62	CM 300	Inbred	--	0.04	0.04	0	GBPAU&T, Pantnaagr
63	CM 400	Inbred	--	0.04	0.04	0	
64	CM 600	Inbred	--	0.10	0.10	0	
65	Pant Sankul Makka 3 (D131)	OPV	2008	2.20	2.20	0	
66	Azad Kamal (R 9803)	OPV	2005	4.20	6.23	2.03	Kanpur
67	Birsa Vikas Makka 2	OPV	2005	0.30		-0.3	BAU, Ranchi

TWCH - Three Way Cross Hybrid

Annexure 5

Human Resource Development

A.Training attended

A1. Under approved HRD Annual Training Plan (ATP) 2017-18

A1.1: Scientific

Name of the scientist	Name of the training programme attended	Venue	Date
Mr. Mukesh Choudhary	Statistical data analysis and interpretation using SAS	ICAR-NAARM, Hyderabad, Telangana.	July 21-August 10, 2017
Dr. Pardeep Kumar	Molecular breeding techniques for crop improvement	ICAR-Indian Institute of Rice Research, Hyderabad, Telangana.	July 21-August 17, 2017
Mr. Pravin Bagaria	Molecular diagnostics of plant pathogens-Whole genome sequencing of plant pathogens: Methods and applications	Division of Plant Pathology ICAR-IARI, New Delhi	December 29, 2017-January 19, 2018
Dr. Alla Singh	Proteomics	National Agri-Biotechnology Institute, Mohali, Chandigarh	February 1-21, 2018

A1.2: Technical

Name of the Technical	Name of the training programme attended	Venue	Date
Mr. Samir Kumar Rai	Farm management: Layout and maintenance of field experiments and recording observations	Division of Agronomy ICAR-IARI, New Delhi	October 3-12, 2017

A1.3: Administrative

Name of the Staff	Name of the training programme attended	Venue	Date
Mrs Kamlesh malik	File and record management: GFR 2017	ISTM, New Delhi	July 19-21, 2017

A2. Others

Name of the scientist	Name of the training programme attended	Venue	Date
Dr. Sujay Rakshit	Executive Development Programme (EDP)	ICAR-NARM, Hyderabad	July 28-August 1, 2017
Dr. S B Singh	Precision phenotyping and digital data management for abiotic stresses	BHU, Varanasi	May 29-31, 2017
Dr. Laxmi Soujanya	Administrative matters	ICAR-Indian Institute of Millets Research, Hyderabad	August 16-18, 2017
Dr. Suby S. B.	Pest Risk Analysis (PRA)	National Institute of Plant Health Management (NIPHM), Hyderabad	November 6-10, 2017
	Hands-on training on prior-art search	Zonal Technology Management and Business Promotion Development (ZTM-BPD) unit, ICAR-IARI, New Delhi	November 15-18, 2017
	Recent advances of bioinformatics in agriculture	ICAR-Indian Agricultural Statistics Research Institute, New Delhi	December 1-21, 2017
Ms. Sapna	Recent techniques and tools for nutritional quality assessment and enhancement of food crops	Division of Biochemistry, ICAR-IARI, New Delhi	January 23-February 12, 2018
Dr. Pardeep Kumar	Genomics assisted Breeding for Crop Improvement	Division of Genetics, ICAR-IARI, New Delhi	March 1-21, 2018
Mr. Vishal Singh	Genomics assisted Breeding for Crop Improvement	Division of Genetics, ICAR-IARI, New Delhi	March 1-21, 2018
All staff of ICAR-IIMR, Ludhiana	Operation of GeM (Government eMarket Place) for the purchase of various articles / equipments	ICAR-CIPHET, Ludhiana	July 25, 2017
All staff of ICAR-IIMR, Delhi unit	GeM (Government eMarket Place) Training for Govt Buyers	DGS&D, New Delhi	August 3-4, 2017

B. Trainings conducted

Name of scientist /organizer	Name of the training programme conducted	Venue	Date
Dr. S B Singh	Farmer Training on "*Ekal Sankar Makkaki Beej Utpadan Takniki*".	Village-Dhurva, Distt Ranchi (Jharkhand)	February 23, 2018
	Farmer-Scientist Interaction cum field day programme on Hybrid maize and its seed production	RMR&SPC, Kushmahaut, Begusarai	March 17, 2018

C. Participation in Conferences/ Seminars/ Workshops/ Important meetings

Name of scientist	Name of the Conference/ Seminar/ Workshop/ meeting attended	Venue	Date
Dr. Ishwar Singh	National Workshop on "Developing a road map for agricultural Knowledge management in India"	NASC, New Delhi	September 27-28, 2017
	Annual surveillance of ISO 9001:2015 certification	ICAR-IIMR, Ludhiana	September 22-23, 2017
Dr. A K Singh	International Conference on "Advances in potassium research for efficient soil and crop management"	NASC, New Delhi	August 28-29, 2017
Dr. S B Singh	Annual review and planning meeting of CRMA project	Banaras Hindu University (BHU), Varanasi	May 29-31, 2017
	XII Annual Review Meeting of ICAR Seed Project "Seed Production in Agricultural Crops"	Mahatma Phule Krishi Visvavidhyalaya, Rahuri	July 29-30, 2017
	Establishment of Soil lab under model village of Member of Parliament Scheme in Begusarai	District Agriculture office, Begusarai	September 25, 2017
	Scientific Advisory Committee Meeting of KVK Khagaria	KVK, Khagaria	October 11, 2017
	A meeting called by Hon'ble Union Agriculture and Farmer Welfare Minister regarding agriculture strategies for development of Begusarai district	Circuit House, Begusarai	January 20, 2018

Name of scientist	Name of the Conference/ Seminar/ Workshop/ meeting attended	Venue	Date
	International Conference on "Global Research Initiatives for Sustainable Agriculture and Allied Sciences (GRISAAS - 2017)"	Rajasthan College of Agriculture, MPUAT - Udaipur	December 2-4, 2017
	ATMA management committee for District Begusarai	District Agriculture office, Begusarai	January 27, 2018
Dr. Ramesh Kumar	International Conference on "Global Research Initiatives for Sustainable Agriculture and Allied Sciences (GRISAAS-2017)"	Rajasthan College of Agriculture, MPUAT, Udaipur	December 2-4, 2017
	National Conference on "Enhancing efficiency and effectiveness of Institutional Administration/ Management and effective Implementation of Official Language Policy in ICAR"	IIHR, Hesaraghatta, Bengaluru	November 8, 2017
Dr. N. Sunil	Monitoring of Bio-safety Research Level -1 trials on transgenic maize being conducted by M/s. Pioneer Hi - Bred Pvt. Ltd., Hyderabad	Dharwad & Belgaum, Karnataka	October 5-6, 2017 and November17-18, 2017
	DUS Review meeting	IISR, Lucknow	January15-17, 2018
Dr. S L Jat	Agriculture-Nutrition linkage workshop" jointly organized by Department of Agriculture and Cooperation, GoI and The Bill and Melinda Gates Foundation	NASC, New Delhi, India	June 6, 2017
	International Conference on "Advances in potassium research for efficient soil and crop management"	NASC, New Delhi, India	August 28-29, 2017
	Brain storming meeting of the crop science institute for identification of Engineering intervention in crop	ICAR-CIAE, Bhopal	February 26-27, 2018
Dr. Suby S. B.	International conference on bio-control and sustainable insect pest management (ICBS, 2018)	Agricultural College and Research Institute, Tamil Nadu Agricultural University, Killikulam	January 29-31, 2018

Name of scientist	Name of the Conference/ Seminar/ Workshop/ meeting attended	Venue	Date
Mr. Abhijit Kumar Das	Digital Field Book	Dept. of PBG, PAU, Ludhiana	March 15, 2018
Mr. Pravin Bagaria	Workshop on "Simulation Modelling In Agricultural Research: Modelling Plant Disease Epidemics And Yield Losses"	Department of Plant Pathology & Indian Society of Plant Pathologists, Department of Plant Pathology PAU, Ludhiana	November 13-15, 2017
Mr. Mukesh Choudhary	HTPG workshop on "Forward breeding for crop improvement"	ICRISAT, Hyderabad	December 3-6, 2017
	Digital Field Book	Dept. of PBG, PAU, Ludhiana	March 15, 2018
Dr. Pardeep Kumar	ICAR-DBT brainstorming on forage crops	ICAR-Indian Grassland & Fodder Research Institute, Jhansi	December 21-22, 2017

D. Organization/participation of Kisan Mela/Kisan Gosthi/Field Day

Name of Scientist	Programme	Venue	Date
Dr. S B Singh	Participated and exhibited IIMR technologies in the stall with live demonstration of Maize and Popcorn in the *Champaran Satyagrah Satabadi Samaroh Kisan Kalyan Mela*	Zila High School Ground, Distt. Motihari,	April 15-19, 2017
	Attended *Sankalp Se Sidhi* Programme, Chaired by Hon,ble Minister for Social welfare, Govt of Bihar Smt. ManjuVerma and Member of Parliament (LokSabha), Dr. Bhola Singh	KVK, Khodawantpur , Begusarai	August 19, 2017
	Organized a *Kisan Gosthi* on "Maize Hybrid Technology"	Kisan Kalyan Mela Parisar at Motihari	April 18, 2017.
	Organized the IIMR Stall for exhibition and live demonstration of IIMR technologies in the *Kisan Mela* on the occasion of Bihar Divas	Gandhi Maidan, Begusarai	March 22-23, 2018

Name of Scientist	Programme	Venue	Date
	Organized viewing of live telecast of Hon'ble Prime Minister Shri Narendra Modi from *Krishi Unnati Mela*, IARI, Pusa New Delhi. The programme was chaired by Hon'ble Member of LokSabha Dr. Bhola Singh MP, Begusarai	RMR&SPC, Begusarai	March 17, 2018
Ms. Sapna	Agriculture Education Day	ICAR-IIMR, Ludhiana	December 3, 2017

E. Foreign Deputation

Name of scientist	Programme	Location	Date
Dr. Sujay Rakshit	As an expert to provide input in the workshop on "Maize Mega Environment of South Asia"	Dubai, UAE	July 10-11, 2017
	As an expert to participate in review and planning meeting of the project "Heat Stress Tolerant Maize for South Asia (HTMA)"	Bangladesh	August 9-10, 2017
	As a trainee to participate in "Crawford Fund Master Class in Agricultural Research Leadership and Management"	Malaysia	October 30-November 3, 2017
Dr. J.C. Sekhar	As an expert to provide input in the workshop on "Maize Mega Environment of South Asia"	Dubai, UAE	July 10-11, 2017
Dr. Pranjal Yadava	Nehru-Fulbright Postdoctoral Fellowship	Stanford University, USA	January 30, 2017 - January 29, 2019
Mrs. Sapna	Presented paper and attended 10th International conference on Agriculture and Horticulture (Agri-2017)	London, United Kingdom	October 2-4, 2017

Annexure 6

Lectures/T.V./Radio Talks Delivered

Lectures

S. No.	Person	Lecture Topic	Conference/Event	Venue and Date
1.	Dr S B Singh	Breeding Stress Resilient Maize for Sustainable Grain Production	International Conference on Global Research Initiatives for Sustainable Agriculture and Allied Sciences	Rajasthan College of Agriculture, MPUA&T, Udaipur, Rajasthan (December 2-4, 2017)
		Scientific Crop Management in Maize for Higher Production During Kharif	Farmer Scientist Interaction Programme by DAO, Begusarai	District Agriculture Office Begusarai, Bihar (August 4-5, 2017)
		Higher Production of Soybean Crop in Begusarai	Farmer Scientist Interaction Programme by DAO, Begusarai	District Agriculture Office Begusarai, Bihar (August 4-5, 2017)
		Seasonal Crop Management of Hybrid Maize During Kharif	Training Programme organized by ATMA, Begusarai	Village Kesava, Barauni, Distt. Begusarai (August 11, 2017)
		एकल संकर मक्का के बीज उत्पादन की तकनीकी	Farmer Training on Seed Production Technology of Single Cross Maize Hybrid	Village Dhurva, Distt Ranchi (Jharkhand) (February 23, 2018)
		पूर्वी भारत के लिए उपयक्त संकर मक्का की किस्में	Farmer Training on Seed Production Technology of Single Cross Maize hybrid	Village Dhurva, Distt Ranchi (Jharkhand) (February 23, 2018)
		बीज प्रसंस्करण, प्रमाणीकरण तकनीक	Farmer Training on Seed Production Technology of Single Cross Maize Hybrid	Village Dhurva, Distt Ranchi (Jharkhand) (February 23, 2018)
2.	Dr A K Singh	New Research Opportunities in Maize System using Nutrient Expert.	Invited Talk at 82nd Annual Convention of ISSS	Amity University, Kolkata, West Bengal (December, 2017)
3.	Dr Alla Singh	Emerging Trends in Gene Cloning	Invited Extension Lecture	Khalsa College of Women, Civil Lines, Ludhiana (January 17, 2018)

TV/Radio Talks

S. No.	Topic	Purpose	Venue	Date
Dr. S L Jat				
1.	जायद मक्का की खेती	कृषि दर्शन	डीडी 1	मार्च 9, 2018
2.	रबी मक्का की खेती	हेल्लो किसान लाइव कार्यक्रम	डीडी किसान	दिसम्बर 19, 2017
3.	बेबी कॉर्न एवं स्वीट कॉर्न की खेती	हेल्लो किसान लाइव कार्यक्रम	डीडी किसान	अक्टूबर 31, 2017
4.	खरीफ मक्का की खेती में समसामयिक कार्य	हेल्लो किसान लाइव कार्यक्रम	डीडी किसान	जुलाई 11, 2017
5.	अनाज हेतु मक्का की खेती	हेल्लो किसान लाइव कार्यक्रम	डीडी किसान	मई 24, 2017
6.	मक्का फसल में सामयिक कार्य	कृषि दर्शन	डीडी 1	अप्रैल 12, 2017
Dr. Soujanya PL				
7.	Post Harvest management of maize	Rythu Nestham programme	Doordarshan Channel-Yadagiri (Telugu)	September 7, 2017

Annexure 7

Publications

Research papers (National and International)

1. Arsode P, Krishna KM, Sunil N, Sree V, Charan RA (2017) Combining ability and heterosis studies for grain yield and its components in hybrids of quality protein maize (*Zea mays* L.). Int J Curr Microbiol Appl Sci 6(12):2538-45

2. Changan S, Chaudhary DP, Kumar S, Kumar B, Kaul J, Guleria S, Jat SL, Singode A, Tufchi M, Langyan S, Yadav OP (2017) Biochemical characterization of elite maize (*Zea mays*) germplasm for carotenoids composition. Indian J Agr Sci 87(1):46-50

3. Dhillon MK, Chaudhary DP (2017) Physicochemical mechanisms of resistance in sorghum to *Chilo partellus* (Swinhoe). Indian J Exp Biol 56:29-38

4. Gopala, Gogoi R, Hossain F, Hooda KS, Sekhar JC (2017) Molecular characterization of maize inbred lines against stalk rot complex of maize (*Zea mays* L.). Int J Curr Microbiol Appl Sci 6(7):230-237

5. Hargilas, Singh AK, Jat SL, Rokadia PK, Kumar A (2017) Response of maize (*Zea mays*) hybrids to nutrient management practices for enhancing productivity and profitability under sub-humid condition of Southern Rajasthan. Indian J Agron 62(3):326-331

6. Jat ML, Jat RK, Singh P, Jat SL, Sidhu HS, Jat HS, Bijarniya D, Parihar CM, Gupta R (2017) Predicting yield and stability analysis of wheat under different crop management systems across agro-ecosystems in India. Am J Pl Sci 8:1977-2012

7. Jat RK, Singh P, Jat ML, Dia M, Sidhu HS, Jat SL, Bijarniya D, Jat HS, Parihar CM, Kumar U, Ridaura SL (2018) Heat stress and yield stability of wheat genotypes under different sowing dates across agro-ecosystems in India. Field Crops Res, 218:33-50

8. Kaje VV, Sharma DK, Shivay YS, Jat SL, Bhatia A, Purakayastha TJ, Bandyopadhyay KK, Bhattacharyya R (2018) Long-term impact of organic and conventional farming on soil physical properties under rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system in north-western Indo-Gangetic plains. Indian J Agr Sci 88(1):107–13

9. Kaul J, Kumar R, Nara U, Jain K, Olakh DS, Tiwari T, Yadav OP, Dass S (2017) Development of data base of maize hybrids and open pollinated varieties released and notified for cultivation in India. J Agri Sci 9(10):105-113

10. Kumar S, Sinha A, Meshram S, Singh MK, Singh V, Hooda KS (2018) Myco-toxins monitoring device and their management strategies through detoxifying agents in feed. Int J Curr Microbiol Appl Sci 7(1):3410-3426

11. Kumar S, Sinha A, Shekhar M, Singh V (2017) Detection of aflatoxin B_1 through indirectELISA from fresh grains obtained from three maize growing zones of India. J Appl & Nat Sci 9(2):796 – 798

12. Malik VK, Singh M, Hooda KS, Yadav NK, Kumar PC (2018) Efficacy of newer molecules, bioagents and botanicals against maydis leaf blight and banded leaf and sheath blight of maize. Plant Pathol J 34(2):121-125

13. Mehta BK, Hossain F, Muthusamy V, Zunjare RU, Sekhar JC, Gupta HS (2017) Analysis of responses of novel double mutant (sh2sh2/su1su1) sweet corn hybrids for kernel sweetness under different sowing-and harvest-time. Indian J Agr Sci 87 (11):1543-48

14. Mehta BK, Hossain F, Muthusamy V, Zunjare RU, Sekhar JC, Gupta HS (2017) Analyzing the role of sowing and harvest time as factors for selecting super sweet (-sh2 sh2) corn hybrids. Indian J Genet Pl Br 77(3):348-356

`15. Mukri G, Kumar R, Rajendran A, Kumar B, Hooda KS, Chikkappa GK, Singh V, Jat SL, Das AK, Sekhar JC, Singh SB (2018) Strategic selection of white maize inbred lines for tropical adaptation and their utilization in developing stable, medium to long duration maize hybrids. Maydica 63(1)

16. Parihar CM, Jat SL, Singh AK, Ghosh A, Rathore NS, Kumar B, Pradhan S, Majumdar K, Satyanarayana T, Jat ML, Saharawat YS, Kuri BR, Saveipune D (2017) Effects of precision conservation agriculture in a maize-wheat-mungbean rotation on crop yield, water-use and radiation conversion under a semiarid agro-ecosystem. Agric Water Manag 192:306-319

17. Parihar CM, Jat SL, Singh AK, Kumar B, Rathore NS, Jat ML, Saharawat YS, Kuri BR (2018) Energy auditing of long-term conservation agriculture based irrigated intensive maize systems in semi-arid tropics of India. Energy 142:289-302

18. Parihar CM, Yadav MR, Jat SL, Singh AK, Kumar B, Pooniya V, Pradhan S, Verma RK, Jat ML, Jat RK, Saharawat YS (2017) Long term conservation agriculture and intensified cropping systems: effect on growth, yield, water and energy-use efficiency of maize in north-western India. Pedosphere 10.1016/S1002-0160(17)60468-5

19. Pradhan S, Sehgal VK, Bandyopadhyay KK, Sahoo RN, Panigrahi P, Parihar CM, Jat SL (2017) Comparison of vegetation indices from two ground based sensors. J Indian Soc Remote 10.1007/s12524-017-0671-0

20. Reddy MT, Pandravada SR, Sivaraj N, Kamala V, Sunil N, Dikshit N (2017) Classification and characterization of landscapes in the territory of Adilabad district, Telangana, Deccan region, India. Open Access Library Journal 4:e3745.

21. Reddy MT, Sivaraj N, Kamala V, Pandravada SR, Sunil N, Dikshit N (2018) Classification, characterization and comparison of aquatic ecosystems in the landscape of Adilabad district, Telangana, Deccan region, India. Open Access Library Journal 5:e4459

22. Rialch I, Dev J, Kumar B (2017) Heterosis and combining ability studies for quality traits in soybean [*Glycine max* (L.) Merrill]. Int J Curr Microbiol Appl Sci 6(8):3443-3451

23. Sharma S, Mishra DP, Kumar B, Kaur H, Jewlia HR (2017) Genetic diversity of maize (*Zea mays* L.) inbred lines revealed by simple sequence repeat markers. Int J Curr Microbiol Appl Sci 6(12)543-550

24. Shekhar M, Singh N, Bisht S, Singh V, Kumar A (2018) Biological control of aflatoxin in maize grain at ambient storage conditions. Int J Curr Microbiol Appl Sci 7(04)

25. Shekhar M, Singh N, Dutta R, Kumar S, Mahajan V (2017) Comparative study of qualitative and quantitative methods to determine toxicity level of *Aspergillus flavus* isolates in maize. PLoS ONE 12(12):e0189760

26. Singh I, Chikkappa GK, Atkare AP, Shukla PK, Avni, Yadava P (2017) Identification of heat-stress tolerant recombinant inbred lines in maize (*Zea mays* L.). Maize J 6(1&2):9-21

27. Singh SB, Phagna RK, Kumar B, Kumar S (2017) Determination of selection indices for waterlogging stress tolerance in maize (*Zea mays* L.) under field conditions. App Biol Res 19(2):172-179

28. Singh V, Amaradasa, Bimal S, Chikappa GK, Lakshman DK, Hooda KS, Kumar A (2018) Morphological and molecular variability among Indian isolates of *Rhizoctonia solani* causing banded leaf and sheath blight in maize. Eur J Plant Pathol

29. Singh V, Chikkappa GK, Lakshman DK, Kumar A, Mehra R, Shekher M (2018) Phytotoxic and cross-protective effects of culture filtrate of *Rhizoctonia solani* isolates on *Zea mays*. Ann Pl Protec Sci 26 (1):153-159

30. Singh V, Shekhar M, Bisht S, Kumar S, Gogoi R (2017) Role of soil health management in minimizing the incidences of important disease in *Zea mays*. Maize J 1-8(1&2):

31. Sivamurugan AP, Ravikesavan R, Yuvaraja A, Singh AK, Jat SL (2017) Weed management in maize with new herbicides. Chem Sci Rev Letters 6(22):1054-1058

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Review articles

1. Agarwal A, Yadava P, Kumar K, Singh I, Kaul T, Pattanayak A, Agrawal PK (2018) Insights into maize genome editing *via* CRISPR/Cas9. Physiol Mol Biol Plants 24(2):175–83
2. Kaul J, Kumar R, Nara U, Jain K, Olakh DS, Tiwari T, Yadav OP, Dass S (2018) An overview of registration of maize genetic resources in India. Int J Curr Microbiol Appl Sci 7(2):933-950
3. Nehra M, Sharma RK, Choudhary M (2017) An overview on molecular basis of genetic recombination. Int J Curr Microbiol Appl Sci 6(4):1154-1167

Popular articles

1. Kumar P, Nautiyal MK, Esakkimuthu M (2017) Participatory plant breeding: a way forward. Indian Farmer's Digest 50(11)
2. Sapna, Siddiqui WA (2017) Nutritional and medicinal value of maize silk. Indian Farming 67(5):15-16
3. Mishra S, Kumar A, Jat SL, Parihar CM, Sharma V, Chikkappa GK, Singh AK (2017) Single cross hybrid seed production in maize. Indian farming 67(05):22-24
4. Kaul J, Kumar R, Nara U, Jain K, Olakh DS, Tiwari T, Yadav OP, Dass S (2017) Indian maize cultivar database: a tool for breeders. Maize Genetics Cooperation Newsletter 91
5. सी.एम. परिहार, एस.एल. जाट, बी.आर. कुडी (2016) रबी मक्का उत्पादन की उन्नत तकनीकियाँ। खाद पत्रिका (दिसम्बर) 7-13
6. एन. सुनील, जे.सी. शेखर, जी.के. चिक्कापा, प्रदीप कुमार एएं सुजय रक्षित (2018) संकर मक्का के विकास के लिए इन्ब्रेड्स जननद्रव्य का निर्णय समर्थन प्रणाली। कृषि चेतना (मक्का विशेषांक) 1:80–81
7. कृष्ण कुमार, अवनि (2018) ट्रांसजेनिक मक्का की स्थितिः एक समीक्षा। कृषि चेतना (मक्का विशेषांक) 1:89–92
8. गणपति मुक्रि, ज्योति कौल, टी. नेपोलियन, आर.एन. गदग, दिग्वेंद्र पाल, राजेश कुमार (2018) भोजन और पोषण सुरक्षा के लिए भारत में सफेद मक्का के प्रजनन की संभावनाएं। कृषि चेतना (मक्का विशेषांक) 1:45–47
9. गोरधन गेना, महेश चंद मीणा, शंकर लाल जाट, राम स्वरूप बाना (2017) जैव अपशिष्ट से आय का सर्जन। खेती (जुलाई): 47–49
10. दिव्या चौहान, दिलीप सिंह, एस.एस. शर्मा (2018) मीठी मक्का की खेती की उप्पादन तकनीक। कृषि चेतना (मक्का विशेषांक) 1:36–39
12. धर्म पाल चौधरी, सपना, रमेश कुमार फागना (2018) क्वालिटी प्रोटीन मक्का (क्यू.पी.एम.): उत्तम सेहत की पहचान। कृषि चेतना (मक्का विशेषांक) 1:43–44
13. निरंजन सिंह, सुदर्शना कुमारी (2018) मक्का के साथ लोबिया की लाभदायक खेती। कृषि चेतना (मक्का विशेषांक) 1:82–83
14. पी.लक्ष्मी सोजन्या, एस.बी.सुबी, ज्वाला जिंदल, महासिंह जागलान, एम.एल.के. रेड्डी, जे.सी. शेखर, सुजय रक्षित (2018) मक्का फसल के मुख्य कीट एवं उनका प्रबंधन। कृषि चेतना (मक्का विशेषांक) 1:65–72
15. पी.लक्ष्मी सोजन्या, जे.सी. शेखर, एस.बी.सुबी, ज्वाला जिंदल, महासिंह जागलान, सुजय रक्षित (2018) लघु स्तर पर भण्डारित मक्का के कीटो का पर्यावरण हितैषी प्रबंधन। कृषि चेतना (मक्का विशेषांक) 1:73–79
16. प्रदीप कुमार, पूनम चौधरी, मुकेश चौधरी, बी.एस. जाट, विशाल सिंह, रमेश कुमार (2018) शिशु मक्का (बेबी कॉर्न): एक व्यवसायिक फसल। कृषि चेतना (मक्का विशेषांक) 1:40–42
17. प्रवीण कुमार बगडिया, कर्मबीर सिंह हुड्डा, बी.एल. बहेती (2018) मक्का की फसल में सूत्रकृमी की समस्या एवं समाधान। कृषि चेतना (मक्का विशेषांक) 1:61–64
18. भूपेंद्र कुमार, प्रदीप कुमार, मुकेश चौधरी, शंकर लाल जाट, बहादुर सिंह जाट, विशाल सिंह (2018) विभिन्न कृषि–पारिस्थितिकी में संकर मक्का। कृषि चेतना (मक्का विशेषांक) 1:8–18

19. ममता गुप्ता, मुकेश चौधरी (2018) बीटी मक्का और इसके फायदे। कृषि चेतना (मक्का विशेषांक) 1:86–88

20. मीना शेखर (2018) मक्का में एफ्लैटाक्सिन प्रदूषण का महत्व और उसका प्रबंधन। कृषि चेतना (मक्का विशेषांक) 1:57–60

21. मुकेश चौधरी, प्रदीप कुमार, बहादुर सिंह जाट, शंकर लाल जाट, पूनम चौधरी (2018) हरा मक्का चाराः पशुधन पालन हेतु सुनहरा विकल्प। कृषि चेतना (मक्का विशेषांक) 1:48–50.

22. राजेश खुल्बे, दिबाकर महन्त, राजशेखरा एच., जे. स्टेनली, दिनेश जोशी, जी.एस. बिस्ट, एम.सी. पन्त, लक्ष्मी कान्त, अरुणव पट्टनायक (2018) उत्तराखण्ड में मक्का उत्पादकता में वृद्धि हेतु उन्नत उत्पादन तकनीकी। कृषि चेतना (मक्का विशेषांक) 1:31–35

23. विशाल सिंह, मुकेश चौधरी, प्रदीप कुमार, प्रवीण कुमार बगड़िया, आला सिंह, अभिजीत कुमार दास, बहादुर सिंह जाट, मनेश चंद्र डागला (2018) सहभागी पादप प्रजननः मक्का के सन्दर्भ सहित एक परिचय। कृषि चेतना (मक्का विशेषांक) 1:84–85

24. शंकर लाल जाट, सी.एम. परिहार, भूपेंद्र कुमार, सुबी एस.बी., मुकेश चौधरी, आदित्य कुमार सिंह, प्रवीण कुमार बगडिया (2018) कृषि में लाभप्रदता हेतु मक्का की उन्नत तकनीकियाँ। कृषि चेतना (मक्का विशेषांक) 1:1–7

25. श्यामवीर सिंह, रविन्द्र कुमार कसना (2018) बिहार में कृषि आय वृद्धि हेतु मक्का की खेती में संभावनाएं। कृषि चेतना (मक्का विशेषांक) 1:19–22

26. संतोष कुमार सिन्हा, अमित कुमार सिन्हा, दिनेश कुमार ठाकुर, अखिलेश कुमार लकड़ (2018) छत्तीसगढ़ में मक्का उत्पादन की उन्नत तकनीक। कृषि चेतना (मक्का विशेषांक) 1:23–30

27. सपना (2017) बहूपयोगी है मक्के का रेशम। खेती (जून):40–41

28. सपना, धर्मपाल चौधरी, आला सिंह, ईश्वर सिंह (2018) अजैविक तनाव और फसल प्रबंधन के अनाज की संरचना पर प्रभावः खाद्य गुणवत्ता और सुरक्षा। कृषि चेतना (मक्का विशेषांक) 1:55–56

29. स्नेहा अधिकारी, अंजली जोशी, नरेन्द्र कुमार सिंह (2018) बदलते जलवायु परिवेश में जंगली प्रजातियों द्वारा मक्का में सम्भावनाये। कृषि चेतना (मक्का विशेषांक) 1:51–54

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1. Chaudhary DP (2017) Nutritional and nutraceutical/functional properties of maize. In: Watson D (ed) Achieving sustainable cultivation of maize. Burleigh Dodds series in agriculture science, pp177-185

2. Chikkappa GK, Sekhar JC, Soujanya PL, Suby SB, Kaur J, Mallikarjuna MG, Kumar P (2017) Breeding for resistance to insect pests in maize. In: Arora R, Sandhu S (eds) Breeding insect resistant crops for sustainable agriculture. Springer, Singapore, pp 201-229. ISBN 978-981-10-6056-4

3. Hooda KS, Bagaria PK, Khokhar MK (2017) Maize diseases: current status and their management. In: Gautam HR, Gupta SK (eds) Diseases of commercial crops in India. Neoti Book Agency Pvt Ltd, New Delhi, pp 81-100

4. Hossain F, Muthusamy V, Zunjare R, Mehta B, Chhabra R, Chauhan HS, Baveja A, Das AK, Sarika K, Bhat JS (2018) Quality enhancement in sweet corn through marker-assisted selection. In: Behera TK, Singh S, Sharma BB, Tomar BS (eds) Molecular breeding for higher productivity, quality, food colorants, nutraceuticals and bioactive health compounds in vegetable crops. MS Printers, New Delhi, pp 20-29

5. Kumar K, Aggarwal C, Sapna, Singh I, Yadava P (2018) Microbial genes in crop improvement. In: Prasad R, Gill SS, Tuteja N (eds) New and future developments in microbial biotechnology and bioengineering: crop improvement through microbial biotechnology. Elsevier, Amsterdam, Netherlands, pp 39-54. ISBN: 978-0-444-63987-5)

6. Kumar P, Singh R (2017) Agriculture renewal with ancient agricultural practices in Indian perspective. In: Agriculture renewal-green to evergreen revolution. Lap Lambert Academic Publishing, pp 7-14. ISBN: 978-3-330-07027-1

7. Kumar P, Suby SB, Kaur J (2018) Integrated pest management- maize. In: Chattopadhyay C, Tanwar RK, Sehgal M, Birah A, Bhagat S, Ahmad N, Mehta N (eds) Handbook of integrated pest management. Indian Council of Agricultural Research, pp 483-496

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1. Singh AK, Jat SL, Parihar CM (2017) Response of maize genotypes to potassium nutrition under diverse agro-ecologies of India. In: Book of extended summaries and abstracts of an international conference on "advances in potassium research for efficient soil and crop management" from 28th to 29h August 2017 held at New Delhi, India. pp 46-47

2. Hooda KS (2017) Australian plant biosecurity and its relevance to India. In: National symposium on "biorational approaches in plant disease management" and annual meeting of INSOPP, Oct. 27-28, 2017 at YSPUHF, Nauni (Solan)

3. Hooda KS (2018) Plant biosecurity system of Australia and its implications for India. In: Proc. 105th Indian Science Congress (16-20 March, 2018), Manipur University, Imphal

4. Soujanya PL, Sekhar JC, Suby SB (2018) Sustainable and novel eco-friendly approaches towards rice weevil management in stored maize. In: Book of abstracts, national symposium on "promoting entreprenurial growth through innovative approaches in food processing sector" held at ICAR-CIPHET, Ludhiana from March 16th to 17th, 2018.

5. Shekhar M, Bishat S (2017) Integrated management: An approach for reducing aflatoxin in maize. In: International conference on global research initiatives for sustainable agriculture and allied science, Dec 2-3, 2017. pp 415

6. Shekhar M, Singh V, Singh N, Bisht S (2018) Study of thermal longevity of *Macrophomina phaseolina* and phytotoxic effect of its cultural effect on *Zea mays*. In: National Symposium on plant health management: embracing eco-sustainable paradigm at AAU, Jorhat, February 15-17, 2018, S-3/SNIP/O-4

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Training Manuals

1. Hossain F, Muthusamy V, Zunjare R, Mehta B, Baveja A, Chauhan H, Chhabra R, Das AK, Sarika K, Bhat J (2018) Genomics-assisted selection in maize: specialty traits. In: Singh AK, Hossain H, Krishnan G (eds) Genomics-assisted breeding for crop improvement. Sponsored by ICAR-HRM. 1-21 March, 2018 Division of Genetics, IARI, New Delhi, India, pp 237

2. Hossain F, Muthusamy V, Zunjare R, Das AK, Sarika K , Mehta B, Basu S, Bhat JS (2018) Principles and practices of seed production in maize. In: Vijay D, Joshi MA, Lal SK, Yadava DK, Jain SK, Yadav SK, Peddireddi UR (eds) International training on seed production and quality evaluation. Sponsored by Ministry of Rural Development, Government of India and AARDO. 14-28 January, 2018 Division of Seed Science and Technology, ICAR-Indian Agricultural Research Institute, New Delhi, India, pp 417

Annexure 8

On-going Projects

List of Ongoing Institute Projects

Sl.No.	Title of the project	PI	Co-PI(s)	Project Duration
	Agronomy			
1	Sensor guided nitrogen management in Maize base cropping system under conventional and conservation agriculture practices	Dr. SL Jat	Dr. A.K. Singh, Dr. C. M. Parihar, Dr. Dilip Singh, Dr. D. Sreelatha, Dr. C.S. Singh, Dr. Mahesh Kumar, Dr, Amit Kumar Bhatnagar, Dr. D.R. Thakur, Dr. P.C. Ghashal, Dr. Meena Shekhar, Dr. Suby S.B.	July 2017 to June 2022
2	Development of precision conservation agriculture practices in cereal based system in Indo-Gagatic Plains	Dr. AK Singh	Dr. S.L. Jat, Dr. Mr. P.K. Bagaria, Dr. Mahesh Kumar	July 2017 to June 2022
	Biochemistry			
3	Analysis of Starch diversity and digestibility in Maize	Dr. Dharam Paul	Mr. Alla Singh, Dr. A.K. Das	April 2017 to March 2022
	Biotechnology			
4	Development of Banded Leaf and Sheath Blight resistant transgenic maize	Dr. Krishan Kumar	Mr. Praveen Bagaria Dr. Deepak S. Bisht Dr. K.S. Hooda (Need Based) Dr. Pranjal Yadava (Need Based)	July 2016 to June 2021
5	Development of assay for testing protein quality in Maize	Dr. Alla Singh	Dr. Dharam Paul (Need Based) Dr. Pranjal Yadava (Need Based)	Sep. 2016 to Aug. 2019
	Entomology			
6	Development of management tools for maize pests	Dr. S.B. Suby	Dr. P.L. Soujanya, Dr. Amrender Kumar	Jan. 2016 to Dec. 2018
7	Management of Maize Stem Borers through Host plant resistance	Dr.P. Lakshami Soujanya	Dr. J.C. Shekhar, Dr. Chikkappa G. K., Dr. Jawala Jindal, Dr. Maha Singh, Dr. C.V. Ratnavathi	July 2017 to June 2022
	Plant Pathology			
8	Studies of host-pathogen interaction between *M. phaseolina* & *F. moliniforme* (stalk rot pathogens) in maize and identification of source of resistance against Post Flowering Stalk Rots of maize.	Dr. Meena Shekhar		Jan 2013 to Dec 2018
9	Development of IDM strategy for major disease of maize with available effective tools	Dr. K.S. Hooda	Mr. P.K. Bagaria, Dr. Amrender Kumar	April 2016 to March 2021

	Plant Breeding			
10	Genetic enhancement of QPM Germplasm	Dr. Ramesh Kumar	Dr. A.K. Das, Dr. Dharam Paul, Dr. S.B. Singh, Dr. Sunil Neelam, Mr. P.K. Bagaria, Mrs Suby S.B.	July 2017 June 2022
11	Genetic enhancement of White Maize for Food Purpose	Dr. Abhijit Kumar Das	Dr. S.B. Singh, Dr. Mukesh Vayas, Dr. Narendra Kumawat, Dr. S.K. Guleria, Savita Sharma, Dr. Baljit Singh	July 2017 June 2022
12	Breeding for High Yielding and better quality fodder cultivars in Maize	Mr. Mukesh Choudhary	Dr. Pardeep Kumar, Dr. M.M. Das, Dr. A.K. Singh,	July 2017 June 2022
13	Breeding for development of baby corn hybrids	Dr.Pradeep Kumar	Dr. Sujay Rakshit, Mr. Mukesh Choudhary, Mr. Praveen Kumar Bagaria, Dr. Meenakshi Goyal	July 2017 June 2022
14	Development of early maturing maize hybrid with enhanced yield and stress tolerance.	Dr. Manesh Chander Dagla	Mr. Mukesh Choudhary, Dr. B.S. Jat, Dr. Meena Shekhar, Dr. J.C. Sekhar	July 2017 June 2022
15	Diversification of sweet corn and popcorn germplasm	Dr. Chikkappa GK		
16	Characterization and diversification of maize germplasm.	Dr. Chikkappa GK	Dr. K.S. Hooda, Dr. S.B Singh, Dr. Sunil Neelam, Dr. Bhupender Kumar, Mr. Vishal Singh, Mr. Yatish K.R.,	June 2014 to May 2019
17	Genetic Enhancement of Maize for oil and methionine	Dr. Vislal Singh	Dr. Dharam Paul, Dr. Pranjal Yadava, Mr. Mukesh Choudhary, Mr. Yatish K.R.	August 2014 to July 2019
18	Decision Support System of Maize Inbred Germplasm	Dr. N. Sunil	Dr. K.P. Singh	April 2016 to April 2020
19	Development of high yielding maize hybrids for different ecologies.	Dr. Bhupender Kumar	Mr. Vishal Singh, Dr. S.B. Singh, Dr. Chikkappa G.K., Dr. Ramesh Kumar, Dr. K.S. Hooda, Dr. Ravi Kesavan R,	June 2014 to May 2019
20	Development of maize hybrids for eastern India	Dr. S.B. Singh	Dr. Krishan Kumar, Mr. P. K. Bagaria, Dr. B.S. Jat, Dr. Bhupender Kumar	Oct. 2014 to Sep. 2019
21	Breeding for tolerance to abiotic stresses in maize	Dr. Ramesh Kumar	Dr. Ishwar Singh, Mr. P.K. Bagaria, Dr, Bhupender Kumar, Dr. Chikkappa G.K.	2014 to 2019
	Physiology			
22	Physiological and Biochemical basis of nitrogen use efficiency in Maize	Dr. Ishwar Singh	Dr. S.L. Jat, Dr. Krishan Kumar	July 2017 to June 2020

List of Ongoing Externally Funded Projects

Project	Funding agency	Principal Investigator/ Mentor	Duration
Genetic Transformation and Development of Elite Transgenic Maize (*Zea mays* L.) for Biotic and Abiotic Stresses Tolerance	ICAR-National Agriculture Science Fund (NASF)	Dr. Krishan Kumar (CCPI) Dr. Ishwar Singh (Co-PI)	1st July 2015 – 31st Dec 2018
Climate Resilient Maize for Asia (CRMA)	CIMMYT	Dr Ramesh Kumar (CCPI) Dr S.B. Singh (CO-PI) Dr. Bhupender Kumar (CO-PI)	2016 -2018
Frontline Demonstration in Maize under NFSM	Department of Agriculture and cooperation, Ministry of Agriculture and Farmers ‘ Welfare, Govt of India	Dr Shankar Lal Jat (PI)	April 2014 and continuing
ICAR Project on “ Seed Production in Agricultural Crops”	ICAR-IISR, Mau	Dr. S. B. Singh (CCPI)	Ongoing (as per Plan)
Consortia Research Platform on Molecular Breeding (CRP on MB)	Indian Council of Agricultural Research	Dr. Chikkappa G. Karjagi (PI)	2015 -2020
Consortia Research Platform on Agrobiodiversity (CRP AB)	Indian Council of Agricultural Research	Dr. Chikkappa G. Karjagi (PI)	2014 -2020
Strengthening of DUS test centres under central sector scheme for implementation of PVP legislation	Protection of Plant Varieties and Farmer’s Rights Authority (PPV&FRA), MoA&FW, GoI	Dr. Chikkappa G. Karjagi (PI)	2007 -2019
Morphological Physiological and Molecular Characterization of Diverse Set of Maize Germplasm (SERB -DST N-PDF Project)	Department of Science and Technology (DST), Government of India	Dr. Chikkappa G. Karjagi (Mentor)	2017 -2019
CRP on Maize Biofortification	Indian Council of Agricultural Research	Dr Bhupender Kumar (PI)	2017-2020
Genetic enhancement for abiotic stresses tolerance in maize-(NICRA-Phase-II)	Indian Council of Agricultural Research	Dr Bhupender Kumar	2017-2020

Annexure 9

Annual Financial Statement (2017-18)

(Amount in Rupees)

RE 2017-18				Actual Expenditure during 2017-18		
Head of Account	**Unified Plan**	**Plan Schemes**	**AICRP on Maize**	**Unified Plan**	**Plan Schemes**	**AICRP on Maize**
Grant in Capital	32200000	0	0	27370955	0	0
Grant in Salary	50020000	0	131200000	48720565	0	131200000
Grant in General	70750000	10821683	28500000	65399832	10145339	28500000
TSP	500000	0	0	500000	0	0
NEH	2300000	0	0	1926250	0	0
Total	**155770000**	**10821683**	**159700000**	**143917602**	**10145339**	**159700000**

Revenue Generation during the year 2017-18

Particulars	Amount (In Rupees)
Sale of Farm produce	1238127
Sale of Seed	2809351
Sale of publications and tender documents	0
Standard License fee	73596
Analytical and testing fee	0
Receipts from Service rendered	24422
Interest earned on short term deposits	965982
Income generated from IRG	0
Training miscellaneous receipts	2050401
Total	**7161879**

Funds received for externally funded projects during the year 2017-18

Particulars	Amount (In Rupees)
Seed Project	925000
DUS	1165029
CRMA	821176
FLD	1470000
SERB	960000
Total	**5341205**

Annexure 10

Personnel, transfers, new joining, superannuation, promotions

Name	Designation	Discipline
Indian Institute of Maize Research, P.A.U. Campus, Ludhiana		
Dr. Sujay Rakshit	Director	Plant Breeding
Dr.Vinay Mahajan	Principal Scientist	Plant Breeding
Dr. Karambir Singh Hooda	Principal Scientist	Plant Pathology
Dr. Aditya Kumar Singh	Principal Scientist	Agronomy
Dr. Dharam Paul	Principal Scientist	Plant Biochemistry
Ms. Sapna	Scientist	Plant Biochemistry
Mr. Vishal Singh	Scientist	Plant Breeding
Dr. Abhijit Kumar Das	Scientist	Plant Breeding
Dr. Ramesh Kumar	Principal Scientist	Plant Breeding
Mrs. Mamta Gupta	Scientist	Agricultural Biotechnology
Dr. Pardeep Kumar	Scientist	Plant Breeding
Dr. Alla Singh	Scientist	Agricultural Biotechnology
Mr. Mukesh Chaudhary	Scientist	Plant Breeding
Mr. Pravin Kumar Bagaria	Scientist	Plant Pathology
Mrs. Seema Khatter	PS to Director	
Mrs. Kamlesh Malik	Assistant	
Ms. Chinkey Agarwal	Assistant	
Mr. Dharambir Singh	Senior Clerk	
Sh. Amar Nath	SSS	
Sh. Ram Kishan	SSS	
Indian Institute of Maize Research, Unit Office, Delhi		
Dr. Ishwar Singh	Principal Scientist	Plant Physiology
Dr. Meena Shekhar	Principal Scientist	Plant Pathology
* Dr. M.L Jat (On Deputation)	Senior Scientist	Agronomy
Dr. Chikkappa G. Karjagi	Scientist	Plant Breeding
Dr. Shankar Lal Jat	Scientist	Agronomy
Ms. Suby S.B	Scientist	Entomology
Dr. Bhupender Kumar	Scientist	Plant Breeding
Dr. Krishan Kumar	Scientist	Agricultural Biotechnology
Ms. Avni	Scientist	Agricultural Biotechnology
Sh. Anwar Ali	SSS	
Winter Nursery Center, Hydearbad		
Dr. J.C. Shekar	Principal Scientist	Entomology
Dr. N. Sunil	Senior Scientist	Plant Breeding
Dr. P..Laxmi.Soujanya	Scientist	Entomology
Regional Maize Research and Seed Production Center, Begusarai, Bihar		
Dr. S.B. Singh	Principal Scientist	Plant Breeding
Mr. Samir Kumar Rai	T3	
Mr. Rahul	T3	
Mr. Kamal Vats	T3	

SSS-Skilled Supporting Staff; T3-Technical Assistant

*Under Consideration in ICAR

Staff Positions of ICAR-IIMR as on 31st March, 2018

Type of Post	Approved by D/O expenditure	In Position	Vacant
Scientific	40	29	11
Technical	5	3	2
Administrative	13	8	5
Supporting	3	3	0

Scientists on study Leave

Name	Time Period of Study Leave	Institute Name
Dr. Pranjal Yadava*	30.1.2017 to 29.12.2019	Stanford University, USA
Ms. Mamta Gupta	12.03.2018 to 11.03.2020	IARI, New Delhi
Sh. K.R. Yatish	1.7.2015 to 30.7.2018	IARI, New Delhi
*on deputation		

New Joinings

Name	Date	Place	From
Dr. M.C Dagla, Scientist	06.07.2017	ICAR-IIMR, Ludhiana	CAZRI, Jodhpur
Sh. Ashwani Kumar, AO	01.01.2018	ICAR-IIMR, Ludhiana	IARI, New Delhi
Sh. Permod Sharma, AF&AO	23.11.2017	ICAR-IIMR, Ludhiana	ATARI, Jodhpur
Sh. Prashant Garg, Assistant	01.08.2017	ICAR-IIMR, Ludhiana	ASRB
Sh. Bhagesh Sharma, Assistant	01.08.2017	ICAR-IIMR, Ludhiana	ASRB

1. Silking stage
2. Teosinte maize cross
3. Hydroponic culture.
4. Green seeker device
5. Shoot initiation from maize embryogenic callus
6. Maize field

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch