Annual Report
2016-17

ICAR-Indian Institute of Maize Research
P.A.U. Campus, Ludhiana - 141004
INDIA

भाकृ अनुप ICAR

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Editorial Team : Meena Shekhar
Suby S.B.
Alla Singh
S. L. Jat
Chikkappa G. Karjagi

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ICAR-Indian Institute of Maize Research
Punjab Agricultural University Campus,
Ludhiana - 141004
Email: pdmaize@gmail.com
Website: http://iimr.icar.gov.in/

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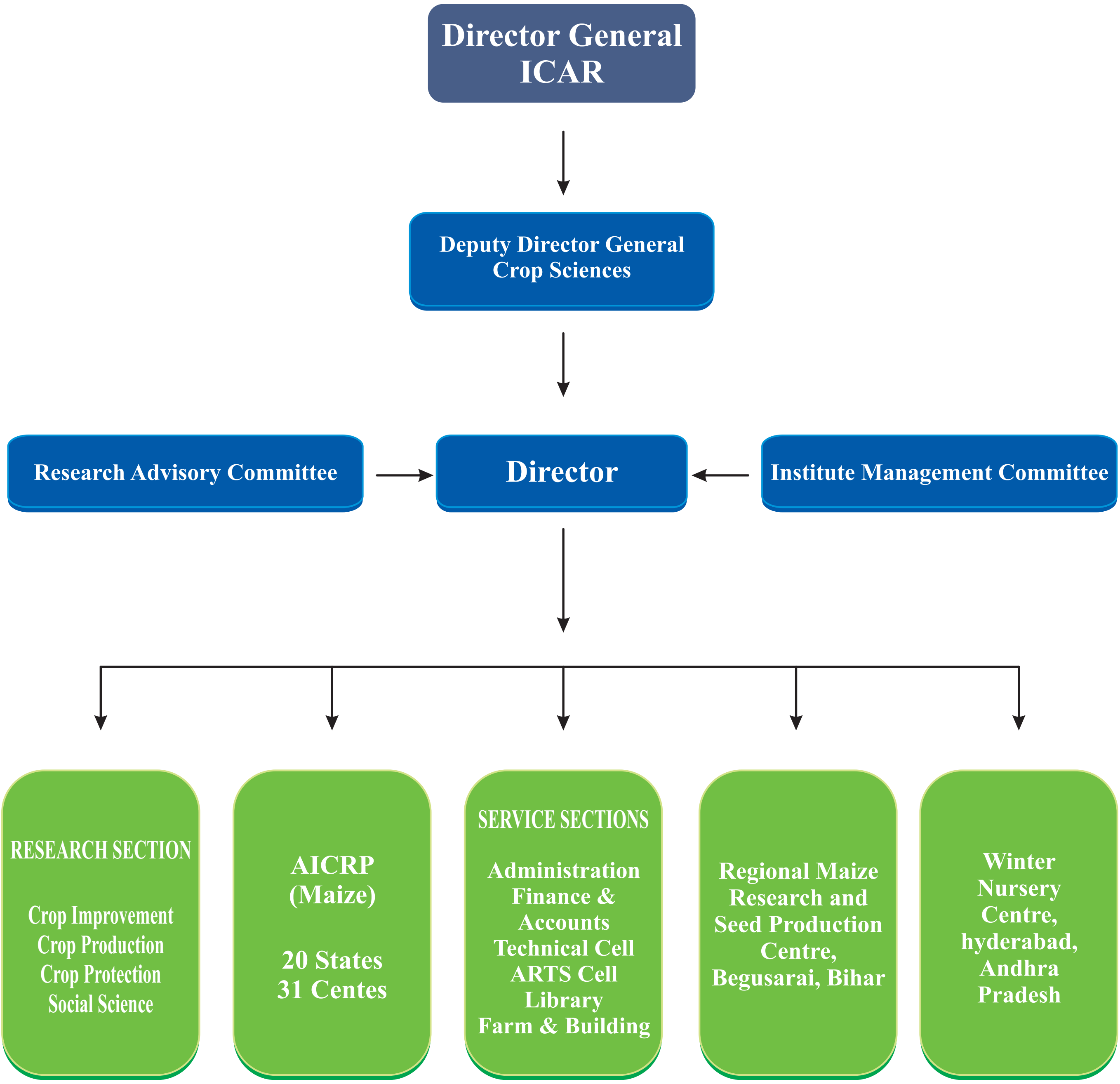
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Preface

ICAR-Indian Institute of Maize Research (IIMR), seeded as All India Coordinated Research Project (AICRP) on Maize, the first co-ordinated agricultural research programme in India, has completed six decades of its service to the nation in this year. Since its inception in 1957, the maize community continues to generate technologies for sustained maize production in the country as witnessed by the boom in maize production in recent years. During 1950-51, India produced only 1.73 million tonnes (mt) of maize, which has reached 22.57 mt in 2015-16. This has been possible due to both increases in area as well as productivity. A total of 144 hybrids and 121 composite varieties of maize have been released till date by the public sector for cultivation in varied production ecologies of the country.

IIMR has been sharing germplasm lines to its AICRP centres every year. Since 2003, IIMR has shared more than 31000 germplasm lines and together with its AICRP partners it has registered 98 genetic stocks with NBPGR, and 47 hybrids and 36 composites with PPV&FRA. In last 10 years, the new technologies have been exhibited to the farmers throughout the country through Field Level Demonstrations (FLDs) as well as through exhibitions and training programmes. In addition, the technologies have also spread to remote tribal areas through 'Tribal Sub-Plan' (TSP). A pilot project for improved technologies has been deployed at tribal farmers field in the Manipur state where intercropping with improved practices resulted in Rupees fifteen thousand more returns over the farmer's practices.

In this era of single cross hybrids, the maize productivity of India (2.56 t/ha) is far behind the global average of 5.52 t/ha. The major reasons for low productivity is mainly abiotic stresses as >70% maize area is under rainfed condition. In addition, the incidence of economically significant losses due biotic stresses like insect pests and diseases also cause losses in yield. To tackle this, several initiatives have been taken towards broadening the genetic diversity of breeding material, heterotic grouping etc.

It is estimated that by 2025, India would require 50 mt maize grain, of which 32 mt will be required in the feed sector, 15 mt in the industrial sector, two mt as food, and one mt for seed and miscellaneous purposes. Moreover, the annual export potential of maize stands at 10 mt. An annual growth rate of 7-8% would be required to achieve this target. This opens up the opportunity to strategically deploy all the resources to optimize maize technologies developed over the six decades to meet the challenges. This also prompts to revamp the future course of maize research in line with the shift in geography and utilization pattern.

I express sincere thanks and gratitude to Dr. T. Mohapatra, Secretary, DARE and DG, ICAR for his invaluable guidance in promoting maize research in India. I am also deeply thankful to Dr. J.S. Sandhu, DDG (CS) and Dr. I.S. Solanki, ADG (FFC) for their consistent support, encouragement and timely suggestions for strengthening maize research. My sincere thanks is also due to Dr. Vinay Mahajan for leading the institute activities in the reporting year. I put on record my sincere appreciation to the editorial team and all staffs of IIMR and AICRP-Maize for their whole hearted co-operation.

(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 the maize crop. The research programmes of the institute are built around two major theme areas: Crop Improvement and Crop Management. The institute also coordinates the All India Coordinated Research Project (AICRP) on Maize and also carries out extension and outreach programmes. During 2016-17, the institute made significant research achievements in different areas of maize research.

CROP IMPROVEMENT

Genetic enhancement of maize continued to be the major focus of the institute. The crop improvement programme mainly focussed on germplasm collection and characterization; germplasm development for resistance to various biotic and abiotic stresses; enhancement of quality traits; engineering of novel germplasm through genetic modification; and development of new hybrids of different maturity to suit varied agro-climatic conditions of the country.

Strengthening of maize germplasm

The base germplasm comprising inbred lines, populations and pools plays a crucial role in maize breeding program. In the reporting period, four populations and around 2000 established inbred lines were maintained through self pollination under different programmes. The systematic documentation of available germplasm has also been started under development of decision support system where the data on the 14 traits are being recorded on 575 fixed inbred lines. Further, new germplasm has been injected into maize breeding programme by procuring 85 temperate maize germplasm accessions from USDA-ARS Germplasm Resources Information Network (GRIN), USA through National Bureau of Plant Genetic Resources (NBPGR). In addition, 418 maize germplasm comprising 93 registered inbred lines and 325 indigenous collections were also procured from NBPGR. Recycling of inbred lines has been attempted by making seven crosses between elite inbred lines within the heterotic groups. The details of the crosses which will be handled by following pedigree breeding methodology are DQL 2180 × DQL 2274, DQL 2248 × DQL 2184, DQL 2058-1 × DQL 2064, DQL 2164 × DQL 2180 (Heterotic group B) and DQL 2024 × DQL 2184, DQL 2024 × DQL 2208 and DQL 2248 × DQL 2208 (Heterotic group A). In order to diversify the existing germplasm base, crosses have been attempted between elite inbred lines and wild species of maize, *viz.*, *Zea mays* subsp. *parviglumis, mexicana* and *luxurians.*

Development of hybrids

During the year 2016-17, the seeds of 34 hybrids of field maize, and eight QPM hybrids were multiplied by hand pollination. They were contributed to different stages of AICRP testing. In addition, a set of 19 QPM inbred lines were crossed with CML 161 and CML 165, a proven QPM testers identified by CIMMYT following line × tester mating design to develop test-crosses for heterotic grouping.

Germplasm for combating biotic stresses

A set of 600 inbred lines with diverse genetic background were evaluated for major maize disease *viz.*, maydis leaf blight (MLB), turcicum leaf blight (TLB), banded leaf and sheath blight (BLSB), sorghum downy mildew (SDM), Rajasthan downy mildew (RDM) and charcoal rot (CR) at hot-spot locations under artificial inoculated conditions. Thirteen inbred lines each were identified for resistance against spotted stem borer *Chilo partellus* in *kharif,* pink stem borer *Sesamia inferens* in rabi and five lines for shoot fly *(Atherigona* spp.) resistance during spring season.

Breeding for abiotic stress tolerance

A set of 90 inbred lines were evaluated for moisture stress condition and observations were recorded on several traits including grain yield. Based on yield under stress, the following inbred lines *viz.*, EC 639538, DML 1213 and DML 1230, ASL109 and ASL81 showed very less loss during stress conditions whereas other lines namely DML 1620, DML 1163 and DML 1126 showed maximum yield loss.

Enhancement of nutritional quality

Enhancement of methionine in the genetic background of quality protein maize (QPM) is one of the major activities of improvement of nutritional quality in maize. In this regard, 32 families comprising of 488 lines based on opaqueness of seeds were selected from 640 lines with high methionine in QPM genetic background. The selected lines were advanced from F3 to F4 generation during kharif 2016. In addition, a set of 52 productive inbred lines (planted and selfed at Begusarai and Hyderabad) were also analyzed for methionine content, where CML 145 was identified with relatively higher methionine concentration (2% of total protein). A set of 42 elite lines are evaluated for various quality traits and some high protein and high starch lines were identified. Three lines (UMI 1201, LM 13 and BML 7) out of this stock were found to be rich both in protein as well as starch. A set of 55 lines grown at two locations (Begusarai and Hyderabad) were evaluated for protein starch, oil and methionine content. Some exceptionally superior lines were identified for protein (CA14502/CA14509)-F2-14-BBB-CML451-BBB-OPc14S1, 4840, CML44, EC646016, PFSRR3AAAA and PFSRS3), Starch (DMRPE6-2, HP963-17, NZB 2012), oil (HKI42050) and methionine (CML145 and NZB 2012) across locations. Apart from this a large number of lines at various stages of QPM development were analyzed for protein quality. A set of four lines were identified as high oil (□5%) lines out of a large stock of samples analyzed for this trait. In addition to this, four lines were evaluated for β–carotene (pro-vitamin A) at freshly harvested stage and after different periods of storage at normal and under vacuum packing.

Transcriptional profiling of phosphate and nitrate responsive miRNAs

Low concentration of nitrate and phosphate in the Indian soils are major constraints for maize growth and development. To delineate the underlying molecular and physiological mechanisms involved in nitrate and phosphate stress in maize, a system of imposing quantifiable stress using hydroponic techniques was deployed. It was revealed that, both under low nitrate and phosphate, there are major changes in plant root architecture. The RNA from root and shoot samples of these stressed and unstressed plants were subjected to deep sequencing to generate miRNA profile under +P/-P and +N/-N conditions. A set of differentially expressed miRNAs were identified.

CRISPR/Cas 9 based gene editing for herbicide tolerance in maize

The clustered regularly interspersed short pallindromic repeats (CRISPR)/Cas system has recently emerged as an attractive nuclease based method for efficient and versatile genome engineering. For glyphosate tolerance in maize, a CRISPR/Cas9 based gene editing construct was used to transform immature embryo derived type II callus of hybrid Bio9544 and inbred line CM300.

Isolation and cloning of orthologs of NAC1 transcription factor

With an objective to prospect drought stress responsive NAC1 gene from two different inbred lines of maize (viz. drought stress tolerant LM 17 and drought stress susceptible HKI 1015), 939 bp of NAC1 gene was isolated by PCR-based approach using cDNA generated from leaf tissue. Subtle sequence polymorphisms (SNPs) between the sequences of NAC1 gene cloned from drought tolerant and drought susceptible genotypes were observed, which could be the key to unravel drought tolerance mechanism.

CROP MANAGEMENT

While genetics plays a great role in development of high quality, high yielding, and stress resistant seeds, the ways and means to manage the crop plays an important role in achieving desirable farm productivity and sustainability. The crop management programme of the institute is directed at tillage and nutrient management on one hand, while disease and insect pest management on the other hand.

Tillage, nutrient and cropping system management

In tillage management, 8th year productivity (maize equivalent yield) for various maize based systems was recorded significantly higher by 20.6% in zero tillage (ZT) flat planting compared to conventional till (CT) flat planting. The results showed that in 7th year, grain/seed yield of maize, chickpea and mustard was 22.3, 31.6 and 27.6% higher under ZT flat planting over to CT flat, respectively, and the wheat grain yield was 24.0 % higher in permanent raised bed (PB) planting over CT flat. Overall, result demonstrated that, succeeding crops planted in maize based rotations during 7th year under CA based practices (ZT flat/PB) increased the systems net profit from 32.6 to 37.3% compared to CT planting.

In the fourth year of nitrogen management under conservation agriculture, the residue application (WR) increased maize-mustard-mungbean (MMuMb) system yield by 17.5% while it increased maize-wheat-mungbean (MWMb) system yield by 12.6% over without residue (WoR) application. The application of sulphur-coated urea (SCU) gave 16% higher MMuMb productivity and the application of neem-coated urea (NCU) gave 3.7% higher MWMb systems yield over PU application. The highest net returns of the MMuMb system was observed with residue and SCU application, which was 10.9 and 5.5% higher over WoR and PU application, respectively. However, in MWMb system, highest net returns was observed in NCU and residue application treatment, which was 13.9 and 10.4% higher over PU and WoR application.

Site-specific nutrient management (SSNM) registered higher maize grain yield in 5th year by 28.1 to 78.1%, and biomass yield by 24.4 to 51.0% and net returns 45.1 to 95.6% compared to unfertilized and farmers fertilizsation practices (FFP), respectively. The system productivity (in terms of maize equivalent yield) was recorded highest in PB (14.0 t/ha) and the lowest was with CT (10.7 t/ha) during 4th year. Amongst nutrient management, the systems productivity (15.0 t/ha) was highest in SSNM. Similar to system productivity, the system net returns was also recorded highest in PB with 51.6% increment over to CT, however among the nutrient management practices SSNM registered highest net returns, which was 77.9, 38.9 and 6.8% higher compared to unfertilized, FFP and RDF, respectively.

Disease and Insect pest management

The crop protection programme give emphasis to integrated approaches in pest and disease management, of which host plant resistance is the major component. Five resistant crosses were identified against rice weevil *(Sitophilus oryzae)* infesting stored maize. 75% hexane/ethyl acetate fraction of *Tinospora cordifolia* leaf extract exhibited significant repellent activity towards S. oryzae at 0.5 to 1.5% concentration. Also, the combination of sun drying of maize grains for 4 hours from 11.00 a.m. to 3.00 p.m. at weekly intervals along with application of leaf powder of *Erythrina indica* at the rate of 2% provided the best protection against this pest. Husk extension and stalk penetration resistance were found to be promising host plant resistance traits against *H. armigera* and *C. partellus* respectively. These traits can be used for screening maize germplasm for identifying resistant sources against the pests.

AICRP ON MAIZE

Apart from its core research activities, the institute also coordinates maize research programmes of various agricultural universities through All India Coordinated Research Project on Maize (AICRP-Maize). During kharif 2016, 298 maize entries were evaluated in all India coordinated trials. A total of 451 breeding trials were allotted to various AICRP centers for evaluation. Of 298 entries, 200 were evaluated in national initial varietal trial (NIVT), 33 in advance varietal trial-I (AVT-I), 8 in advance varietal trial-II (AVT-II), 21 in quality protein maize (QPM) trial, and 36 in specialty corns trials (13 in baby corn, 10 in sweet corn, and 13 in popcorn trials). Of total entries received, 199 were contributed by public and 99 by the private sector. Fifteen breeding trials (four each in NIVT, AVT-I, specialty corns and three of AVT-II) were constituted for evaluation at 65 locations (34 regular and 31 volunteers) across the country. During rabi 2015-16, a total of 112 entries were received for multi-location evaluation under late, medium maturity and quality protein maize (QPM) trials. Of 112 test entries, 63 entries were received in NIVT, 24 in AVT-I, 23 in AVT-II and two entries in QPM trials. Total seven different breeding trials were constituted and put for evaluation at 18 test centers across the four zones. There were 89 entries available for promotion from first and second year of testing, out of which only 32 entries got promoted to their advance stage of testing.

During 2016-17, entries contributed under AICRP quality trial grown at Ludhiana, Almora and Delhi were analyzed for protein quality parameters like protein, tryptophan and lysine. Most of the entries possessed the desired concentration of tryptophan and lysine to be categorized as QPM.

The major agronomic research in AICRP-Maize during kharif 2016 and rabi 2015-16 were focused on optimization 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 and long term trial on exploring integrated nutrient management in maize. Differential response of pre-release genotypes and popular maize hybrids to density was recorded where some genotype out-yielded with normal density whereas some with higher density. In rainfed cropping system, zero tillage resulted in 7.0-11.6% higher yields during 5th year. At farmer field in Andhar Pradesh, the 60 x 20 cm2 planting density along with STCR based nutrient application with improved fertilizer placement resulted in maximum yield of zero-till rabi maize. A new post emergence herbicide, Tembotrione @ 120 g/ha at 25 DAS was found effective for weed management and enhancing yield at 13 locations. A differential response to potassium fertilization (60-150 kg/ha) in kharif maize was found in Eastern India.

In order to identify superior germplasm resistant to various maize diseases, 34 trials (27 in *kharif* & 7 in *rabi*) including 468 hybrids in both *rabi* & *kharif* and 1425 inbred lines in *kharif* were screened against MLB, TLB, BLSB, RDM, SDM, curvularia leaf spot, post-flowering stalk rot (PFSR), rommon rust, polysora rust, bacterial stalk rot (BSR) and cyst nematode. A total of 294 genotypes found promising by showing multiple disease resistance. Based on disease reaction, the seven promising entries were identified by Variety Identification Committee (VIC).

Search for resistant sources 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 is the major component of the entomology programme. During *kharif* 2016, 152 genotypes were evaluated against *C. partellus* at NWPZ (Delhi, Karnal and Ludhiana), NEPZ (Dholi), PZ (Kolhapur, Hyderabad) and CWZ (Udaipur). During rabi 2015-16, 56 hybrids were screened at Kolhapur against *C. partellus* while, at Delhi and Karnal against *S. inferens.* During spring 2016, 66 inbred lines were screened against *Atherigona* spp. at Delhi and Ludhiana. The population of *H. armigera* was monitored weekly by installing pheromone traps from tasseling to harvesting stage of maize, where peak population coincided with maize flowering across the locations. The new pesticides Flubendiamide 480SC (0.1 and 0.2ml/l) and Chlorantaniliprole 20SC (0.3 and 0.4ml/l) were effective for the management of *C. partellus* across the locations, while Delffin 5 WG @5gm/l was effective among various bio-pesticides tested.

EXTENSION AND OUTREACH

Apart from addressing the research requirements, the institute also has a vibrant extension and outreach programme to reach to its stakeholders. The institute reaches out to its farmer stakeholders through conducting Front Line Demonstrations of improved package of practices. Under Tribal Sub Plan (TSP) scheme, 186 hectares demonstrations were carried out at tribal farmers fields through AICRP centres in different states. The average yield of maize in demonstrations was 7012 kg/ha during *rabi* 2015-16 and 4350 kg/ha during *kharif* 2016. The Institute organized nine National Level Training programmes for tribal farmers in which, 389 tribal farmers from ten states were trained. AICRIP centres conducted 13 Regional training programmes, wherein 626 tribal farmers were exposed to latest technologies. To uplift the economic conditions of the farmers, seed of improved maize hybrids, maize sheller, literature, Line Marker, knapsack sprayer, weeder, power operated sprayer etc. were provided to them. To promote improved maize production technologies in the North Eastern Himalayan Region of India, different activities like demonstrations, trainings and farm input distribution were organized in Manipur in collaboration of ICAR Research Complex for NEH Region, Manipur. A total of 185 farmers were trained in five trainings on various aspects before sowing and during crop growing stage in selected district and 40 FLDs on maize cultivation were conducted. The institute participated in various exhibitions in different location in various parts of the country to showcase latest maize hybrids, specialty corn and improved production technologies to enhance farmer's income. More than 5000 visitors including farmers, researchers, students and agro-entrepreneurs visited the exhibitions and enriched with the maize production, protection and value addition knowledge. Under '*Mera Gao Mera Gaurav'* 24 villages from five states have been adopted during 2016-17 and *'Kisan Vaigyanik Sanvad'* was organized in the adopted villages.

1

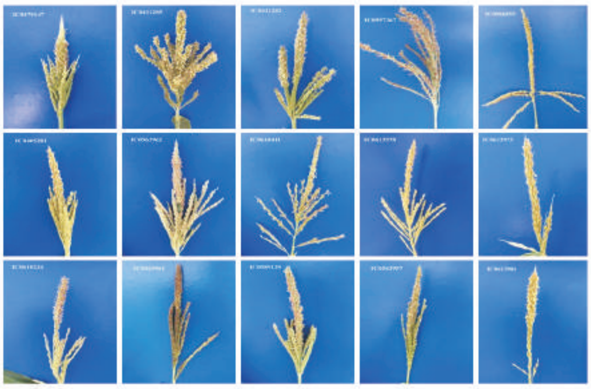
Crop Improvement

Maintenance of germplasm

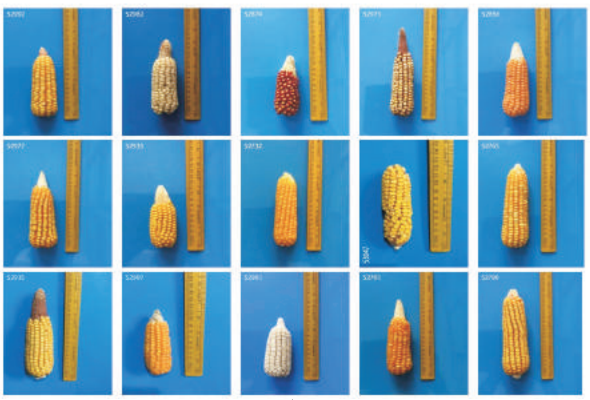
The base germplasm like pools and population plays a crucial role in maize breeding program. In this regard, four populations were maintained. In addition, around 2000 established inbred lines developed under different programmes/collected from different sources were maintained through self pollination across different centres, *viz.*, Hyderabad, New Delhi, Begusarai and Ludhiana. The seeds of selected lines were multiplied for their utilization in crossing program as well as evaluation for different traits across different locations.

Decision support system of maize inbred lines

Fourteen traits were selected to develop decision support system for inbred lines. Five hundred and seventy five fixed inbred lines were characterized for these traits during *rabi,* 2016-17. The tassel (Fig. 1.1a & 1.1b) and cob images of all the accessions have been captured and are being uploaded into the decision support system.



a



b

Fig. 1.1 The glimpses of variation in the tassel traits (a) and ear traits (b) observed among inbred lines.

Strengthening genetic base of maize germplasm

Procurement of new and diverse germplasm

Towsrds injecting new germplasm into maize breeding programme 85 temperate maize germplasm accessions were procured from USDA-ARS Germplasm Resources Information Network (GRIN), USA through National Bureau of Plant Genetic Resources (NBPGR). The temperate germplasm procured from USA were maintained through selfing at Bajaura centre in Himachal Pradesh. In addition, 418 maize germplasm comprising 93 registered inbred lines and 325 indigenous collections were also procured from NBPGR. The above procured accessions were classified into early (146), medium (101) and late (37) maturity based on flowering data.

New inbred line development and advancement of germplasm

Thirty-six inbred lines (including sister lines) which were derived from Hey Pools and other sources were selected from S6-S7 generation as they were nearly fixed. In addition, 143 S3 lines selected purely on the basis of earliness and agronomic superiority were advanced to S4 and were selected from 368 S2 lines derived from different pools and populations. Further, another set of 80 lines which were identified putatively for different biotic stress tolerance were also advanced from S4-S5 generation. A separate set of 579 new families derived from various diverse sources were selected and advance to different stages.

Diversification of maize germplasm

Multiplication of maize wild species

The wild species of maize, *viz., Zea mays* subsp. *parviglumis*, *mexicana* and *luxurians* which were procured from USDA were multiplied during *kharif 2016* at Hyderabad and New Delhi (Fig. 1.2).

Development of crosses between wild species and elite inbred lines

Fig. 1.2. Seeds of wild relatives of maize

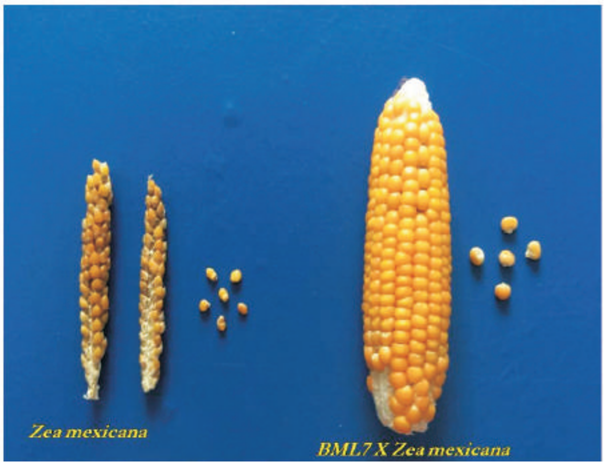


Fig. 1.3a. The cross between BML7 and Zea mexicana

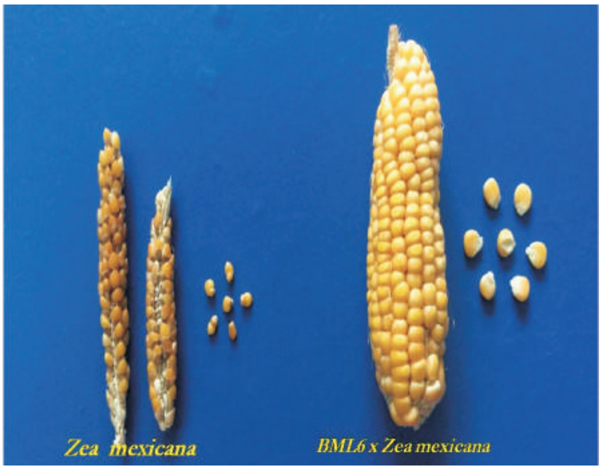


Fig. 1.3b. The cross between BML6 and Zea mexicana

Crosses between elite inbred lines and the wild relatives (Fig. 1.3a & 1.3b) were attempted during rabi 2016-17 at winter nursery centre, Hyderabad. Promising inbreds, BML 6 and BML 7 were used. Out of 10 crosses attempted with 100% success seed setting in all the attempted crosses together obtained 1000-1200 seeds.

Evaluation of germplasm for different traits

Disease resistance

A set of 300 inbred lines, constituted from diverse genetic background were evaluated for different diseases at Bajaura, Mandya and Dharwad against turcicum leaf blight (TLB) at Delhi, Ludhiana and Hyderabad against charcoal rot (CR) and at Dharwad against common rust during *Kharif* 2015 and 2016. The inbred lines with resistance to TLB, TLB+common rust and charcoal rot+common rust in different years across hot spot locations are given in Table 1.1a, 1.1b, and 1.1c, respectively. In addition, six disease phenotyping trials comprising separate set of 88-134 inbred lines were evaluated for major maize diseases like TLB, MLB, banded leaf and sheath blight (BLSB), Rajasthan downy mildew (RDM), sorghum downy mildew (SDM) and CR at hot-spot locations under artificial inoculations. The total number of unique inbred lines in disease phenotyping trials was 284. Based one year data, out of 284 inbred lines, 131 were resistant to one or more diseases. The resistant lines will be further re-confirmed by re-evaluating in 2017.

Table 1.1a. Inbred lines with resistance to TLB under artificial inoculations

S. No.	Genotype	*Kharif* 2015 [TLB (1-5)]					*Kharif* 2016 [TLB (1-9)]			
		Bajaura	Mandya	Dharwad	Mean	Class#	Bajaura	Mandya	Mean	Class#
1	IML16-17	1.5	3.0	2.0	2.2	MR	3.0	1.0	2.0	R
2	IML12-135	2.0	3.0	2.0	2.3	MR	3.0	1.0	2.0	R
3	IML12-133	2.0	3.5	2.0	2.5	MR	2.0	1.0	1.5	R
4	IML15-244	2.5	3.0	2.0	2.5	MR	2.0	2.0	2.0	R
5	IML12-116	1.5	4.0	2.0	2.5	MR	3.0	1.0	2.0	R
6	IML12-10	2.0	3.0	3.0	2.7	MR	2.0	2.0	2.0	R
7	IML12-74	2.0	4.0	2.0	2.7	MR	2.0	2.0	2.0	R
8	IML16-134	2.5	4.0	2.0	2.8	MR	2.0	1.0	1.5	R
9	IML16-108	2.0	3.5	3.0	2.8	MR	2.0	1.0	1.5	R
10	IML15-112	2.5	4.0	2.0	2.8	MR	3.0	1.0	2.0	R
11	IML13-62	2.5	4.0	2.0	2.8	MR	2.0	2.0	2.0	R
12	IML16-27	2.0	4.0	3.0	3.0	MR	2.0	1.0	1.5	R
13	CM202(Check)	5.0	5.0	5.0	5.0	S		4.5	4.5	MR

#R-resistant; MR-moderately resistant; S-susceptible

Table 1.1b. Inbred lines with resistance to TLB and Common rust under artificial inoculations

S. No.	Genotype	*Kharif* 2015							*Kharif* 2016						
		TLB (1-5)					C.Rust (1-9)		TLB (1-9)					C. Rust (1-9)	
		Bajaura	Mandya	Dharwad	Mean	Class#	Dharwad	Class#	Bajaura	Dharwad	Mandya	Mean	Class#	Dharwad	Class#
1	IML15-244	2.5	3.0	2.0	2.5	MR	3.0	R	2.0	2.0	2.0	2.0	R	4.0	MR
2	IML15-112	2.5	4.0	2.0	2.8	MR	2.0	R	3.0	3.0	1.0	2.0	R	3.0	R
3	IML 15-65	2.5	4.5	2.0	3.0	MR	3.0	R	3.0	4.0	2.0	3.0	R	2.0	R
4	IML12-180	2.0	4.0	3.0	3.0	MR	1.0	R	4.0	4.0	2.0	3.0	R	2.0	R
5	IML12-10	2.0	3.0	3.0	2.7	MR	3.0	R	2.0	4.0	2.0	3.0	R	2.0	R
6	IML13-62	2.5	4.0	2.0	2.8	MR	1.0	R	2.0	5.0	2.0	3.5	R	2.0	R
7	CM202 (C)	-	5.0	5.0	5.0	S	4.0	MR	-	9.0	8.5	8.8	S	8.0	S

#R-resistant; MR-moderately resistant; S-susceptible

Table 1.1c. Inbred lines with resistance to charcoal rot and common rust under artificial inoculations

S. No.	Geno-type	*Kharif* 2015							*Kharif* 2016						
		C. Rot (1-9)					C. Rust (1-9)		C. Rot (1-9)					C. Rust	
		Ludhiana	Delhi	Hyderabad	Mean	Class#	Dharwad	Class#	Ludhiana	Delhi	Hyderabad	Mean	Class#	Dharwad	Class#
1	IML	3.4	1.8	6.6	3.9	MR	2.0	R	5.0	1.0	3.0	3.5	MR	2.0	R
2	IML	5.0	2.0	6.3	4.4	MR	3.0	R	4.5	1.0	2.8	4.8	MR	4.0	MR
3	IML	4.0	3.0	6.8	4.6	MR	1.0	R	3.7	1.0	2.4	4.6	MR	4.0	MR
4	CM501	7.6	-	6.5	7.1	S	4.0	MR	8.0	-	8.0	-	S	8.0	S

#R-resistant; MR-moderately resistant; S-susceptible

Insect resistance

A set of 130 early maturity inbred lines derived from different genetic backgrounds was screened for two years (2015 and 2016) by artificially infesting them with pink stem borer neonates at Hyderabad. Among those 13 lines *viz.,* Meghalaya-214-⊗⊗ (2.2), IIMR PBT Pool-⊗5⊗ ⊗ (2.38), IIMR PBT Pool-⊗6⊗⊗ (2.50), HEY Pool-2011-12-1-1-3-3-1-⊗⊗ (2.57), HEY Pool-2011-12-3-5-2-3-1-⊗⊗ (2.57), HEY Pool-2011-12-3-7-2-3-1-⊗⊗ (2.60), DMR E 63(2.67), WNZPBTL 9 /CML 451MF4-41-⊗⊗ ⊗⊗(2.71), IIMR PBT Pool-⊗3⊗⊗⊗⊗ (2.80), WNZPBTL 9 / CML 451 MF2-46-9- ⊗⊗⊗⊗ (2.83), IC 5859131-⊗⊗⊗⊗ (2.86), Meghalaya – 215-⊗⊗⊗⊗ (2.88) and NAI-175- ⊗⊗ (2.89) recorded less than 3.0 LIR and another 43 lines recorded LIR less than resistant check, CM 500 (4.0).

Development of field corn hybrids for different ecologies

Early maturity

A total of 104 experimental hybrids were evaluated in three separate trials with 42, 29 and 33 hybrids, respectively in *kharif* 2016 at Ludhiana along with check hybrids. Observations were recorded for various traits. The results showed significant variation among the hybrids and seven hybrids recorded superiority (10%)

Table 1.2. Performance of promising experimental cross combinations

S. No.	Hybrids	Maturity (days)	Grain yield (ton/ha)	Trial No.
1	CML470 × CML482	90	6.4	1
2	CML470 × CML421	92	6.8	1
3	CML342 × CML9	84	6.5	1
4	CML50 × NAI175	90	6.8	1
5	CM13 × CML 306	90	6.8	1
	Vivek Hybrid 9	**92**	**5.85**	**1**
6	CM13 × CML482	90	6.8	2
7	CM13 × CML421	90	6.9	2
	Vivek Hybrid 9	**91**	**6.1**	**2**

over best checks in terms of grain yield. Among 104 experimental hybrids evaluated, the following hybrids *viz.*, CML470 × CML482, CML470 × CML421, CML342 × CML9, CML50 × NAI175, CM13 × CML 306 CM13 × CML482 and CM13 × CML421 were recorded 10 % superior over best check 'Vivek Hybrid 9' for grain yields (Table 1.2).

Field corn hybrids under AICRP testing

During the year 34 hybrids were multiplied through hand pollination. These were contributed to different stages of AICRP testing. The details of hybrids promoted are given below

AVT -II Early	DMRH 1305
AVT -I Medium	IMH 1603, IMH 1527, DMRH 1410; DMRH 1419
Baby corn III	IMHB 1531, IMHB 1532, IMHB 1537, IMHB 1538, IMHB 1529, IMHB 1539, IMH 1525
Popcorn III	IMHP 1540, IMHP 1535
Rainfed I to II	IMH 1533, IMH 1618

Table 1.3. Kernel opaqueness, protein and tryptophan content of promising QPM lines

S. No	Inbred Line	Opaque -ness (%)	Protein (%)	Tryptophan (% of Protein content)
1	DQL 2104	100	9.42	1.03
2	DQL 2214	100	8.60	1.02
3	DQL 2082	100	8.10	0.93
4	DQL 2178	100	8.39	0.99
5	DQL 2063	100	9.26	0.92
6	DQL 2062	75	9.53	0.89
7	DQL 2064-1-1	75	6.91	0.87
8	DQL 2017	75	9.17	0.86
9	DQL 2026	75	7.31	0.80
10	DQL 2018-5	75	8.40	0.83
11	DQL 2028-1	50	7.20	0.83
12	DQL 2063-1	50	7.48	0.80
13	DQL 2040	50	10.81	0.71
14	DQL 2030-1	50	8.07	0.70
15	DQL 2158	50	10.49	0.70
16	DQL 2241	25	6.93	0.70
17	DQL 2184	25	9.94	0.61
18	DQL 2039-2	25	8.03	0.62
19	DQL 2235	25	9.60	0.60
20	DQL 2271	25	9.58	0.60
21	DQL 2293	25	8.38	0.60

Table 1.4 Heterotic grouping of promising QPM lines

S. No.	Female or Line	SCA	Heterotic Group	S. No.	Female or Line	SCA	Heterotic Group
1	DQL 2216 × CML161	2.82	B	21	DQL 2248 -1× CML161	-9.84	A
2	DQL 2216 × CML165	-2.82		22	DQL 2248 × CML165	9.84	
3	DQL 2192 × CML161	2.32	B	23	DQL 2180 × CML161	0.16	B
4	DQL 2192 × CML165	-2.32		24	DQL 2180 × CML165	-0.16	
5	DQL 2164 × CML161	2.82	B	25	DQL 2172 × CML161	1.99	B
6	DQL 2164 × CML165	-2.82		26	DQL 2172 × CML165	-1.99	
7	DQL 2230 × CML161	1.99	B	27	DQL 2261 × CML161	-2.34	A
8	DQL 2230 × CML165	-1.99		28	DQL 2261 × CML165	2.34	
9	DQL 2238 × CML161	0.66	B	29	DQL 2274-1 × CML161	0.99	B
10	DQL 2238 × CML165	-0.66		30	DQL 2274-1 × CML165	-0.99	
11	DQL 2169 × CML161	3.49	B	31	DQL 2208 × CML161	-5.34	A
12	DQL 2169 × CML165	-3.49		32	DQL 2208 × CML165	5.34	
13	DML 1302 × CML161	7.66	B	33	DQL 2184 × CML161	-5.67	A
14	DML 1302 × CML165	-7.66		34	DQL 2184 × CML165	5.67	
15	DQL 2248 × CML161	-0.34	A	35	DQL 2187 × CML161	-0.01	A
16	DQL 2248 × CML165	0.34		36	DQL 2187 × CML165	0.01	
17	DQL 2165-1 × CML161	-0.51	A	37	DQL 2209 × CML161	-0.34	A
18	DQL 2165 × CML165	0.51		38	DQL 2209 × CML165	0.34	
19	DQL 2211 × CML161	-0.51	A				
20	DQL 2211 × CML165	0.51					

Development of quality protein maize (QPM) germplasm

Identification of hard kernel QPM hybrids is one of the main selection criteria in development of new and high yielding QPM hybrids. Twenty-one promising inbred lines with different levels of opaqueness were selected with and subjected to biochemical analysis (Table 1.3). Based on the results of biochemical analysis the QPM lines, viz., DQL 2241, DQL 2184, DQL 2039-2, DQL 2235, DQL 2271 and DQL 2293 with high-tryptophan content > 0.6 and 25% opaqueness were selected. These lines will be further used in development of QPM hybrids with better yield and storability.

Heterotic grouping

A set of 19 QPM inbred lines were crossed with CML 161 and CML 165. These two lines are proven heterotic QPM testers identified by CIMMYT. Crossing was made following line × tester mating design to develop test-crosses for heterotic grouping. Based on the test-crosses evaluation data the specific and general combining abilities were estimated and the inbred lines were classified into two groups. The details of the lines classified are given in Table 1.4.

QPM hybrids under AICRP testing

Eight QPM hybrids have been promoted from IVT to AVT-I and the name of the hybrids are given in Table 1.5.

Table 1.5. QPM hybrids promoted from IVT to AVT-1 in year 2016-17

S. No.	Name of the hybrid	Promoted (Zones)
1.	IIMRQPMH 1601	Zone II, III and IV
2.	IIMRQPMH 1602	Zone III and Zone IV
3.	IIMRQPMH 1603	Zone I,III and V
4.	IIMRQPMH 1605	Zone I.II and IV
5.	IIMRQPMH 1606	Zone IV
6.	IIMRQPMH 1608	Zone III
7.	IIMRQPMH 1609	Zone III
8.	IIMRQPMH 1610	Zone III

Recycling of lines

Inbred lines development is a continuous process. The recycling of inbred lines has been attempted by making seven crosses between elite inbred lines within the heterotic groups. The details of the crosses which will be handled by following pedigree breeding methodology are DQL 2180 × DQL 2274, DQL 2248 × DQL 2184, DQL 2058-1 × DQL 2064, DQL 2164 × DQL 2180 within heterotic group B and DQL 2024 × DQL 2184, DQL 2024 × DQL 2208 and DQL 2248 × DQL 2208 within heterotic group A.

Breeding for abiotic resistance

A set of 30 inbred lines were evaluated under moisture stress condition. The observations were recorded on several traits including grain yield. Based on yield under stress, the inbred lines viz., EC 639538, DML 1213 and DML 1230 recorded very less yield loss under stress. On the contrary inbred lines like DML 1620, DML 1163 and DML 1126 showed maximum yield loss. The following clearly indicated that the tolerant lines have recorded less stress susceptibility index and more stress tolerance index as compared to the susceptible ones.

Table 1.6. Oil content (%) in the selected inbred lines

S. No.	Pedigree/background	Oil content (%)
1	TLWQ(HO)QPMC15BBB20BB-1	4.89
2	TLWQ(HO)QPMC15BBB20BB-4	5.08
3	Temp×Trop(HO)QPMBBB2BBB-1	4.02
4	Temp×Trop(HO)QPMBBB2BBB-2	4.96
5	Temp×Trop(HO)QPMBBB57-1	4.02
6	TLWQ(HO)QPMC15BBB20BBB	5.26
7	TLWQ(HO)QPMC15BBB28BBB	4.63
8	TLWQ(HO)QPMC15BBB34BBB	5.20
9	TLWQ(HO)QPMC15BBB38BBB	6.00

Table 1.7. Methionine content in the selected set of inbred lines

S. No	Pedigree/Source	Methionine concentration (% of protein)	
		Hyderabad	Begusarai
1	100	-	1.18
2	4839	-	1.06
3	4840	1.23	1.10
4	4854	1.50	1.12
5	5000	1.84	-
6	5086	1.66	1.02
7	5153	1.54	-
8	5183	1.59	-
9	6329	-	1.57
10	6338	1.86	-
11	6345	1.39	1.3
12	(CA14502/CA14509)-F2-14-1-BBB-CML451-BBB-OPc14-S1	1.57	1.48
13	42050-1⊗⊗⊗	1.44	1.19
14	BGS686-1	1.44	1.28
15	BML15ÄÄ	1.74	-
16	CM117-3-4-1	1.81	1.18
17	CM133⊗⊗⊗⊗	1.66	0.92
18	CM144	1.50	-
19	CM145	2.00	2.00
20	CML141⊗⊗⊗⊗	1.72	1.03
21	CML269⊗⊗⊗⊗	1.45	1.33
22	CML287	1.30	1.35
23	CML333	1.44	1.80
24	CML409⊗⊗⊗⊗	1.36	1.13
25	CML44	1.57	0.79
26	CML491⊗⊗⊗⊗	1.50	-
27	DMRPE6-2	1.89	1.21
28	EC440642	1.50	0.86
29	EC618201	1.14	-
30	EC618988	1.46	-
31	EC646016	1.89	1.24
32	EC656087⊗⊗⊗⊗	2.04	-
33	HKI42050	1.77	0.86
34	HP963-17	1.95	1.16
35	HY10RN-10235-118-1-3	1.61	1.27
36	ITINA004	1.48	-
37	JCY3-7	1.77	-
38	JCY3-7⊗⊗⊗⊗	1.43	1.17
39	NZB2012	1.98	1.92
40	P61C1-BBB-47-BBB-2	1.64	-
41	PFSR10	1.79	1.02
42	PFSR5106/1⊗⊗⊗⊗	1.91	-
43	PFSRR10	1.02	-
44	PFSRR3⊗⊗⊗⊗⊗⊗	1.58	0.82
45	PFSRS3	1.70	1.45
46	Temp x Trop (H0)QPM⊗⊗	1.91	-
47	UMI1210	1.75	1.26
48	WNCDMRNC370	1.80	1.09
49	WX0384	1.68	-
50	WNCDMR10RYSDWS 8707	-	1.35
51	Acc.No.527290	-	0.81
52	Acc.No.563959⊗⊗	-	1.52
	%CV	**14.72**	**19.61**

In addition, a separate set of 60 inbred lines, 30 each of medium and late maturity were also evaluated at New Delhi and Karimnagar under managed drought stress. Based on the yield two inbred lines, viz., ASL 109 and ASL 81 were identified as moderately drought stress tolerant.

Biochemical characterization of maize germplasm

A set of 27 inbred lines were evaluated for kernel oil content. Significant variation for oil content was recorded which ranged from 1.39 to 6.00% (Table 1.6).

Germplasm registered at NBPGR

S. No.	Registered Germplasm Line	INGNR NO.	Traits for which registered
1	DQL 2048	17014	Moderately resistant to MLB, TLB and high tryptophan content
2	DQL 2105-1	17013	Moderately resistant to MLB, TLB and high tryptophan content
3	DQL 1019	17023	Tolerant to charcoal rot, high tryptophan and lysine content
4.	DML 339	17022	Tolerant to charcoal rot and ASI (2.0 days)

Another set of 52 productive inbred lines (planted and selfed at Begusarai and Hyderabad) were also analyzed for methionine content (Table 1.7). CML 145 was identified with relatively higher methionine concentration (2% of total protein).

Breeding for improved nutritional quality

Enhancement of methionine in the genetic background of quality protein maize (QPM) is one of the major activities of improvement of nutritional quality in maize. In this regard, 32 families comprising 488 lines from 640 lines with high methionine in QPM genetic background were selected based on opaqueness of seeds and were advanced from F3 to F4 generation during *kharif* 2016. In addition, a set of 15 inbred lines with high or low oil content were inter-mated with each other following half diallel mating design during *kharif* 2016. A trial comprising progenies of half diallel crossing program will be conducted in spring 2017 at Ludhiana.

Biochemistry

Nutritional evaluation of maize

The biochemistry unit of IIMR plays a pivotal role in the QPM development programme of India. Apart from protein quality, carbohydrate profile, oil content and carotenoids composition are also evaluated to in decide the nutritional quality of maize. The biochemistry laboratory facilitates the identification of nutritionally superior germplasm for various quality traits such as protein quality, carbohydrate profile, oil content and carotenoids composition.

Table 1.8 Protein quality of promising lines

S. No	Pedigree	100 seed wt.	Sugar (%)	Protein (%)	Trypto-phan (% of protein)
1	DQL 2025	14.88	1.24	9.67	0.63
2	DQL 2104	15.25	1.08	12.89	0.63
3	DQL 2055	17.47	1.24	11.17	0.65
4	DQL 2071	20.81	1.30	9.37	0.66
5	DQL 2010	15.82	1.31	9.31	0.67
6	DQL 2031	19.63	1.96	9.02	0.68
7	DQL 2111	20.22	1.26	9.37	0.68
8	DQL 2046	13.01	1.30	9.75	0.68
9	DQL 2020	17.09	1.42	9.85	0.68
10	DQL 2105-1	19.03	1.35	10.97	0.71
11	DQL 2048	18.76	1.56	9.21	0.73
12	DQL 2006	12.67	1.05	11.86	0.75

During the period of 2016–2017 a large number of samples received under quality programme of AICRP as well as of the institute were analyzed for protein quality and other quality parameters. A set of 22 elite inbreds received from IIMR, Ludhiana was analyzed for protein quality. The kernels were screened on the basis of opaqueness to select representative samples. Out crossed as well as non uniform kernels were discarded. The endosperm was separated, defatted and processed for protein quality. The range of protein was 7.92 to 13.11 per cent with lowest and highest values being exhibited by the genotypes DQL 2028 and DQL 2038, respectively. The range of tryptophan was 0.42% (DQL 2039) to 0.75% (DQL 2006). A total of 11 lines were found to possess the threshold concentrations of protein quantity as well as quality for QPM breeding (Table 1.8)

Another set of 42 elite lines were also evaluated for protein quality. Although the samples were uniform but opaqueness was absent. The tryptophan content was also well below the threshold concentration (0.6% of endosperm protein). However, 13 lines possessed high protein content. The range of protein was 9.80 to 13.86 % with lowest and highest values being exhibited by the genotypes DMRH1302 and DMRH 1301, respectively. Notwithstanding that the lines with high protein content possess lower values for tryptophan.

Evaluation of maize germplasm developed by IIMR for nutritional quality

A set of 42 lines was evaluated for starch and oil content. The oil content ranged from 2.21% (CML 170) to 4.32% (BML 7) and starch content from 68.14% (CML269QPM) to 75.88% (DMRH 1305). Twelve lines were rich in starch content, whereas two lines (BML 7 and DMRH 1308) contained good amount of oil along with high starch values. Three lines (UMI 1201, LM 13 and BML 7) out of this stock were rich both in protein and starch.

Another set of 27 samples received from IIMR Ludhiana were analyzed for oil content. Four lines (TLWQ(HO) QPMC15BBB20BB-4, TLWQ(HO) QPMC15 BBB34BBB, TLWQ(HO)QPMC15BB B20BBB and TLWQ(HO)QPMC15BBB38BBB) possessed more than 5% oil. However, the standard for high oil maize is ≥6 per cent and one lines out of this stock meets the threshold concentration.

In a separate experiment a set of 55 lines grown at Begusarai and Hyderabad were analyzed for protein, methionine, oil and starch in order. Some lines identified for higher protein percentage were CA14502/CA14509)-F2-14-BBB-CML451-BBB-OPc14S1, 4840, CML44, EC646016, PFSRR3AAAA and PFSRS3; for starch DMRPE6-2, HP963-17 and NZB 2012; for oil HKI42050 and for methionine CML145 and NZB 2012 across replications and locations.

Physiology

Expression profiling of heat shock proteins (HSPs) genes conferring tolerance to heat-stress in maize

To study the expression profiling of HSP genes in maize, six genes were studied. The molecular weights and theoretical isoelectric points of the amino acid sequences of these genes were calculated using EXPASY portal (https://www.expasy.org/) (Table 1.9). The expression profiling of these genes *(ZmHsp-22, ZmHsp-26, ZmHsp-60, ZmHsp-70, ZmHsp-82, ZmHsp-101)* was studied in two contrasting maize inbred lines (LM 17, heat-stress tolerant; HKI 1015wg8, heat-stress susceptible) at seedling stage. The plants were grown in green house at 25/20ºC (14h day/10h night) temperatures. Twenty one days old seedlings of both the genotypes were shifted to two plant growth chambers maintained at 42/27ºC (14h day/10h night) and 25/20ºC (14 hr day/10 hr night) temperatures, respectively. Plant tissues were harvested at 0 hr, 3 hr, 6 hr, 12 hrs and recovery after 24 hrs of heat treatment.Total RNA was isolated 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 carried out through qRT-PCR. *ZmHsp* genes showed differential expression under heat-stress in the two contrasting genotypes. *ZmHsp22* and *ZmHsp101* showed strong up-regulation during recovery phase in LM 17. *ZmHsp22, ZmHsp70* and *ZmHSp82* showed upregulation at 12h of heat-stress treatment in LM 17. Genes *ZmHsp22, ZmHsp70, ZmHSp82* and *ZmHsp-101* appeared to be important in imparting heat stress tolerance in LM 17. Role of above four *ZmHsp* genes is now being confirmed at flowering stage of plant.

Biotechnology

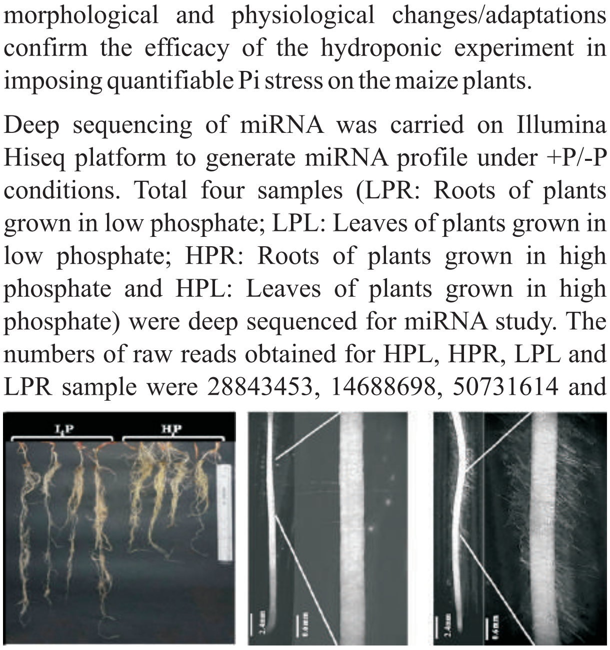
Transcriptional profile of phosphate responsive miRNAs in maize

Table 1.9. Molecular weights and theoretical isoelectric points of 6 HSPs

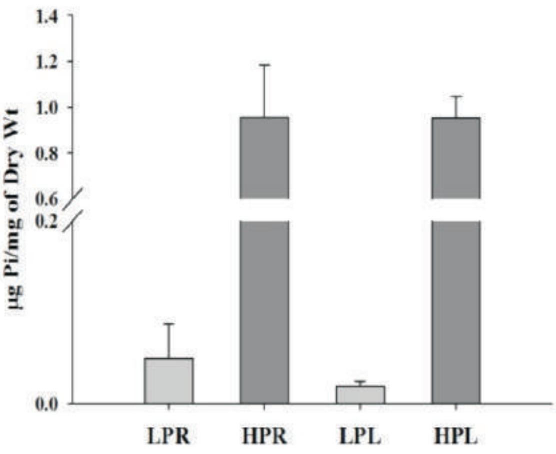
Gene Name	Accession Number	Molecular Weight (Dalton)	Isolectric Point (pl)	Family
ZmHsp22	NP_001105607.1	23816.00	6.47	sHsp
ZmHsp26	NP_001105583.1	26377.94	7.86	sHsp
ZmHsp60	NP_001105690.1	60935.09	5.67	Hsp60
ZmHsp70	NP_001148198.1	71138.34	5.05	Hsp70
ZmHsp82	NP_001135416.3	81802.6	5.03	Hsp90
ZmHsp101	NP_001104935.2	101118.68	5.84	Hsp100

To study phosphate (Pi) stress responsive miRNA, a comparative analysis of miRNA among roots and shoots of Indian maize genotype (HKI-163) grown in sufficient [High phosphate (HP): 1000 µM KH_2PO_4] and deficient hydroponic phosphate condition [Low phosphate (LP): 5 µM KH_2PO_4] was performed (Fig. 1.4a). After 21 days, the plants grown under LP conditions depicted observable symptoms of Pi starvation with respect to shoot growth, root architecture, lateral roots, root hairs, leaf coloration and stems (Fig. 1.4). Further, the Pi stress treatment was confirmed by measuring the levels of endogenous Pi content in shoots and roots of the plant grown under Pi sufficient and deficient conditions (Fig. 1.4d). The study demonstrated increased root length, reduced total biomass, number of lateral roots, increase in the length of the lateral and axial roots, increased root: shoot ratio and reduced level of total Pi uptake in root and shoot significantly ($P < 0.05$) at low Pi condition compared to sufficient Pi condition (Fig. 1.4 and Table 1.9). These morphological and physiological changes/adaptations confirm the efficacy of the hydroponic experiment in imposing quantifiable Pi stress on the maize plants.

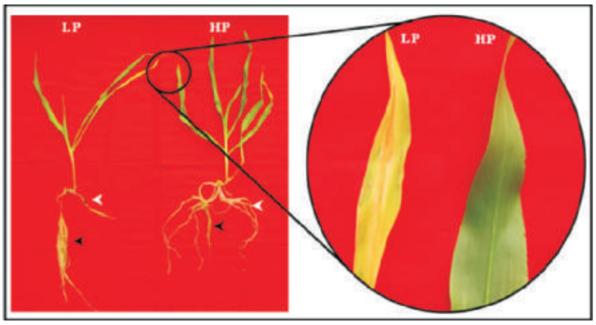
Deep sequencing of miRNA was carried on Illumina Hiseq platform to generate miRNA profile under +P/-P conditions. Total four samples (LPR: Roots of plants grown in low phosphate; LPL: Leaves of plants grown in low phosphate; HPR: Roots of plants grown in high phosphate and HPL: Leaves of plants grown in high phosphate) were deep sequenced for miRNA study. The numbers of raw reads obtained for HPL, HPR, LPL and LPR sample were 28843453, 14688698, 50731614 and



(a) (b)



(c)



(d)

Fig. 1.4. HKI-163 maize plants grown under HP (high phosphate, 1000 uM KH_2PO_4) and LP (low phosphate, 5 uM KH_2PO_4) conditions (Photographs were taken after 21 days of phosphate treatment). **a & b:** HKI-163 Maize root architecture under sufficient (HP) and phosphate deprived (LP) conditions. **c:** Effect of phosphate availability on accumulation of phosphorus in maize. **d:** Shoot/ leaf architecture under sufficient (HP) and phosphate deprived (LP) conditions.

Table 1.10. Physiological parameter of maize plants under differential phosphorous content.

	Phosphorous content	
Physiological parameter	**High (HP)**	**Low (LP)**
Plant Fresh weight (g/plant)	10.21±0.91	7.16±0.59
Plant Dry weight (g/plant)	1.02±0.7523	0.74616±0.067
Root Fresh Wt (g/plant)	1.11±0.12	0.82±0.14
Root Dry Weight (g/plant)	0.1606±0.0127	0.1475±0.0315
Shoot Fresh Wt (g/plant)	9.12±0.82	6.09±0.43
Shoot Dry Wt (g/plant)	0.8573±0.065	0.6011±0.052
Root:Shoot Ratio	0.12±0.0092	0.13±0.017
Root length (cm)	30.5±1.45	56.33±1.89
Shoot length (cm)	58.00±1.032	49.50±1.65
Stem girth (mm)	23.83±1.85	18.83±1.14
No of crown roots	10.17±1.013	0.17±0.17

Table 1.11. Summary of differentially expressed phosphate stress responsive mi-RNAs in maize

	Known miRNA			**Novel miRNA**		
Sample Name	**Up-regulated**	**Down-regulated**	**Total**	**Up-regulated**	**Down-regulated**	**Total**
HPL vs. LPL	12	23	**35**	18	22	**40**
LPR vs. HPR	15	12	**27**	37	9	**46**

57930107, respectively. The known miRNA sequence reads belonged to 116, 109, 120 & 120 entities referring 24, 20, 21 & 22 families for HPL, HPR, LPL and LPR, respectively. Several novel phosphate stress responsive miRNA were also obtained. These miRNAs showed differential expression pattern in roots and shoots in different phosphate conditions. Among known miRNAs, 34 miRNA belonging to 14 families were found significant in shoots/leaf and 27 miRNA belonging to 12 families showed note worthy significant differential expression in roots (Table 1.10). Among these, 10 significant miRNA families were common in roots and shoot/leaf region. In total, 40 and 46 novel, significant miRNA were found in shoots and roots, respectively (Table 1.10). These miRNAs may be a key factor affecting adaptation of maize plant in scarce Pi condition via regulating expression of Pi responsive genes and hence phosphorus homeostasis.

Transcriptional profile of nitrate stress responsive miRNAs

This study was taken up to delineate the nitrate stress adaptation response in maize for identification of potential target small RNAs/mi-RNA that can be used to engineer enhanced nitrogen use efficiency (NUE). Maize inbred line HKI 163 was grown hydroponically in one-half-strength modified Hoagland solution. The plants were grown with (2 mM) and without nitrogen (N) under controlled conditions in phytotron. The plants were phenotyped for different root and shoot parameters (Table 1.11). Nitrogen stress responsive morphological changes (yellow leaves and dwarf plants) were observed in plants grown without N as compared to plants grown with N (Fig. 1.5). It is important to note that mostly growth parameters responded negatively to (–) N stress as compared to (+) N condition except the root length and root volume.

Small RNA NGS Analysis: The deep sequencing of miRNA was carried on Illumina Hiseq platform to generate miRNA profile under +N/-N conditions. Total four samples (N- Root: Roots of plants grown in low nitrogen; N+ Root: Roots of plants grown in high nitrogen; N- Shoot: Shoot of plants grown in low nitrogen; and N+ Shoot: Shoot of plants grown in high nitrogen) were deep sequenced for miRNA study. The numbers of raw reads obtained for sample (N- Root, N+ Root, N- Shoot and N+ Shoot) were 31919154, 29329403, 33526467 and 44145539, respectively (Table 1.12). The read length of processed sequences varied between 18-24 nucleotides as shown in Fig. 1.6.

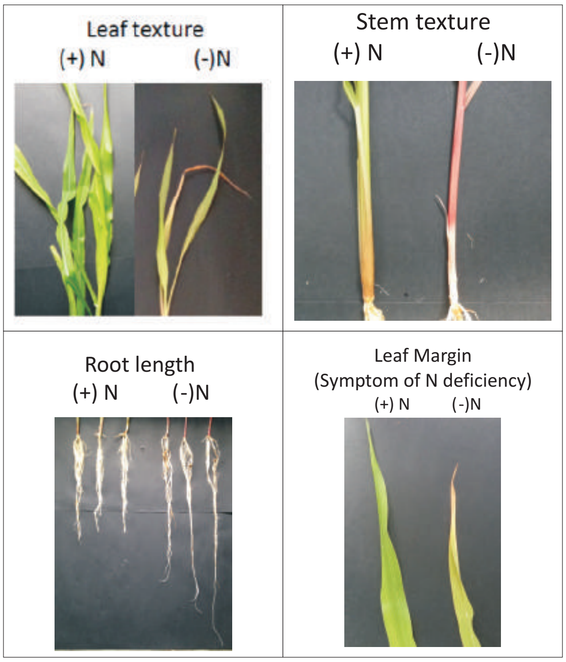


Fig. 1.5. Morphological and developmental characteristics of maize plants affected under low nitrogen (-N) and optimum nitrogen (+ N) conditions at 21 days : (a) Leaf texture, (b) Stem texture, (c) Root length, (d) Leaf margin

Table 1.12. The morphological parameters of maize under (+) N and (–) N conditions at 21 days of growth. Measurements represent an average from three plants ±SD

Treatment	Shoot				Root			
	Shoot height (in cm)	Shoot fresh biomass (in gm)	Shoot dry biomass (in gm)	Stem girth	Root length (in cm)	Root fresh biomass (in gm)	Root dry biomass (in gm)	Root volume (in cm^3)
(+)N level	12.17 ± 0.33	12.7 ± 0.68	0.92 ± 0.38	3.07 ± 0.08	32.5 ± 1.6	1.51 ± 0.0	0.2 ± 0.01	3.7 ± 0.3
(-)N level	9.1 ± 0.16	2.88 ± 0.25	0.28 ± 0.03	1.3 ± 0.06	51.7 ± 3.8	1.2 ±0.1	0.13 ± 0.02	9.4 ± 0.1

Table 1.13. Statistics of Nitrogen miRNA libraries

Table 1.13. Statistics of Nitrogen miRNA libraries

	N- Root	N+ Root	N- Shoot	N+ Shoot
Raw Reads	31919154	29329403	33526467	44145539
Clean Reads	5380590	5141943	6128587	10326490
Unique reads	1147741	1268946	981256	943628

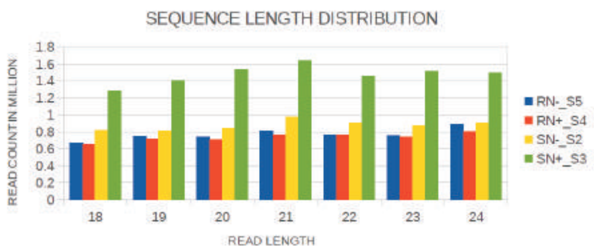


Fig. 1.6. Length distribution of small RNA reads grown in nitrogen (2mM) and without nitrogen hydroponic solution ('R' and 'S' indicate Root and Shoot, respectively; N+ and N- refer to presence and absence of Nitrogen, respectively; S2, S3, S4 & S5 are sample numbers)

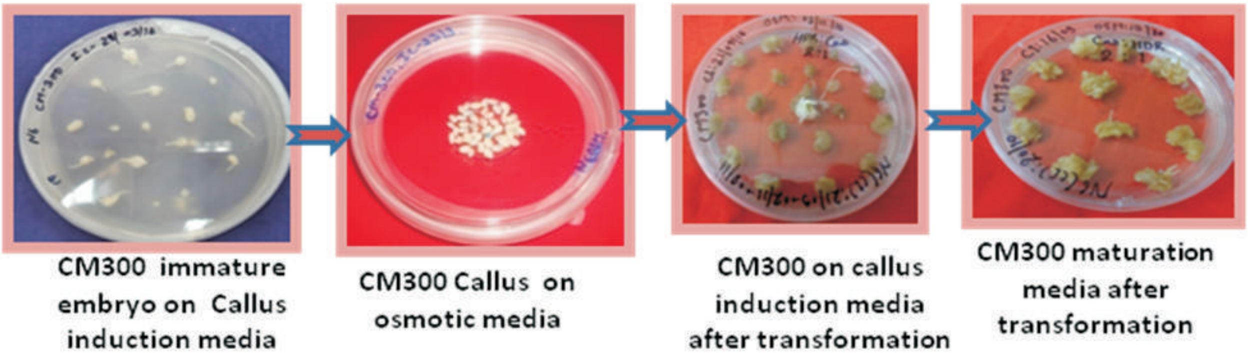


Fig. 1.7 A pictorial representation of transformation of maize for Herbicide resistant by biolistic method using immature embryo of inbred line CM300 with constructs employing CRISPR/Cas9-based gene editing.

The known miRNA sequence reads belonged to 101, 88, 113 and 107 entities referring 13, 20, 25 and 18 known miRNA families for N- Root, N+ Root, N- Shoot and N+ Shoot, respectively. The differential expression of miRNA between samples was evaluated using edgeR in miARma-Seq software as shown in Table 1.12. Several novel nitrogen stress responsive miRNA were also obtained. These miRNAs showed differential expression pattern in roots and shoots in different nitrate conditions. In total, three known miRNAs and 26 novel miRNA were found differentially expressed in root while, 23 known miRNAs and 53 novel miRNAs were differential expressed in shoot/leaf (Table 1.12).

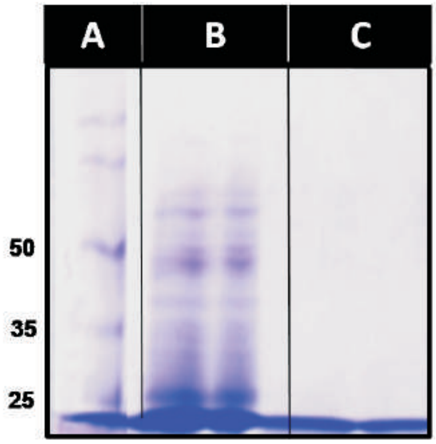
Transformation of maize for herbicide tolerance (HT) and insect resistance (IR)

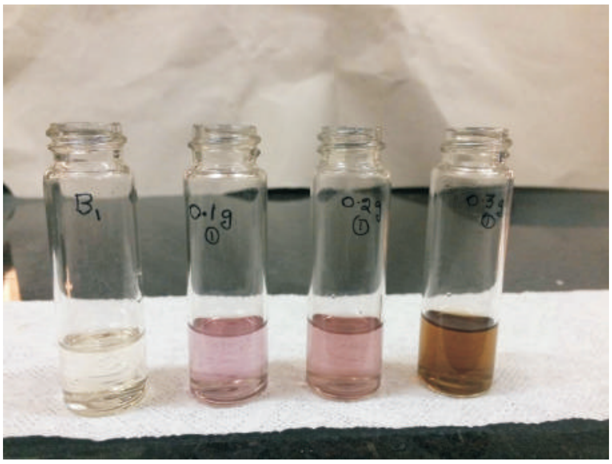
HT: The CRISPR-Cas9 based gene editing construct, pYLCRISPR/Cas9 Pubi-B, was acquired from ICGEB, New Delhi for editing of maize EPSPS (5-enolpyruvylshikimate-3-phosphate synthase) gene to induce glyphosate tolerance. At ICAR-IIMR, 840 and 150 immature embryo derived type II callus of hybrid Bio9544 and inbred line CM300, respectively (from rabi cropping season) and 1295 callus of CM300 (from kharif cropping season) were transformed using CRISPR/Cas9 construct (Cas9-gRNA plasmid + PCR amplified 1084 bp donor fragment in 1:2 ratio) through biolistic transformation method.

IR: Six hundred explants from inbred line HKI 163 were transformed for insect resistance by in-planta transformation method using Agrobacterium strain EHA 105 having vector pCAMBIA3301 harbouring cry1Ab gene under ubiquitin promoter. The transformed seedlings were transferred to vermiculate and coco peat mixture in glass house for vegetative development at 30-34°C. Presently, 69 putative transformants are in seedling stage in green house. The presence of transgene in putative transformants is being analyzed by PCR.

Isolation and cloning of orthologs of NAC1 transcription factor from maize

Transcription factors (TFs) are key proteins which regulate gene expression at transcription level. Stress responsive TFs interact with promoter elements of stress genes which may result in over expression or down-regulation of many functional genes, thereby playing a crucial role in imparting stress endurance to plants. NAC1 transcription factors are associated with many biological processes, including abiotic stress response in plants. With an objective to prospect drought stress responsive NAC1 gene from two different inbred lines, viz., LM-17 and HKI1015 which were identified earlier as highly tolerant and highly susceptible to drought stress, respectively, 939 bp of NAC1 gene was isolated by PCR-based approach using cDNA from leaf tissue. Since, the cloned sequences showed identity with Zea mays ZmNAC1 transcript as per the BLASTn analysis, the variants were designated as NAC1.The full-length NAC1 cDNA have 939 bp open reading frame and the gene is predicted to code a protein of 312 amino acids. The NAC1 gene sequences is submitted with GenBank at NCBI(Sequence ID KX219576.1 and KX421276.1). Subtle sequence polymorphisms (SNPs) between the sequences of NAC1 gene cloned from drought tolerant (LM 17) and drought susceptible (HKI 1015) genotypes have been observed, which could be the key to unraveling the tolerance mechanism. The cloned genes are being further characterized through bioinformatics and homology modelling.





Sample: 0 100 200 300 (in mg)

A: Protein marker (in kilodaltons)
B: Crude protein of maize endosperm
C: Maize endosperm treated for 30 mins.

(a) **(b)**

Figure 1.8. Demonstration of maize endosperm protein hydrolysis and colour development for tryptophan estimation through 'proprietary formulation' developed at IIMR. **(a) A:** Protein markers with size shown in kDa; B: Crude protein isolated from maize endosperm; **C:** Maize endosperm sample treated with 'proprietary formulation' for 30 minutes. **(b)** Colour development for estimating tryptophan released after hydrolysis of proteins. The four tubes shown contain (from left to right): 0 mg, 100 mg, 200 mg & 300 mg of starting maize endosperm sample, hydrolyzed through the new method using 'proprietary formulation'.

Development of assay for testing protein quality in maize

In order to make QPM a commercial success, it is necessary to develop a rapid method for differentiating QPM from normal maize. The conventional laboratory protocol (Hernandez & Bates, 1969) involves papain hydrolysis of protein sample, followed by estimation of tryptophan content. The whole protocol takes about four days to be completed. It is postulated that defatting of sample is required for efficient hydrolysis of proteins through enzymatic method by papain. Defatting takes three days to complete, while protein hydrolysis by papain taken 16 hours. A new method using a 'proprietary formulation' developed at IIMR completes hydrolysis of maize endosperm proteins in 30 minutes. Fig. 1.8 demonstrates hydrolysis of maize endosperm proteins upon treatment with 'proprietary formulation' in Sodium dodecyl sulphate- Polyacrylamide gel electrophoresis (SDS-PAGE) setup, with 10 µl loading and staining with Coomassie Brilliant Blue dye. The new procedure is expected to drastically shorten the time required for tryptophan estimation, and can be used for estimating other amino acids as well. The effect of defatting on the results of new procedure is currently in progress.

Production System and Technology

Conservation agriculture for improving resource use efficiency and mitigating GHGs emission in maize based cropping systems.

Indian agriculture is facing the problems of declining water table, escalating fuel prices, labour shortage, deteriorating soil health along with frequent climatic extremes leading to higher production cost and lower economic returns. To address these challenges of future food security and to bridge management yield gaps and sustain natural resources the principles and practices of conservation agriculture (CA) were identified. An attempt was made to develop and evaluate the performance (as individual crop productivity, system productivity and monitory returns) of different tillage, crop establishment practices [permanent bed (PB), zero tillage (ZT) flat and conventional till (CT)] under four intensified irrigated maize systems [maize-wheat-mungbean (MWMb), maize-chickpea-Sesbania (MCS), maize-mustard-mungbean (MMuMb) and maize-maize-Sesbania (MMS)] in Delhi.

The total rainfall in *rabi* (2015-16) season (November to April) was 22.2 mm, and during summer (2016) season (May to June) was 48.2 mm. The ranges of mean monthly minimum and maximum temperature during rabi, 2015-16 and summer, 2016 were between 10.9-27.6°C and 24.0-39.6°C, respectively. The results indicate that the performance (in terms of grain/seed yield) of all the rabi crops (except wheat) grown in rotation with kharif maize was maximum with ZT flat planting. However, in wheat PB plots gave maximum grain yield in rabi 2015-16. In rabi 2015-16 the grain/seed yield of maize, chickpea and mustard was 22.3, 31.6 and 27.6 % higher under ZT flat planting over to CT flat, respectively, and the wheat grain yield was 24.0 % higher in PB plots over to CT plots (Fig. 2.1). The CA based management practices (ZT flat and PB) also helped in reducing the production cost and enhancing the net returns over to CT flat system. Overall, result of our study demonstrated that, succeeding crops planted in maize based rotations under CA based practice (ZT flat/PB) increased the systems net profit from 32.6 to 37.3% compared to CT planting (Fig. 2.2). During eighth year of study, the summer mungbean yield was 31.0% higher under ZT flat over to CT flat, while among both cropping systems the summer mungbean seed was significantly differ and the highest yield was recorded in MWMb system which was 11.3 % higher over to MMuMb system (Fig. 2.3). The higher system productivity (in terms of maize equivalent yield) was recorded in ZT plots, which was 20.6 % higher over to CT plots in 2015-16. However, among the cropping sequences, the systems productivity was highest in MMuMb cropping system (Fig. 2.4). Over the years, synergistic effect (in terms of higher productivity) of summer season legumes (mungbean and Sesbania) inclusion with CA based crop management practices in traditional cereal based systems was observed.

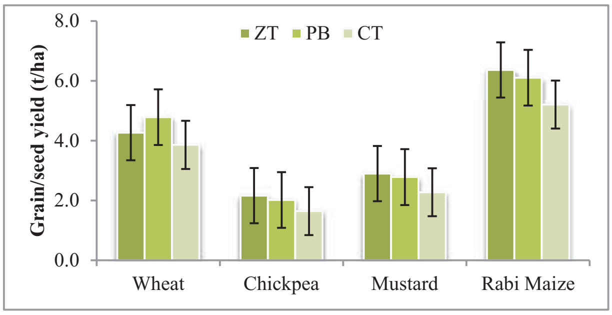


Fig. 2.1 Productivity of *rabi* (2015-16) crops as affected by different tillage practices under maize based cropping systems (ZT: Zero tillage; PB: Permanent bed; CT: Conventional tillage).

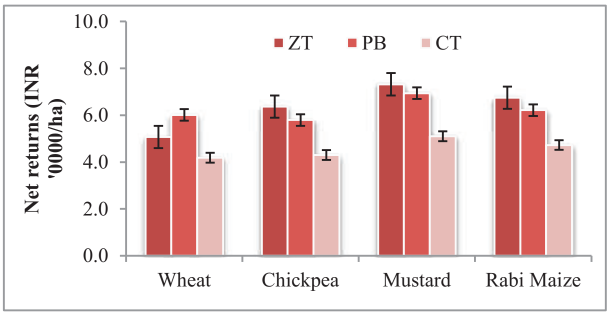


Fig. 2.2 Net returns of *rabi* (2015-16) crops as affected by tillage practices under different maize based cropping systems (ZT: Zero tillage; PB: Permanent bed; CT: Conventional tillage).

Nitrogen management under conservation agriculture in maize-based cropping systems

The Conservation agriculture (CA) practices are proving as the best alternative for resource degrading tillage intensive cropping systems in Indo-Gangetic plains and elsewhere. The most of the nitrogen nutrient applied in the crops by top-dressing lies on the crop residues and get lost by volatilization and immobilization results in poor

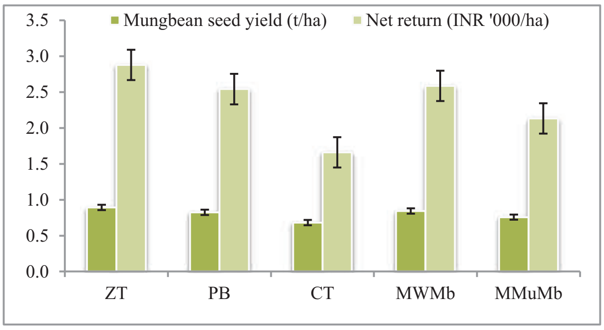


Fig. 2.3 Summer mungbean productivity and net returns under different maize based rotations and tillage practices (ZT: Zero tillage; PB: Permanent bed; CT: Conventional tillage; MWMb: maize-wheat-mungbean; MMuMb: maize-mustard-mungbean).

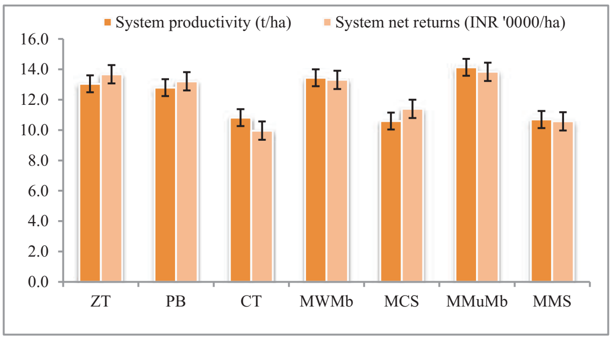


Fig. 2.4 System productivity (MEY) and system net returns of different maize based rotations as affected by tillage practices (ZT: Zero tillage; PB: Permanent bed; CT: Conventional tillage; MWMb: maize-wheat-mungbean, MCS: maize-chickpea-Sesbania, MMuMb: maize-mustard-mungbean; MMS: maize-maize-*Sesbania)*.

nutrient use efficiency. At the same time, this may results in more negative environmental footprints of crop production. Thus, under CA proper nutrient management, especially alteration in traditional N management practices may not only further enhance its adoption at large scale but also it can make CA as more eco-friendly agriculture practice. The application of coated N fertilizer could be better options for enhancing N-use efficiency under such situations. In order to explore the feasibility of one time application of such coated nitrogen fertilizer like *neem*- or sulphur-coated urea under CA, this experiment was started in July 2012 for intensified maize-based systems.

An analysis of the four years trends in the system yield of the maize-mustard-mungbean (MMuMb) system showed that the system productivity increased in the residue retention (WR) plots in all the treatments (Fig. 2.5). 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. In fourth year, the residue application increased MMuMb system yield by 17.5% over WoR treatments. However, the application of sulphur-coated urea (SCU) registered maximum productivity of the systems in all the years where its application increased productivity of the systems by 16% over prilled urea (PU) application.

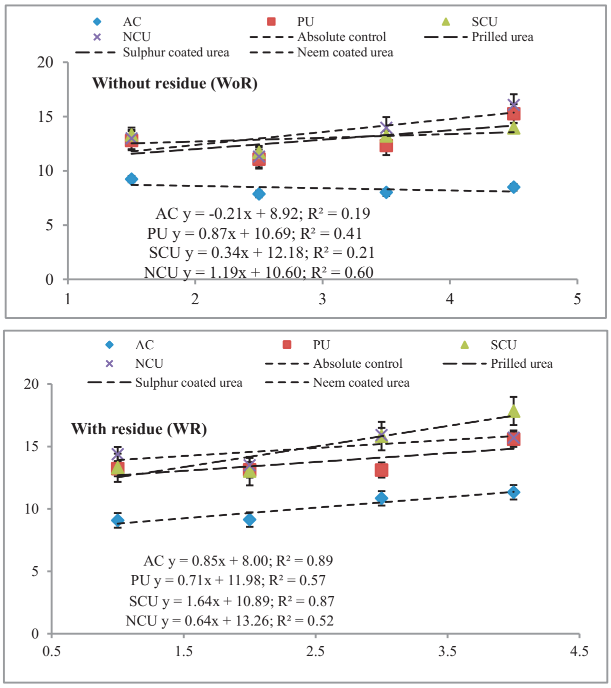


Fig. 2.5 Four-year trend in system productivity of maize-mustard-mungbean system under contrasting nutrient and residue management scenario (AC: Absolute control; PU: Prilled urea; SCU: Sulphur coated urea; NCU: Neem coated urea).

The maize-wheat-mungbean (MWMb) system productivity increased in the residue retention (WR) plots in all the urea application treatments along with control might be due to legume inclusion in intensified cropping system (Fig. 2.6). 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. In fourth year, the residue application increased MMuMb system yield by 12.6% over WoR treatments. However, the application of neem-coated urea (NCU) registered

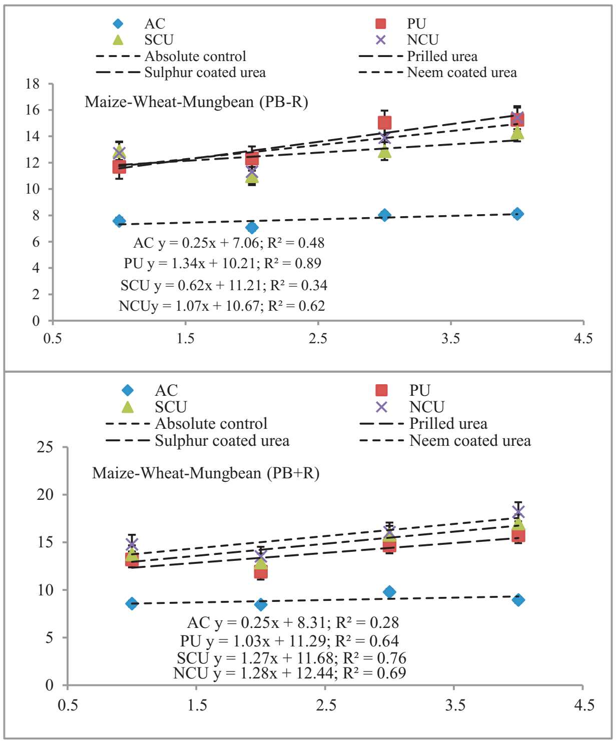


Fig. 2.6 Four-year trend in system productivity of maize-wheat-mungbean system under contrasting nutrient and residue management scenario (AC: Absolute control; PU: Prilled urea; SCU: Sulphur coated urea; NCU: Neem coated urea).

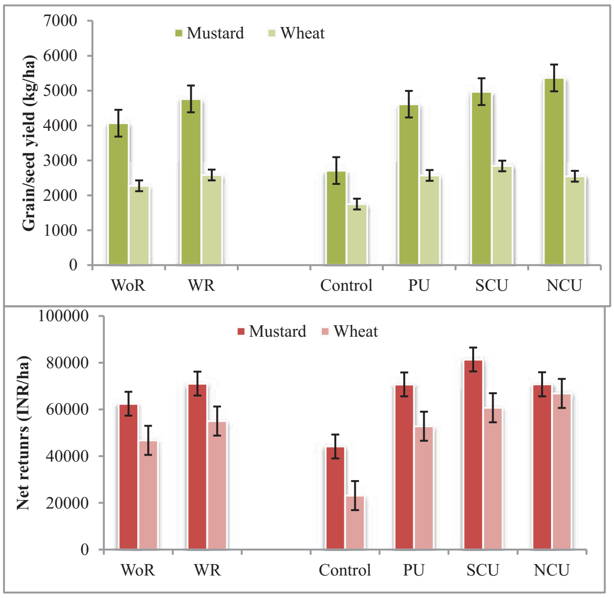
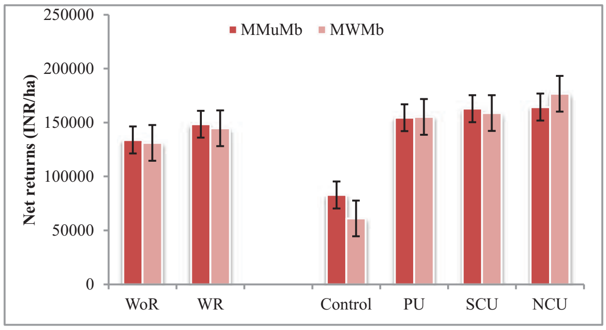


Fig. 2.7 Effect of coated fertilizer application on *rabi* crop yields and net returns in intensified maize systems under different residue management scenario during fourth year of experimentation (AC: Absolute control; PU: Prilled urea; SCU: Sulphur coated urea; NCU: Neem coated urea).



maximum productivity of the systems in all the years where its application increased productivity of the systems by 3.7% over PU application.

The application of residue in CA enhanced the wheat yield by 17.1% whereas the net returns by 17.8% compared to residue removal during fourth cropping cycle (Fig. 2.7). However, the corresponding increase in the mustard yield and net returns was 13.7 and 13.8%, respectively. It shows that residue application gives rich dividend in long-term under CA. The application of neem coated urea in wheat proved best N management strategies where it increased the grain yield by 16.3% whereas net returns by 26.5% during fourth year compared to PU application. In case of the mustard, the increase was highest in case of SCU application, which was 10.5 and 15.1%, respectively in case of the yield, and net returns over PU application.

The resource-use efficiency of residue and coated fertilizer application in two maize systems was also estimated. The application of residue in wheat and mustard lead to increase in biomass radiation conversion efficiency by 14.9 and 12.8% over no residue application. Similarly, the application neem coated urea in wheat and sulphur coated in mustard increased incident radiation conversion efficiency by 12.3 and 7.2%, respectively over conventional prilled urea application.

The application of residue decreased the penetration resistance in the soil compared with the WoR. An increase of the potassium status of the soil was also found after fourth cropping cycle in the experiment with residue application over WoR. However, the N application treatments (PU, SCU and NCU) also showed decreased penetration resistance compared with control treatment.

The highest net returns of the MMuMb system during fourth year of the experimentation was observed with residue and SCU application, which was 10.9 and 5.5%

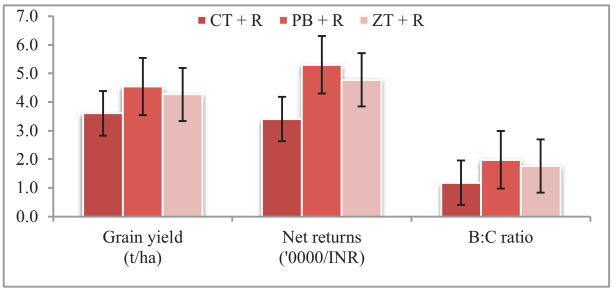


Fig. 2.8 Effect of coated fertilizer application on system net returns in intensified maize systems under different residue management scenario during fourth year of experimentation (AC: Absolute control; PU: Prilled urea; SCU: Sulphur coated urea; NCU: Neem coated urea).

higher over WoR and PU application, respectively (Fig. 2.8). However, in MWMb system, highest net returns was observed in NCU and residue application treatment, which was 13.9 and 10.4% higher over PU and WOR treatments during fourth year of the study. However, highest B: C ratio (>2.4) was observed in the NCU treatments irrespective of the cropping system which was at par with SCU application.

Site-specific nutrient management in maize based cropping systems

Site-specific nutrient management (SSNM) provides specific principles for optimally supplying nutrients. SSNM has led to decision tools and guidelines for farmers and extension workers. Many countries in Asia have started replacing existing blanket fertilizer recommendations with site-specific guidelines suited to local needs. SSNM combined with good crop management practices helps farmers to attain high yield and profitability both for short and medium-term. Hence, an experiment was initiated during *kharif* 2012, to assess the performance (as individual crop productivity, system productivity and economic profit), and water-use and radiation conversion efficiency of maize-wheat-mungbean (MWMb) system under three tillage and crop establishment practices [zero tillage (ZT), permanent beds (PB) and conventional tillage (CT)] layered with four nutrient management strategies [Control (unfertilized), farmers' fertilizer practice (FFP), recommended dose of fertilizers (RDF/Ad-hoc) and a site-specific nutrient management (SSNM" using the Nutrient Expert®) decision support tool. Among all cereals, maize in general and hybrids in particular are responsive to applied nutrients either through organic or inorganic sources. The rate of nutrient application depends mainly on soil nutrient status/balance and cropping system. Thus, for obtaining desirable yields, the doses of applied nutrients should be matched with plant demand by keeping in view of the soil supplying capacity and (SSNM) preceding crop (cropping system).

Results demonstrated that tillage methods had significant effect on wheat grain and biomass yield (in *rabi,* 2015-16) and was the highest in PB plots (4.5 and 11.1 t/ha, respectively) compared to CT (3.6 and 8.6 t/ha, respectively) (Fig. 1), however the ZT was intermediate (4.3 and 10.3 t/ha, respectively). The grain and biomass yields of wheat crop with PB were increased significantly ($P<0.05$) by 25.8 and 28.9% compared to CT, respectively. PB planting resulted maximum net returns and B:C ratio of *rabi* (2015-16) season wheat crop grown in rotation with *kharif* maize (Fig. 2.9). Amongst nutrient management practices SSNM registered increase in grain yield by 23.7 to 61.9% and biomass yield by 20.7 to 57.0% compared to unfertilized plots and and FFP, respectively. Similarly, SSNM based nutient management plots registered maximum net returns and B:C ratio of wheat crop compared to unfertilized plots and and FFP, respectively (Fig. 2.10). *Kharif* maize grain and biomass yields, and net returns were significantly differ with tillage practices, and the highest grain yield (5.9 t/ha), biomass yields (16.4 t/ha) and net returns were recorded in PB system plots which was 40.2, 30.3 and 71.1% higher compared to CT systems, respectively (Fig. 2.11), while the ZT was intermediate (5.5 and 16.1 t/ha, respectively for grain and biomass yields). Among nutrient management practices SSNM registered higher maize grain yield by 28.1 to 78.1%, and biomass yield by 24.4 to 51.0% and net returns 45.1 to 95.6% compared to unfertilized plots and FFP, respectively (Fig. 2.12).

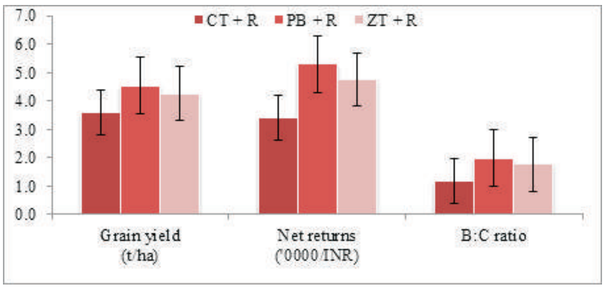


Fig. 2.9 Productivity and economics of *rabi* (2015-16) wheat crop as affected by different tillage and crop establishment practices under maize-wheat-mungbean cropping system (CT: Conventional tillage; PB: Permanent bed; ZT: Zero tillage; R: Residue).

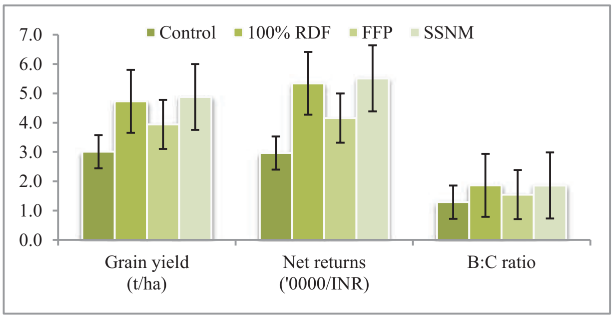


Fig. 2.10 Productivity and economics of *rabi* (2015-16) wheat crop as affected by different nutrient management practices under maize-wheat-mungbean cropping system (RDF: Recommended dose of fertilizers; FFP: Farmers fertilization practices; SSNM: Site-specific nutrient management).

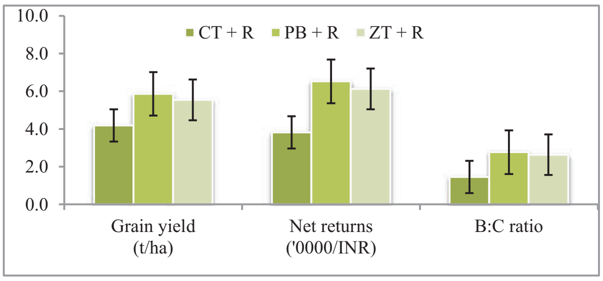


Fig. 2.11 *Kharif* maize (2016) grain yield, net returns and B:C ratio under different tillage and crop establishment practices (CT: Conventional tillage; PB: Permanent bed; ZT: Zero tillage; R: Residue).

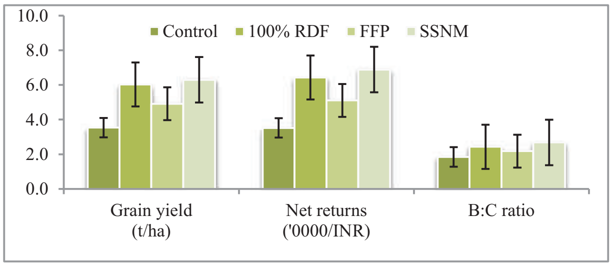


Fig. 2.12 *Kharif* maize (2016) grain yield, net returns and B:C ratio under different nutrient management practices (RDF: Recommended dose of fertilizers; FFP: Farmers fertilization practices; SSNM: Site-specific nutrient management).

The system productivity (in terms of maize equivalent yield) was recorded highest in PB plots (14.0 t/ha) and the lowest was with CT plots (10.7 t/ha) during 2015-16 (Fig. 2.13). However, among the nutrient management plots, the systems productivity (15.0 t/ha) was highest in SSNM plots (Fig. 2.14). Similar to system productivity, the system net returns was also recorded highest PB plots with 51.6% increment over to CT plots, however among the nutrient management plots SSNM plots registered highest net returns, which was 77.9, 38.9 and 6.8% higher compared to unfertilized, FFP and RDF/Ad-hoc plots, respectively (Fig. 2.13 and 2.14).

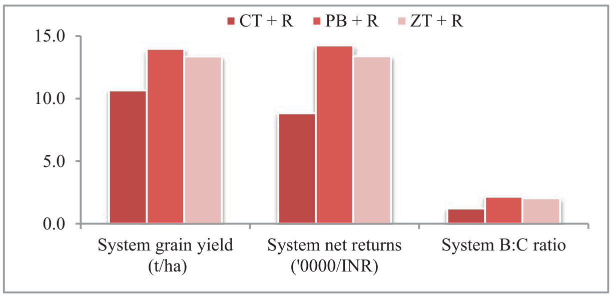


Fig. 2.13 System productivity (MEY) and system net returns of maize-wheat-mungbean rotation as affected by different tillage and crop establishment practices (CT: Conventional tillage; PB: Permanent bed; ZT: Zero tillage; R: Residue).

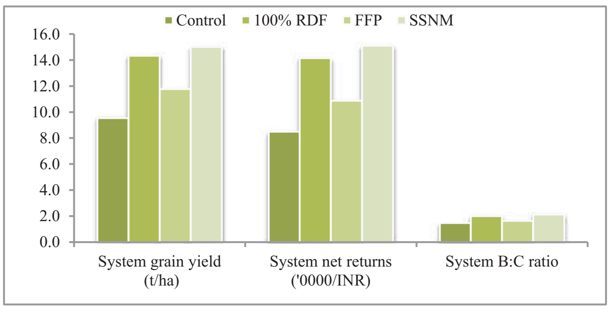


Fig. 2.1 System productivity (MEY) and system net returns of maize-wheat-mungbean rotation as affected by different nutrient management practices (RDF: Recommended dose of fertilizers; FFP: Farmers fertilization practices; SSNM: Site-specific nutrient management).

3

Crop Protection

Insect pests and diseases can have a devastating effect on yield and quality of maize crop, which prevent to achieve the potential yield of a cultivar. In order to reduce the losses due to insect pest 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 at different agro-climatic zones to identify resistant sources forms its integral part. Development of management tools for integrated pest management is another important aspect in crop protection.

Host plant resistance

Host-pathogen interaction between post-flowering stalk rot pathogens and identification of sources of resistance in maize

Post-flowering stalk rot of maize is a devastating disease in India, its incidence ranges from 10 to 42%. In order to identify the biochemical mechanisms of host plant resistance against this disease, an experiment was conducted towards differential expression profiling of proteins, where 45 genetically diversified and identified resistant maize lines were inoculated with *Fusarium verticilloides* and *Macrophomina phaseolina* separately. Total protein was extracted from both treated and untreated roots and stems samples. The electrophoretic separation of samples was done by one dimensional SDS-PAGE and protein bands were visualized for possible variations. Nineteen genotypes showed different band pattern under inoculated condition when compared with un-inoculated control. Further studies are required to confirm the above findings.

Evaluation of maize germplasm to identify resistant sources for various diseases under artificial inoculation conditions

To identify resistance sources for post-flowering stalk rot (PFSR), 148 maize genotypes along with the susceptible check (Vivek QPM 9) were evaluated in 3X0.75 m rows, replicated twice under artificial toothpick inoculation condition in IIMR experimental field during 2016 *kharif.* Based on diseases reaction a total of 85 lines were selected and planted in winter nursery Hyderabad for evaluation and seed multiplication. A total of 134 maize inbred lines were evaluated against maydis leaf blight (MLB), turcicum leaf blight (TLB) , banded leaf and sheath blight (BLSB), rajasthan downy mildew (RDM) and charcoal rot (CR) at different hot spot locations under artificially created epiphytotic conditions during *kharif* 2016. Out of them, 28 lines were moderately resistant to MLB in NWPZ; 36 and 15 lines were resistant to TLB in NHZ and PZ, respectively. One inbred line (BGS-27) showed resistance to BLSB in NWPZ, while 10 were moderately resistant. Two lines, *viz.*, EC618179 and EC618235 were resistant to CR whereas, 60 lines showed moderate resistance reaction in NWPZ. In CWZ, 38 and 39 lines exhibited resistant and moderately resistant reactions to RDM, respectively. Promising genotypes with resistant reaction are:

S No	Disease/ Tested Zone	Resistant genotypes
1	TLB (NHZ)	BGS-4, BGS-21, BGS-22, BGS-24, BGS-27, BGS-28, BGS-30, BGS-32, BGS-35, BGS-37, BGS-38, BGS-39, BGS-41, BGS-42, BGS-47, BGS-58, BGS-59, BGS-68, BGS-72, BGS-76, BGS-77, BGS-78, BGS-79, BGS-80, BGS-81, BGS-86, BGS-94, BGS-95, BGS-97, BGS-100, 4840, CM 111 'Zeadiploperennis' CM111, CM 117-3-4-1, CML420, JYC 2-1-2-1, PAC 745
2	TLB (PZ)	BGS-24, BGS-32, BGS-58, BGS-59, BGS-68, BGS-80, BGS-94, BGS-95, 4840, CM111 'Zeadiploperennis' CM111, CM 117-3-4-1, CML420, JYC 2-1-2-1, LM 13, PAC 745, PFSRR 9
3	RDM	BGS-3, BGS-11, BGS-12, BGS-20, BGS-24, BGS-28, BGS-36, BGS-43, BGS-45, BGS-53, BGS-60, BGS-65, BGS-66, BGS-80, BGS-88, BGS-95, BGS-97, 5191, Acc. No. 524093, Bio 688, CM111'Zeadiploperennis' CM111, CM 143, CML 287, CML 327, DMRWNCHOC45, EC440415-2, EC 440608, EC 440638, EC 646061, LM 5, NZB 2012, NZBOPH, PAC745-4, PFSR 46, WLS-F102-3-2-1-B-1-B/WLS-F287-1-3-1-B-1-B*6-B, WLS-F191-2-1-1-B-1-B/SO4YLWL-172-B-1-1-B-1-B*5-B1-B, WNCDMR11R27290
4	BLSB	BGS-27
5	CR	EC 618179, EC 618235

PFSR- Post flowering stalk rot, MLB – Maydis leaf blight; TLB – Turcicum leaf blight; BLSB - Banded leaf and sheath blight; CR – Charcoal rot; RDM – Rajasthan downy mildew; NHZ – North Hill Zone; PZ – Peninsular Zone

Evaluation of maize germplasm to identify resistant sources for spotted stem borer, Chilo partellus (Swinhoe)

Out of 104 early lines evaluated against *C. partellus* under artificial infestation during *kharif* 2016, HEY Pool -2011-12-3-3-3-1-1⊗⊗ (3.89), HEY Pool -2011-37-2-1-3-1-1⊗⊗(3.92), PFSR-10104⊗⊗ (4.0) , PFSR-10104⊗⊗ (4.0), IC-656142⊗⊗(4.0), HEY Pool -2011-12-1-3-1-2-1⊗⊗(4.25), HEY Pool -2011-15-3-2-1-1-1⊗⊗(4.25), HEY Pool -2011-12-1-2-1-1-1⊗⊗(4.29), HEY Pool -2011-15-3-6-1-2-1⊗⊗(4.31), HEY Pool -2011-15-3-7-3-1-1⊗⊗(4.40), CML-342⊗⊗(4.50), HEY Pool -2011-41-2-1-2-1-1⊗⊗(4.64) and CML-482⊗⊗(4.67) recorded Leaf Injury rating (LIR) less than the resistant check CM 500 (4.7).

Evaluation of maize germplasm to identify resistant sources for pink stem borer, *Sesamia inferens* Walker

Out of 130 early lines \evaluated for second year against S. *inferens* during *rabi* 2016, MEGHALAYA-214⊗⊗ (2.2), IIMRPBTPOOLÄ5⊗⊗(2.3.8), IIMRPBTPOOLÄ6⊗⊗(2.50), HEY Pool-2011-12-1-1-3-3-1⊗⊗(2.57), HEY Pool-2011-12-3-5-2-3-1⊗⊗(2.57), HEY Pool-2011-12-3-7-2-3-1⊗⊗(2.60), DMR E63(2.67), WNZPBTL9/CML451MF4-41⊗⊗⊗⊗(2.71), IIMRPBTPOOLÄ3⊗⊗⊗⊗(2.80), WNZPBTL9/CML451MF2-469⊗⊗⊗⊗(2.83), IC5859131⊗⊗⊗⊗(2.86), MEGHALAYA-215⊗⊗⊗⊗(2.88) and NAI-175⊗⊗(2.89) recorded less than 3.0 LIR.

Evaluation of maize germplasm to identify resistant sources for Shoot fly, *Atherigona spp.*

Sixty six lines were evaluated against shoot fly at Delhi under natural infestation during spring 2016 for the third year, no dead hearts were formed in the line WS 2, while PFSR5106/1 (8.33), CM117-3-4-1(8.33), WINPOP-8 (8.33) and HKI1831 (9.09) recorded less than 10% dead hearts.

Evaluation of maize germplasm to identify resistant sources for rice weevil, *Sitophilus oryzae* (L.) infesting stored maize

Laboratory screening of seven F1 crosses (crosses between resistant and susceptible lines) CM149 × AccN0527290, 5183 × EC645987, 5144 × ENT2-3, EC645987 × 5183, AccNo 527290 × 6327, 4854 × 5183, ENT2-3 × 5144 against *S. oryzae* were done based on Dobie's index. Among them, EC645987 × 5183 was found to be moderately resistant. Screening of ten F2 crosses (crosses between resistant and susceptible lines) 4854 × 5183, 5183 × EC645987, AccNo 527290 × 6327, CM149 × AccN0527290, ENT2-3 × 5144, 6327 × 4854, 5183 × EC645987, EC645987 × AccNo 527290, 5144 ×ENT2-3, CM149 × 5183, ENT2-3 x Acc.no.52729 identified five resistant crosses (Dobie's index 0-4), viz., 5183 × EC645987, AccNo 527290 × 6327,CM149 × AccN0527290, ENT2-3 × 5144, ENT2-3 x Acc.no.52729.

Identification of host plant resistance traits for maize germplasm screening against the cob borer, *Helicoverpa armigera*

Thirteen sweet corn varieties were evaluated for their ear characteristics *viz.*, husk extension, tight/looseness of husk and number of husks in relation to *H. Armigera* infestation. Two parameters *viz.*, extension of husk from the tip of the cob and husk tightness emerged as promising resistance factors, exhibited significant negative correlation of 0.84 (p=<.0001) and 0.69 (p=0.005) respectively with% ear infestation of the pest, where husk extension showed significant differences among genotypes. Husk extension as a host plant resistance trait was later validated in 22 genotypes of medium maturity and 26 genotypes of late maturity under three different conditions, *viz.*, stress free, moisture stress at flowering stage and moisture stress at grain filling stage. The harvested ears were examined for the cob damage as well as the extension of husk from the tip of the cob. The genotypes under both the maturity groups were differing highly significantly for% cob damage and husk extension with significant negative correlation between the parameters. This proves husk extension is a promising trait for *H. armigera* resistance breeding.

Role of penetration resistance in host plant resistance to *C. partellus*

Twenty inbred lines were evaluated for stalk penetration resistance of the basal internodes at three, four and five week stages by TA + Di Texture Analyzer. It was found that penetration resistance at the pith of three (-0.66, p=0.001) and four (-0.46, p=0.04) weeks old plants and at the rind of three (-0.56, p=0.01), four (-0.58, p= 0.007) and five (-0.75, p= 0.0001) weeks old plants are negatively correlated with the extent of damage caused by the pest. Penetration resistance was found to influence the dispersal behavior of larvae and also its weight gain.

Disease and pest management strategies through biocontrol, botanicals and chemicals.

Efficacy of newer fungicides in management of maize diseases

Efficacy of newer fungicides to BLSB was evaluated at Bajaura, Delhi and Godhra centres. Data revealed that Trifloxystrobin 25% + Tebuconazole 50% @ 0.05% gave 42.47% disease control of BLSB with 44.82% increase in yield followed by Validamycin @ 0.1% and Azoxystrobin @ 0.05% which showed 39.18 and 33.40 per disease control with 26.70 and 23.42% yield increase, respectively. Besides, Trifloxystrobin 25% + Tebuconazole 50% @ 0.05% also reduced common rust up to 40.25% with yield increase of 67.78% at Karnal. Similarly, foliar application of Tebuconazole 250 EC @ 0.1% found to check TLB and common rust (69.48 and 60.71%, respectively) with an increase of yield up to 38.16% at Dharwad centre.

Efficacy of bio-agents, fungicides and potash in control of post-flowering stalk rots at Udaipur

Application of local strains of fungal antagonists @ 0.5% as seed treatment, bio-agent fortified FYM (1:50) and spray @ 0.5% checked PFSR up to 65.67 with 66.78% increase in yield as compared to inoculated control and at par with foliar spray of Propiconazole @ 0.1% at 40 days after sowing (DAS) and double dose of muriate of potash at 45 DAS with 65.67 and 60.00% disease control, respectively.

Efficacy of bio-agents and fungicides in control of downy mildews of maize

Effectiveness of bioagents and fungicides were tested to control RDM and SDM. Seed treatment as well as spray of Fosetyl-al @ 0.2% effectively controlled RDM (80.62%) with yield increase of 94.00 % at Udaipur centre. Whereas, seed treatment and spray of metalaxyl+mancozeb (0.25%) and Azoxystrobin (ST @ 0.2% and spray @ 0.15%) found to be exhibited 93.15 and 91.24 % disease control of SDM at Mandya centre with 84.37 and 83.25% yield increase compared to check.

Efficacy of bioextracts/ natural products on the incidence of maize diseases

Bioextracts/ natural products efficacy were evaluated at Delhi, Karnal and Dholi centres to control MLB. Data revealed that spray of *Azadiracta indica (Neem)* leaves and *Allium sativum (garlic)* cloves extract (10%) inhibited MLB up to 30.59 and 27.86% with increase in yield up to 34.44 and 25.63%, respectively.

Management of BLSB through stripping of basal leaves

Field experiments on disease management through leaf stripping method in maize were conducted at Delhi, Karnal, Ludhiana and Godhra on different varieties/ inbred lines during *kharif* 2016 and data revealed that the practice prevents the progress of BLSB to the extent of 32-50% with 9-30% yield enhancement.

Management of maize cyst nematode *(Heterodera zeae)* at Udaipur

Application of *Trichoderma viride* @ 2% w/w + neem cake @ 2 q/ha and *Pochonia chlamydosporia* @ 2% w/w + lantana leaf @ 1 q/ha reduced final larvae (per 100 cc soil) up to 47.32 and 38.10 % with yield increase of 47.77 and 43.91%, respectively compared to check.

Management of rice weevil, *S. oryzae* infesting stored maize

Different fractions of ethyl acetate extract of leaf of *Tinospora cordifolia* such as 25 % $CHCL_3$/MeoH , 100 %E, 10% $CHCL_3$/MeoH, $CHCL_3$ 100%, 50% H/E , 75% H/E were evaluated for repellent activity against *S. oryzae.* Among them, 75% hexane/ethylacetate fraction exhibited significant repellent activity of 80.0% towards *S. oryzae* at 0.5 to 1.5% concentration.

The combination of sun drying of maize for 4 hours from 11.00 a.m. to 3.00 p.m. at weekly intervals along with application of leaf powder of *Erythrina indica* at the rate of 2% provided the best protection as it recorded lowest number of adults (56.20%), reduced per cent weight loss (2.77 to 5.50) and reduction of F1 progeny emergence (58.93%). This study suggests that integration of solar heat along with application of leaf powder of *E. indica* is cheap, effective, and economic and offers great prospect for successful protection of stored maize by the resource poor farmers.

4

Extension

Front Line Demonstrations

The institute is providing extension services to the nation through organizing Frontline Demonstrations (FLDs), field days, trainings etc. The institute organized FLDs in collaboration with different AICRP centres spread across the country. Under NFSM, 160 hectares FLDs in *rabi*/spring 2015-16 and 190 hectares FLDs in *kharif* 2016 were allocated to IIMR. Out of these, FLDs were conducted on 70.7 hectares during *rabi* 2015-16, 40 hectares in spring 2016 and 197.2 hectares FLDs during *kharif* 2016. Eighteen centers in thirteen major maize growing states took up these demonstrations. In these, total numbers of beneficiaries were 163, 74 and 458 during *rabi,* spring and *kharif,* respectively. All promising technologies, viz., single cross hybrids, specialty corn, intercropping, weed management, nutrient management, etc were demonstrated at farmers' fields. All promising technologies, viz., single cross hybrids, specialty corn, intercropping, weed management, nutrient management, etc. were demonstrated at farmer's field. The demonstrations were conducted in Andhra Pradesh, Bihar, Chhattisgarh, Delhi, Gujarat, Jammu and Kashmir, Jharkhand, Karnataka, Odisha, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh. Fifteen hectares FLDs in kharif 2016 on baby corn were also conducted in NCR of Delhi using variety G-5414. Maize intercropping FLDs were also conducted with arhar in Uttar Pradesh where significnat yield gains were observed over sole cropping.

Demonstration on Maize-Groundnut intercropping in Manipur

Table 4.1 Technology demonstration under Front Line Demonstration in NFSM

Technology demonstration	FLDs (ha)	State
	Rabi. 2015-16	
Hybrid	60.7	Assam, Bihar, Madhya Pradesh, Tamil Nadu, Telangana
Quality Protein Maize	10	Bihar
	Spring, 2016	
Baby corn + vegetable intercropping	5	Sonipat
Sweet corn hybrid	5	Sonipat
Hybrid	10	Punjab
Quality Protein Maize	20	Bihar, Karnal
	Kharif 2016	
Baby corn intercropping with leafy vegetables	15	Haryana
Hybrid	142	Karnataka, Tamil Nadu, Telangana, Rajasthan, Madhya Pradesh, Gujarat, Chhattisgarh, Jammu & Kashmir, Uttar Pradesh, Punjab, Maharashtra
Bio-9682 + soybean intercropping	20	Rajasthan
Weed management by Atrazine Pre-Emergence application	10	Madhya Pradesh
HQPM -1 with liming, weed management and optimum planting density	10	Jharkhand

In *kharif* season of 2016, the FLDs were conducted on 197 ha area focused on hybrid, weed management and intercropping where an yield advantage of 1.8 to 72% was

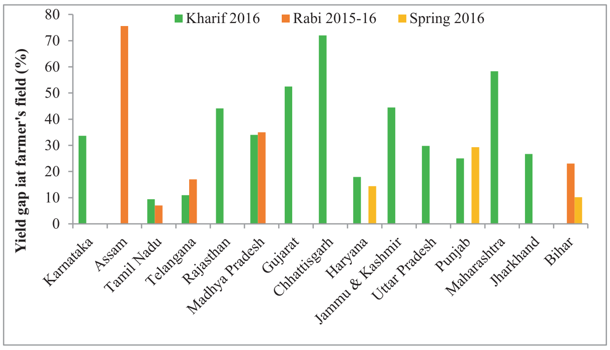


Fig. 4.1 Seasonal variation in the yield-gaps observed at farmers' field in maize cultivation.

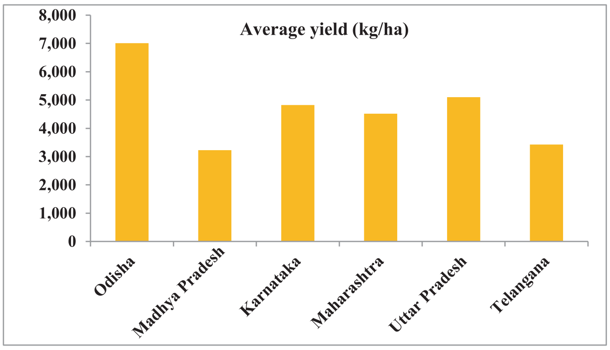


Fig. 4.2 Average grain yield observed in demonstrations under TSP programme at tribal farmer's field during 2016-17 in various states.

recorded in different states (Fig. 4.1). On an average yield increase was 29% as compared to the farmers practices which indicate a huge adoption gap of improved technologies in maize production at farmers field. In *rabi* season of 2015-16, the FLDs was conducted on 70.7 ha area focused on hybrid and quality protein maize where an yield advantage of 6.4 to 75.6% was recorded in different states. On an average yield increase was 27% as compared to the farmers' practices. In spring season of 2016, the FLDS was conducted on 40.0 ha area focused on hybrid, baby corn, sweet corn and quality protein maize where an yield advantage of 10.2 to 29.3% was recorded in different states (Table 4.1). On an average yield increase was 16.5% as compared to the farmers' practices which indicates a lesser adoption gap of improved technologies in maize production at farmers field in spring season.

Tribal-sub plan

Tribal Sun 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. The various activities performed under TSP scheme were demonstration of latest maize technologies at tribal farmers field, National and Regional level training for tribal farmers, input distribution, field days etc. Demonstrations in 186 hectares were conducted in Hyderabad, Odisha, Madhya Pradesh, Maharashtra, Karnataka, and Uttar Pradesh by IIMR and AICRP centres. Each demonstration was conducted in one acre (0.4 ha) of land using maize hybrids P 3522, DKC 9081, NMH 713,900 M Gold, Bio 9544, Rasi 4794, NWMH 95011, NMH 4040, Nithyashree, Hema, Hybrid, DKC-7074, DHM-117, P 3441 and P 3501 with improved agronomic management practices. The average yield of maize in demonstrations was 7012 kg/ha during *rabi*

Trainings/Field days organized by IIMR and AICRP centers

2015-16 and 4350 kg/ha during *kharif* 2016 (Fig. 4.2).

Promoting improved technology of maize production among the tribal farmers in NEH region

A pilot project for demonstration of the improved maize production technologies was undertaken by IIMR in collaboration of ICAR NEH Manipur centre. Five trainings benefitting 185 farmers and 40 FLDs on maize cultivation conducted were conducted under institutes TSP programme. These intercropping demonstrations increased maize equivalent yield by 1500 kg/ha was recorded, which gave rupees 15504 more monetary benefits per ha over sole maize growing during kharif 2016.

IIMR organized nine National level training programmes at New Delhi, Hyderabad and Ludhiana under TSP programme. These include a special training programme for tribal farmers of Odisha at IIMR, New Delhi and six field visits in Aternna and Manuali village (Sonepat) wherein 389 tribal farmers from Andhra Pradesh, Assam, Chhattisgarh, Gujarat, Jharkhand, Jammu and Kashmir, Madhya Pradesh, Mizoram, Rajasthan and Uttar Pradesh were benefited. AICRP centres on maize also conducted 13 regional training programmes in Madhya Pradesh, Odisha, Karnataka, Tamil Nadu and Rajasthan wherein 626 tribal farmers were exposed to latest maize production technologies in TSP programme. In addition, eight field days were also organized by AICRP centres in Madhya Pradesh, Tamil Nadu and Karnataka. Apart from the above-mentioned activities, inputs like hybrid seed, maize sheller, weeders, line markers, knapsack and power operated sprayer, etc.) were also distributed to the farmers for enhancing profitability through recent technologies in maize cultivation. Literature in hindi and vernacular languages were also distributed on production technologies of normal maize, hybrid seed and specialty corn production were distributed among tribal farmers by IIMR and AICRP centres on maize in different parts of the country.

Trainings/ Field days	No. of Trainings/ Field days	Beneficiaries
National level trainings	9	389
Regional level trainings (in NEH region)	8	185
Field days	6	280
Trainings/Field days by AICRP centers		
Regional level trainings	13	626
Field days	8	328

- Distribution three tyne weeders to tribal farmers of Kakunoor village, Ranga Reddy district, Telangana
- Input Distribution in TSP National Level Training Programme at IIMR, New Delhi
- Seed Distribution at Chandel, Manipur
- Value addition in Rachappaji nagar, Chamarajanagara, Karnataka
- Seed Distribution in TSP Training Programme at IIMR, New Delhi
- Interaction with farmers in a training at Manipur
- Spray Machine Distribute in IIMR, New Delhi











- Visit of farmers to Farming System Model at IARI, New Delhi
- Visit of tribal farmers to baby cron and sweet corn processing unit at Atterna Village, Haryana
- Conservation agriculture Field Visit by tribal farmers at IIMR, New Delhi

Farmers' training on specialty corn for improving livelihood security and farm profitability

As a follow up action of the visit of ICAR team in the areas of increasing eucalyptus plantation in Odisha in place of field crops, a special training on the "Specialty corn for improving livelihood security and farm profitability" was conducted at IIMR, New Delhi during 2nd - 4th March for tribal farmers of Nabrangpur (Odisha). Fifty tribal farmers were trained in latest maize production technologies, specialty corn and value addition. During the training programme, a field visit to the zero tillage maize production systems on the institute farm at Pusa Campus was also arranged. The farmers were convinced with technology which saves input and enhances soil health and cropping intensity so that farmers can get more from unit land. A visit to the 'baby corn village' Atterna, 'sweet corn village' Manuli and a baby corn, sweet corn processing plant established by a successful maize farmer in Sonipat district of Haryana was also made during training. The farmers were impressed to see the large-scale cultivation and processing of baby corn and sweet corn and prosperity driven by their cultivation.

In order to enhance more profitability and nutritional security at farmers level, a visit to a viable and productive farming system established at IARI, New Delhi was also made where enterprises like duck rearing, poultry, fishery, vegetables, flowers, fruits, baby corn, dairying, biogas, annual grain crops (wheat, maize, mustard), intercropping of baby corn with pea under zero tillage, etc. in integrated manner with a potential income of Rs 1000 per day from one hectare land was appreciated by farmers to replicate at their field.

During the programme, input (10 kg hybrid maize seed and one knapsack sprayer and one hand maize sheller) and value added maize products (quality protein maize *kheer* mix, maize chips and processed baby corn) were distributed to each farmer in order to channelize their interest towards maize cultivation than to go after eucalyptus. The feedback from the farmers reveals their amazement that agriculture, especially maize base systems can be such a profitable enterprise. They also expressed interest to develop baby corn and sweet corn hub in their district. The programme was much appreciated by the officers of the state government of

Kissan mela/exhibition	Duration	Place
Gramoday Se Bharat Uday Abhiyan	23-24 April, 2016	Jamshedpur, Jharkhand
Kishan Mela	07 May, 2016	Nawla Village, District – Muzaffarnagar, U.P.
3rd Indian International MSME Expo & Summit	11-13 August, 2016	Pragati Maidan, New Delhi
Krishi Unnati Mela	26-29 September, 2016	Mathura, U.P.
Diwali Mela	15-16 October, 2016	Pandara Park, New Delhi
4th International Agronomy Congress	22-26 November, 2016	Mela Ground, Pusa Campus, New Delhi
Northern Regional Agricultural Fair- Krishi Kumbh	28-30 November, 2016	G.I.C. Ground, Muzaffarnagar, U.P.
Krishi Unnati Mela	15-17 March, 2017	Mela Ground, Pusa Campus, New Delhi

Odisha, Mr Anshuman Pattnaik and Mr. Srikant Sahu accompanying the farmers.

Participation in exhibitions

The IIMR participated in eight kissan mela/exhibitions in different locations in various parts of the country to show case latest maize hybrids, specialty corn and improved production technologies to enhance farmers income. More than 5000 visitors including farmers, researchers, students and agro-entrepreneurs visited the exhibition and enriched with the maize production, protection and value addition knowledge.

Interface meeting with farmers at Village Harma, Garhshankar, in Punjab

Table 4.2. Summary of beneficiaries of interface meetings

Name of activity	No. of activities conducted	No. of farmers participated/ benefitted
Visit to village by teams	20	388
Interface meeting/ *Goshthies*	16	430
Mobile based advisories	30	30
Literature support provided	1274	1274
Awareness created	15	471
Linkages developed with other agencies	6	601
Seed distributed	11.60 quintals for 82.9 ha	264
3-tyne manual weeders distributed	30	30

Mera Gaon Mera Gaurav (MGMG)

The institute has seven teams of the scientists for implementation of MGMG programme where 24 villages have been adopted during 2016-17 in the district Sonipat (Haryaana), Banswara (Rajasthan), Ranga Reddy (Telengana), Begusarai (Bihar), Hoshiarpur and S.B.S. Nagar (Punjab). The special emphasis were laid on the specialty corn based cropping system, hybrid maize production technologies, value addition and mechanized maize cultivation beside providing regular advisory services, literature and input distribution (Table 4.2). The farmers were also given information on crop insurance, Swatch Bharat Mission, Climate Change (GHG), lowering of Ground Water(Water conservation) and technologies like conservation agriculture to check the decreasing soil fertility and productivity.

The major problems identified under MGMG visits were related to high cost of irrigation for crop production, lack of storage bins, shortage quality seed availability of hybrid crops, lack of awareness of recommended package of practices, post harvest processing/storage, development of resistance to pesticides, information on soil health card making, cold wave injury in some maize crop fields in the month of January, attack of pink stem borer in maize besides white rust in mustard fields.

Interaction of farmer with MGMG team in village Jakholi, Sonipat, Haryana

Students visit: A group of 73 students of final year B.Sc. Agriculture programme studying at Agricultural College and Research Institute Killikulam, Tamil Nadu Agricultural University, Tamil Nadu visited the Institute on 9th December, 2016. The students were briefed about the institute profile and the research and development of maize in the country.

Farmers: A group of 30 farmers under *"Mukhyamantri Khet Tirth Yojna"* from Datiya (M.P) visited the institute on 21st December, 2016. The farmers and extension officials with them were exposed to the best production technologies like hybrids cultivars, conservation agriculture, neem coated urea, production of different types of corn, industrial importance of maize, hybrids with high nutritional quality, insect and disease management and hybrid seed production technologies.

All India Coordinated Research Project (AICRP)

Maize has the earliest coordinated program i.e. All India Coordinated Research Project (AICRP) on maize which started in 1957 with the objective to develop and disseminate superior cultivars and production/ protection technologies. Based on agro-climatic conditions, country has been demarcated into five zones (Fig. 5.1) constituting 30 centres (Table 5.1) for varietal testing. AICRP organizes interdisciplinary, inter-institutional, co-operative and systematic testing of newly developed cultivars from both private and public sectors in different agro-climatic zones of the country.

Plant Breeding

The entire maize growing area in India is divided in five major zones [Northern Hill Zone (NHZ), North West Plain Zone (NWPZ), North East Plain Zone (NEPZ), Peninsular Zone (PZ) and Central West Zone (CWZ)] for effective evaluation of the maize breeding materials and experimental cultivars (Fig. 5.1). During *kharif* 2016, 298 maize entries were evaluated in all India coordinated trials (Table 5.2). Total 451 breeding trials were allotted to various AICRP centers for evaluation. Of 298 entries, 200 entries were evaluated in National Initial Varietal Trial (NIVT), 33 in Advance Varietal Trial-I (AVT-I), 8 in Advance Varietal Trial-II (AVT-II), 21 entries in Quality Protein Maize (QPM), and 36 in specialty corns trials (13 in baby corn, 10 in sweet corn, and 13 in popcorn trials). Of total entries received, 199 were contributed from public and 99 by the private sector. Fifteen breeding trials (four each in NIVT, AVT-I, specialty corns and three of AVT-II) were constituted for evaluation at 65 locations (34 regular and 31 volunteers) across country. Data received was reviewed and analyzed critically for yield and related traits. The performance of each variety was compared with 29 relevant checks varieties of different types and maturity in a zone. The test entries were promoted from first year (NIVT) to second year (AVT-I) one the bases of set criteria

Fig. 5.1 Zone Map from Journey of Maize

Trials were rejected from final report, if the C.V. of trial goes above 20% (NWPZ, NEPZ, PZ) and 30% (NHZ and CWZ) and trial mean yield below state average yield of the year. Out of 290 entries available for promotion from *kharif* 2016, only 102 entries were got promoted to kharif 2017 in different maturity groups.

AICRP rabi 2015-16 & 2016-17 trials

During *rabi* 2015-16, total 112 entries were received for multi-location evaluation in AICRP late, medium maturity and quality protein maize (QPM) trials. Of 112 test entries, 63 entries were received in NIVT, 24 in AVT-I, 23 in AVT-II and 2 entries in QPM trials. Total seven different breeding trials were constituted and put for evaluation at 18 test centers across the four zones. There were 89 entries available for promotion from first and second year of testing, out of which only 32 entries got promoted to their advance stage of testing. The detail list of entries promoted from *rabi* 2015-16 to rabi 2016-17 are given in Table 5.3. Out of 37 test entries evaluated in NIVT late, 14 were found superior for set criteria and therefore were promoted to AVT I-Late. Similarly, in NIVT medium, 3 out of 26 entries; AVT-I Late, 5 out of 15; AVT-I Medium, 8 out of 9, and in QPM 2 out of 2 were found superior and hence, promoted to next level of their testing during *rabi* 2016-17. During *rabi* 2016-17, total 99 entries were received for testing in AICRP trial. Total, seven breeding trials were constituted and are being conducted at 20 locations across country.

Table 5.1. Locations and soil characteristics of AICRP Centres

Zone	States	Centres	Latitude	Longitude	Altitude (masl)	Soil Type
NHZ	Himachal Pradesh	CSK, Himachal Pradesh Krishi Vishvidhyala, Bajaura	33º22’ N	77º0’ E	1090	Grey wooded Podzolic soil
		Himachal Pradesh Krishi Vishvidhyala, Dhaulakuan	30 º 30' N	77 º20' E	468.0	
		CSK, Himachal Pradesh Krishi Vishvidhyala, Kangra	32º6' N	76 º16' E	2404	Brown alluvial and grey brown podzolic soil
	Jammu and Kashmir	Sher-e-Kashmir University of Agricultural Science and Technology of Jammu,Udhampur, Jammu	32º56' N	75º8' 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	29º37' N	79º40' E	1650	Clay loam
	North Eastern States	ICAR Research Complex for NEH region, Barapani	25^{0}70’ N	91^{0}97’ E	1500	Sandy loam
		Assam Agricultural University (AAU), Gossaigoan, Assam	26º45' N	94º13' E	91.0	Sandy loam
NWPZ	Punjab	Punjab Agricultural University, Ludhiana	30º54' N	75º51' E	247	Sandy, clay loam
	Punjab	Indian Institute of Maize Research Ludhiana				
	Haryana	Chaudhary Charan Singh, Haryana Agricultural University, Uchani, Karnal	29º41' N	76º59' E	257	Loamy soil
	Delhi	Indian Agricultural Research Institute, Delhi	28º39' N	77º13' E	228	Loam to sandy loam
	Uttar Pradesh	Chandra Shekhar Azad University of Agricultural and Technology, Kanpur	26º28' N	80º21' E	125	Sandy loam
	Uttarakhand	Govind Ballabh Pant University of Agriculture and Technology.	29º6' N	79º30' E	243	Clay loam
NEPZ	Bihar	Rajendra Agricultural University, Dholi	25º54' N	85º36' E	51.8	Sandy loam
	Jharkhand	Bisra Agricultural University, Ranchi	23º21' N	85º20' E	652	Sandy loam
	Orissa	Orissa University of Agriculture and Technology, Bhubaneswar	20º14' N	85º50' E	45	Clay loam
	Eastern	Banaras Hindu University, Varanasi	25º20' N	83º0' E	128.93	Sandy loam
	Uttar Pradesh	Narendra Dev University of Agriculture and Technology, Bahraich	27º35' N	81º36' E	130	Sandy loam
	West Bengal	Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal	22°97’N	88°43’E	16	Alluvial
PZ	Karnataka	University of Agricultural Sciences, Bangalore, Mandya	12º33'N	76º54' E	695	Light red sandy loam
		University of Agricultural Science, Dharwad, Arbhavi	16°13' N	74°48' E	640	Black soil; Medium black
	Andhra Pradesh	Professor Jayshankar Telangana Agricultural University, Hyderabad, Telangana	17º23'N	78º29' E	530	Black Clay loam
		Professor Jayshankar Telangana Agricultural University, Karimnagar, Telangana	18º26'N	79º9' E	869	Red sandy-loamy
	Tamil Nadu	Tamil Nadu Agricu ltural University, Coimbatore	11º0'N	76º58' E	411.5	Black
		TNAU, Vagarai	10° 35' N	77° 34' E	926	Black
	Maharashtra	Kolhapur	21º0' N	77º52' E	574	Light to medium black
CWZ	Rajasthan	Maharana Pratap University of Agriculture and Technology, Banswara	23º33' N	74º27' E	218	Red loam
		MPUA &T, Udaipur	24º35' N	73º41' E	572	Loam to sandy loam
	Gujarat	Anand Agriculture University, Godhra	22º45' N	73º38' E	119.4	Sandy loam
	Madhya Pradesh	Jawaharlal Nehru Krishi Viswa Vidyalaya, Chhindwara	22° 4' N	78° 56' E	682	Medium clay
		Rajmata Vijayaraje Scindia Krishi Viswa Vidyalaya, Jhabua	22º46' N	74º36' E	318	Clayey to Sandy
	Chhattisgarh	RMD College of Agriculture and Research Station, Ajirma, Ambikapur	23º7' N	83º12' E	1978	Sandy loam

Table 5.2. The summary of AICRP *kharif* 2016 trials is given below

Trial	Entries	Checks varieties	Mode of operation
NIVT-Late Maturity	92	CMH08-287, CMH 08-282, Bio 9682	Across zones
NIVT-Medium Maturity	73	CMH08-292,BIO,9544, DHM 121,	Across zones
NIVT-Early Maturity	31	BIO605 , PMH5, DKC7074	Across zones
NIVT-Extra Early Maturity	4	Vivek Hybrid 51, Vivek Hybrid 45	Across zones
AVT-I – Late Maturity	16	PMH1, Seed Tech 2324, Bio 9681,	Zone specific
AVT-I-Medium Maturity	11	PMH4, Bio 9637, HM9	Zone specific
AVT-I-Early Maturity	6	Prakash, PMH5	Zone specific
AVT-II-Late Maturity	5	PMH1, Seed Tech 2324, Bio 9681,	Zone specific
AVT-II-Medium Maturity	3	PMH4, Bio 9637, HM9	Zone specific
QPM 1-2-3	21	HQPM1, HQPM4, HQPM5, HQPM7 Vivek QPM9, Pratap QPM Hybrid 1	Across zones
Popcorn-1-2-3	13	VL Amber Popcorn	Across zones
Sweet Corn-1-2-3	10	Madhuri, Misthi, Priya,	Across zones
Baby Corn-1-2-3	13	HM4	Across zones
Total	**298**		

Table 5.3. Summary detail of AICRP *rabi* 216-17 trial is given below

Trial	Entries	Checks varieties	Mode of operation
NIVT-Late Maturity	44	P3522, Seed tech 2324, Buland, Bio 9981	Across zones
NIVT-Medium Maturity	31	DHM 117, Bio 9544, HM 10, Bio 9637	Across zones
AVT-I – Late Maturity	8	P3522, Seed tech 2324, Buland, Bio 9981	Zone specific
AVT-I-Medium Maturity	3	DHM 117, Bio 9544, HM 10, Bio 9637	Across zones
AVT-II-Late Maturity	4	Seed tech 2324, Buland, Bio 9981	Across zones
AVT-II-Medium Maturity	5	HM 10, Bio 9637	Across zones
QPM 1 -2-3	4	HQPM1, HQPM4, HQPM5, HQPM7 Vivek QPM9, Pratap QPM Hybrid 1	Across zones
Total	**99**	HQPM1, HQPM5, HQPM7	Across zones

Agronomy

The major agronomic research areas during *kharif* 2016 and *rabi* 2015-16 were focused on optimization 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 and long term trial on exploring integrated nutrient management in maize.

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

A total of six pre-release genotypes of late maturity group were evaluated with 6 national checks under two densities and two nutrient levels (200:65:80, 250:80:100 N:P2O5:K2O kg/ha) for late maturity hybrids. The genotype DMH-192 yielded significantly higher yield over best check in PZ with high nutrient levels (250:80:100 N: P2O5: K2O kg/ha) and planting density (83,000), while in CWZ, DKC9151 (IM8902) was found superior over best check (PMH-1) at low nutrient levels (200:65:80 N: P2O5: K2O kg/ha) and higher planting density (83,000). This shows that there is need for having customized Package of Practice of individual hybrids, rather than going for blanket recommendation.

In *rabi* 2015-16, late and medium-maturing group responded up to 250:95:95 N:P2O5:K2O kg/ha. A set of 17 pre-release late maturing genotypes evaluated where KH 3021, DMRH 1308, X35F880 and DKC 9161 (IM 8222) found significantly superior over best check in NEPZ but in PZ, KH 2192, DKC 9161 (IM 8222), HTMH 5108 and X35F880 gave significantly higher yield over checks. The genotype CP 111 exhibited significantly superior yield over the best checks at higher nutrient level and plant density in CWZ.

Seven pre-release medium maturing genotypes were also evaluated in *rabi* season 2015-16 under different nutrient levels and densities at nine locations. In NWPZ, genotypes BL 900, BL147, IM8303, BL798, DMRH1301 and KH-517 yielded significantly higher than best check at high nutrient levels and planting density. At Bahraich and Dholi (NEPZ) the genotypes DMRH 1301 and IM 8303 yielded significantly higher than the best check Bio 9637 (C), but at Kalyani BL 147 genotype gave significantly superior at higher nutrient levels and planting density. However, the genotype BL 798, KH 517 and BL 147 in yielded significantly superior over the best check at Karimnagar and Dharwad (PZ). The genotype BL798 yielded significantly higher than the best checked Bio9637 (C) at Banswara (CWZ).

Experiments on nutrient management in maize based cropping system under different tillage practices:

Maize-mustard/chickpea system under rainfed condition of maize with zero tillage resulted in 7.0-11.6% higher yields in various zones. In maize-wheat-greengram cropping system, zero tillage resulted in significantly higher crops yield and site specific nutrient management (SSNM) gave higher yield over farmer's fertilization practices (FFP) and RDF at Banswara. The RDF and SSNM also resulted in significantly higher yield at maize-wheat-mungbean system at Pantnagar over FFP.

Nutrient management in Rice- Maize cropping system under different tillage practices

In rice-maize cropping system, at Dholi the tillage practice of permanent beds (PB) resulted in significantly higher cob yield and site specific nutrient management (SSNM) gave higher yield over farmer's fertilization practices (FFP) and RDF in grain yield and RDF found statistically *at par*.

Nutrient management in rainfed cropping systems under different tillage practices

In maize-mustard cropping system, permanent beds (PB) resulted in significantly higher crops yield over zero tillage (ZT) and site specific nutrient management (SSNM) gave higher yield over farmer's fertilization practices (FFP) and RDF at Chhindwara while conventional tillage (CT) found statistically at par. In maize based cropping system, zero tillage (ZT) resulted in significantly higher maize equivalent yield of mustard yield over CT while PB was statistically *at par*. Further, the application of 100% RDF gave higher yield over the control however, SSNM and 50% RDF + CR @ 2.5 t/ha was found statistically *at par.*

Plant density and nutrient management practices for hybrid in *rabi* season

The location and hybrid specific reposes to the nutrient management and planting density was observed during *rabi* season. The STCR based nutrient management gave significantly higher yields over RDF at higher plant density in hybrid Bio 9628 at Banswara (CWZ) while at Chhindwara, nutrient management under SSNM gave significantly higher yield in DKC 7074 but plant density was found to be non significant. In Karimnagar, the nutrient application based on 150% RDF gave significantly higher yield over RDF and SSNM at low planting density, while STCR and SSNM found statistically at par. While at Pantnagar, no significant yield effect was found under different planting density, nutrient management and hybrids.

Similarly at Vagarai, only hybrid K-3110 resulted in significantly higher yield. However, at Dholi the STCR based nutrient management gave significantly higher yields at higher plant density in NK7720 but SSNM (225:60:80) based nutrient management recorded significantly higher yield at low planting density under hybrid Dekalb 900 at Bahraich. At Coimbatore, the nutrient application based on RDF resulted in significantly higher yield over SSNM at high planting density under hybrid COH 7 but STCR found statistically at par but SSNM was significantly superior over RDF and STCR at high planting density under hybrid ranger SMH-1188 at Dharwad.

Weed management in maize systems

The yield losses estimated due to weed infestation were 29.3 to 60.8% in Peninsular zone and Central western zone, respectively during *kharif* 2016. For finding best post emergence herbicide it was found that Atrazine @ 1.5 kg/ha pre-emergence fb Tembotrione 120 g/ha PoE at 25 DAS at 13 locations, while Atrazine @ 1.5 kg/ha pre-emergence fb Halosulfuron 60 g/ha 25 DAS) found effective for weed management in *kharif* maize at five locations (Srinagar, Udhampur, Karnal, Bahraich and Dholi).

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 this long term experiment was initiated during *kharif* 2014 at Pantnagar. After completion of three years, significantly higher maize grain yield (5.73 t/ha) was obtained with 100% RDF + 5 t/ha FYM, however, it remained *at par* with 100% RDF+ 5 kg Zinc Sulphate (5.47 t/ha). On the contrary, economic analysis showed a new path for organic cultivation of maize and in second consecutive year it was found that maize + cowpea as intercrop with FYM 10 t/ha + Azotobacter resulted in highest net returns and B: C ratio of maize or maize-wheat system. In maize-wheat cropping system, the application of 100% RDF + 5 t/ha FYM under integrated nutrient management gave significantly superior system yield but Maize + cowpea with FYM 10 t/ha + Azotobacter gave significantly higher system net returns over all the remaining treatment.

Optimization of plant geometry and nutrient management for *rabi* zero-tillage maize

This experiment was conducted at the farmer's field. The use of the 60 × 20 cm^2 planting density along with STCR based nutrient application with improved nutrient management of fertilizer placement resulted in maximum yield of zero-till *rabi* maize at Hyderabad over higher plant population, farmer fertilizer doses and the surface phosphorus nutrient application. It suggest the existing practices of the higher planning density and inappropriate nutrient management practices needs to be reoriented for yield maximization and sustainability of *rabi* maize.

Enhancing water-use efficiency in rainfed maize

The experiments were conducted at six locations to find practices for enhancing water-use efficiency in rainfed maize responded to zero tillage + mulch over conventional tillage without mulch. However, the application of hydrogel @ 2.5 or 5.0 kg/ha in maize could not able to increase the succeeding wheat yield in any tillage practices. However, the succeeding wheat yield was at par under all for tillage and residue management practices of conventional tillage or zero tillage with and without mulching at Dholi which suggest that the ZT can be adopted in Eastern IGP as it has no yield penalty on succeeding wheat crop besides saves cost of field preparation.

Optimization of potassium fertilization for eastern India

This experiment was initiated in *kharif* 2016 with the objective to work out economic optimum dose of potassium in maize for eastern India at 5 locations Baharaich, Dholi, Ranchi, Ambikapur and Kalyani. The treatment comprises of graded doses of K_2O from 0-150 kg/ha. Results revealed that potassium dose of 150 kg/ha resulted in significant increase at Ranchi and Ambikapur, while at Dholi it responded up to 120 kg/ha and at Kalyani and Bahraich upto 60 kg/ha only. It was inferred that there is variable response of maize to the potassium fertilization in Eastern India.

Pathology & Nematology

Survey and surveillance of maize diseases

Disease survey and surveillance was undertaken in 115 maize growing locations of Himachal Pradesh (16), Uttarakhand (3), Punjab (6), Haryana (4), Bihar(20), West Bengal (5), Rajasthan (13), Gujarat (18), Karnataka (24), and in Tamil Nadu (6). In Telangana all districts were covered. Banded leaf and sheath blight (BLSB), Turcicum Leaf Blight (TLB), Maydis leaf blight (MLB) and Post flowering stalk rot (PFSR) were the most important diseases in all areas. Curvularia Leaf Spot (CLS) is gaining importance in Punjab, H.P., Karnataka, Gujrat and Rajasthan though the incidence was from low to moderate. In Tamil Nadu incidence of Sorghum downy mildew (SDM), Turcicum Leaf Blight (TLB) and Post flowering stalk rot (PFSR) were sever. Bacterial leaf and sheath (BLS) and Brown strip downy mildew (BSDM) recorded in low and in traces respectively from Punjab areas. Based on the survey surveillance maize disease map was updated (Fig. 5.2)

Coordinated trials

During the reporting period a total of 17 disease evaluation trials were conducted under artificially sick

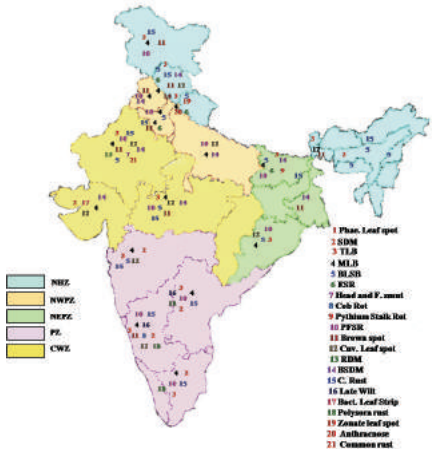


Fig. 5.2 Disease distribution map based on disease survey 2016

plot/epiphytotics at identified hot spot locations viz., Bajaura, Almora, Dhaulakuan, Barapani (AVTs NHZ). Ludhiana, Delhi, Karnal, Pantnagar (NWPZ). Dholi, Midanapur (NEPZ). Arbhavi, Coimbatore, Mandya Hyderabad (PZ) Udaipur (CWZ). A total of 34 trials (27 in *kharif* & 7 in *rabi*) including 468 hybrids in both *rabi* & *kharif* and 1425 inbred lines in *kharif* were screened against MLB, TLB, BLSB, SDM, Rajasthan downy mildew (RDM), Curvularia leaf spot, Post-flowering stalk rots (PFSR), Common rust, Polysora rust, Bacterial stalk rot (BSR) and Cyst nematode for disease resistance.

Promising hybrids

A total of 294 genotypes found promising at one or other location showing multiple disease resistance. The disease reactions of promising entries identified by Variety Identification Committee (VIC) are:

Genotype	Group	Resistant	Moderately resistant
HT 51412616	AVT-II Late	MLB, C.ROT, CLS	MLB, TLB, FSR, BSR, RDM, SDM
DKC 9151 (IN 8902)	AVT-II Late	MLB, C.ROT, CLS, BSR, RDM	TLB, C.ROT, FSR, C.RUST
ADV 0990296	AVT-II Late	MLB, C.ROT, CLS, BSR	MLB, TLB, BLSB, C.ROT, FSR, C. RUST, SDM
JKMH 4848	AVT-II Medium	C.ROT, FSR, CLS	MLB, TLB, CLS, BSR, C.RUST
DMRHP 1402	Pop corn	MLB, CLS	TLB, C.ROT, FSR
BSCH 6	Sweet Corn	MLB, CLS	MLB, TLB, C.ROT
BVM 2	Baby corn	MLB, CLS	MLB, TLB, C.ROT, FSR, C.RUST

During *rabi* a total of 127 genotypes were evaluated during *rabi* against major diseases i.e. SDM at Mandya; C. Rot at Dharwad, Ludhiana and Hyderabad, TLB at Dholi and Mandya under artificial inoculation condition. The promising reaction exhibited by 35 genotypes in NIVT Late maturity, 28 in NIVT Medium maturity, 29 and 9 genotypes in AVT-I and AVT-II Late maturity and in AVT-II & AVT-I Medium maturity respectively

Nematology

Screening of maize hybrids against cyst nematode *(Heterodera zeae)* at Udaipur

A total of 335 maize hybrids belonging to different maturity groups of IVT and AVT were screened against cyst nematode *(Heterodera zeae)*. Out of them, 24 entries, viz., HT 16607, IMHBG 016-3, OMH 14-27 (CAH1511), JH 13337, BIO 716, OMH 14-18 (CAH 1519), IMHBG 2016-4, IMHBG 2016-1, IMHBG 2016-6, LMH 616, IMH 1533, KMH 14-46, KH 102, CP 802, ADV 7022, HT 51412616, LMH 615, JH 31605, CP 201, BQPMH 16, and exhibited moderately resistant reaction.

Occurrence of maize cyst nematode *(H. zeae)* in Rajasthan

Occurrence of maize cyst nematode was reported from maize growing areas of Dungarpur, Chittorgarh, Udaipur and Rajsamand districts of southern Rajasthan. Out of 51 samples collected from above districts, 33 samples were found to be infested with maize cyst nematode i.e. 64.71% occurrence was estimated in Rajasthan. Besides this, root lesion nematode, *Pratylenchus zeae* was observed in most of the samples in high numbers (150-320 nemas/100 cc soil).

Entomology

The entomology component of AICRP-Maize is devoted to the management of 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 though host plant resistance and other pest management interventions. Finding resistant germplasm source against the pests is the major component of the programme, where 306 genotypes were evaluated at various maize zones *viz.*, NWPZ (Delhi, Karnal and Ludhiana), NEPZ (Dholi), PZ (Kolhapur, Hyderabad) and CWZ (Udaipur) during 2015-16 (Table 5.4). Genotypes found resistant to C. *partellus* during *kharif* 2016 is given in Table 5.5.

Table 5.4. Number of genotypes screened against major pests of maize during 2016-17

Target pests	Genotypes	No. of entries screened	No. of resistant entries			
			NWPZ	NEPZ	PZ	CWZ
C. partellus	Hybrids					
	Late	24	0	3	0	2
	Medium	17	0	3	0	3
	Early	8	0	1	0	1
	QPM	27	0	4	0	8
	Pop corn	11	0	1	0	2
	Baby corn	14	0	2	2	3
	Sweet corn	13	0	1	0	1
	Inbred lines	38	5	5	1	7
S. inferens	Hybrids					
	Late	35	9			
	Medium	21	1			
Atherigona spp. (Delhi)	Inbred lines	66 (3rd yr.)	5			
		32 (1rst yr.)	1			
A. naqvii (Ludhiana)	Inbred lines	66	8			

Table 5.5. Genotypes found resistant to *C. partellus* during *kharif* 2016

	Resistant entries			
Genotypes	NWPZ	NEPZ	PZ	CWZ
Hybrids				
Late maturity	0	KMH-2852, DKC9167 (IP8708), ADV 7022	0	CMH12-686, Seed tech 2324(C)
Medium maturity	0	IIMRNH 2015-4, JH 13347, PE 621	0	JKMH 4103, JH31605, C.P 201
Early	0	JH 31785	0	DMRH 1305
QPM	0	IIMRQPMH 1501, FQH 106, IIMRQPMH 1502, IIMRQPMH 1602	0	KDQH-51, IIMRQPMH 1601, IIMRQPMH 1607 IIMRQPMH 1504, IIMRQPMH 1502, REHQ2014-11, HQPM 1 , HQPM 5
Pop corn	0	SJPC1	0	IHPC-1203, Pop corn
Baby corn	0	BVM-2, IMHB 1531	AH-7043, IMHB 1538	AH-5021, AH-7043, IMHB 1539
Sweet corn	0	Madhula	0	ASKH 4
Inbred lines	EC646047, WNZPBTL8, WNZPBTL9, IIMRSBTPool, IIMRPBT Synthetic	IC565897, IC584542, EC440623, AEBY34-1-1, AEBY34-1-2	DMRE63	AEBY34-1-1, AEBYC538-1,EC440414, EC440612, WNZPBTL9, DMRE63, EC442714

During *rabi* 2015-16, out of 56 hybrids screened under artificial infestation against *C. partellus* at Kolhapur, the only location where *C. partellus* is a major pest in rabi maize, KMH 1411 and PM 14207L of late maturity were found resistant. When the same entries were screened against *S. inferens,* the entry BL 900 of medium maturity was found resistant both at NWPZ (Delhi and Karnal) and PZ (Hyderabad), while ten entries of late maturity showed resistance at NWPZ. The first year screening of 117 inbred lines against *S. inferens* identified CML 202, CML 9, V 353 and HEY Pool 2011-5-4-1-2-1-1 as resistant, while the second year screening of 35 inbred lines identified three viz., EC 440415, IIMRSBTPOOL and BCK/BC4 at WNC, Hyderabad.

During spring 2016, out of 33 inbred lines screened against shoot fly (*Atherigona* spp.) at Delhi, PFSR 5106/1, CM 117-3-4-1, WS 2, HKI 1831 and WINPOP 8 were found resistant with less than ten percent plant mortality. At Ludhiana, PFSR 5106/1, AEB(Y) 1, BML 14, CLQRCYQ 42, CM 117-3-4-1, CML 23, AEBYR (1), BML 7, HKI 164-3-(2-1)-1, HKI 1831 and WINPOP 8 were found resistant to the shoot fly *A. naqvii.*

Monitoring of *Helicoverpa armigera* in maize by pheromone traps

The population of *H. armigera* was monitored weekly by installing pheromone traps from tasseling to harvesting stage of maize during *kharif* 2016 at Delhi, Karnal, Udaipur, Hyderabad and Kolhapur, while it was observed in spring sown maize at Ludhiana. The moths started appearing in third week of August and continued till first week of December at Hyderabad with maximum catch of 18/acre in third week of October. Moth appearance was observed in fourth week of August at Delhi and continued up to third week of October with a maximum of 27.52/ac observed in third week of September. At Karnal, the moths appeared from first week of September and continued up to third week of October, where the maximum catch (44.48/ac) was recorded during third week of September. Moths started appearing from second week of September at Udaipur with maximum activity (12/ac) recorded during first week of October. The maximum catch of 94.68/ac was recorded in spring sown maize at Ludhiana in the 1st week of May. The peak population coincided with maize flowering across the locations.

Evaluation of new insecticides against *C. partellus*

The new greener pesticide molecules, *viz.*, Chlorantaniliprole 20SC (0.3 and 0.4 ml/l), Flubendiamide 480SC (0.1 and 0.2 ml/l) and Novaluron 10EC (0.75 and 1 ml/l) were evaluated with the conventional Deltamethrin 2.8EC (0.4 and 0.8ml/l) at Delhi, Karnal, Ludhiana, Udaipur, Hyderabad and Kolhapur under artificial infestation of *C. partellus* during kharif 2016. Combined block analysis revealed Flubendiamide 480SC @ 0.2 ml/l is effective in reducing the plant damage caused by the pest, while Flubendiamide 480SC (0.1 and 0.2 ml/l) as well as Chlorantaniliprole 20SC (0.3 and 0.4 ml/l) performed at par in terms of grain yield across the locations.

Evaluation of bio-pesticides against *C. partellus*

The efficacy of three *Beauveria bassiana* isolates Bb-5a, Bb-23, Bb-45 and *Metarhizium anisopliae* isolate Ma-35 @10 ml/l, Delffin 5 WG @5 gm/l and a neem formulation @ 5 ml/l along with state recommended insecticide were evaluated at Delhi, Karnal, Ludhiana, Udaipur, Hyderabad and Kolhapur under artificial infestation of *C. partellus* during *kharif* 2016. Combined block analysis revealed the conventional state recommended pesticide is superior in terms of plant damage and grain yield across the locations. Delffin 5 WG @5 gm/l was found the next best treatment.

Biochemistry

During this period, 34 entries contributed from different centres under coordinated maize quality programme were grown at three locations, viz., Ludhiana, Delhi and Almora. The selfed maize ears collected from individual entries were analyzed for protein quality parameters, viz., protein, tryptophan and lysine content. Most of the sample analyzed exhibited threshold concentrations of lysine and tryptophan across locations. The entries developed for higher pro-vitamin A components were analyzed for □-carotene and □-cryptoxanthin. Two entries are received in this programme. The pro-vitamin-A is calculated by adding β-carotene + 1/2 ß-cryptoxanthin values. Since, the pro-vitamin components are reported to be degraded by many environmental factors such as light, heat etc, the entries developed for this purpose were analyzed afresh (November 2017) and after storage for different periods of time i.e. I month (December 2016), 2 months (January 2017) and 3 months (February 2017). Storage effect was also evaluated in vacuum packed samples at different periods of time.

During the period under review, 34 entries under All India Coordinated Quality improvement trials were evaluated for protein quality and promising entries were identified. Two entries were analyzed for provitamin A components such as beta carotene and beta cryptoxanthin and also evaluated for provitamin A losses during grain storage. A total of 11 lines were found to possess the threshold concentrations of protein quantity as well as quality for QPM breeding. A total of 13 lines were found to possess high protein content. Twelve lines were found to be rich in starch content, whereas 2 lines (BML 7 and DMRH 1308) also contain good amount of oil along with high starch values. Some exceptionally superior lines were identified for protein (CA14502/CA14509)-F2-14-BBB-CML451-BBB-OPc14S1, 4840, CML44, EC646016, PFSRR3□□□□ and PFSRS3), Starch (DMRPE6-2, HP963-17, NZB 2012), oil (HKI42050) and methionine (CML145 and NZB 2012) across replications and locations Hyderabad and Begusarai) out of 55 elite lines. Five lines DQL 2105-1 (INGR 17013), DQL 2048 (INGR 17014), DML 339 (INGR 17022), DQL-1019 (INGR 17023), and IML-PFSR-R3 (INGR 17024) were registered with NBPGR for quality traits with NBPGR.

6

Significant Events

59th Annual Maize Workshop

The 59th Annual Maize Workshop was jointly organized by University of Agricultural Sciences Bangaluru (UASB) and ICAR-Indian Institute of Maize Research from 10th-12th April 2017. It was inaugurated by Dr. J.S. Sandhu, DDG (Crop Science), ICAR. Dr. Sandhu highlighted the fact that maize showed tremendous improvement in terms of area, production and productivity. He stressed no the need of adoption of improved technology to enhance profitability. Dr. H. Shivanna, VC, UASB, Chairman, mentioned the potential of adaptability of maize and its prospects in value addition. In the workshop, discussions were conducted on yield performance of new hybrids tested under All India Coordinated Maize Improvement Project (AICMIP) program and zone wise progress of agronomy in last 25 years. Progress during Rabi 2014-15 and Kharif 2015 were reviewed. In the same event, technical programmes

Glimpses of 59th Annual Maize Workshop at Bangaluru (UASB) for the year 2016-17 were formulated. ICAR-CIMMYT International collaborative research was highlighted. Breeder seed production, FLDs and training programs conducted were presented. A total of 30 proposals on different aspects, viz., kharif, rabi, QPM, etc. were received from various institutions and recommendations were made. Both the public and private sector scientists participated in the workshop.

Research Advisory Committee (RAC) meeting

The RAC meeting was held on 27th-28th May, 2016 under the chairmanship of Dr. S.K. Sharma in presence of other members of RAC viz., Dr. R.K. Malik, Dr. B.L. Jalali, Dr. R.P. Dua, Dr. I.S. Solanki, Dr. Vinay Mahajan and Dr. K.S. Hooda. The chairman apprised the house that maize demand is increasing and country would need to produce 65 million MT by 2050. He stressed on the use of single cross hybrids and availability of their seed in adequate quantity along with translational research at farmer's field. The Action Taken Report (ATR) on the recommendations of the previous RAC meeting (2015) and new initiatives taken by the institute in the recent past were presented. This was followed by presentations of research achievements of the institute in areas of Crop Improvement, Crop Production, Crop Protection, Outreach and Computer Application, Biotechnology, Biochemistry and Plant Physiology. The committee made recommendations on the integration of marker assisted selection and doubled haploid technology in the breeding programs, initiation of multi-approach management of *Helicoverpa armigera* and the use of DNA fingerprinting of hybrids/varieties for prepare data base for future reference and use.

Institute Research Council (IRC) meeting

The meeting of was held on 29th May 2016. It was chaired by Dr.Vinay Mahajan, In-charge-Director, IIMR. It was attended by Dr.Pradyuman Kumar, former Director, IIMR and the scientific personnel of the institute. Dr. P. Kumar highlighted the importance of maize in India and mentioned the need of re-orientation of institute's projects to meet growing demand of maize. The ongoing projects of the institute were reviewed. The recommendations included assessment of critical requirements of maize hybrid cultivation in Eastern India and determination of dose effects of plant origin pesticides for use in maize. Three new project proposals (development of decision support system for inbred maize germplasm, development of banded leaf and sheath blight resistant transgenic maize and development of assay for testing protein quality in maize) were received and approved.

Institutional Biosafety Committee Meeting

In exercise of the powers conferred by the 'Rules for the manufacture, use, import, export & storage of hazardous micro-organisms, genetically engineered organisms or cells, 1989'- made under sections 6, 8 and 25 of the Environment (Protection) Act, 1986 (29 of 1986), the central government had constituted an Institutional Biosafety Committee (IBSC) at the institute. The objective of the IBSC is to implement the Rules 1989 with a view to protecting the environment, nature and health, in connection with the application of gene technology and micro-organisms. The IBSC meeting of the year was held on 7th October 2016 in which, the IBSC approved execution of one new project at the institute that involve use of Living Modified Organisms (LMO)/recombinant DNA products. The IBSC approved inter-institutional movement of one gene construct from NRCPB, New Delhi to IIMR. The committee also reviewed the biosafety aspects of ongoing projects involving GMO/LMO and found them satisfactory.

Maize Germplasm Field Day

Indian Institute of Maize Research organized a Maize Germplasm Field Day at its Winter Nursery Centre, Hyderabad on 27th February, 2017. A total of 1401 maize accessions were displayed in a compact block for assessment and selections by breeders, pathologists, agronomists and entomologists from 27 AICRP centres from SAUs and ICAR institutes. The materials included inbred lines from CIMMYT, NBPGR, and large segregating materials with sub-tropical and temperate background from IIMR and seven AICRP Centes. Thirty-eight participants from AICRP, SAUs and ICAR institutes joined in the field day. The field visit was followed by a discussion on various issues like development of high yielding hybrids in kharif, drought and disease tolerant lines, importing of exotic material, strengthening of germplasm on sweet corn and pop corn. Dr. D. Raja Reddy, Director of Research, Professor Jayashanker Telangana State Agricultural University (PJTSAU), Hyderabad graced the occasion as Chief Guest. He suggested having a set of hybrids ready for various contingency conditions. He lauded the initiative of IIMR for sharing the germplasm among the coordinating centers through 'Field Days' at 'Winter Nursery Centre', IIMR, Hyderabad. Dr.Vinay Mahajan, ICAR-IIMR

Maize Germplasm Field Day

encouraged the participants from various centers to work in close collaboration for maximum utilization of genetic resources. He assured full cooperation from IIMR in this regard. He also highlighted the need to come up with the hybrids with yield potential of 10 t/ha during Kharif and tap germplasm for various processable types, viz., corn flakes etc., apart from the baby corn, sweet corn and popcorn. He thanked the collaborators for their active participation in field day. Dr. J.C. Sekhar, In-Charge, Winter Nursery Centre gave details of the germplasm on display and also thanked PJTSAU and Director, IIMR for all the support and facilities for organizing the field day. Dr. N. Sunil proposed vote of thanks.

Short course on Precision Conservation Agriculture at IIMR, New Delhi

A 10 days ICAR sponsored Short Course on "Precision Conservation Agriculture for climatic change adaptation and mitigation in cereal systems" organized at ICAR-Indian Institute of Maize Research, New Delhi from 08th - 17th August, 2016. Speaking on the valedictory function of this training programme Dr. N.S. Rathore, DDG (Education) appreciated the successful conduct of the short course. He emphasized that conservation agriculture (CA) reduces run off and increases infiltration. Speaking on the occasion of inauguration of training, Dr A.K. Vyas, ADG (HRM), ICAR emphasized on importance of the conservation agriculture for maximization of yield and profitability as it enhances soil organic carbon which is the most important from Indian perspective. The training consisted of lectures and practical on the aspect of precision input management (nutrient, water, pesticides, etc.) in conservation agriculture (CA) for ensuring higher benefits from CA. Emphasis was also laid on the climate resilience and relevance of CA through lectures and practical on this aspect. A total of 17 scientists of SAUs from 11 different states (Assam, Chhattisgarh, Gujarat, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Uttar Pradesh, Uttarakhand and West Bengal) participated in this training programme. The trainees were from different disciplines of agricultural sciences encompassing Agronomy, Plant Breeding, Plant Pathology and Plant Physiology. The organizers of this short course were Dr. Aditya Kumar Singh *(Course Director),* Drs. C.M. Parihar and Shankar LalJat *(Course Coordinators).*

RAC meeting held in IIMR Delhi

Lecture and working demonstration during the course

Participants in the short duration course on Precision Conservation Agriculture

Undergraduate training at IIMR, Ludhiana

An undergraduate training was requested and sponsored by Doaba College, Jalandhar at IIMR. Dr. Alla Singh and Dr. Dharam Paul coordinated the training programme entitled 'Biotechnology Platforms for Utility Products in Maize'. It was held from 1st February to 15th February, 2017 at IIMR Ludhiana. The programme was inaugurated by Dr. J.S. Sandhu, DDG (Crop Science), ICAR. Other guests of the event included Dr. K.S. Thind, Head of Department, Plant Breeding and Genetics, PAU and Dr. Praveen Chunneja, Director, School of Agricultural Biotechnology, PAU. Dr. Sandhu appreciated the efforts of IIMR in planning to train and orient the young students in the applied aspects of maize crop and released the training manual. The training programme was aimed to provide orientation to the students regarding use of tools and techniques in Biotechnology to obtain different utility products viz. food, feed, fuel and biopharmaceuticals from maize. A total of 10 students participated. Faculty from four institutions- ICAR-IIMR, ICAR-CIPHET, Punjab Agricultural University and Guru Nanak Dev University delivered lectures in this training programme. Practical orientation to basic laboratory techniques and a study tour was conducted as part of the training programme. The chief guest during the closing ceremony was Dr. S.K. Sharma, ex-VC, Himachal Pradesh Agricultural University. Dr. Sharma congratulated all the personnel of IIMR for successful completion of the training programme. He wished good luck to students and encouraged the scientists to conduct more education outreach programmes in future.

Swachhta Pakhwada 2016

Swachhta Pakhwada was observed in ICAR-Indian Institute of Maize Research and its regional centres. Various activities prescribed by ICAR were undertaken in this event. Initiatives were taken for generating awareness as well as practice in the areas of treatment of wastes, identification of activities that are causal of dirt or garbage, use of eco-friendly technologies including lesser use of plastics, etc. Healthcare awareness including Yoga, positive thinking and water conservation also formed a part of the said event. Experts from outside and staff of the institute took part in Pakhwada. Selected photographs of the activities are attached.

भारतीय मक्का अनुसन्धान संसथान मे हिंदी भाषा के कार्यन्वयन से संबंधित गतिविधियां

संस्थान में दिनाँक 01 से 30 सितम्बर 2016 तक ''हिन्दी चेतनामास'' का आयोजन किया गया जिसके अंतर्गत निम्नलिखित प्रतियोगिताओं का आयोजन किया गया जिसमें सभी वर्गो के अधिकारियों/कर्मचारियों जिसमें अस्थाई कर्मचारी भी सम्मिलित थे, सभी ने बढ़-चढ़ कर प्रतियोगिताओं में भाग लिया और "हिन्दीचेतनामास" को सफल बनाने में अपना योगदान किया।

1. निबंध लेखन
2. काव्य पाठ
3. वाद विवाद
4. अन्ताक्षरी
5. आशुभाषा
6. श्रुतलेख
7. शब्दार्थ
8. मसौदा लेखन
9. हिन्दी में प्रकाशन
10. हिन्दी में सर्वाधिक कार्य

राजभाषा हिंदी के प्रगामी कामकाज को बढ़ावा देने हेतु संस्थान में निम्नलिखित घटनाक्रमों का अयोजन किया गया

Vigilance Awareness Week at ICAR-Indian Institute of Maize Research

Vigilance Awareness Week was observed in IIMR and its regional centres on 26th October-5th November 2016. During this event, oath was taken by all personnel of IIMR

Swachhta Pakhwada at IIMR Ludhiana

Collection of rainwater

Sensitization of school students

Cleaning drive in laboratories and office premises

Promotion of healthcare through Yoga

Crop Residue Management lecture

संस्थान मे हिंदी भाषा के कार्यन्वयन से संबंधित गतिविधियां

विवरण	दिनांक
तिमाही बैठक की समीक्षा विशलेषण	12.05.2016
एक दिवसीय हिंदी कार्यशाला राजभाषा निति की कार्यान्वयन	24.06.2016
राजभाषा कार्यान्वयन की बैमासिक बैठक	8.08.2016
एक दिवसीय हिंदी कार्यशाला	28.09.2016
तिमाही बैठक की समीक्षा	24.10.2016
हिंदी कार्यशाला	3.12.2016
हिंदी राजभाषा कार्यान्वयनकी मासिक बैठक	23.01.2017

to remain vigilant and act in the interests of the nation. Besides, awareness was provided to all regarding the responsibilities and powers of Indian citizens and the need of public participation in the promotion of national integrity as well as eradication of corruption.The employees took active part in the orientation and pledged to remain vigilant in all spheres of working duty.

Discussion on importance of public participation for effective vigilance in IIMR Ludhiana

Oath of vigilance by staff members at Winter Nursery Centre, Hyderabad

Certificate

This is to certify that
The Quality Management System of

ICAR- INDIAN INSTITUTE OF MAIZE RESEARCH

Pusa Campus, New Delhi-110012, India

has been assessed and found to be in compliance
with the requirements of the standard

ISO 9001:2015

for the following scope :

Research & Development of Maize

Certificate No. :1617/QMS/CCLXIII
Issued on :04/08/2016
Validity Date :03/08/2019

BMG QMS
CEO

Awards & Recognitions

Awards

Dr. S.B. Singh awarded with Scientist of the Year Award-2016 for Genetics and Plant Breeding in the Global Agriculture & Innovation Conference (GAIC-2016) held on November 27-29, 2016 at Noida International University, Noida.

Dr. S.B. Singh received Distinguished Scientist Award for Genetics and Plant Breeding in National Conference on Innovative and Current Advances in Agriculture and Allied Sciences (ICAAAS-2016) held on December 10-11, 2016. at PJTSAU, Rajendranagar, Hyderabad

Dr. S.B. Singh received Fellow Award for Genetics and Plant Breeding from the Society for Scientific Developments in Agriculture & Technology in the National Conference on Innovative and Current Advances in Agriculture and Allied Sciences (ICAAAS-2016) held on December 10-11, 2016at PJTSAU, Rajendranagar, Hyderabad.

Dr. K.S.Hooda completed post-doctoral research under Endeavour Research Fellowship from November 1, 2016 to April 29, 2017.

Dr. Ramesh Kumar conferred with Distinguished Scientist Award by Society for Scientific Development in Agriculture &Technology on occasion of National conference on Innovative and Current Advances in Agriculture and Allied Sciences during 10-11 December, 2016 at Prof. Jay Shankar Telangana State Agricultural University, Rajender Nagar, Hyderabad.

Dr. Ramesh Kumar conferred with Best Oral Presentation Award for oral presentation on Classification of newly developed QPM germplasm through heterotic grouping by Hi-Tech Horticulture Societyon the Occasion of Global Agriculture & Innovative Conference held during 27-29 November, 2016 at Noida International University, Greater Noida.

Dr. S.L. Jat received FAI-Dhiru Morarji Award-2016 for Nitrogen Management under Conservation Agriculture in Cereal Based Systems *by*Jat, H.S., Jat, R.K., Yadvinder-Singh, Parihar, C.M.,Jat, S.L.,Tetarwal, J.P., Sidhu, H.S. and Jat, M.L.,published in Indian Journal of Fertilizers. The award was given by Fertilizer Association of India, New Delhi.

Dr. S.L. Jat received Best poster award for Nutrient expert decision support system based SSNM practices for enhancing productivity, profitability, nutritional quality of maize (*Zea mays* L.) hybrids under conservation agriculture at 4th International Agronomy Congress held at New Delhi, India from 22 to 26 November, 2016.

Dr. Sunil Neelam received Dr. R.K.Arora Best Paper award for the year 2015, given by Indian Society of Plant Genetic Resources for the research paper entitled Agri-biodiversity maintained on-farm by ethnic groups in peninsular India: legacy of landrace sustainability in cereals and millets, published in Indian Journal of Plant Genetic Resources awarded on 5th April 2017, New Delhi

Dr. Sunil Neelam received Dr. R. K. Arora Best Paper award for the year 2014, given by Indian Society of Plant Genetic Resources for the research paper entitled Germplasm collection and diversity analysis in yardlong bean (*Vignaunguiculata* subsp. *sesquipedalis*) from coastal Andhra Pradesh and Odisha, published in Indian Journal of Plant Genetic Resources awarded pn 5th April 2017, New Delhi.

Dr. Sunil Neelam was awarded Outstanding Researcher Award during Aufau International Awards 2016 held at Salem, Tamil Nadu on 4th June 2016.

Recognitions

Dr. S.B. Singh was appointed Chairman in Technical Session-VI in the National Conference on Innovative and Current Advances in Agriculture and Allied Sciences (ICAAAS-2016) held on December 10-11, 2016 at PJTSAU, Rajendranagar, Hyderabad.

Dr. S.B. Singh was appointed Chairman of Poster Evaluation Committee in the National Conference on Innovative and Current Advances in Agriculture and Allied Sciences (ICAAAS-2016) held on December 10-11, 2016 at PJTSAU, Rajendranagar, Hyderabad.

Dr. S.B. Singh was elected as Vice President of Society for Scientific Development in Agriculture and Technology, Meerut (U.P.) INDIA.

Dr. S.B. Singh was nominated as Member of National Steering Committee for organization of National Conference on Innovative and Current Advances in Agriculture and Allied Sciences (ICAAAS-2016) held on December 10-11, 2016at PJTSAU, Rajendranagar, Hyderabad.

Dr. P. Lakshmi Soujanya received Travel Grant from Science and Engineering Research Board (SERB), Department of Science and Technology (DST), New Delhi to attend 25th International Congress of Entomology held from 25.09.16 to 30.09.16 at Orlando, Florida, USA.

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Visit of Dignitaries

Dr. T. Mohapatra, DG, ICAR and Secretary, DARE
visited experimental plots of ICAR-Indian Institute of Maize Research at
Pusa Campus, New Delhi on 26th March, 2017.

Dr. J.S. Sandhu, DDG (CS), ICAR releasing training manual in the programme

Dr. S.K. Sharma, ex-VC, HPKV, addressing the participants on closing ceremony of the training programme

Annexure 1

List of cultivars identified during 59th Annual Maize workshop

Cultivar	AICRP Centre/Pvt Company	Pedigree	Public/ Private	Average Yield (t/ha)	Area of adaptation Zones	States	Maturity	Characteristics	Season
X36D601	Pioneer Hi-Bred Private Ltd.	PHSAB × PH1NO6	Private	9.3	IV	Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Maharashtra	Late	Moderate tolerance to TLB, RDM, BSDM and PFSR Moderate tolerance to chillo partellus and sesamianiferens	Kharif
HTMH 5108	Hytech Seed India Pvt.Limited Hyderabad	HM00024 × HM00037	Private	9.7	IV	Andhra Pradesh, Telangana, Maharashtra, Karnataka, and Tamil Nadu.	Late	Resistant to Maydis, PFSR, TLB&P .Rust, Tolerance to chilo paretellus	Kharif
DKC 9133	Monsanto India Ltd., Bangalore	H5228Z × H1620Z	Private	6.3	V	Rajasthan, Guzrat, Chattisgarh and Madhya Pradesh	Late	Tolerant to stalk rots, TLB and MLB. BSPOT and BLSB.	Kharif
HTMH 5402	Hytech Seed India Pvt.Limited Hyderabad	(HM00061 × HM00024) × HM00057	Private	8.9	IV	Andhra Pradesh, Telangana, Maharashtra, Karnataka, and Tamil Nadu.	Medium	Resistant to RDM, SDM, BSR, CLS Tolerance to Chilo paretellus	Kharif
DKC 9144	Monsanto India Ltd., Bangalore	BT049Z × H1620Z	Private	8.6	IV	Andhra Pradesh, Telangana, Maharashtra, Karnataka, and Tamil Nadu.	Medium	-	Kharif
FH 3605	VPKAS , Almora	V407 × V 405	Public	7.6	I&I V	Jammu&Kashmir, Himachal Pradesh, Uttarakhand and North-East Hills (Zone-I) and Karnataka, Tamil Naidu, , Andhra Pradesh, Telangana, Maharashtra (Zone-IV)	Early	Moderate resistance against H.turcicum and H.maydis , common rust and PFSR	Kharif
X35C537 (P 3544)	Pioneer Hi-Bred Private Ltd	PH1H7C × PH1RA9	Private	10.85	II, III& IV	Delhi, Punjab , Haryana , Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Karnataka, Andhra Pradesh, Tamil Nadu, Telangana&Maharashtra	Late	-	Rabi
P 3533	Pioneer Hi-Bred Private Ltd.	PHM6T × PH15K8	Private	8.8	IV	Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Maharashtra	Late	Resistance to TLB and C.rot	Rabi
GK 3150	Ganga Kaveri Seeds Pvt Limited	(GKMZ152 × GKMZ163) × GKMZ53	Private	11.9	II&I V	Punjab, Haryana, Delhi&Uttar Pradesh, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu	Late	Resistant to TLB, SDM, PFSR and moderately resistant to C.rot Resistant to Sesamia inferens and Chilo partellus	Rabi
Bisco X 6573	Bisco bio Sciences	BLI103 × BLI101	Private	11.8	II	Punjab, Haryana, Delhi , Planes of Uttarakhand&Uttar Pradesh	Late	Resistant to TLB, BLSB and C.rust	Rabi
KMH 2589	Kaveri seed company limited	KML-2924 × KML-2323	Private	10.8	II&I V	Punjab, Haryana, Delhi&Uttar Pradesh, Andhra Pradesh, Telangana, Maharashtra, Karanataka, and Tamil Nadu	Late	Resistant to common rust , PFSR and C.rot	Rabi

Cultivar	AICRP Centre/Pvt Company	Pedigree	Public/ Private	Average Yield (t/ha)	Area of adaptation		Maturity	Characteristics	Season
					Zones	States			
IL 8534	Monsanto India Ltd., Bangalore	B1470Z × G7720Z	Private	9.2	IV	Andhra Pradesh, Telangana, Maharashtra, Karanataka, and Tamil Nadu.	Late	Tolerant to PFSR, MLB, BLSB, Moderate tolerant to TLB	Rabi
DKC 9120	Monsanto India Ltd., Bangalore	S8128Z × D1540Z	Private	8.9	III& IV	Eastern Uttar Pradesh, Bihar, Jharkhand, Udisha, West	Late	-	Rabi
ADVSW-2	Advanta Limited, Hyderabad	Hi-Brix53F × Hi-brix53M	Private	13.6	I, II, III& IV	Jammu&Kashmir, Himachal Pradesh, Uttarakhand, North East Hills, Punjab , Haryana , Uttar Pradesh, Bihar, Odisha, Jharkhand, West Bengal, Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, Maharashtra i.e. NHZ (Z-1), NWPZ (Z-2), NEPZ-3 and PZ (Z-4)	Medium	Resistance to Fusarium stalk rot , Rajasthan downey mildew and moderate resistance to TLB and MLB	Kharif
ADVSW-1	Advanta Limited, Hyderabad	Hi-Brix39F × Hi-Brix39M	Private	13.6	I, II, III& IV	Jammu&Kashmir, Himachal Pradesh, Uttarakhand, Punjab , Haryana , Uttar Pradesh, Bihar, Odisha, Jharkhand, West Bengal, Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, Maharashtra, Assam, Manipur, Meghalya, Delhi, Mizoram, Arunachal Pradesh Tripura and Nagaland	Medium	Resistance to Common rust Bacterium stalk rot, , Fusarium stalk rot, Rajasthan downey mildew and moderate resistance to TLB and MLB	Kharif
FSCH 41	VPKAS , Almora	VSL 20 × VSL 7	Public	12.1	I, II, III, IV& V	Jammu&Kashmir, Himachal Pradesh, Uttarakhand, Punjab , Haryana , Uttar Pradesh, Bihar, Odisha, Delhi, Jharkhand, West Bengal, Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, Maharashtra, Rajasthan, Madhya Pradesh, Chattishgarh, Guzarat, Assam, Manipur, Meghalya, Mizoram, Arunachal Pradesh, Tripura and Nagaland	Early	Tolerant to turcicum and maydis leaf blight	Kharif
KDPC 2	SKUAST , Kashmir	HKI-PC-7, HKI-PC-8, KD Local Pop-1, KD Local Pop 3	Public	3.9	I, II, III, IV& V	Jammu&Kashmir, Himachal Pradesh, Uttarakhand, Punjab , Haryana , Uttar Pradesh, Bihar, Odisha, Delhi, Jharkhand, West Bengal, Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, Maharashtra, Assam, Manipur, Meghalya, Mizoram, Arunachal Pradesh, Tripura and Nagaland	Early (95-100 days)	Moderate Resistant to Banded leaf and sheath blight and Fusarium Stalk Rot , Resistant to stem borer	Kharif
Vivek Hybrid 27	VPKAS , Almora	VL 335 × VL345	Public	2.1	I, II, IV& V	Jammu&Kashmir, Himachal Pradesh , Uttarakhand , Delhi, Punjab , Haryana , Uttar Pradesh , Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Maharashtra, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh.	Extra Early (95-97 days)	Moderate resistance against H.turcicum and H.maydis leaf blight	Kharif

Annexure 2

List of cultivars notified during 2016-17

Cultivar	Pedigree	Notification		Name of center /Company	Area of adaptation	Maturity	Average Yield (t/ha)	Characteristics	Season
		Notification No.	Notification Date						
Vivek Hybrid 27 (Central Maize VL Baby Corn 2)	VL 335 × VL345	1007(E)	30-03-2017	VPKAS , Almora	Jammu&Kashmir, Himachal Pradesh , Uttarakhand , Delhi, Punjab , Haryana , Uttar Pradesh , Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Maharashtra, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh.	Extra Early	2.1	Moderate resistance against H.turcicum and H.maydis leaf blight	Kharif
P3401 (X35D601)	PHSAB × PH1NO6	1007(E)	30-03-2017	Pioneer Hi-Bred Private Ltd.	Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Maharashtra	Late	9.3	Moderate tolerance to TLB, RDM, BSDM and PFSR Moderate tolerance to chillo partellus and sesamian iferens	Kharif
P3533	PHM6T × PH15K8	1007(E)	30-03-2017	Pioneer Hi-Bred Private Ltd.	Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Maharashtra	Late	8.8	Resistance to TLB and C.rot	Rabi
P3544	PH1H7C × PH1RA9	1007(E)	30-03-2017	-	Delhi, Punjab , Haryana , Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Karnataka, Andhra Pradesh, Tamil Nadu, Telangana&Maharashtra	-	-	-	Rabi
Central Maize VL 55 (FH3605)	V407 × V 405	1007(E)	30-03-2017	VPKAS , Almora	Jammu&Kashmir, Himachal Pradesh, Uttarakhand and North-East Hills (Zone-I) and Karnataka, Tamil Naidu, , Andhra Pradesh, Telangana, Maharashtra (Zone-IV)	Early	7.6	Moderate resistance against H.turcicum and H.maydis, common rust and PFSR	Kharif
Hi-Brix 53 (ADVSW-2)	Hi-Brix53F × Hi-brix53M	1007(E)	30-03-2017	Advanta Limited, Hyderabad	Jammu&Kashmir, Himachal Pradesh, Uttarakhand, North East Hills, Punjab , Haryana , Uttar Pradesh, Bihar, Odisha, Jharkhand, West Bengal, Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, Maharashtra i.e. NHZ (Z-1), NWPZ (Z-2), NEPZ-3 and PZ (Z-4)	Medium	13.6	Resistance to Fusarium stalk rot , Rajasthan downey mildew and moderate resistance to TLB and MLB	Kharif

Cultivar	Pedigree	Notification No.	Notification Date	Name of center /Company	Area of adaptation	Maturity	Average Yield (t/ha)	Characteristics	Season
VMH 4106	-	1007(E)	30-03-2017	Vibha Agrotech Limited, Hyderabad	Bihar, Uttar Pradesh, Jharkhand, West Bengal and Odisha.	Medium	6.8	Tolerant to MLB, TLB, BLSB, SDM , DM and Rusts Tolerance to chilo paretellus	Kharif
HI Brix-39 (ADVSW-1)	Hi-Brix39F × Hi-Brix39M	1007(E)	30-03-2017	Advanta Limited, Hyderabad	Jammu&Kashmir, Himachal Pradesh, Uttarakhand, Punjab , Haryana , Uttar Pradesh, Bihar, Odisha, Jharkhand, West Bengal, Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, Maharashtra, Assam, Manipur, Meghalya, Delhi, Mizoram, Arunachal Pradesh, Tripura and Nagaland	Medium	13.6	Resistance to Common rust Bacterium stalk rot, , Fusarium stalk rot, Rajasthan downey mildew and moderate resistance to TLB and MLB	Kharif
Shalimar Pop Corn-1 (KDPC-2)	HKI-PC-7, HKI-PC-8, KD Local Pop-1, KD Local Pop 3	1007(E)	30-03-2017	SKUAST , Kashmir	Jammu&Kashmir, Himachal Pradesh, Uttarakhand, Punjab , Haryana , Uttar Pradesh, Bihar, Odisha, Delhi, Jharkhand, West Bengal, Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, Maharashtra, Assam, Manipur, Meghalya, Mizoram, Arunachal Pradesh, Tripura and Nagaland	Early	3.9	Moderate Resistant to Banded leaf and sheath blight and Fusarium Stalk Rot , Resistant to stem borer	Kharif
HTMH 5402	(HM00061 × HM00024) × HM00057	1007(E)	30-03-2017	Hytech Seed India Pvt.Limited Hyderabad	Andhra Pradesh, Telangana, Maharashtra, Karanataka, and Tamil Nadu.	Medium	8.9	Resistant to RDM, SDM, BSR, CLS Tolerance to chilo paretellus	Kharif
GK 3150	(GKMZ152 × GKMZ163) × GKMZ53	1007(E)	30-03-2017	Ganga Kaveri Seeds Pvt Limited	Punjab, Haryana, Delhi&Uttar Pradesh, Maharashtra , Karnataka, Andhra Pradesh, Tamil Nadu	Late	11.9	Resistant to TLB, SDM, PFSR and moderately resistant to C.rot Resistant to Sesamia inferens and Chilo partellus	Rabi

Cultivar	Pedigree	Notification		Name of center /Company	Area of adaptation	Maturity	Average Yield (t/ha)	Characteristics	Season
		Notification No.	Notification Date						
DRONA (KMH-2589)	KML-2924 × KML-2323	1007(E)	30-03-2017	Kaveri seed company limited	Punjab, Haryana, Delhi&Uttar Pradesh, Andhra Pradesh, Telangana, Maharashtra, Karanataka, and Tamil Nadu	Late	10.8	Resistant to common rust , PFSR and C.rot	Rabi
Pant Shankar Makka – 4 (PSM-4) (DEH – 153) (DEH 188)	Pop 31x23-3-3-1-1-1-2-1XYHPB-x-161-1-4-1-2-2-1-1-1	1007(E)	30-03-2017	G.B. Pant University of agriculture and tech. PantNagar	Uttarakhand	Early	4.5	Resistant to TLB, BLSB BSDM and ESR	Kharif
D2244 (DAS-MH-501)	NTC6 × NTC8	112 (E)	13/01/2016	DOW Agro Sciences India Pvt. Ltd., Mumbai	Jammu&Kashmir, Himachal Pradesh, Uttarakhand, North East hills, Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu Madhya Pradesh Rajasthan, Gujarat and Chhattisgarh	Early	7.09	Yellow orange, semi-dent	Kharif
*Shalimar Maize Composite-5 (PS-98)		112 (E)	13/01/2016	SKUAST, Srinagar	Jammu and Kashmir/2013	Early	5.6	-	Kharif
*Shalimar Maize Composite-6 (KDM-322)		112 (E)	13/01/2016	SKUAST, Srinagar	Jammu and Kashmir/2013	Early	6.0	-	Kharif
*Shalimar Maize Composite-7 (KDM-72)		112 (E)	13/01/2016	SKUAST, Srinagar	Jammu and Kashmir/2013	Early	6.6	-	Kharif
LAXMI 3636 (LTH 22)	(YM-2 × YM-212) × YM-3	112 (E)	13/01/2016	Yaaganti Seeds Pvt. Ltd., Hyderabad	Andhra Pradesh, Telangana, Karnataka, Maharashtra and Tamil Nadu	Late	9.06	Orange yellow, semi-dent	Kharif
BIO 9782 (BIO 237)	BY778-nm (CI462 P) × CZ172-nm (BIOPOP9026F)	112 (E)	13/01/2016	Bioseed Research India a Division of DCM Shriram Ltd., Hyderabad	Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Late	10.27	Orange yellow, semi-dent	Rabi

Cultivar	Pedigree	Notification		Name of center /Company	Area of adaptation	Maturity	Average Yield (t/ha)	Charact eristics	Season
		Notification No.	Notification Date						
Dragon (NMH-1247)	NM-183 × NM-199	112 (E)	13/01/2016	Nuziveedu Seeds Limited, Hyderabad	Punjab, Haryana, Delhi, Western Uttar Pradesh	Late	9.97	Bright yellow semi-dent bold kernels with orange tinge	Rabi
PMH 8 (JH 31244)	LM 5 × LM 20	112 (E)	13/01/2016	Punjab Agricultural University, Ludhiana, Punjab	Punjab	Medium	8.3	Yellow-orange, flint	Spring
Hema (NAH-1137)	-	2238(E)	29/06/2016	UAS, Banglore	Karnataka	-	3.2	Yellow-orange, semi-dent , resistant to SDB, TLB and polysora rust	Kharif and Rabi
Pratap Hybrid Maize-3 (PH-1974)	EI-586-2 × EI-670-2	2238(E)	29/06/2016	MPUAT, Udaipur	Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Medium	5.6	Yellow, semi-dent, resistant to FSR, moderate resistant to CLS and RDM	Kharif
UDAY (DMR-248) Mahabeej-1114	-	2238(E)	29/06/2016	Mahabeej Akola (M.S.)	Maharashtra	Medium	8.7	Yellow orange, semi-dent	Kharif
Pratap Makka-9 (EC-3161)	-	2238(E)	29/06/2016	MPUA&T, Udaipur, Rajasthan	Rajasthan	Early	4.5	Yellow, bold semi-dent	Kharif
Karim Nagar Makka 1	-	2238(E)	29/06/2016	PJTSAU, Hyd., Telangana	Telangana	Medium	6.8	Orange, semi-flint, resistant to TLB, BLSB, RDM and CLS	Kharif &Rabi
PMH 7	-		29/06/2016	PAU, Ludhiana	Punjab	Medium	7.5	Orange flint	Spring

Annexure 3

Details of hybrids/varieties registered, application filed for protection at PPVFRA and entries under DUS testing during 2016-17

S.No.	Name	Centre	Period of protection (Years)
1.	Vivek Maize Hybrid 39	VPKAS, Almora	February 1, 2016 to January 31, 2031
2.	Vivek Maize Hybrid 43	VPKAS, AImora	August 19, 2016 to August 18, 2031
3	Vivek Maize Hybrid 45 (FH 3483)	TN AU, Coimbatore	August 26, 2016 to August 25, 2031
4	Co 6	TNAU, Coimbatore	October 22, 2016 to October 21, 2031
5	CoH (M)7 (CMH 08-287)	TNAU, Coimbatore	October 22, 2016 to October 21, 2031
6	CoH (M)8 (CMH 08-292	TNAU, Coimbatore	October 22, 2016 to October 21, 2031
7	CoH (M)9 (CMH 08-350)	TNAU, Coimbatore	October 22, 2016 to October 21, 2031
8	CoH (M)10 (CMH 08-433)	PAU, Ludhiana	August 19, 2016 to August 18, 2031
9	PMH 5 (JH 3110)	PAU, Ludhiana	August 26, 2016 to August 25, 2031
10	PMH 6 (JH 31292)	ANGRAU, Hyderabad	August 19, 2016 to August 18, 2031
11	DHM 119 (BH 4062)	ANGRAU, Hyderabad	August 19, 2016 to August 18, 2031
12	BH -1576 (DHM-111)	ANGRAU, Hyderabad	August 26, 2016 to August 25, 2031
13	BH -1620 (DHM-113)	GBPUA&T, Pantnagar	August 1 9, 2016 to August 18, 2031
14	Pant Shankar Makka-1	CCSHAU, Karnal	August 19, 2016 to August 18, 2031
15	HM -12 (HKH 313)	CCSHAU, Karnal	August 26, 2016 to August 25, 2031
16	HQPM-4	MPUA&T, Udaipur	August 19, 2016 to August 18, 2031
17	PRATAP QPM HYBRID-1 (EHQ-16)	MPUA&T, Udaipur	November 9, 2016 to November 8, 2031
18	Pratap Kanchan-2 (WC-236 (Y))		
	OPVs	CSK HPKV, Bajaura	August 26, 2016 to August 25, 2031
19	Bajaura Makka (L 201 Composite)	GBPUA&T, Pantnagar	August 19, 2016 to August 18, 2031
20	Pant Sankul Makka -3 (D 131)		

Varietal Identification

List of hybrids/ varieties application field for protection at PPVFRA during 2016-17

S. No.	Hybrids	Name of centre	Date of filing	Acknowledgement no.
1	Shalimar Maize Composite-7	SKUAST, Srinagar	21.11.2016	REG/2016/1824
2	Shalimar Maize Composite-6	SKUAST, Srinagar	21.11.2016	REG/2016/1825
3	Shalimar Maize Composite-5	SKUAST, Srinagar	21.11.2016	REG/2016/1826
4	HM-13	CCSHAU, Karnal	02.09.2016	REG/2016/1341
5	Palam Sankar Makka 1 (EHL 162508)	CSKHPKV, Bajaura	07.06.2016	REG/2016/699
6	Palam Sankar Makka 2 (EHL 161708)	CSKHPKV, Bajaura	07.06.2016	REG/2016/698

List of hybrids / varieties under DUS testing during 2016-17

Hybrid DUS trial 2016	Inbred DUS trial 2016	Variety of Common Knowledge	Grow out test (16)
First Year of Testing : 28 PMH 8, PMH 7, GK 3166, AMH-3436, GK 3112, GK 3145, PMH 9, P 3511, P 3399, PH2RBR, P 3466, P 3520, DKC 9155, MM7663, MZ14SO16N, HTMH 5402, DKC 9144, TMMH 844, D 4244, D 4685, SYN-CO-6217, SYN-CO-6304, SYN-CO-6607, SYN-CO-6668, SYN-CO-6850, SYN-CO-7750, SYN-CO-NP-5611, MM 7009 **Second Year of testing : 36** LG 32.81, LG 34.02, LG 34.03, LG 33.01, LG 32.01, P 3007, P 3401, P 1855, P 3596, P 1844, DKC 9135, DKC 9142, Vivek Maize Hybrid 45, Shaktiman 5, Pratap QPM Hybrid 1, Pant Sankar Makka 1, HM 12, NIRMAL 3662, MM 7796, MM 1121, GK 3114, GK 3155, GK 3366, GK 3162, GK 3153, GK 3137, GK 3124, GK 3120, GK 3164, GK 3156, KHCH-333 (Candy), KMH 7021, GK 3118, TMMH 826 **Open Pollinated Varieties : 2** Shalimar Maize Composite 5 Bajaura Makka	**First Yea r of Testing : 25** TSIH 008, WWV 04, TWV 14, KML 5164, PH 218V, PH1RA9, PH217Z, PH1RA5, PH26WP, PH1B26, PH1CGY, MZ14SO20N, MZ14SO18N, MZ14SO17N, MZ14SO19N, BLI 102, TM 800125, SYN-CO-NP-5104, SYN-CO-NP-5197, SYN-CO-NP-5198, SYN-CO-NP-5219, SYN-CO-NP-5322, SYN-CO-NP-5324, SYN-CO-NP-5610, SYN-CO-NP-5616 **Second Year of testing : (17)** BLI 108, AT 226, BLI 107, MZ14SO14N, MZ14SO13N, MHC4T007, MZYA090069, AT 69, PHSAB, PH1NOV, PH1BFW, PH23FC, PHM6M, PH1NO6, PHYOR, PH1WGS, PH23F9	**Hybrid** : HTMH 5202 **Inbred** : TWV 10 , 7SH382	Pivla Lal Makka, Pivla Lahan Makka, Pivala Makka, Keshri Makka, Kukkud Makka, Mira Makai, Desi Makai-1, Desi Makka -M1, Desi Makka, Pili Makka Sathi, Safed Makai, Rama Makka, Pili Makka Desi, Sathi Makka, Mogra, Pila Makai

Details of breeder seed production during 2016-17

S. No.	Name of the Producing centre	Name of variety	Allocation BSP-I	Production	Surplus/Deficit over DAC Indent
1	**Bihar**				
	RAU Dholi	**Shaktiman2**			
		(F) CML176	0.30	1.00	0.70
		(M) CML186	0.70	0.80	0.10
		Total	**1.00**	**1.80**	
2	**Delhi**				
	IARI, New Delhi	**Pusa Extra Early Hybrid Makka5 (AH 421)**			
		(F) CM150	0.28	1.50	1.22
		(M) CM151	0.14	0.60	0.46
		PEHM 2			
		(F) CM137	0.50	0.50	0.00
		(M) CM 138	0.50	0.50	0.00
		PEHM 2			
		Female line	0.21	0.21	0.00
		Male line	0.10	0.10	0.00
		Total	**1.73**	**3.41**	
3	**Haryana**				
	CCSHAU Karnal	**HQPM4**			
		(F) HKI193-2	2.20		
		(M) HKI161	0.80	0.70	-0.10
		HQPM7			
		(F) HKI 193-1	0.15		
		(M) HKI 161	0.06		
		HQPM 5			
		(F) HKI163	1.03	1.03	0.00
		(M) HKI161	0.43		
		HQPM1			
		(F) HKI193-1	1.72		
		(M) HKI 163	0.66	0.47	-0.19
		HM 4			
		HKI 1105	0.08	0.08	0.00
		HKI 323	0.04	0.10	0.06
		HM 4			
		HKI 1105	0.02	0.02	0.00
		HKI 323	0.01	0.01	0.00
		Total	**7.20**	**2.41**	
4	**Karnataka**	**Hema**			
	UAS Mandya	(F)NAH-1137	0.70		
		(M)NAH-1137	0.35		
		Total	**1.05**		
5	**Rajasthan**				
	MPUA & T Udaipur	**Pratap Hybrid3**			
		(F) EI-586-2	6.00	8.10	2.10
		(M) EI-670-2	3.00	3.00	0.00
		Total	**9.00**	**11.10**	**2.10**

S. No.	Name of the Producing centre	Name of variety	Allocation BSP-I	Production	Surplus/Deficit over DAC Indent
6	**Tamil Nadu**				
	TNAU Coimbatore				
		COHM 8			
		(F) UMI 1201	3.05	2.40	-0.65
		(M) UMI1230	1.53	1.53	0.00
		COHM 9			
		(F) UMI 1205	0.05	0.05	0.00
		(M) UMI 1230	0.03	0.03	0.00
		CO-6			
		UMI-1200 (F)	3.00	3.00	0.00
		UMI-1230(M)	1.50	1.50	0.00
		Total	**9.16**	**8.51**	**-0.65**
7	**Telangana**				
	ANGRAU Hyderabad	**DHM117**			
		(F) BML6	4.85	4.85	0.00
		(M) BML7	2.04	2.04	0.00
		Total	**6.89**	**6.89**	**0.00**
	ANGRAU Karimnagar	**DHM121**			
		(F) BML45	6.05	5.82	-0.23
		(M) BML6	2.03	2.03	0.00
		KNMH-4010131			
		PFSR-3	1.50	1.5	0.00
		BML 7	0.75	6.0	5.25
		Total	**10.33**	**15.35**	
		Total	**17.22**	**22.24**	
8	**Uttarakhand**				
	GBPUAT Pantnagar	**Ganga Safed 2**			
		CM 600	0.11	0.12	0.01
		CM400	0.06	0.06	0.00
		CM 300	0.05	0.05	0.00
		Total	0.22	0.23	
	VPKAS Almora				
		Vivek Maize Hybrid 45			
		(F) V 373	0.50	3.00	2.50
		(M) V 390	0.20	0.55	0.35
		Vivek Maize Hybrid 39			
		(F) V 373	0.15	2.88	2.73
		(M) CM 212	0.05	0.05	0.00
		Vivek QPM-9			
		(F) VQL 1	1.30	0.05	-1.25
		(M) VQL 2	0.40	0.10	-0.30
		Vivek Maize Hybrid 39			
		(F) V 373	0.02	0.02	0.00
		(M) CM 212	0.06	0.05	-0.01
		Total	**2.68**	**6.70**	
		Grand Total	**49.26**	**56.63**	

Annexure 5

Human Resource Development
A.Training attended

Name	Programme	Venue	Date
Dr P Lakshmi Soujanya	Nanotechnology	CSIR-Indian Institute of Chemical Technlogy, Hyderabad	December 06 – 23, 2016
Dr S B Singh	Precision Phenotyping for Abiotic Stress Tolerance in Maize on organized	CIMMYT, Hyderabad	July, 29-30,2016
Dr S L Jat and Dr Krishan Kumar	Transforming Government Though ICT: Government Process Reengineering (GPR)	Indian Institute of Public Administration (IIPA), New Delhi	November, 16-18, 2016
Dr Ishwar Singh	Competency Enhancement Programme for Effective implementation of Training Functions by HRD Nodal Officers of ICAR	NAARM, Hyderabad	February 20-22, 2017
Dr Krishan Kumar	DNA Fingerprinting and Barcoding	National Institute of Plant Genome Research (NIPGR), New Delhi	June 28th to July 27th 2016.
Dr Dharam Paul	Summer School on "Engineering and Technological Innovations in Developing Health Foods" organized at	Central Institute of Post Harvest Engineering and Technology, Ludhiana	June 08-28, 2016

B.Trainings conducted

Name	Programme	Venue	Date
Dr S B Singh	Farmer Training on कृषक आय वृद्धि हेतु मक्का की वैज्ञानिक खेती, बीज उत्पादन व अन्य विकल्प	RMR & SPC, Vishnupur, Begusarai	February, 14-15, 2017.
	Farmer-Scientist Interaction cum field day programme on Hybrid maize and its seed production	RMR & SPC, Kushmahaut, Begusarai	March, 17 2017.
Dr AK Singh (Course director) Dr CM Parihar and Dr SL Jat (Course coordinator)	Precision Conservation Agriculture for Climatic Change Adaptation and Mitigation in Cereal System	IIMR, New Delhi	August, 8 -17 2016
Dr Ashok Kumar and Dr SL Jat	मक्का उत्पादन एवं मूल्य संवर्धन	IIMR, New Delhi	September, 07-09 2016
Dr Ashok Kumar	मक्का उत्पादन एवं मूल्य संवर्धन	IIMR, New Delhi	September, 22-24 2016
Dr Ashok Kumar	मक्का उत्पादन एवं मूल्य संवर्धन	IIMR, New Delhi	September, 28-30 2016
Dr Ramesh Kumar and Dr Vishal Singh	मक्का उत्पादन एवं सुरक्षा की उन्नत तकनीकियां	IIMR, Ludhiana	October, 21-22 2016
Dr S L Jat and Dr Chikkappa GK	कृषि लाभप्रदता बढ़ाने हेतु विशिष्ट मक्का	IIMR, New Delhi	February 25-27, 2017
Dr S L Jat and Dr Bhupender Kumar	कृषि लाभप्रदता बढ़ाने हेतु विशिष्ट मक्का	IIMR, New Delhi	March, 02-04 2017
Dr P. Laxshim Soujanya, Dr Sunil N. and Dr JC Sekhar	Maize Production and Protection Technologies	WNC, Hyderabad	March, 21 2017
Dr P Laxshim Soujanya, Dr Sunil N and Dr J C Sekhar	Maize Production and Protection Technologies	WNC, Hyderabad	March, 28 2017
Dr S L Jat and Dr Krishan Kumar	लाभप्रदता हेतु सामान्य एवं विशिष्ट मक्का की उन्नत तकनीकियां		March, 27-29 2017
Dr Alla Singh & Dr Dharam Paul	Biotechnology Platforms for Utility Products in Maize	IIMR, Ludhiana	February 1-15 2017

C. Participation in conferences/seminars/workshops.

Name	Programme	Venue	Date
Dr P Lakshmi Soujanya	25th International Congress of Entomology	Orlando, Florida, USA	October 25th to 30th, 2016
	National Symposium on "The role of Vrikshayurveda and traditional practices in organic agriculture".	Udaipur, Rajasthan	6th to 8th March, 2017
Dr P. Laxmi Soujanya	Training programme in the field of Nanotechnology	Nano Materials Laboratory, I & PC Division, CSIR-IICT, Hyderabad	06-23 December 2016
Drs P L Soujanya S B Singh S L Jat C M Parihar, , AK Singh, Ashok Kumar, Meena Shekhar	59th Annual maize workshop	GKVK campus, UAS, Bangalore	April 10 - 12th 2016
Dr S B Singh	Meeting on the external funded project "Climate Resilient Maize for Asia"	CIMMYT, Hyderabad	July, 29-30, 2016
	XI Annual Review Meeting of ICAR Seed Project- "Seed Production in Agricultural Crops" held during	GBPUAT-Pantnagar.	August 17-18, 2016
	Mission on Agricultural Extension and Technology (NMAET)	Office of District Magistrate, Begusarai	September 20th 2016
	Scientific Advisory Committee Meeting	KVK, Khagaria	October 20-10, 2016
	Global Agriculture & Innovation Conference (GAIC-2016)	Noida International University	November, 27-29 2016
	Scientist Farmer Interaction Meeting	DAO office Begusarai	November 23-24 2016
Drs Meena Shekhar S B Singh, Ramesh Kumar	National Conference on Innovative and Current Advances in Agriculture and Allied Sciences (ICAAAS-2016)	PJTSAU, Rajendranagar, Hyderabad	December 10-11, 2016.
Dr C M Parihar	International Plant Nutrition Institute (IPNI) Cooperators' Meet, 2016.	Visva-Bharati, Shanti niketan, West Bengal, India	April 8th to 9th , 2016
Dr C M Parihar, SL Jat, AK Singh, Ashok Kumar	4th International Agronomy Congress	New Delhi, India	November, 22–26 2016,
Dr SL Jat	Attended and made oral presentation in 'National Group Meeting Kharif-2016' of AICRP on Forage Crops and Utilization	SKUAST, Srinagar	16-17 May, 2016
Dr S L Jat	Attended and made oral presentation in 'India Maize Summit 2016'	FICCI, Federation House, New Delhi	May, 26th 2016
Dr S L Jat	Attended and made oral presentation in the meeting on "Nutrient Use Efficiency"	Krishi Bhawan, New Delhi	June, 21st 2016

Name	Programme	Venue	Date
Dr Bhupender Kumar	Asia regional collaborative Project "Climate-resilient maize for Asia (CRMA)"	CIMMYT Office, ICRISAT Campus, Hyderabad, India	29-30 July, 2016
Dr Ishwar Singh	24th Meeting of ICAR Regional Committee No V	IARI, New Delhi	October 3-4, 2016
	National Seminar on "Challenges of climate change and green environmental solutions",	CCS University, Meerut	December 10, 2016
	10th Annual Review Meeting of *"ICAR-Network Project on Transgenics in Crops"*	NRCPB, New Delhi	December 19-21, 2016
Dr Pranjal Yadava	Meeting on "Nutrient Use Efficiency"	ICAR, Krishi Bhavan, New Delhi	June 21, 2016
	Annual Report and Technical Review Meeting of the project ""Genetic modifications to improve biological nitrogen fixation for augmenting nitrogen needs of cereals" under XII Plan scheme 'Incentivizing Research in Agriculture'	NRCPB, New Delhi	April 5, 2016
	Interaction Meeting of Sh Radha Mohan Singh, Hon'ble Minister for Agriculture and Farmer's Welfare with farmers	PAU, Ludhiana	May 27, 2016
	10th Annual Review Meeting of *"ICAR-Network Project on Transgenics in Crops"*	NRCPB, New Delhi	December 19-21, 2016
Dr Krishan Kumar	3rd NASF Annual Review Meeting	NASC complex New Delhi	March 1st 2017
Dr Dharam Paul	Workshop cum Training: "Yield enhancement in maize through breeding and testing of newly developed genotypes in all India coordinated research programme	Indian Institute of Maize Research, Delhi	June 1-3, 2016.
	National Conference on Innovative Food Processing Technologies for Food and Nutritional Security	Central Institute of Post Harvest Engineering and Technology, Ludhiana	September, 29-30, 2016.
Dr Meena Shekhar Dr Sunil Neelam Mr Mukesh Choudhary	Presented poster in 1st International Agro biodiversity Congress	NAASC New Delhi	6-9 November, 2016
Drs A K Singh Ashok Kumar CM Parihar SL Jat Bhupender Kumar	Fourth International Agronomy Congress	ICAR-IARI	22 – 26 November, 2016
Drs A K Singh Bhupender Kumar SL Jat	Annual Review Workshop on NICRA project	NASC, New Delhi	9-10 December, 2016

Annexure 6

Lectures/ Radio/ Television talks Delivered

Scientist	Topic	Programme	Venue	Date
Dr. S. B. Singh	Advance breeding strategies for enhancing waterlogging tolerance in maize (*Zea mays* L.)	National Conference on Innovative and Current Advances in Agriculture and Allied Sciences (ICAAAS-2016)	PJTSAU, Rajendranagar, Hyderabad	December 10-11, 2016.
Dr. A.K. Singh	रबी मक्का का खेती	हेल्लो किसान लाइव कार्यक्रम	डीडी किसान	21 फरवरी 2017
	Introduction to conservation agriculture (CA)	ICAR sponsored short training course on "*Precision Conservation Agriculture for Climatic Change Adaptation and Mitigation in Cereal System*".	ICAR-IMR, Pusa Campus, New Delhi	8 August 2016
Dr. C. M. Parihar	फसल विविधीकरण	Television Talk	DD 1	April, 6th , 2016
	Maize production technologies	National level training programme on "*Integrated crop management in maize*" for the farmers of Tamil Nadu under ATMA -SSEPERS.	ICAR-IIMR, New Delhi	August , 29th ,2016
	मक्का की नवीनतम सस्य विधियां	National level training programme on मक्का उत्पादन तकनीकियाँ एवं मूल्य संवर्धन- for tribal farmers under Tribal Sub Plan of ICAR.	ICAR-IIMR, Pusa Campus, New Delhi	September, 7th, 2016
	मक्का की नवीनतम सस्य विधियां	National level training programme on :मक्का उत्पादन तकनीकियाँ एवं मूल्य संवर्धन- for tribal farmers under Tribal Sub Plan of ICAR.	ICAR-IIMR, Pusa Campus, New Delhi	September, 22nd, 2016
	मक्का की नवीनतम सस्य विधियां	National level training programme on :मक्का उत्पादन तकनीकियाँ एवं मूल्य संवर्धन- for tribal farmers under Tribal Sub Plan of ICAR.	ICAR-IIMR, Pusa Campus, New Delhi	September, 28th , 2016
	Calibration of conservation agriculture equipments.	ICAR sponsored short training course on "*Precision Conservation Agriculture for Climatic Change Adaptation and Mitigation in Cereal System*".	ICAR-IIMR Pusa Campus, New Delhi	August, 9th 2016
	Green seeker a tool for precision nitrogen management in cereals.	ICAR sponsored short training course on "*Precision Conservation Agriculture for Climatic Change Adaptation and Mitigation in Cereal System*".	ICAR-IIMR Pusa Campus, New Delhi	August, 10th 2016
	Measuring of green house gases in conservation agriculture plots.	ICAR sponsored short training course on "*Precision Conservation Agriculture for Climatic Change Adaptation and Mitigation in Cereal System*".	ICAR-IIMR Pusa Campus, New Delhi	August, 10th 2016
	Green house gases emission and mitigation potential of conservation agriculture.	ICAR sponsored short training course on "*Precision Conservation Agriculture for Climatic Change Adaptation and Mitigation in Cereal System*".	ICAR-IIMR, Pusa Campus, New Delhi	August, 11th 2016.

Dr S. L Jat	मक्का में समसामयिक कार्य	हेल्लो किसान लाईव कार्यक्रम	डीडी किसान	मार्च14 2017
	मक्का में समसामयिक कार्य	हेल्लो किसान लाईव कार्यक्रम	डीडी किसान	December 17
	रबी मक्का की बुवाई	हेल्लो किसान लाईव कार्यक्रम	डीडी किसान	नवम्बर 22 2016
	मक्का के साथ अन्तः फसलीकरण	कृषि दर्शन	डीडी 1	नवम्बर 22 2016
	खरीपफ फसलों के अनुमान पर चर्चा	विचार विमर्श कार्यक्रम	डीडी किसान	अक्तूबर,14 2016
	Maize-a crop of diverse uses	TSP training 7 to9 Sep., 2016	IIMR Delhi	Sept 07, 2016
	मक्का में समसामयिक कार्य	हेल्लो किसान लाईव कार्यक्रम	डीडी किसान	सितम्बर07, 2016
	Uses of maize	A training program eon "Integrated crop management in maize' for the Tamil Nadu farmers under ATMA -SSEPERS	IIMR, New Delhi	29 August, 2016
	मक्का, बाजार एवं ज्वसार में समसामयिक कार्य	हेल्लो किसान लाईव कार्यक्रम	डीडी किसान	16 अगस्त, 2016
	Status of conservation agriculture	ICAR sponsored Short Course on "Precision Conservation Agriculture for climatic change adaptation and mitigation in cereal systems	IIMR Delhi	8 August 2016
	Green seeker a s a tool for precision nutrient management in cereals	ICAR sponsored Short Course on Precision Conservation Agriculture for climatic change adaptation and mitigation in cereal systems	IIMR Delhi	10 August, 2016
	Hands on SSNM through STCR and nutrient expert software	ICAR sponsored Short Course on Precision Conservation Agriculture for climatic change adaptation and mitigation in cereal systems	IIMR Delhi	17 August, 2016
	मक्का की बुवाई	डीडी किसान लाईव कार्यक्रम	डीडी किसान	जून 22 2016
	विशेष मक्का के खेती	कृषि दर्शन कार्यक्रम	डीडी नैशनल	17 जून, 2016
	Status of maize in India	India Maize Summit 2016' on 26th May, 2016 at FICCI, Federation House, New Delhi.	FICCI, Federation House, New Delhi	26 May, 2016
	Maize perspective as dual purpose fodder crop	National Group Meeting Kharif-2016' of AICRP on Forage Crops and Utilization at Srinagar from 16-17 May, 2016.	SKUAST, Srinagar	17 May, 2016
Dr Nirupma Singh	Breeding for cold tolerance in maize: present status and way ahead. In Souvenir: National Conference	National conference on Innovative and current advances in agriculture and allied sciences (ICAAAS-2016).	PJTSAU Rajendra Nager, Hyderabad (Telangana)	December 10, 2016
Dr Meena Shekhar	Integrated Disease management in Maize'	A training program on "Integrated crop management in maize' for the Tamil Nadu farmers under ATMA -SSEPERS	IIMR, New Delhi	29 August, 2016
	Biochemical basis of defense response in maize against Post flowering stalk rot pathogens	National conference on Innovative and current advances in agriculture and allied sciences (ICAAAS-2016).	PJTSAU Rajendra Nager, Hyderabad (Telangana)	December 10, 2016
	Diseases of maize and their management	Maize production technology and value addition under TSP programme	ICAR-IIMR, New Delhi-12	September 28 & February 27th 2017

	Major diseases of maize and their management	Specialty corn for improving on profitability under TSP programme	ICAR-IIMR, New Delhi-12	March 3rd 2017
	Insect pests of maize and their management	Improved normal and specialty corn technologies for profitability under TSP programme	ICAR-IIMR, New Delhi-12	March 29th 2017
Suby SB	Integrated pest management in Maize'	A training program eon "Integrated crop management in maize' for the Tamil Nadu farmers under ATMA -SSEPERS	IIMR, New Delhi	29 August, 2016
	Testing of maize hybrids for various insect-pests in All India Coordinated Research Programme	Workshop cum Traini ng on "Yield enhancement in maize through breeding and testing of newly developed genotypes in all India coordinated research programme	ICAR-IIMR, New Delhi-12	June, 1-3 2016
	Pest incidence measurement in conservation agriculture fields	Precision Conservation Agriculture for climatic change adaptation and mitigation in cereal systems	ICAR-IIMR, New Delhi-12	August 17 2016
	Insect pests of maize and their management	Maize production technology and value addition under TSP programme	ICAR-IIMR, New Delhi-12	September28 & February 27th 2017
	Insect pests of maize and their management	Specialty corn for improving on profitability under TSP programme	ICAR-IIMR, New Delhi-12	March 3rd 2017
	Insect pests of maize and their management	Improved normal and specialty corn technologies for profitability under TSP programme	ICAR-IIMR, New Delhi-12	March 29th 2017
Dr. Bhupender Kumar	Association mapping, a sophisticated highway to explore QTLs in Plant sciences"	Invited Talk	CSKHPKV Palampur, Himachal Pradesh	September 6th, 2016
	Improved normal and specialty corns technologies for profitability"	TSP (total lectures delivered :3)	ICAR-IIMR, New Delhi-12	Feb., 25th & March,2nd & 27th 2017
	AMMI analysis to identify maize hybrids adapted under drought stress and normal ecologies in tropical climate"			

Annexure 7

PUBLICATIONS

Research Papers

1. Anishetty NM, Rao VR, Sivaraj N, Babu BS, Sunil N, Varaprasad KS (2016) Gene Banks: Management of Genetic Erosion in Ex Situ Collections. Indian Journal of Plant Genetic Resources 29(3): 268-271.
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7. Dwivedi N, Nautiyal PC, Singh K, Singh I (2016) Evaluation of maize hybrids for leaf thermostability, photosynthetic rate, stem reserves and productivity under rain-fed conditions. Indian Journal of Agricultural Sciences 86(11): 1426-32.
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9. Hargilas, Jat SL (2016) Effect of tillage management on direct seeded rice (*Oryza sativa*)-maize (*Zea mays* L.) cropping system. Maize Journal 5(1&2): 59-62.
10. Hooda KS, Khokhar MK, Kaul J, Chikkappa GK, Kumar B, Sharma SS, Gogoi R, Kaur H, Mallikarjuna N, Devlash RK, Basandrai A, Chandrashekara C, Kumar V, Singh SK, Kumar P, Kalppanavar, IK, Behera, P (2016) Climate resilient options for management of maize diseases in India. Indian Phytopathology 69(4s): 355-357.
11. Hooda KS, Khokhar MK, Shekhar M, Chikkappa GK, Kumar B, Mallikarjuna N, Devlash RK, Chandrashekara C, Yadav OP (2016) Turcicum leaf blight—sustainable management of a re-emerging maize disease. Journal of Plant Diseases and Protection. doi: 10.1007/s41348-016-0054-8.
12. Hooda, KS, Singh V, Bagaria P, Gogoi R, Kumar S, Shekhar M (2016) Emerging biotic constraints to maize production in the global climate change-An overview. Maize Journal 5(1&2): 1-13.
13. Jat HS, Jat RK, Singh Y, Parihar CM, Jat SL, Tetarwal JP, Sidhu HS, Jat ML (2016) Nitrogen Management under Conservation Agriculture in Cereal Based Systems. *Indian Journal of Fertilisers 12(4): 76-91.*
14. Jat ML, Jat HS, Jat RK, Tetarwal JP, Jat SL, Parihar CM, Sidhu HS (2016) Conservation agriculture-based sustainable intensification of cereal systems for enhancing pulse production and attaining higher resource-use efficiency in India. Indian Journal of Agronomy 61(4^{th} IAC Special issue): S182-S198.gh B, Saveipune D (2017) Plant density and fertilization in hybrid quality protein maize (*Zea mays L.*): Effects on the soil nutrient status and performance of succeeding wheat (*Triticum aestivum*) and productivity of cropping system. Indian Journal of Agricultural Sciences 87(1): 23-28.
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Patel JM, Kumar V, Parihar CM, Jat SL, Singh V, Yathish KR, Das A, Sekhar JC, Bhati P, Kaur H, Kumar M, Singh A K, Varghese E, Yadav OP (2016) Selection indices to identify maize (*Zea mays* L.) hybrids adapted under drought stress and normal ecologies in tropical climate. Crop and Pasture Science. doi: 10.1071/CP16141.

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19. Kumar B, Hooda KS, Singh V, Sekhar JC, Kumar V, Parihar CM, Jat SL, Singh AK, Kaul J, Kaur H, Kaur H, Yadav OP (2017) Multi-environment field testing to identify stable sources of resistance to charcoal rot (*Macrophomina Phaseolina*) disease in topical maize germplasm. Maydica 62: 1-7.

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27. Kumar S, Parihar SS, Singh M, Jat SL, Meena BL, Mirjha PR, Ram H (2016) Conservation agriculture practices and irrigation scheduling affects the energy dynamics in a maize production system. *Ecology, Environment and Conservation* 22(2): 485-491.

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Books Edited

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Annexure 8

Personnel, transfers, new joinings, superannuation, promotions

Name	Designation	Discipline
Indian Institute of Maize Research, PAU Campus, Ludhiana		
Dr. Sujay Rakshit	Director	Plant Breeding
Dr. Vinay Mahajan	Principal Scientist	Plant Breeding
Dr. K.S. Hooda	Principal Scientist	Plant Pathology
Dr. Dharam Paul	Senior Scientist	Plant Biochemistry
Dr. Ramesh Kumar	Senior Scientist	Plant Breeding
Sh. Vishal Singh	Scientist	Plant Breeding
Sh. Yatish K.R **	Scientist	Plant Breeding
Ms. Sapna**	Scientist	Plant Biochemistry
Sh. Abhijit Kumar Das**	Scientist	Plant Breeding
Dr. Alla Singh	Scientist	Agricultural Biotechnology
Sh. Mukesh Choudhary	Scientist	Plant Breeding
Sh. Pravin Kumar	Scientist	Plant Pathology
Smt. Mamta Gupta	Scientist	Plant Biotechnology
Dr. Pardeep Kumar	Scientist	Plant Breeding
Mrs. Seema Khatter	PS to Director	
Mrs. Kamlesh Malik	Assistant	
Ms. Chinky Aggarwal	Assistant	
Mr. Dharambir Singh	Senior Clerk	
Sh. Amar Nath	SSS	
Sr. 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. Aditya Kr. Singh	Principal Scientist	Agronomy
Dr. M. L. Jat*	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. Pranjal Yadav*	Scientist	Agricultural Biotechnology
Ms. Avni	Scientist	Agricultural Biotechnology
Dr. Krishan Kumar	Scientist	Agricultural Biotechnology
Sh. Anwar Ali	SSS	
Winter Nursery Center, Hyderabad		
Dr. J.C. Shekar	Principal Scientist	Entomology
Dr. N. Sunil	Senior Scientist	Plant Breeding
Dr. P. L. 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	

* On Deputation ** On study leave

Staff Position of ICAR – IIMR as on 31st March, 2017

Type of post	Approved by D/O expenditure	In Position	Vacant
Scientific	40	28	12
Technical	05	03	02
Administrative	13	04	09
Supporting	03	03	00
Total	**61**	**38**	**23**

Superannuation:Nil

Transfers

Name	Date of Transfer from IIMR	Transferred to
Dr. Jyoti Kaul	02/09/2016	IARI, New Delhi
Dr. Ashok Kumar	16/11/2016	ICAR, Headquarters
Dr. K. P. Singh	18/08/2016	ICAR, Headquarters
Dr. Nirupama Singh	29/08/2016	IARI, New Delhi
Dr. C.M. Parihar	31/08/2016	IARI, New Delhi
Dr. Ambika Rajendaran	30/06/2016	IARI, New Delhi
Sh. H. C. Ghildyal	13/01/2017	IARI, New Delhi
Ajay Kumar Singh	15/05/2016	IARI, New Delhi
Raj Kishor Singh	26/07/2016	IARI, New Delhi

New Joinings

Name	Date	Place	From
Dr Sujay Rakshit	23/03/2017	ICAR-IIMR	Director
Dr. Alla Singh	11/04/2016	ICAR-IIMR	New ARS Joining
Sh. Mukesh Chaudhary	11/04/2016	ICAR-IIMR	New ARS Joining
Sh. Pravin Kumar Bagaria	11/04/2016	ICAR-IIMR	New ARS Joining
Smt. Mamta Gupta	11/11/2016	ICAR-IIMR	DMR, Solan
Dr. Pardeep Kumar	03/02/2017	ICAR-IIMR	CPRI, Shimla

Annexure 9

Annual Financial Statement

Financial Expenditure (2016-17)								
	2016-17 Sanctioned Budget (Rupees)				2016-17 Expenditure (Rupees)			
Head of Account	Plan	Plan Schemes	Non-Plan	AICRP on Maize	Plan	Plan Schemes	Non-Plan	AICRP on Maize
Grant in Capital					30,00,000.00		10,00,000	
Grant in Salary					-----		45150000	
Grant in General	4,20,00,000	18,09,31,773	7,99,00,000	162033139	3,90,00,000	18,09,31,773	33490896	155933139
TSP							------	6100000
Total	4,20,00,000	18,09,31,773	7,99,00,000	162033139	4,20,00,000		79640896	162033139

Resource Generation	
Particulars	**In Rupees**
Sale of Farm produce	5744108
Sale of publications and tender documents	------
Standard License fee	------
Analytical and testing fee	1530000
Receipts from Service rendered	------
Interest earned on short term deposits	------
Income generated from IRG	------
Training miscellaneous receipts	90000
Total	21134108

Funds received for externally funded projects (Rupees)	
Particulars	**In Rupees**
FLD	2331100
DUS Testing	2170485
BMZ(CRMA) Project	867333
Host-Pathogen interaction Project	800000
Total	6168918

Annexure 10

Annual Physical and Financial Targets and Achievements (April 2016 to March, 2017)
Indian institute of Maize Research, Ludhiana

A. Physical targets and achievements

S No	Category	Total No. of Employees	No. of trainings planned for 2016-17 as per ATP	No. of employees undergone training during April-Sept 2016	No. of employees undergone training during Oct 2016 to March 2017	Total no. of employees undergone training during April 2016 to March 2017	% realization of trainings planned during 2016-17
1	2	3	4	5	6	Col. 5 + 6 =7	Col. 7*100/ Col. 4 = 8
1	Scientist	23	5	1	4	5	100
2	Technical	3	2	2	0	2	100
3	Administrative & Finance	4	2	2	0	2	100
4	SSS	3	3	0	3	3	100
Total		33	12	5	7	12	100

B. Financial targets and achievements (All employees)

S.No	RE 2016-17 for HRD			Actual Expenditure up to 31st March, 2017 for HRD			% Utilization of RE
	Plan	Non-plan	Total	Plan	Non-plan	Total	
	(Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)	2016-17
1	2	3	2+3=4	*5*	*6*	Col. 5+6=7	Col. 7*100/ Col.4=8
1	2.40	2.00	4.40	2.39	1.98	4.37	99.31

C. Category-wise trainings attended by employees during 2016-17
C 1 - Category: Scientists

S No	Name of employee	Designation	Discipline /Section	Name of training programme attended	Actual Expenditure incurred (Rs)	Entered in ERP system (Yes/ No)	Concerned Employee attended training as per ATP 2016-17 (Yes/No)	If no, the reason thereof
1	Dr. Krishan Kumar	Scientist	Agrl Biotechnology	DNA Bar coding and finger printing	0.00	Yes	Yes	
2	Dr. Neelam Sunil	Scientist	Plant Breeding	Phenotyping for crop improvement	2574.00	Yes	Yes	
3	Dr. P. Laxmi Soujanya	Scientist	Agrl Entomology	Nanotechnology pest forecast module	0.00	Yes	Yes	
4	Dr. Chikkappa, GK	Scientist	Plant Breeding	Recent analytical techniques in statistical genetics and genomics	0.00	Yes	Yes	
5	Dr. K.S. Hooda	Principal Scientist	Plant Pathology	Plant quarantine national regulations and procedures	0.00	Yes	Yes	

C 2 Category: Technical staff

S No	Name of employee	Designation	Discipline /Section	Name of training programme attended	Actual Expenditure incurred (Rs)	Entered in ERP system (Yes/No)	Concerned Employee attended training as per ATP 2016-17 (Yes/No)	If no, the reason thereof
1	Mr. Rahul	Technical Assistant	Technical	Computer application	2405.00	Yes	Yes	
2	Mr Kamal Vats	Technical Assistant	Technical	Farm management	9320.00	Yes	Yes	

C 3 -Category: Administrative staff

C 4 - Category: SSS

S No.	Name of employee	Desig-nation	Discipline / Section	Name of training programme attended	Actual Expenditure incurred (Rs)	Entered in ERP system (Yes /No)	Concerned Employee attended training as per ATP 2016-17 (Yes/No)	If no, the reason thereof
1	Mr Dharambir	Sr. Clerk	Admin	FMS-MIS/ERP	0.00	Yes	Yes	
2	Ms Chinky	Assistant	Admin	FMS-MIS/ERP	0.00	Yes	Yes	

S No	Name of employee	Discipline /Section	Name of training programme attended	Actual Expenditure incurred (Rs)	Entered in ERP system (Yes/No)	Concerned Employee attended training as per ATP 2016 -17 (Yes/No)	If no, the reason thereof
1	Mr. Anwar Ali	SSS	Diary, dispatch and record management	2715.00	Yes	Yes	
2	Mr. Amar Nath	SSS	Diary, dispatch and record management	0.00	Yes	Yes	
3	Mr. Ram Kishan	SSS	Diary, dispatch and record management	0.00	Yes	Yes	

D - Number of trainings organised for various categories of ICAR employees including winter/summer schools and short term trainings

S. No.	Category	No. of trainings organised during April 2016 to September 2016	No. of trainings organised during October 2016 to March 2017	Total no. of trainings organised during April 2016 to March 2017	No. of participants (Only ICAR employees)		
					Organizing Institute	Other ICAR Institutes	Total
1	2	3	4	Col. 3+4=5	6	7	6+7=8
1	Scientist	NIL	NIL	NIL			
2	Technical	NIL	NIL	NIL			
3	Administrative & Finance	Nil	Nil	Nil			
4	SSS	0	1	1	3	0	3
Total							


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