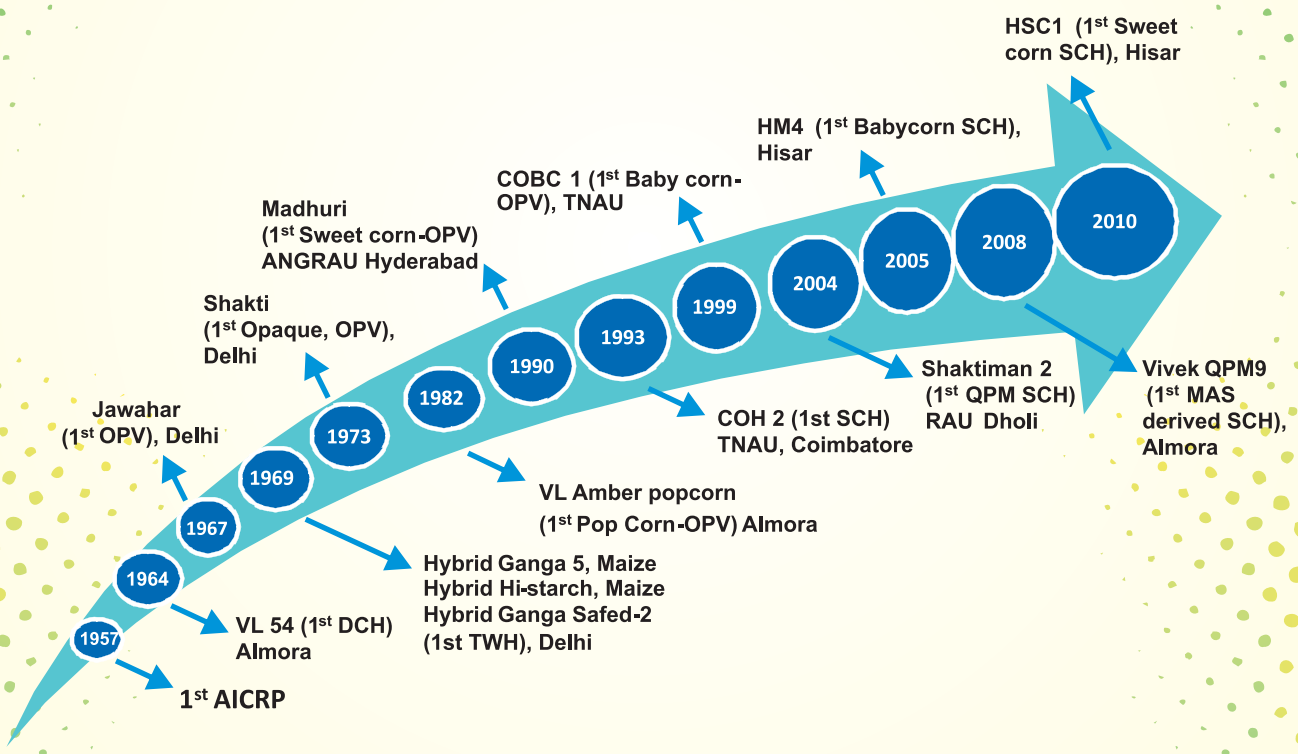
ANNUAL REPORT
2015-16

ICAR–Indian Institute of Maize Research
Pusa Campus, New Delhi-110012
India

Timeline of AICRP Maize Achievements

First Hybrids/OPV notified in Maize AICRP



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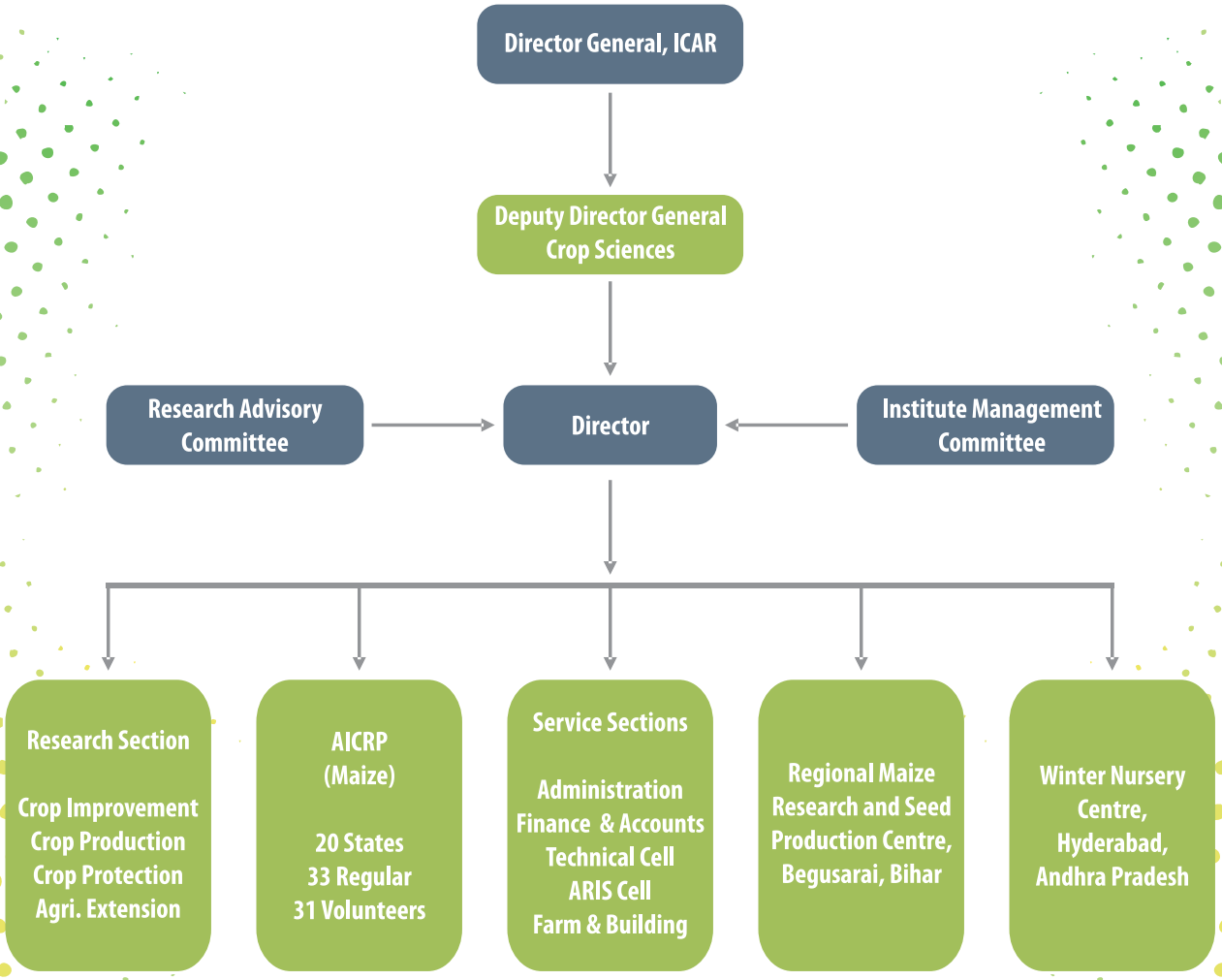
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Andhra Pradesh

Letter from the Director

ICAR-Indian Institute of Maize Research (IIMR) sustained its strong presence in maize research and the Institute focus around major theme areas - Crop Improvement, Crop Management, Crop Protection and Out-reaching to the individual needs of all the partners. The demand for maize is constantly increasing in view of growing demand from poultry, livestock, industrial and export sectors. In last decade, maize production has registered the highest growth rate among all cereals because of enhanced feed and industrial requirements. In India, the production of maize witnessed a significant increase of more than 14 times from a mere 1.73 million tons in 1950-51 to 24.17 million tons in 2014-15. Presently it occupies 9.23 million hectare area with the mean yield of 2.56 tons/hectare.

The achievements of IIMR are remarkable despite more than 70% of maize area being under rainfed and low input conditions. Next year the 2017, All India Maize Coordinated Programme is completing 60 years of wonderful achievements. Since its inception, the maize coordinating programme has released more than 300 hybrids/OPVs for cultivation in varied production ecologies of the country, but the real boost has come in last 25 years, the programme has released its first "Single Cross Hybrid' 'COH 2' in 1993 from TNAU, Coimbatore. During the period 226 hybrids/OPVs were released and notified and more than 2500 qt breeder seed was produced. Among them, 13 SCH have been shared so far with 17 private seed sector companies.

Since 2003, IIMR has shared more than 31000 germplasm lines and registered 98 genetic stocks. IIMR has registered 47 hybrids and 36 composites with PPV&FRA. In last 10 years, the new technologies have been exhibited to the farmers throughout the country with more than 50000 front line 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). IIMR has been sharing germplasm lines to 25 to 30 AICRP centres every year.

Emphasis is given to biotic and abiotic stresses with special efforts in the field of tillage management in different cropping system, nutrient and weed management, cropping system and moisture conservation. Five years of rigorous evaluation has resulted in short listing of 34 maize inbred lines with multiple disease resistance. Number of promising genotypes were identified with biochemical basis of resistant traits favouring PFSR resistance in the host plant. The biochemistry laboratory is a centralized analytical facility that caters to the needs of maize breeders across India and does a pivotal role in developing maize hybrids for quality parameters especially 'Quality Protein Maize'.

We will be marking 'Diamond Jubilee' in 2017 and this year is a time to look back how these six decades of hard work had contributed to the well-being of the maize growers as well as the end users. It is also the appropriate time to look forward and strategize on how the Institute can remain a torch bearer over the coming decades as it works towards a healthy and sustainable national food system.

I express my heartful thanks and sincere 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 programme.

Vinay Mahajan
Director

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

Overview

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 build around two major theme areas- Crop Improvement and Crop Management. The institute also coordinates the All India Coordinated Research Project on Maize and also carries out extension and outreach programmes.

During 2015-16, 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.

Germplasm collection, evaluation and characterization

Induction of new germplasm is one of the important processes to diversify the existing germplasm base to continuously support the inbred-hybrid development programme of maize. This year, 158 segregating lines (S_3) were procured from The International Maize and Wheat Improvement Center (CIMMYT), Mexico and were advanced through selfing from S_3 to S_4. In addition 1685 segregating inbred lines (S_3-S_7) were advanced through selfing as part of development of new inbred lines. A total of 1515 inbred lines /germplasm lines were evaluated. Under the Consortium Research Platform on Agro-biodiversity, 2500 accessions of maize were characterized as per 30 common descriptors at five centres. Further, development of maize germplasm decision support database has been initiated at the Winter Nursery Centre. The database allows selection of various inbred lines with different permutations and combinations of the 13 traits along with high-quality images of the tassels and the cobs. This database, which is a systematic documentation of the maize inbred germplasm, would be helpful for breeders in the selection of parental lines based on needs and requirements of various research programmes. A step towards precision phenotyping has been initiated at the Winter Nursery Centre, ICAR-IIMR using the 'Fieldlog' software developed at CIMMYT, Hyderabad. The android based software installed in a data recording handset enables us to capture data in the field in the digital form which

can be saved as excel format thus enabling enhanced precision in field trials, saving time and precluding errors while documenting data from manually recorded data sheets.

Germplasm for combating biotic stresses

In order to identify superior germplasm that is intrinsically resistant to various biotic stresses, extensive screening of material is being conducted. A total of 112 maize lines were evaluated against major diseases at different hot spot locations under artificially created epiphytotic condition during *kharif* 2013 to 2015 (three years). Out of them, 47 lines exhibited multiple disease resistance. Plant phenolics are secondary metabolites responsible for host resistance. In order to know the response of some identified resistant inbred lines to pathogens *M. phaseolina* and *F. verticilloides*, biochemical analysis was done in inoculated and un-inoculated plants in field conditions. Overall, highest amount of total phenolic compound (TPC)-189.27 mg/100g; total soluble sugar (TSS)-82.71 mg/100g and total flavonoid acids (TFA)-46.29 mg/100g on dry weight basis was estimated in mixture purple genotype (3 lines) and PFSR (Y)-CO1×-4-1×-1-1-13×-1-1-1 lines derived from pools. Recombinant Inbred Line (RIL) mapping populations derived from crosses CML269 × HKI4C4B, P72clXbrasil1177-2 × ESM 113 genotypes have been developed to map Maydis leaf blight (MLB) resistance through bulk segregants analysis. The parental polymorphism survey along with resistant and susceptible bulks has been completed using microsatellite markers. The polymorphism between resistant and susceptible bulk has putatively identified the genomic region for MLB resistance on chromosome 1. Further, molecular markers linked to gene(s) governing sorghum downy mildew (SDM) and banded leaf and sheath blight (BLSB) resistance are being validated. For identification of insect resistance germplasm, a total of 38 genotypes were screened against *Chilo partellus*, of them ten lines recorded leaf injury rating of less than resistant check. Another 25 were moderately resistant. One hundred and twelve early lines were screened against Pink stem borer, only four lines recorded leaf injury rating less than 3.0. Sixty six lines were evaluated against shoot fly, *Atherigona soccata* for the third year, and the line WS 2 was found to be most promising as no dead hearts were formed. A total of 43 inbred lines were screened for *S. oryzae* lines and three lines were found to be moderately resistant.

Germplasm for combating abiotic stresses

Abiotic stresses pose significant yield reduction and development of superior germplasm resilient to abiotic stresses is a major goal for the institute. A total of 48 inbred lines were evaluated for cold, heat and drought stress tolerance. Based on the seedling stage data, five lines *viz.,* EC 639538-2, DML 1620, DML 1610, EC 632066-1, Z 172-338-2 and DML 1104 were found tolerant to cold stress, whereas for drought tolerance, following lines *viz.,* DML 1094, AZ-14, DML 1568, DML 1126, DML 1230, DML 1635, DML 1687 and DML 1451-1 were identified tolerant on the basis of Anthesis-Silking Interval. In addition, a sub set of 22 and 28 RILs out of 221 $F_{6:7}$ RILs were developed by advancing F_1 generated by crossing heat stress tolerant inbred (LM17) with heat stress sensitive inbred line (HKI 1015-wg8) were crossed with inbred tester LM13 and LM14, respectively to understand the behaviour of inbred lines under heat-stress condition. The two sets of test-crosses generated were evaluated during spring 2015. Out of 26 morpho-physiological parameters studied, 13 parameters showed significant differences among test-crosses indicating considerable variation among RILs. Further, the association studies showed that chlorophyll content was in strong positive association with grain weight (0.30), leaf breath (0.50), leaf colour (0.59), leaf length (0.54), stem diameter (0.52) and stem vigour (0.53). Similarly, barrenness showed very high and negative association with grain weight (-0.42). The identified RILs can be used for developing stress resilient hybrids in future by using RILs as one of the parental lines.

Germplasm for enhanced quality

A set of 60 Quality Protein Maize (QPM) inbred lines was evaluated for grain yield and its attributing traits. On the basis of morphological data, cluster analysis was done to see the genetic diversity among these lines. Five major clusters have been formed. A set of 34 newly developed QPM lines was crossed with CML 161 and CML 165 for generating test crosses. The test crosses were evaluated for grain yield, and the grain yield data was used to group inbred lines into different heterotic groups. A set 259 experimental hybrids was evaluated during *kharif* 2015 and 19 promising QPM lines have

been identified which are having good yield as well as tryptophan and lysine content. During the period under review, around 1600 samples (mostly inbreds) were analyzed for protein quality and other nutritional components and the promising materials was identified and the information supplied to the concerned breeder. A promising inbred (HP704-9) containing more than 6 ppm of b-carotene was identified during carotenoids profiling of maize germplasm.

CRISPR/Cas 9 based genome editing for novel trait development

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. In order to establish the proof of concept of gene editing in a tractable model system, like *Arabidopsis* and then scale-up to edit maize gene for herbicide resistance trait development, the phytoene desaturase (PDS) gene of *Arabidopsis thaliana* (Col 0) was targeted. A 20 bp sequence with NGG region at its downstream and minimum number of off-targets was selected as the targeted loci in both the genes. Using CRISPR/Cas 9 techniques, the gene editing construct has been developed.

Optimization of *in-vitro* regeneration system for tropical maize using mature embryos

So far, almost all the maize tissue culture and transformation protocols involve the use of immature zygotic embryos as an explant. However, immature embryos are seasonally available and have strictly limited suitable duration of culture. Therefore, optimization of *in-vitro* regeneration system using mature embryos was taken up. Out of nine tropical maize inbred lines selected for optimization of protocol, embryogenic calli were induced in BML7, HKI-163, DMI-51, and DMI-63 genotypes.

Transcriptional profiling of phosphate and nitrate responsive genes and small RNAs

Low concentration of nitrate and phosphate in the Indian soils are major constraints for maize growth and development. There is tremendous scope of enhancing nutrient use efficiency of plants through genetic enhancement. 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 developed. It was revealed that, both under low nitrate and phosphate, there are major changes in plant root architecture. Quantitative Realtime PCR analysis identified the expression pattern of the nitrate and phosphate responsive genes in several metabolic pathways, whose expression was modified under different nutrient levels in the root zone. The RNA from root and shoot samples of these stressed and unstressed plants were subjected to deep sequencing on Illumina HiSeq platform. More than 300 million reads of transcriptomic data was generated.

Hybrid development and evaluation

Development of new hybrids is the final aim of the crop improvement programme. As a precursor to hybrid development, the institute also undertook evaluation of experimental cross-combinations and hybrids. During year 2015-16, in total 2925 experimental cross combinations were generated and evaluated at station trials as part of development of normal maize hybrids under different programmes viz., extra early and early maturity, and different ecologies, line eastern India. Out of which 45 cross combinations extra early and early maturity were generated by following diallel mating design were evaluated at four locations. Among the tested entries, the most desirable hybrids were DE1519 and DE1537 because of their high stability along with high mean yield across locations. Five single cross hybrids viz., DE1515 (21.1%), DE1501 (18.6%), DE1519 (14.9%), DE1539 (13.8%) and DE1542 (11.1%) exhibited more than 10% heterosis over the best check 'Vivek Maize Hybrid 43'. Under hybrids for different ecologies, 780 experimental hybrids were evaluated under station trials during *rabi* 2014-15. Out of which, 32 best promising combinations were identified and 16 were selected for seed increase. The station trials has identified the following promising hybrids *viz*., DML 1409 x LM 5, DML 1856 x LM 17 and DML 1364 x LM 17 with 6-23 percent superiority over the best check Bio9780. The new promising hybrids were contributed to different stage of testing during the year and total 12 hybrids in *kharif* and 3 during *rabi* were got promoted to second and third year of testing.

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 and insect pest management on the other hand.

Tillage, nutrient and cropping system management

The institute is evaluating the long term effects of various tillage practices, *viz*. permanent bed, zero tillage flat and conventional till. The results demonstrated that, when grown in rotation with *kharif* maize, all the succeeding *rabi* season crops (except wheat) resulted in maximum yields and economic returns under zero tillage; however wheat yield was recorded maximum in permanent bed plots(2014-15). The yield of *rabi* maize, chickpea and mustard were increased by 23.1, 25.6 and 27.4% under zero tillage over conventional till planting, respectively, whereas the wheat grain yield was 23.7% higher in permanent bed over conventional tillage. Proper nutrients management under conservation agriculture is crucial to its success. In order to explore the feasibility of one time application of coated nitrogen fertilizer like *neem* or sulphur coated urea under conservation agriculture, an experiment was started in July 2012 for intensified maize-based systems. The combined analysis of four years data revealed that the one-time neem coated urea application was beneficial under conservation agriculture. Further, the application of residue has led to significant enhancement in system productivity by 910 kg/ha over without residue. Incorporation of crop residue of previous crop and application of fungal consortia in maize wheat-mungbean cropping system enhanced the yield of all three crops *i.e.* maize, wheat and mungbean to the tune of 5.8 and 106; 4.2 and 18.2; and 11.3 and 27.7% over with and without crop residue incorporation, respectively. Moreover, site specific nutrient management improved maize grain yield over absolute control, but it remained at par with that of 100% recommended dose of fertilizer. In cropping system management, the compatibility of two inter-crops *viz*. mungbean and cowpea were tested in different maize hybrids during *kharif* season of 2015. Inter-cropping of mungbean and cowpea significantly reduced the maize yield to the tune of 4.05 and 10.1%, respectively compared to maize sole. However, the system productivity data in terms of maize equivalents showed that of inter cropping of mungbean in maize resulted in the highest productivity, which was 53.8 and 13.4 per cent higher than maize sole and maize + cowpea intercropping, respectively.

Insect pest management

Crop management practices have a profound impact on incidence of insects and diseases. Insects and diseases and can be agronomically managed though various interventions. In the insect management aspect, the incidence of green semi looper, *Chrysodeixis acuta* (Walker) (Noctuidae: Lepidoptera) has been observed for the first time on maize crop grown in Winter Nursery centre, Rajendranagar, Hyderabad, during second week of September, 2015 recording 1-2 larvae/ cob and completely disappeared during 2nd week of October, 2015. Parasa Lepida Cram commonly known as nettle caterpillar was observed on maize crop during the month of October, 2015 at Mandya in Karnataka. It belongs to the family Limacodidae, order Lepidoptera. Young larvae feed on leaf epidermis and as they grow, defoliate the maize plant severely leaving only the midrib. Natural available plants were evaluated for insecticidal activities against *S. Oryzae*. Ethyl acetate and hexane extracts of *Tinospora cordifolia* and the solvent eluted fractions were evaluated against *S. oryzae*. Among all the fractions, TCH25% and TCH 50% at 1% concenteration exhibited highest repellency of 86.22 and 79.11%, respectively towards *S. oryzae*. Hexane, ethyl acetate and methanol plant extracts from leaves of *Strychnos nux-vomica* were also evaluated against *S. oryzae*. Ethyl acetate extract of *S. nux-vomica* was most active compared to hexane and methanol extracts at all concentrations.

AICRP ON MAIZE

Apart from its core research activities, the institute also supports and coordinates maize research programmes of various agricultural universities through All India Coordinated Research Project on Maize (AICRP-Maize). As new initiative, the AICRP zones have been re-named so that it is easy to understand by everyone. The zones which are renamed are Zone I (North Hill Zone); Zone II (North West Plain Zone); Zone III (North East Plain Zone); Zone IV (Peninsular Zone)

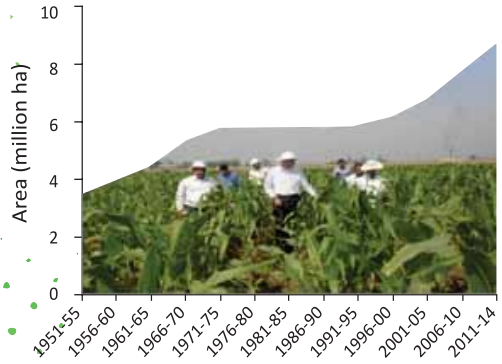
and Zone V (Central-western Zone). Since Initial varietal trial (IVT) trials are conducted throughout the country across zones in all the states, hence it is worthwhile to rename IVT as National Initial varietal trial (NIVT). The promotion/ release criteria have also been modified. Only those entries will be promoted which are within non-significant group to the best entry (rank-1 entry) at CD 10% for NIVT to AVT-1 and at CD 5% (from AVT-1 to AVT-2), respectively. In addition, the qualifying entry shall be numerically superior to the best check as well as five years yield mean of the released hybrids in the category (maturity and trials).

During *kharif 2015*, 343 maize entries were evaluated in all India coordinated trials. Of 343 entries, 219 entries were evaluated in national initial varietal trial (NIVT), 40 in advance varietal trial-I (AVT-I), 18 in advance varietal trial-II (AVT-II), 30 entries in quality protein maize (QPM), and 36 in specialty corns trials (17 in baby corn, 10 in sweet corn, and 9 in popcorn trials). Of total entries received, 221 contributed by public and 122 by the private sector. Fifteen breeding trials (four each of NIVT, AVT-I, specialty corns and three of AVT-II) were constituted for evaluation at 64 locations (33 regular and 31 volunteers) across country. Data received from 54 locations, were reviewed, analyzed for yield and related traits and performance of varieties compared with respective checks. Based on superiority, 24.1% (76 out of 315) entries were promoted to their advance stage. Further four essentially derived varieties (EDV) of QPM *viz*., AQH8 (PZ), AQH4 (NWPZ), AQH9 (NEPZ) and APQH9 (NHZ, PZ) developed by marker assisted selection (MAS) were tested in final year trial. During *rabi* 2014-15, a total of 128 maize entries were evaluated in 9 different breeding trials at 17 locations across four zones and 103 entries were promoted. In 2015-16, 51 test entries were promoted for their advance generation in addition to that,112 entries were received for testing in AICRP and 63 entries were received in NIVT, 24 in AVT-I, 23 in AVT-II, and 2 entries were in QPM trials. Further, in total, 35 were contributed from public sector and 77 from private partners. All trials are under testing at 17 locations across country. The various AICRP centres also carried out diverse research activities in plant breeding, agronomy, pathology, nematology, and entomology.

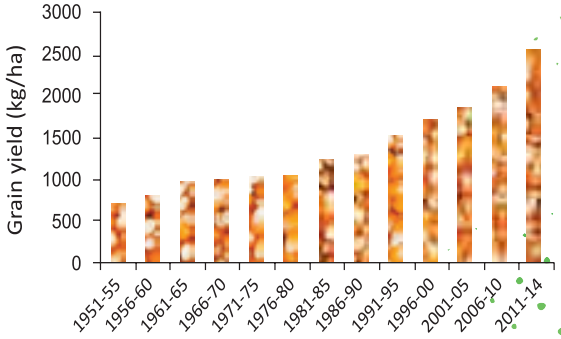
EXTENSION AND OUTREACH

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, 209 hectares demonstrations were carried out at tribal farmer's field by IIMR through its AICRIP centres in different states. The average yield under the demonstration varied from 3,441 kg/ha to 7,500 kg/ha with 12.0 % to 34.6% increase over state average yield during *rabi,* 2014-15 and 2,420 kg/ha to 5,090 kg/ha with 39.1% to 186.3 % increase over state average yield during *kharif,* 2015. The Institute organized six National Level Training programmes for tribal farmers in which, 224 tribal farmers from ten states were trained. AICRIP centres conducted 17 Regional training programmes and 17 field days, wherein more than 2,300 tribal farmers were exposed to latest technologies. To uplift the economic conditions of the farmers seed of improved maize hybrid, maize sheller, literature, biofertilizer, vermicompost, seed storage bin, Line Marker, Kunte, Tarapaulins, knapsack sprayer were provided to them. To promote improved maize production technologies in the North Eastern Himalayan Region of India, different activities like demonstrations, trainings, farm input distribution were organized in four districts of Manipur in collaboration of ICAR Research complex for NEH Region, Manipur. The demonstrations were undertaken on 60 ha area and number of beneficiaries was 59. Six trainings on various aspects before sowing and during crop growing stage in selected district were also conducted and 276 persons were trained. The institute participated in various exhibitions and it also organized *"Kisan Vaigyanik Sanvad'* on the birth day of Hon'ble former prime minister Sh. Atal Bihari Vajpayee and to remember the contributions of Hon'ble former Prime Minister Chaudhary Charan Singhji on 25 December, 2015. The institute also participated in various exhibitions, farmer's fairs, trade fairs etc. The year was also marked with various activities and official events organized by the institute.

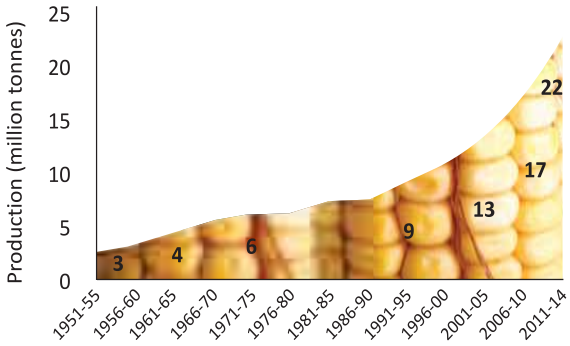
Three times increase in area



Four times increase in productivity



Seven times increase in production



Mandate

- *Basic and strategic research aimed at enhancement of productivity and production of maize, including specialty corn*
- *Coordination of multi-disciplinary and multi-location research to identify appropriate technologies for varied agro-climatic conditions*
- *Dissemination of improved technologies, capacity building and developing linkages*

Glorious 60 Years of Maize Breeding

Maize has the earliest coordinated program. The first trials started in 1957 and the first maize workshop was held in 1958. The program started with an emphasis on hybrids and the first hybrid was notified in 1964 (VL 54). However, due to none availability of productive inbreds leading to the uneconomical hybrid seed production the emphasis, in sixties and seventies, was shifted to composite breeding in public sector, while the private sector the shift was towards mutli-parent hybrids approach to address the problem of economic seed production. Thus, first OPV was notified in 1967 (Jawahar) and the first TWC was notified in 1969 (Hybrid Ganga 5), in these years maize breeders had emphasized on the development of productive maize inbreds with a target of economic seed production. However, with the development of productive inbred lines the SCH took the emphasis in nineties onwards and the first single cross hybrid (SCH) was notified in 1993 (COH 2). Since than 106 hybrids were released and notified by public and private sector.

Simultaneously, the emphasis was on breeding for quality parameters and the first OPV Quality Protein Maize (QPM) was notified in 1973 (Shakti) and SCH QPM in 2004 (Shaktiman 2). The first QPM hybrid developed through MAS was in notified in 2008 (Vivek QPM 9) by VPKAS, Almora. In addition, first popcorn (OPV) was notified in 1982 (VL Ambar popcorn) and first baby corn (OPV) was notified in 1999 (COBC-1) and SCH in 2005 (HM 4), On the other hand, Madhuri was the first OPV sweet corn was notified in 1990 and SCH sweet corn in 2010 (HSC 1).

Since 1991, with an emphasis on SCH, there is continuous increase of maize yields in all the zones. The remarkable efforts of AICRP on maize are evident from the fact that presently the trial productivity in all the zones has reached upto 7000-9000kg/ha in late maturing crop. The gain is 117kg/ha/year in NWPZ; 246kg/ha/year in NEPZ; 100kg/ha/year in PZ and 113kg/ha/year in CWZ, in late maturity maize. The overall gains are highest in NEPZ and lowest in NWPZ which may be attributed to lowest yields of around 2500kg/ha in 1991 in NEPZ. Based on Compound Annual Growth Rate (CAGR) in different agro-climatic zones exhibited lowest CAGR was in NWPZ and the highest CAGR in NEPZ.

Among the 226 hybrids and composites notified in last 25 years, (Fig. 1 & 2) more hybrids were released by public sector (73) than private sector (33). Until 2010, public sector has been emphasizing more on the SCH, however in last five years private sector is giving more emphasis on SCH over multi-parent hybrids. In last 15 years. Public sector has reduced its emphasis on composite breeding and concentrating on SCH. Even though private sector is leading in high input area, while the public sector is emphasizing on stress and remote areas, thus complimenting each other in increasing maize production in the country.

Since 1995-96, the hybrid technologies were demonstrated in 49404 FLDs which includes normal hybrids (48369), sweet corn (112), baby corn (677), popcorn (31) and seed production (215).

The NIVT formerly called as IVT is evaluated all over the country in all the maturity groups *viz.* early, medium and late. The 30 regular centres of AICRP were now increased to 34 centres along with 31 volunteer centres, spread over five agro-climatic

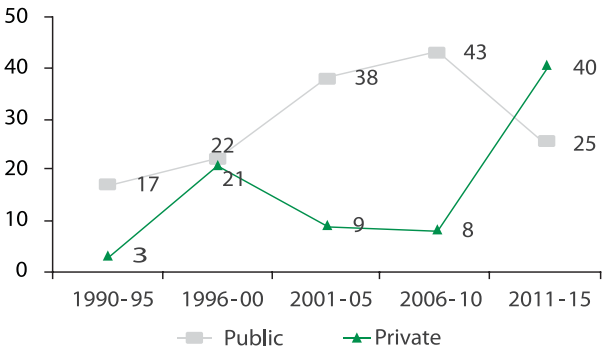


Figure 1. Total Hybrids/Composites Notified

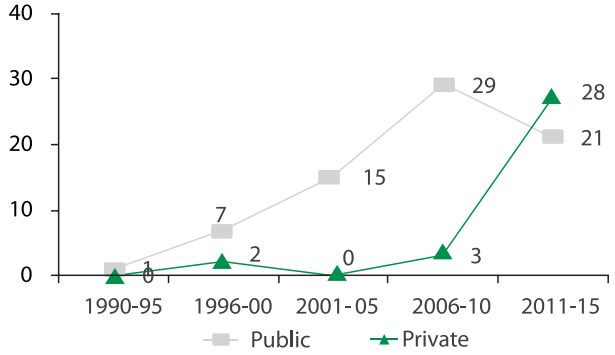


Figure 2. SCH Hybrids Notified

zones *viz*. Zone I (North Hill Zone); Zone II (North West Plain Zone); Zone III (North East Plain Zone); Zone IV (Peninsular Zone) and Zone V (Central-western Zone).

In past, the entries in the coordinated trials were promoted on the basis of 10% yield advantage over the best. Presently, the promotion of entries will be on statistical basis wherein, the entries will be promoted on the basis of first non-significant group from the best entry (Rank 1) but are numerically superior over the best check of the trials at CD (*P*=0.05). In order to support the breeding program of up-coming centers 'Pre-breeding Maize Nursery' and 'Superior Segregating Nursery' will be provided.

The results of last 25 years reveal, highest percent of entries were promoted from 'IVT' to 'AVT I' in extra-early maturity group while maximum promotion was from 'AVT I' to 'AVT II' in full season maize.

The results of last 25 years on the mean performance of 'IVT', 'AVT I' and 'AVT II' trials as well as the best entry in zones NWPZ (Fig. 3), NEPZ (Fig. 4), PZ (Fig. 5) and CWZ (Fig. 6) in full season maize trials revealed that there was marginal change in 'IVT' and 'AVT I' trials and best entry. However there is reduction in yield for the best entry as well as mean trial from 'AVT I' to 'AVT II'.

Since 2003, 19322 germplasm were demonstrated and 31048 were shared. The germplasm were shared with around 30 center/SAUs every year. In addition, ninety-eight genetic stocks are registered for different characters. Since 2005, 7314 new diverse

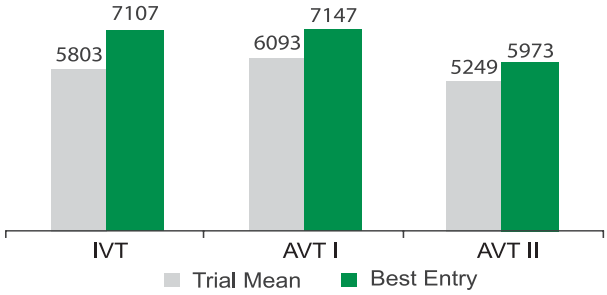


Figure 3. North Western Plains Zone

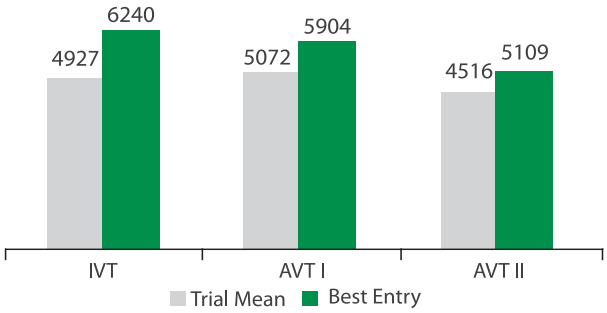


Figure 4. North Eastern Plains Zone

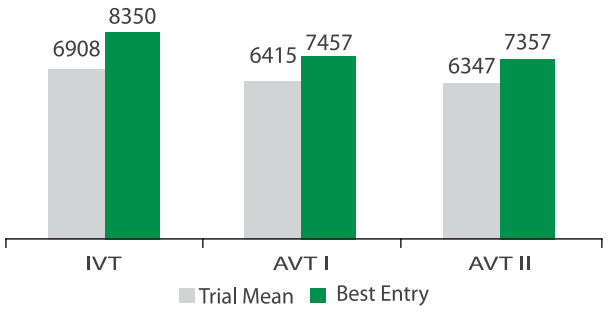


Figure 5. Peninsular Zone

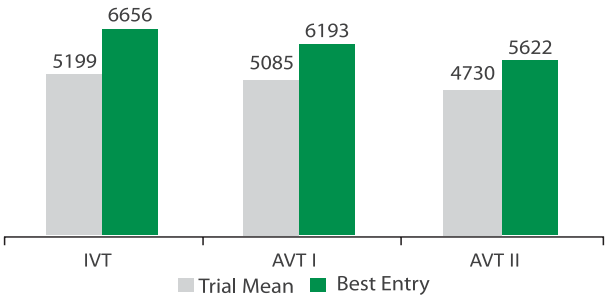


Figure 6. Central Western Zone

germplasm received from NBPGR sere regenerated.

Since 2009, 83 maize genotypes were registered with PPV& FRA, among them 47 were hybrids and 36 composites.

1

Crop Improvement

In India maize is emerging as one of the important crop due to its increased trend in area, production and productivity. Indian Institute of Maize Research is focusing on important aspects of maize improvement namely germplasm characterization, diversification and enhancement; development of new hybrids of different maturity to suit varied agro-climatic conditions of the country; breeding for abiotic stress tolerance and improvement of quality protein maize as well as other nutritionally important quality traits especially provitamin to make maize cultivation more profitable to farmers.

Strengthening Maize Germplasm

Collection and evaluation

A total of 158 segregating lines (S_3) were procured from CIMMYT during the period and were advanced through selfing from S_3 to S_4. In addition 1685 segregating inbred lines (S_3-S_7) were advanced through selfing as part of development of new inbred lines. A total of 1515 inbred lines/germplasm were evaluated, of them a total of 227 productive lines were identified. Out of which, 120 inbred lines were evaluated under multi-location trials for agronomic performance, response to major diseases (TLB, BLSB, FSR, CR, RDM, SDM etc.) of maize under artificial inoculation at hot spot locations. Based on the results 11 multiple diseases resistant lines *viz*., CML117-3-4-1-1-4-1, CML3, JCY 2-2-4-1-1, JCY2-7-1-2-1-B-1-2-1-1, CML321, DTPWC9-F31-1-1-3, CML451Q, JCY-3-7-1-2-1-B-2-3-2-1-3-2, CUBA377, CM128 and HKI1105, were identified.

DUS characterization under CRP on maize agro-biodiversity

Under the consortium research platform on maize agro-biodiversity, 2500 accessions of maize were characterized as per 30 common descriptors at five centres, *viz.,* PAU Ludhiana, CSKHPKV Bajaura, MPUA&T Udaipur, WNC IIMR Hyderabad and IIMR New Delhi. In addition, 485 accessions during *kharif* and 250 in *rabi* have been multiplied at WNC, Hyderabad.

Digital documentation

Development of maize germplasm decision support database has been initiated at the Winter Nursery Centre, ICAR-IIMR. The database was developed using the latest version of Drupal (7.34). Hypertext Preprocessor (PHP) was used for front end development and database (back end) was developed in My Structured Query Language (MySql). The database allows selection of various inbred lines with different permutations and combinations of the 13 traits along with high-quality images of the tassels and the cobs. This database, which is a systematic documentation of the maize inbred germplasm, would be helpful for breeders in the selection of parental lines based on needs and requirements of various research programmes.

Electronic data recording

A step towards precision phenotyping has been initiated at the Winter Nursery Centre, ICAR-IIMR using the 'Fieldlog' software developed at CIMMYT, Hyderabad. The android based software installed in a data recording handset enables us to capture data at field in the digital

form which can be saved as excel format thus enabling enhanced precision in field trials, saving time and precluding errors while documenting data from manually recorded data sheets. More than 30 traits for the 292 accessions of maize, received under CRP-Agrobiodiversity project, are being recorded using the 'Fieldlog'.

Heterotic Grouping and Hybrid Development

Heterotic grouping of QPM inbred lines

A set of 34 newly developed QPM lines was crossed with two testers *viz.,* CML161 and CML165 for generating test-crosses. The test-crosses were evaluated for grain yield at Ludhiana during *kharif* 2015. The grain yield data was used to group inbred lines into different heterotic groups. The lines having positive *sca* effects with CML165 fell in group A (Fig. 7 upper circle), similarly the lines having positive sca effects with CML161 fell in group B (Fig. 2 lower circle).

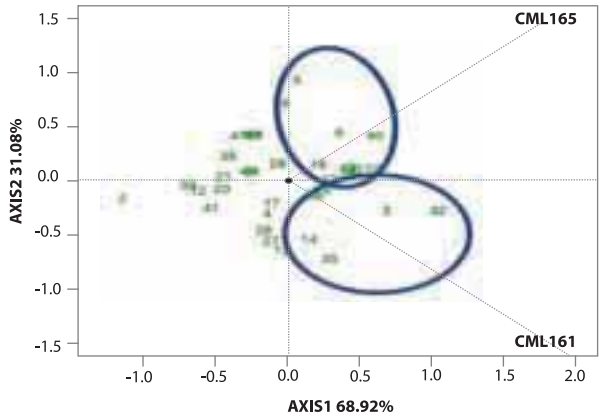


Figure 7. Heterotic grouping of QPM lines by using CML 161 (Female) and CML165 (Male) as testers.

Development of normal hybrids for different ecologies

During 2015-16, in total 2925 experimental cross combinations were generated and evaluated at station trials as part of development of normal maize hybrids under different programmes *viz.*, normal maize hybrids with different maturity (extra-early, early, medium late, *etc.*), different ecologies like eastern India and rest of the country *etc.*

A set of 45 cross combinations of extra-early and early maturity, generated by following diallel mating design, were evaluated at four locations *viz.,* Ludhiana (Punjab), Barapani (Meghalaya), Udhampur (J&K plains) and Srinagar (J&K hills). AMMI and GGE biplots were worked-out to assess the stability of genotypes and their interaction with environments. Environment view of GGE biplot suggests Meghalaya (E2) and Ludhiana (E3) were better environments to differentiate the performance of entries in comparison to Srinagar and Jammu (Fig. 8). The most desirable hybrids were DE1519 and DE1537 because of their high stability and mean yield across locations. Five single cross hybrids *viz.*, DE1515 (21.1%), DE1501 (18.6%), DE1519 (14.9%), DE1539 (13.8%) and DE1542 (11.1%) exhibited more than 10% heterosis over the best check 'Vivek Maize Hybrid 43'.

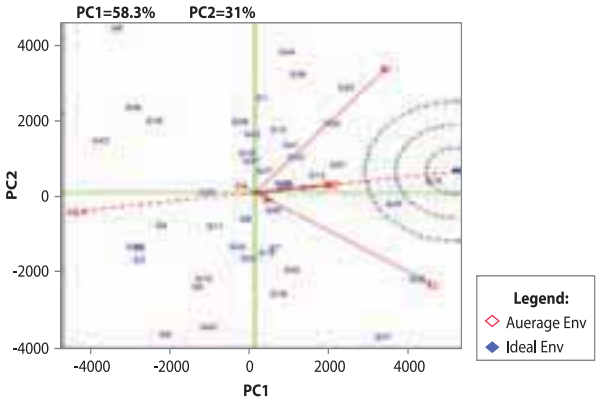


Figure 8. GGE biplot displaying ideal environment to differentiate the yield performance of test entries.

In another programme, 780 experimental hybrids were evaluated under station trials during *rabi* 2014-15. Out of which, 32 best promising combinations *viz.*, DML1409 x LM5, DML1856 x LM17 and DML1364 x LM17 etc. were identified, which showed 6-23 percent superiority over the best check Bio9780. The identified promising hybrids were contributed for multi-location testing under AICRP on maize and are now under different stage of testing during the year, out of which 12 hybrids in *kharif* and 3 hybrids during *rabi* have been promoted to second and third year of testing (Table 1).

Table 1. Details of hybrids under different stage of testing in AICRP on maize.

AVT-I – Medium, Early	DMRH1419, DMRH1305
AVT-II – Late, Medium	DMRH1301, DMRH1308
Baby corn II	IMHB1531, IMHB1532, IMHB 1537, IMHB1538, IMHB1529, IMHB1539, IMH1525
Popcorn II & III	DMRHP1402, IMHP1540, IMHP1535

Development of QPM hybrids

A set 259 experimental hybrids were evaluated during *kharif* 2015 at Ludhiana. The best hybrids were selected on the basis of per cent superiority over best check along with flowering data for contribution to multi-location evaluation under AICRP. 19 promising QPM lines have been selected which were having good yield as well as tryptophan and lysine content, for further testing. DQL2160 has recorded highest yield (7.10 q/ha) followed by DQL2027 (7.08 q/ha), DQL2223 (6.68 q/ha), DQL2181 (6.57 q/ha). Further, five QPM hybrids *viz*., IIMRQPM1501 (NEPZ), IIMRQPM1502 (NHZ, NWPZ, PZ), IIMRQPM1503 (NHZ), IIMRQPM1504 and IIMRQPM1508 (NWPZ) have also been promoted from IVT to AVT I for different zones.

Breeding for Abiotic Stress Tolerance in Maize

The experiment comprising 48 inbred lines were evaluated for cold and heat stress tolerance at Ludhiana and Delhi. Based on the seedling stage data, five lines *viz*., EC639538-2, DML1620, DML1610, EC632066-1, Z172-338-2 and DML1104 were tolerant to cold stress. Similarly, an experiment comprising inbred lines was conducted under managed drought stress condition to identify drought tolerant lines. Based on the results, following lines *viz.,* DML 1094, AZ-14, DML1568, DML1126, DML1230, DML1635, DML1687 and DML1451-1 were identified tolerant to drought stress on the basis of ASI (Anthesis Silking Interval). The ASI was ≤5 under flowering as well as grain filling stage stress in tolerant lines as compared to 1-3 days under stress-free condition.

In addition, a sub-set of 22 and 28 RILs out of 221 $F_{6:7}$ RILs, developed by advancing F_1 generated by crossing heat stress tolerant inbred (LM17) with heat stress sensitive inbred line (HKI1015-wg8), were crossed with inbred tester LM13 and LM14, respectively to understand the behaviour of inbred lines under heat-stress condition. The two sets of test-crosses generated were evaluated during spring 2015; out of 26 morpho-physiological parameters studied, 13 parameters showed significant differences among test-crosses indicating considerable variation among RILs. Further, the association studies showed that chlorophyll content showed significant positive association with grain weight (0.30), leaf breath (0.50), leaf colour (0.59), leaf length (0.54), stem diameter (0.52) and stem vigour (0.53). Similarly, barrenness showed negative association with grain weight (-0.42). The identified RILs can be used for developing stress resilient hybrids in future by using RILs as one of the parental lines.

Breeding for Biotic Stresses

RILs mapping populations derived from crosses CML269 × HKI4C4B, P72clXbrasil 1177-2 × ESM113 have been developed to map Maydis leaf blight (MLB) resistance through bulk segregants analysis. The parental polymorphism survey along with resistant and susceptible bulks has been completed using SSR markers. The polymorphism between resistant and susceptible bulk has putatively identified the genomic region for MLB resistance on chr1. The polymorphic markers will be further validated in RIL population to exactly locate the genomic region. A diverse association mapping panel of 300 inbred lines has been constituted, maintained and phenotyped for charcoal rot, TLB, MLB, and 10 lines *viz.,* CML175, UMI1210-C, IML12-9, IML12-22, IML12-52, IML12-55, LM13, UMI1210, IML12-180, IML12-193 were identified with multiple diseases resistance (Charcoal rot, MLB, TLB) based on first year screening. In addition, a set of 25 QPM lines was screened against MLB, TLB, C. rust, BLSB and P. rust at hot spots in different parts of the country (MLB-Ludhiana, Karnal, Delhi; TLB-Mandya, Bajaura; C. rot-Delhi, Ludhiana; BLSB-Karnal and P. rust Mandya. The lines namely, DQL2009, DQL2054, DQL2057, DQL2071, DQL 2015-1 and DQL2111 were observed as resistant lines with disease score ≤2.0 whereas DQL2019, DQL2055, DQL2068 and DQL2157 showed susceptible

reaction with score more than 3.0. None of the lines found resistant against Polysora rust. Further, molecular markers linked to gene(s) governing sorghum downy mildew (SDM) and banded leaf and sheath blight (BLSB) resistance are being used for validation.

Biochemical Characterization of Maize Germplasm

Identification of maize germplasm with better nutrients is the prerequisite for developing nutritionally improved maize cultivars. The biochemistry unit of IIMR has played a pivotal role and will continue to play an important role in breeding for improved nutritional quality traits in maize. It facilitates the identification of nutritionally superior germplasm for various quality traits such as sugar, starch, oil, amylose, carotenoids, protein quality, carbohydrate profile, waxyness etc. It provides a strong supports to the institute as well as AICRP centers especially Uchani, Bajaura, Udaipur, Arbhavi, Bhuvneshwar, VPKAS Almora, PAU Ludhiana, etc. in QPM development programme of India. The simple analytical techniques were used to analyze large number of samples in a rapid and efficient manner to make right decision at right time by the breeders.

Protein content and quality

QPM development requires continuous monitoring of protein quality. In total, 383 inbred lines were analyzed for protein quality. The representative samples containing 25 to 50% of opaqueness were considered for analysis. The endosperm was separated, defatted and processed for protein quality. The per cent range of protein was 7.01 (DQL2202 and DQL 2168) to 13.88 (DQL2039-1-1) whereas the percent range of tryptophan was 0.34 (DQL2017-1) to 0.80 (DQL1327 and DQL2202). A total of 71 lines having ≥ 9% protein with≥ 0.6% tryptophan in the endosperm protein, the threshold concentrations of protein quality were selected as promising QPM material for breeding programme. In addition, 600 samples received under CRP-biofortification project and other maize germplasm from SKUAST, Srinagar and VPKAS Almora were also analyzed for protein quality under QPM strengthening programe.

Minerals content estimation

A diverse association mapping panel of 300 inbred lines has been constituted, maintained and phenotyped for Fe, and Zn for which genotyping have been initiated. A set of 7 lines *viz.*, CLQRCYQ107, CML312, DML16, CML40BBB, DML134B, UMI1230, IML15-2 has high Fe content ranges from 49 to 61 ppm; 8 lines *viz.*, DQL779-1, DQL785-1-1, IML15-124, CML114, DML18-1, DQL506-12-2, DML19, DQL1005 with high Zn content (ranges from 41 to 52ppm) were found.

Oil content

A multi-location trial comprising sixteen hybrids *viz.*, BIO237, BIO9637, BIO9681, BISCOX6571, Buland, HM4, HQPM1, HQPM7, KMH7148, NMH1247, PMH189, PMH2589, PMH5, Prakash, Rasi750 and Seedtech2324 were evaluated for oil content to understand the genotype and genotype x environment (GGE) interaction and stability of the trait. The AMMI and GGE biplot analysis showed significant genotype and environment interaction. The kernel oil content was ranged from 2.18 to 5.09 percent. Hybrid 'Buland' showed maximum mean value for oil content (4.32%). The GGE biplot indicated that HQPM1 (G7) and PMH5 (G13) displayed strong interaction with the environment at Hyderabad (E3) and Begusarai (E1) respectively. Buland (G5) hybrid was found as most desirable

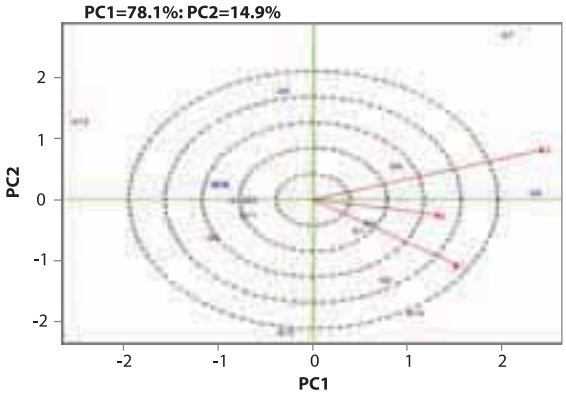


Figure 9. GGE biplot showing strong interaction between genotypes and location for kernel oil content

hybrid with relatively higher oil content and stability across locations (Fig. 9). Hyderabad (E3) emerged as a better environment than other for differentiating genotypes with respect to oil content.

Breeding for improved nutritional quality

Selected genotypes from a CIMMYT QPM-Methionine trial were selfed and F_3 families were planted for advancement at Ludhiana for the purpose of development of high methionine inbred lines. A set of inbred lines are being evaluated for methionine content.

Improvement of quality traits through MAS

HP704-9 and HP704-22, donors for provitamin A trait were screened for beta-carotene content. The results of the estimates showed relatively higher kernel beta-carotene content. Molecular markers linked to gene(s) governing quality traits *viz.,* high-lysine and tryptophan (QPM), provitamin A and low phytic acid are validated. Marker assisted introgression for these traits through backcross breeding is underway. Presently, BC_1F_1 populations for provitamin A are planted at Ludhiana and leaf samples are being analysed for the presence of desirable allele through gene specific DNA based molecular markers (foreground selection). The individual plants carrying alleles determining high provitamin A trait will be further subjected for selection based on morphological features for further advancement through self-pollination to BC_1F_2 generation. The crosses were attempted by crossing between trait specific donor lines and their respective recipient recurrent parental lines for other traits during *rabi* 2015-16 at winter nursery centre (WNC), ICAR-Indian Institute of Maize Research, Rajendra Nagar, Hyderabad to undertake marker assisted backcross breeding (MABB) to convert elite parental lines of commercial maize hybrids.

Germplasm distribution

During 2015-16 a total of 559 germplasm lines with the total distributions of 1816 were supplied to 23 AICRP on maize or cooperating centres involved in maize research and development. The 559 germplasms lines include yellow (405), white (22), QPM (66), sweet corn (30) and popcorn (32); the number of distributions ranged from 22 to 340.

ICAR-CIMMYT collaborative programme

Breeding and disease phenotyoing trials were conducted under ICAR-CIMMYT collaborative technical programme during *rabi* 2014-15 and *kharif* 2015. During, *rabi* 2014-15, 19 breeding trials were conducted across four locations *viz.*, ARS, Karimnagar, BAU, Ranchi, AAU, Godra and SDAU, Biloda. Out of 19 trials, five trials at ARS, Karimnagar were conducted under Abiotic stress condition (drought), whereas the remaining were conducted under optimum management conditions. The trials comprise yellow maize hybrids of medium/medium-early maturity groups. During *kharif* 2015, 7 breeding trials under optimum management condition at AAU, Godra, ICAR Research Complex for NEH, Barapani and PAU, Ludhiana, 4 water-logging trials at RMR & SPC, Begusarai and disease phenotyping trials for FSR (Ludhiana), MSR (Hyderabad), TLB (Almora, Larnoo (Kashmir) and Dharwad) and BLSB (Delhi) were conducted. In addition, 5 trait specific breeding nurseries *viz.*, elite lines of QPM, non-QPM to QPM conversion, high methionine × QPM, drought and superior agronomic performance were also conducted at IIMR, New Delhi, PAU, Ludhiana and IIMR, Ludhiana.

Biotechnological Interventions

Functional analysis of contrasting genotypes in terms of heat tolerance

Two contrasting maize inbred lines, *viz.*, DTPYC9F119 (heat-tolerant) and K64R (heat-susceptible) were functionally analysed for expression of antioxidant genes *viz., Sod2*, Cat1 and *Apx1*, at normal (25/20°C) and heat-stress (38/28°C) during flowering stage heat-stress under controlled environment conditions. The degree of increase in *Sod2* gene expression under heat-stress between the two contrasting genotypes was different and the increase was more prominent in DTPYC9F119. In case of K64R, increase in *Sod2* expression was relatively low (Fig. 10a). Heat-stress also had significant influence on *Cat1* expression level in two genotypes. Initially, the relative level of gene expression was 7.53 and 8.54 and after 6 days of high temperature treatment it reached to 15.16 and 10.34 for DTPYC9F119 and K64R, respectively. Percent increase in *Cat1* gene expression was 98.27 and 26.98 percent in DTPYC9F119, K64R, respectively (Fig. 10b). The relative *Apx1* expression was 2.95 for

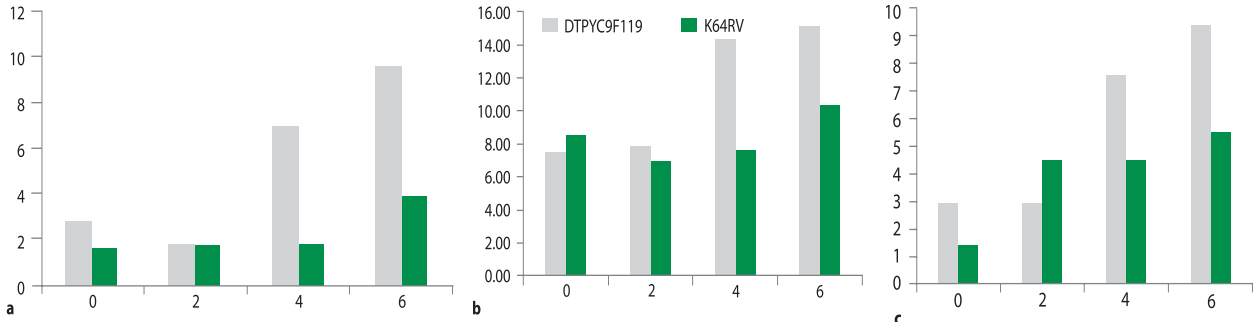


Figure 10. Functional analysis of gene expression (Y-axis) of (a) *Sod2* (b) *Cat1* (c) *Apx1* after days (x-axis) after exposure to high temperature.

DTPYC9F119 and 1.42 for K64R before exposure to high temperature treatment but it increased to the level of 9.43 and 5.53, respectively in these genotypes after 6 days of heat-stress treatment (Fig. 10c).

CRISPR/Cas 9 based genome editing for novel trait development

To establish the proof of concept of gene editing in a tractable model system, like *Arabidopsis* and then scale-up to edit maize gene for herbicide resistance trait development, the phytoene desaturase (PDS) gene of *Arabidopsis thaliana* (Col 0) was targeted. The knockout of PDS gene shall result in visible photo-bleaching phenotype. To identify target sites in *A. thaliana,* CRISPR-P software was employed. Target region for AtPDS in At4g14210 (GenBank ID: AF360196.1) was selected based on scoring value more than 98 for the guide sequence and with minimum off targets. The plasmid (pYLCRISPR/Cas9P35S-N) with *cas* gene was procured from Addgene. The presence of *cas* gene was confirmed in the *cas* plasmid. The fragment of plasmid containing a modified *ccdB* flanked by two *BsaI* was substituted with the *sgRNA* gene. For the construction of *sgRNA* gene, the *A. thaliana* U6 promoter (accession number KR029101.1) was followed by the guide sequence (GGATCAATGATCGGTTGCAG) which was ultimately followed by *sgRNA* scaffold. At both the ends of the *sgRNA* gene construct, *BsaI* sites were attached. The synthetic *sgRNA* gene transcript was attached in place of modified *ccdB* to the pYLCRISPR/Cas9P35S-N plasmid using golden gate assembly mix. The restricted/ligated product was transformed into NEB alpha competent cells. Plasmid isolated using alkaline lysis method was verified via PCR using primers (*sgRNA* and *sgRNA-A*) (Fig. 11,12). *sgRNA* primers were complementary to the flanking region of *ccdB* in plasmid. Therefore, in transformed plasmid, the amplicon shall be 500 bp, but in case of untransformed plasmid the same primer (*sgRNA*) shall give amplification around

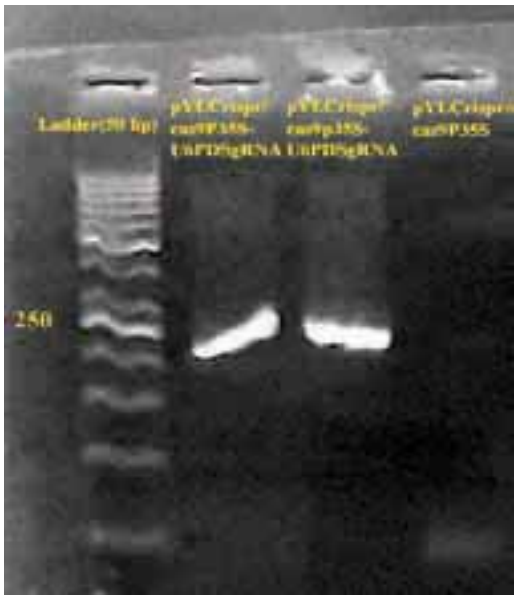


Figure 12. Confirmation of the developed pYLCRISPR/Cas9p35S-U6:PDSsgRNA construct by PCR

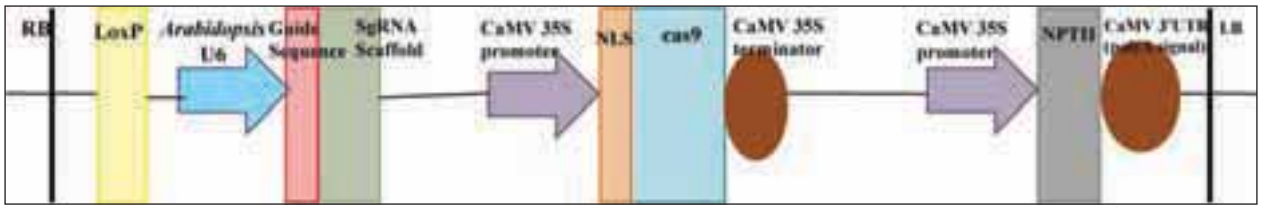


Figure 11. The construct design for PDS gene editing construct developed at IIMR

800 bp. The *sgRNA-A* primer are specifically complementary to the region of synthetic *sgRNA* transcript and therefore, amplification around 230 bp will be obtained from transformed plasmid whereas non transformed plasmid will show no amplification. Thus, the gene editing construct has been developed.

Optimization of *in-vitro* regeneration system for tropical maize using mature embryos

Optimization of *in-vitro* regeneration system using mature embryos (Fig 13) was initiated using nine tropical maize inbred lines *viz.,* BML10, BML7, CML182, CML132, HKI163, HKI193-1, DMRPE6-1, DMI63, and DMI51. The seedlings with developed nodes were selected and the nodes were excised. The nodes were split longitudinally into two halves. The split nodes and plumular leaf were placed on the callus induction medium (CIM), cut surface facing down and touching the medium. A total of 100 split-nodes per genotype were cultured on the CIM medium (10 seeds per 90 mm petri dish) and incubated under dark at 28°C ± 2°C. The frequency of primary callus induction (%) was calculated as the ratio of calli induced to the total number of split node placed on the callusing medium. The primary calli were separated from mucilegenous and non-embryogenic tissues and were sub-cultured onto the same medium (CIM) for two cycles under the dark condition at 28°C ± 2°C. The embryogenic calli of above genotypes were placed on embryogenesis media (CIM media + 36.4 gm/l sorbitol and 36.4 gm/l mannitol) in light at culture room condition. Embryogenic calli were induced in BML7, HKI163, DMI51, and DMI63.

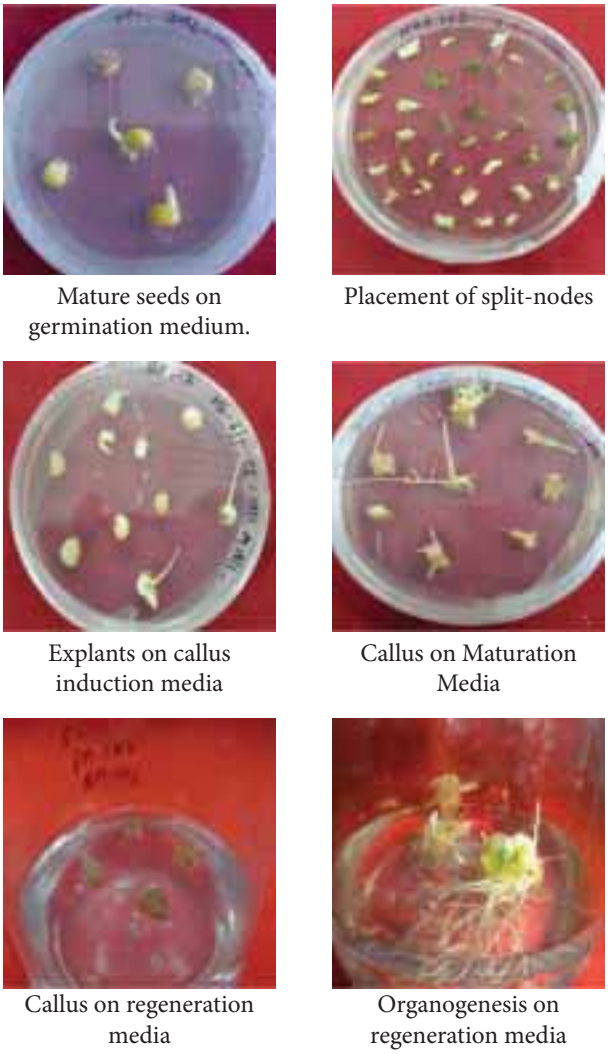


Figure 13. *In vitro* regeneration in maize using mature embryos

Transcriptional profile of phosphate and nitrate responsive genes and small RNAs

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 developed (Fig. 14). Using this system, important physiological changes related to adaptation to low nutrients were characterized. It was revealed that, both under low nitrate and phosphate, there were major changes in plant root architecture. Quantitative Realtime PCR analysis identified the expression pattern of the nitrate and phosphate responsive genes in several metabolic pathways, whose expression was modified under different nutrient levels in the root zone. Taken together, the results offer a simple picture of the transcriptomic changes of these genes that are

Figure 14. HKI-163 maize plants grown hydroponically in two growth conditions, Low Phosphate, LP (5 uM Phosphate) and High Posphate, HP (1mM Phosphate conditions. Photographs were taken after 21 days of phosphate treatment

differentially regulated on the availability of nitrate/phosphate. Further, as small RNAs are known to regulate gene expression significantly, the RNA from root and shoot samples of these stressed and unstressed plants were subjected to deep sequencing on Illumina HiSeq platform. More than 300 million reads of transcriptomic data has been generated and being analyzed to reveal nodes of regulation in adaptation to phosphate and nitrate stress.

Brassinosteroids as anti-stress agents

Brassinosteroids (BRs) are a family of about 70 structurally related polyhydroxy steroidal phytohormones that regulate a number of physiological processes in plants. Among these, brassinolide (BL), 28-homobrassinolide (28-homoBL) and 24-epibrassinolide (24-EpiBL) are more common. The usefulness of 24-epiBL in ameliorating the impacts of heat-stress in maize along with its role in regulating cellular antioxidant defense system was studied. Maize hybrid PMH3 was grown in pots under green house maintained at 14 hours day (25°C)/10hours night (17°C). A solution of 24-epiBL (1 µM) was applied externally at V4 stage. Leaf tissues were sampled from both treated and control plants. Subsequently, both the groups of pots were placed in plant growth chamber maintained at high temperature (48°C; RH 50%). Plants were sampled for biochemical analysis after 3, 6, 9, 24 and 48 hours of high temperature exposure. Exogenous application of 24-EpiBL arrested protein degradation and enhanced cell membrane stability, as compared to the control. The biochemical activities of antioxidant enzymes such as catalase (CAT), superoxide dismutase (SOD) and peroxidase (POX) were found to be dynamically and variably modulated post 24-epiBL treatment. Thus, the study supports the role of BRs as anti-stress agents.

Comparative modelling and phylogenetic analysis of SOD 2 in drought tolerant maize inbred line HKI-335

The SOD 2 protein from drought tolerant maize inbred line HKI335 was bioinformatically characterized. The *Sod2* gene was amplified using gene specific primers and cloned. Plasmid was sequenced and the sequences were submitted in NCBI. FASTA sequences were retrieved and used for homology modelling and secondary structure prediction. Comparative modeling revealed the secondary and tertiary structure of the 151 amino acid residues present in the SOD2 protein of HKI335. The maize HKI335 SOD2 structure exhibited 83% identity with SOD2 (PDB ID: 2Q2L_A) of *Potentilla atrosanguinea*- a vigorous herbaceous perennial of the rose family that typically grows at lower elevations in the Himalayas. The model was evaluated on the basis of geometrical and stereo-chemical constraints using PDBsum and ProSA-Web. Ramachandran plot revealed (~98.0% expected) 193 (84.6%) residues falling in most favoured region (~2.0% expected), 34 (14.9%) residues in additionally allowed region, and 0.4% residues in generously allowed region with no residues in the disallowed region. In PROSA-Web plots displaying Z-scores, value (-6.51) of the target model was determined by X-ray crystallography (represented in light blue) and NMR (represented in dark blue) (Fig. 15). This value was extremely close to the value of template 2Q2L (-6.44). Root Mean Squared Deviation (RMSD) was used to see three dimensional structural similarities between target and template. Multiple sequence alignment was done to infer the phylogenetic relationship between members of the antioxidant gene family. It showed a clear demarcation of plant SOD 2 into two prominent clusters; cluster A and B. Cluster A comprised of sequences from monocots (10), whereas cluster B included sequences from dicots (8).

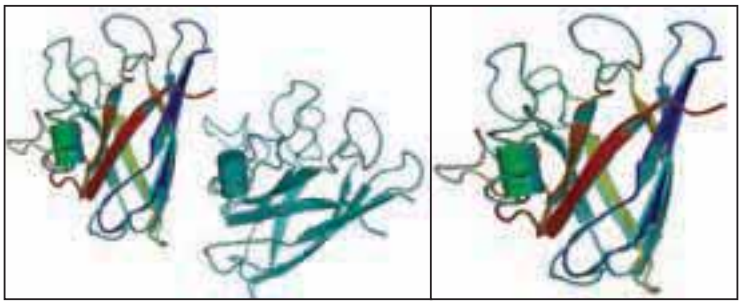


Figure 15. Superposed structure of SOD-2 (ZmHKI-335) on crystal structure of SOD-2 from Potentilla

2

Production System and Technology

The declining natural resources base in crop production systems is the biggest challenge to sustain the crop productivity. In order to develop suitable maize based cropping system to mitigate the resource degradation, particularly declining water table and climate-change-induced variability in rainfall and temperature, a long-term experiment was started at fixed site. The important work on site specific nutrient management (SSNM) provides specific principles for optimally supplying nutrients to avoid blanket fertilizer recommendations. Performance evaluation of genotypes such as productivity, system productivity and economic profit of different tillage, crop establishment practices and compatibility of inter-crops are being conducted at IIMR.

Conservation agriculture in maize based cropping systems

In order to develop a suitable maize based cropping system to mitigate resource degradation, particularly declining water table and climate-change-induced variability in rainfall and temperature, a long-term experiment at fixed site (since 2008) is being carried-out at Indian Institute of Maize Research, New Delhi. The experiment was conducted (i) to evaluate the performance in terms of individual crop productivity, system productivity and economic profit under different tillage crop establishment practices *viz.*, permanent bed (PB), zero tillage (ZT) flat and conventional till (CT) in four intensified irrigated maize based cropping systems *viz.*, maize-wheat-mungbean (MWMb), maize-chickpea-Sesbania (MCS), maize-mustard-mungbean (MMuMb) and maize-maize-*Sesbania* (MMS); (ii) to find out the suitable conservation agriculture (CA) practices in maize based cropping systems.

The results demonstrated that, when grown in rotation with *kharif* maize, all the succeeding *rabi* season crops (except wheat) resulted maximum grain/seed yields and economic returns under ZT planting, however wheat yield was recorded maximum in PB plots (2014-15). The grain/seed yield of *rabi* maize, chickpea and mustard was increased by 23.1, 25.6 and 27.4% under ZT over CT planting, respectively, whereas the wheat grain yield was 23.7% higher in PB plots over CT plots (Fig. 16).

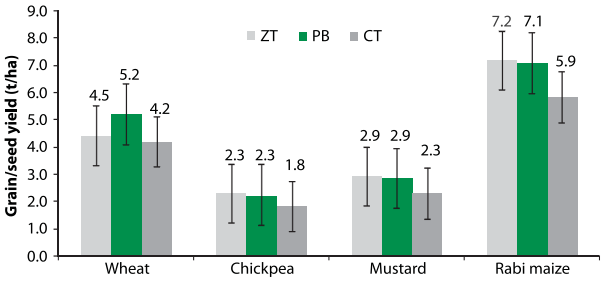


Figure 16. Productivity (t ha-1) of *rabi* crops as affected by different tillage practices under maize based cropping systems (2014-15).

The net returns of *rabi* maize, chickpea and mustard were 49.0, 40.0 and 51.5% higher under ZT, respectively and wheat net returns was 41.6% higher in PB system as compared to CT (Fig 17).

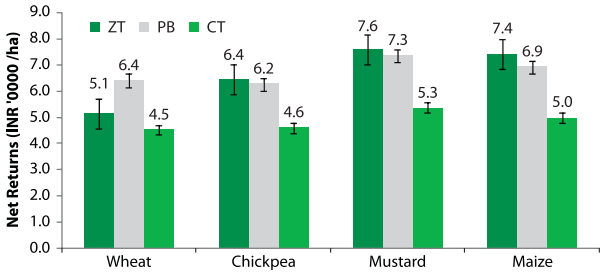


Figure 17. Net returns (INR '0000/ha) of *rabi* crops as affected by tillage practices under different maize based cropping systems (2014-15).

The *kharif* maize yield (5.6 and 5.5 t/ha) and net returns (Rs. 59,000 and 58,000/ha) were significantly ($P<0.05$) higher under ZT and PB compared to CT. However, *kharif* maize grain

yield and net returns differed significantly under different cropping systems. The highest yield and net returns were recorded in MCS system plots which were 2.59, 10.19 and 14.08% higher compared to MWM, MMuMb and MMS systems, respectively (Fig. 18).

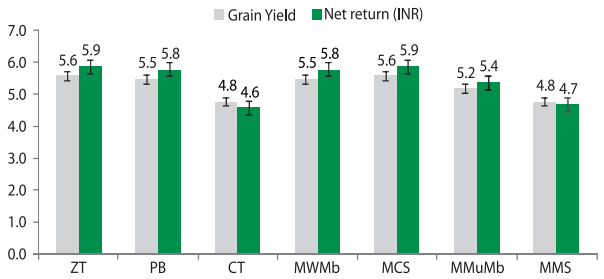


Figure 18. *Kharif* Maize (2015) grain yield (t/ha) and net returns (INR '0000/ha) under different maize based cropping systems.

The system productivity in terms of 'maize equivalent yield' (MEY) was recorded highest in ZT plots (12.4 t/ha) and the lowest was with CT plots (10.3 t/ha) during 2014-15. The system productivity and the system net returns were also calculated for different maize based rotations under different tillage practices. The highest systems productivity (13.4 t/ha) and highest net returns were recorded in MMuMb rotation system plots. The net returns in MMuMb rotation system plots were 47.8, 27.9 and 11.6 per cent higher compared to MMS, MCS and MWMb systems, respectively. Under different tillage practices, the ZT plots system recorded highest net returns with 36.7% increment over CT plots (Fig. 19).

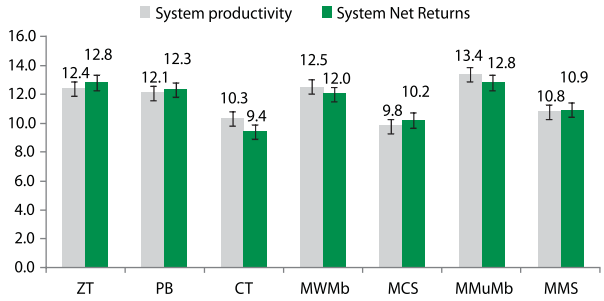


Figure 19. System productivity (MEY, t/ha) and system net returns (INR '0000/ha) of different maize based rotations.

The CA based management practices (ZT flat and PB) also helped in reducing the cost of production and enhancing the net returns over CT system. The result of long term study demonstrated that succeeding crops planted in maize based rotations under CA based practice (ZT flat/PB) increased the systems net profit from 31 to 37 per cent compared to CT planting due to synergistic effects of summer legumes (*mungbean* and *Sesbania*) after winter legume/oilseed/cereal.

Nitrogen management under conservation agriculture

The most of the nitrogen nutrient applied to crops by top-dressing under conservation agriculture (CA) practices lies on the crop residues and get lost by volatilization and immobilization results in poor nutrient use efficiency. Therefore proper nutrients management under CA may not only further enhance its adoption at large scale but also it can make CA as more eco-friendly agriculture practice.

In order to explore the feasibility of one time application of coated nitrogen fertilizer like neem or sulphur coated urea under CA, an experiment was started in July 2012 for intensified maize-based systems. The combined analysis of four years data revealed that the one-time neem coated urea (NCU) application was beneficial under CA. Further, the application of residue (WR) has led to significant enhancement in system productivity by 910 kg/ha over without residue (WoR). In third year, the system productivity was significantly higher with application of either sulphur (SCU) or neem coated urea (NCU) in intensified maize systems. The SCU or NCU lead to enchantment in system productivity by 12 or 10% over conventional *prilled* urea application. The maize-mustrad-mungbean (MMuMb) system yielded significantly higher over maize-wheat-mungbean (MWMb) by 5.7%. Significant

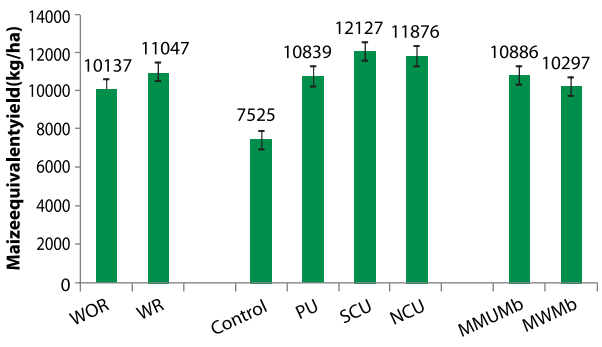


Figure 20. Effect of coated fertilizer application on system productivity of intensified maize systems under different residue management scenario in third year.

residue into 'N' application interactions were found where the coated fertilizer application resulted in significantly higher yield in WR while under WoR the *prilled* urea performed on *par* with coated fertilizers (Fig. 20).

The application of residue in maize after a dry spell of 10 days has led to depletion in canopy temperature by more than 3.5°C compared to less than 2.5°C in WoR in most of the cases (Fig. 21).

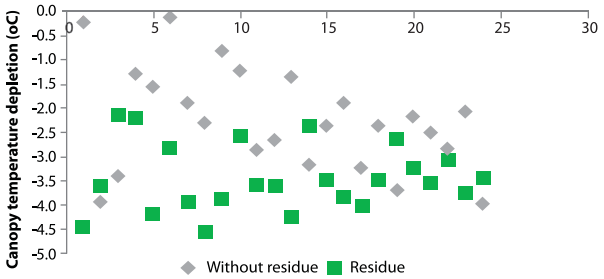


Figure 21. Effect of crop residue application on canopy temperature depletion in maize after 10 days dry spell.

The favourable moisture regimes under residue retention may be the major reason for better yield under residue (WR) compared to no residue (WoR) in maize. The application of residue in mustard significantly enhanced the seed yield by 12 percent over WoR but in wheat, no significant difference was observed by residue application during third year of study (Fig. 22).

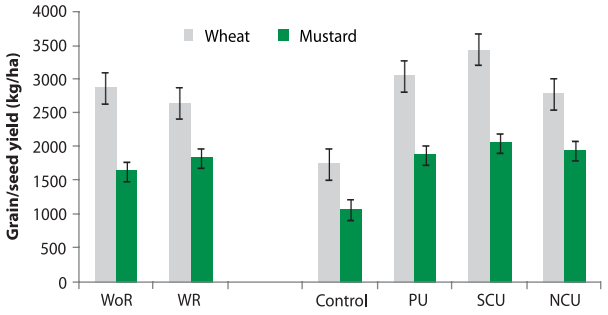


Figure 22. Effect of coated fertilizer application on *rabi* crop yields in intensified maize systems under different residue management scenario during third year of experimentation.

The application of SCU resulted in 12.4 and 9.4 per cent higher yield of grain in wheat and seed in mustard, respectively. The application of residue and coated urea lead to enhancement in system water productivity (WP) during third years of experimentation. The system total and irrigation water productivity was 10.0 and 9.2 per cent higher respectively with residue application over WoR. However, the application of SCU and NCU increased the total WP by 13 and 11 while irrigation WP by 12 and 10 per cent over prilled urea application, respectively (Fig. 23).

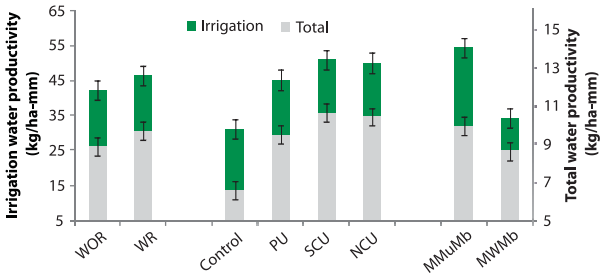


Figure 23. Effect of coated fertilizer application on water productivity of intensified maize systems under different residue management scenario after three years.

Site specific nutrient management

Cultivars, so called modern crop varities/ hybrids are responsive to nutrients applied and maize hybrids are no exception. To obtain desirable yields, the doses of nutrients applied should match with plant demand. The rate of nutrient application depends mainly on soil nutrient status/balance or soil supplying capacity, preceding crop and the cropping system. In addition 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 in short and medium-term. SSNM has led to decision tools and guidelines for farmers and extension workers.

Effect of SSNM on grain yield

SSNM improved maize grain yield over absolute control and 50% farmer's fertilizer practice (FFP). However, SSNM remained at

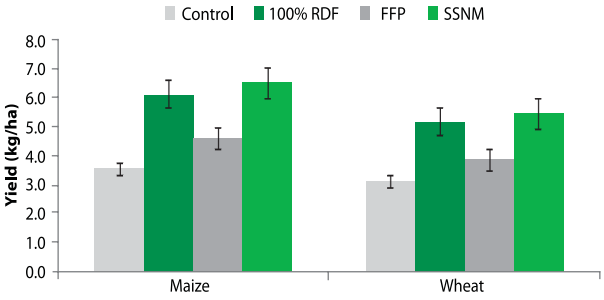


Figure 24. Grain yield of maize (2015) and wheat (2014-15) under different tillage practices.

par with 100% recommended dose of fertilizer (RDF). While in case of wheat, significantly higher yield was obtained with SSNM over all nutrient management *viz.,* absolute control, 100% RDF and FFP (Fig. 24).

Effect of SSNM on system productivity

The significantly higher system productivity was obtained by SSNM during 2013-14 under maize-wheat-mungbean sequence, which was 44.4, 6.1 and 18.6 per cent higher over absolute control 100% RDF and 50% RDF, respectively. Similar results were also obtained during 2014-15 where 24.1, 48.9 and 20.5 per cent higher system productivity was obtained with SSNM, 100% RDF and FFP over absolute control, respectively (Fig. 25).

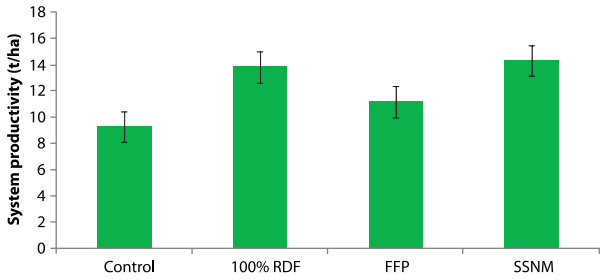


Figure 25. System productivity (as maize equivalent yield, t/ha) of maize-wheat-mungbean sequence under different nutrient management practices (2014-15).

Compatibility of inter crops with different hybrids of maize

The compatibility of two inter-crops *viz.*, mungbean and cowpea were tested with different maize hybrids during *kharif* season of 2015 (Table 2). Inter-cropping of mungbean and cowpea significantly reduced the maize yield to the tune of 4.05 and 10.1 per cent respectively as compared to maize sole. However, the system productivity data in terms of maize equivalents showed that inter-cropping of mungbean in maize resulted in the highest productivity, which was 53.8 and 13.4 per cent higher than maize sole and maize + cowpea inter-cropping, respectively. Similarly, the net returns (Rs 71,277/ha) and net return per rupee invested (Rs 2.17) were also maximum with maize + mungbean inter-cropping system. The grain yield of different maize hybrids varied significantly. PMH3 gave the maximum grain yield (6,011 kg/ha), net return (Rs 71,845/ha) and net return per rupee invested (Rs. 2.42), whereas, DHM117 was the second most productive hybrid.

Table 2. Productivity and economics of maize and intercrops

Treatments	Grain Yield (kg/ha)	MEY (kg/ha)	Cost of cultivation (Rs/ha)	Net Return (Rs/ha)	B:C
Sole Maize	5111.1	5111.1	23870.0	43852.2	1.84
Maize + Cowpea	4903.9	6931.2	31070.0	60768.2	1.81
Maize + Mungbean	4596.1	7860.2	32870.0	71277.0	2.17
CD (P=0.05)	249.9	296.8	0.03	3932.2	0.14
HM4	4366.7	6157.7	29270.0	52319.6	1.71
DHM117	5023.0	6720.3	29270.0	59774.4	1.98
VivekQPM9	4080.7	6026.5	29270.0	50581.0	1.64
PMH3	6011.0	7632.1	29270.0	71854.8	2.42
CD (P=0.05)	170.2	198.9	0.03	2635.6	0.09

Crop residue and potassium management in maize-wheat-mungbean cropping system

Incorporation of crop residue of previous crop and application of fungal consortia in maize wheat-mungbean cropping system enhanced the yield of all three crops *i.e.* maize, wheat and mungbean to the tune of 5.8 and 10.6; 4.2 and 18.2; and 11.3 and 27.7 per cent over with and without crop residue incorporation, respectively (Table 3). Similarly, the highest system productivity (16.5

t/ha) in terms of maize equivalents was found with crop residue incorporation and fungal consortia application. Although, application of recommended dose of potassium (RDK) to maize and wheat gave the maximum yield, but when potassium dose was reduced to 75% of recommended dose coupled with KSB application, the yields of both maize and wheat remained *at par* to recommended dose of potassium. However, in case of mungbean no significant differences in yield were recorded with recommended dose of potassium, 50% RDK+KSB and 75% RDK+KSB treatments. The potassium contents in soil with 75% of RDK+KSB treatment remained *at par* with RDK. System productivity data indicate that crop residue incorporation plus fungal consortia treatment with application of 75% of RDK and KSB is the best treatments for maize-wheat mungbean cropping system, which could save 25% of fertilizer K.

Table 3. Productivity of maize-wheat-mungbean cropping system and residual potassium content in soil

Treatments	Yield (t/ha)			System productivity (t/ha)	Available K (kg/ha)
	Maize	Wheat	Mungbean		
No-crop residue	4.91	4.44	1.01	13.51	185.1
Crop residue incorporation	5.13	5.05	1.16	15.08	200.3
Crop residue incorporation +Fungal consortium	5.43	5.25	1.29	16.49	219.6
CD (P=0.05)	0.19	0.17	0.08	1.34	10.11
Control	4.56	4.20	1.08	13.53	169.8
KSB	4.91	4.36	1.12	14.30	164.9
RDK (100 %)	5.69	5.56	1.16	16.15	236.6
RDK (50 %)+KSB	5.11	5.12	1.18	15.16	214.3
RDK (75 %)+KSB	5.51	5.32	1.22	15.99	222.6
CD (P=0.05)	0.20	0.25	0.07	0.46	14.73

- Started 1963 in AICMIP with 10 identified hot spot locations for screening of genotypes
- Guideline for techniques of scoring for resistance in diseases of maize in India was established after six days seminar held at Hyderabad in 1982.
- Brown stripe downy mildew (BSDM) caused by *Sclerophthora rayssiae* var. *zeae* Payak & Renfro, was first reported in India.
- Sorghum downy mildew caused by *Philippinensis sorghi* was identified as Rajasthan downy mildew caused by *Perenosclerospora heteropogoni* in 1980.
- Only centre Nematology to screen germplasm against nematodes was added in late eighties at Udaipur
- Three hot spot locations were added in 1994 with two voluntary centres (13+2).
- At present 17 screen centre (13+ 4 voluntary) doing screening for 12 major diseases.
- CYMMIT collaborative programme was started in early nineties to find sources of resistance against BLSB, PFSR, TLB and Downy mildews.
- Under the ICAR-CIMMYT collaborative programme, >3000 inbred lines have been screened, about 50 materials have shown some level of tolerance

Some major epidemics due to maize diseases in India

- Bacterial stalk rot - (1959, 1969)
- Brown stripe downy mildew - (1962-1965)
- Sorghum downy mildew - (1968-1973)
- Turcicum leaf blight - (1974)

After strengthening maize pathology pregramme no such epidemic was occurred due to development of resistant cultivars & management strategies

Changes in diseases spectrum scenario

- Maydis Leaf Blight, Pythium stalk rot and Erwinia Stalk Rot are becoming diseases of lesser economic importance due to climate change pattern, availability and use of sources of resistance in the newly developed hybrids and varieties.

Disease of minor importance in early sixties now become major

- BLSB – presently common in all over India wherever maize is grown.
- P. Rust–most sever in peninsular region whereas in early eighties it was minor disease.
- PFSR-late seventies it was disease of minor importance but now it is a major disease due to high soil temperature, water stress at flowering time which are predisposing factors
- Pre harvest cob rots-due to changing the weather condition, this disease is gaining importance
- Curvularia leaf spot-As per the survey and surveillance report of IIMR, this disease has shown widespread occurrence in Rajasthan and moderate to traces in Punjab, H. P. and Karnataka

Management technology developed -

Banded leaf and sheath blight – *Rhizoctonia solani* f.sp. *sasakii*

- Stripping of 2 lower leaves along with leaf sheath
- Foliar spray (30-40 days old crop) of Rhizolex 50 WP @ 10 gm/10 litre of water.
- Seed treatment of peat based formulation @ 16 g/kg of *Pseudomonas fluorescence* or as soil application @ 7 g/litre of water.
- Hybrids *viz.,* EH-1389, JH-10704 were found to have moderate level of resistance

Post Flowering Stalk Rots

- Crop rotation and adoption of good agricultural practices.
- Avoidance of water stress at flowering & balance soil fertility, increase potash level up to 80 kg/ha.
- Use of fortified FYM with *Trichoderma* formulation @10g/kg FYM in furrows at the time of sowing.

Erwinia stalk rot – *Erwinia chrysanthemi* pv *zeae*

- Field should have proper drainage, avoidance of water logging.
- Planting of the crop on ridges.
- Avoid use of sewage water for irrigation
- Soil drenching with bleaching powder containing 33% chlorine @10kg/ha.

Identified resistant sources & hybrid

1. **TLB** - Pusa early hybrid, Pusa prakash, Bio 9636, Pro 345, MCH 2, JH 10655, NECH 117, X 1280, NAH 2049
2. **MLB**-Pro324, ICI-701, Bio9636, PEH-5, Pusa prakash, Pro- 345, JH 10655, JKMH – 1701, X 1280
3. **Common rust** - Sheetal, Buland, pusa prakash, Pro 345, JH 10655, JKMH – 1701, ICI 768.
4. **P. rust** – sources NAI 112, SKV 18, SKV 21,
5. **R Hybrid** - NAH 2049 resistant hybrid for Karnatka
6. **Brown strip downy mildew** - Pusa early hybrid– 5, Bio 9636, pro 345, JH 10655, NECH 117, X1280.

Prevention and Management of mycotoxin contamination

- New Technique-Fast screening Tech. developed/ validated for the first time in maize to identify the toxic and nontoxic strain of *Aspergillus flavus* through Ammonia vapour test
- Potassium Carbonate (non toxic chemicals) @ 4g/ kg seed was most effective in minimizing AFB_1 conc. by reducing growth/population of mold on grain surface.
- Morphological and biochemical traits associated with resistant genotypes were identified.

3

Crop Protection

A wide range of diseases and pests are responsible to scale down the maize production. To reduce the losses due to diseases and pests, simultaneously increasing maize production, various research approaches on management strategies are being carried out. However, the evaluation of maize germplasm against major diseases and pests in different agro-climatic conditions is an integral part of our programs.

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

Post-flowering stalk rot of maize is an important and destructive disease prevailing in the country. The disease caused by soil borne pathogens and disease incidence recorded in India ranged from 10 to 42% occurs both in *rabi* & *kharif* seasons. Following experiments to study the host resistance were carried out;

Biochemical analysis

Plant polyphenolics are secondary metabolites responsible for host resistance. In order to know the biochemical basis of resistant traits favouring PFSR resistance in the host plant, biochemical analysis was done in 24 identified resistant inbred lines. Study was conducted in experimental field under inoculated and un-inoculated conditions with pathogens *M. phaseolina* and *F. verticilloides*, in different blocks. Overall, highest amount of total phenolic compound (TPC)-189.27 mg/100g; total soluble sugar (TSS)-82.71 mg/100g and total flavonoid acids (TFA)-46.29 mg/100g on dry weight basis was estimated in mixture purple genotype -1, -2: and -4 (lines derived from germplasm obtained from NE regions) and in PFSR (Y)-C0-1⊗-4-1⊗-1-1-1-3⊗-1-1-1-1 PFSR (Y)-C1-B-⊗-1-1-1 lines derived from PFSR resistant pools.

Response of phenolic compounds in diseased host plants as compared to healthy host plants at Knee high, flowering and at cob formation/ grain filling stage

Response of TPC; TSS and TFA in these resistant genotypes was studied. It is evidence from the data that there is more than 4 folds increase in total phenol content in diseased (inoculated) plants in some of the tested genotypes as compared to healthy plants. Varied response of these genotypes for phenolic compounds was observed as a defence mechanism when challenged with stalk rot pathogens. However in susceptible check increase of these compounds as compared to other genotypes was insignificant (Fig 26, 27 & 28). This increase in

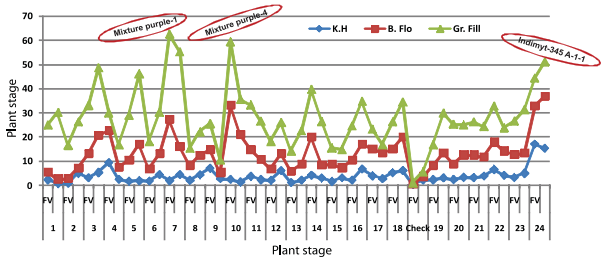


Figure 26. Response of total phenolic acids in diseased plants as compared to healthy plants at Knee high, flowering and at cob formation/grain filling stage

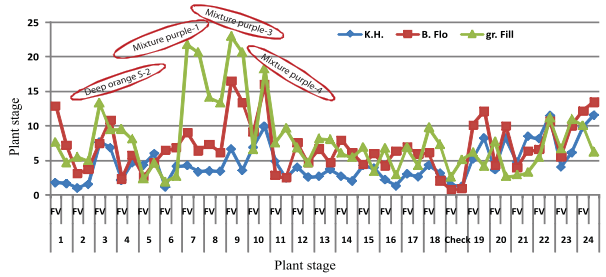


Figure 27. Response of total soluble sugar compound in inoculated plants as compared to healthy plants at knee high, flowering and at cob formation/ grain filling stage

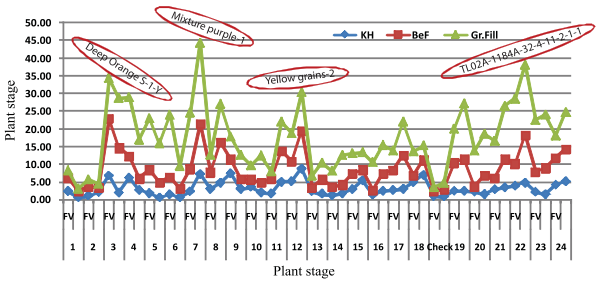


Figure 28. Response of total flavonoides compound in inoculated plants as compared to healthy plants at knee high, flowering and at cob formation/ grain filling stage

diseased plant shows elicitation of biochemical defence by host tissue.

Promising genotypes identified

Promising genotypes having biochemical basis of resistant traits favouring PFSR resistance in the host plant were identified. These lines exhibited high amount of total phenolic compound as a defence mechanism against infection caused by stalk rot pathogens, are listed in Table 4 & Fig. 29.

Table 4. Best genotypes with high amount of TPC, TFA and TSS

S. No.	Best genotypes	(mg/100 g dwt)					
		TPC		Total Flavo.		Total Solu. Sugar	
		Un-ino.	Ino.	Un-ino.	Ino.	Un-ino.	Ino.
1.	(6-Mixture purple)-1	160.40	199.43	46.04	69.60	40.02	61.72
2.	(6-Mixture purple)-2	159.51	169.13	49.39	60.23	51.93	66.02
3.	Deep orange S-2	97.64	125.40	22.51	36.56	42.88	65.82
4.	(6-Mixture purple)-4	127.81	153.70	30.34	37.82	35.81	53.98
5.	PFSR (Y)-C0-1⊗-4-1⊗-1-1-1-3⊗-1-1-1-1	149.29	159.22	30.28	50.14	29.94	41.08
6.	PFSR (Y)-C0-1-⊗-4-1⊗-1-1-1-3⊗-1-1-1	134.96	152.83	26.23	41.27	18.27	29.18
7.	TL02A-1184A-32-4 -1-1-2-1-1	98.31	111.86	16.66	31.72	16.78	20.04
8.	Yellow grains -2	117.12	129.99	29.19	40.11	23.36	30.23
9.	Indimyt-345 ⊗-1-1	83.65	97.76	8.93	19.41	11.03	21.04
	S. Check	96.17	98.10	16.84	18.65	19.10	24.18

Ino: Inoculated , Un-ino- Un-inoculated


Mixture Purple-1


Mixture Purple-2


PFSR (Y)-C0-1⊗-4-1⊗-1-1-1-3⊗-1-1-1-1


Mixture Purple-4


Indimyt-345 ⊗-1-1


PFSR (Y)-C0-1-⊗-4-1⊗-1-1-1-3⊗-1-1-1


TL02A-1184A-32-4-A


Yellow Grains-2


Deep Orange S-2

Figure 29. Cobs of promising genotypes exhibited high amount of total phenolic, total sugar and total flavonoides contents

Identification of stable sources of resistance to major diseases of maize

A total of 112 maize lines were evaluated against major diseases at different hot spot locations under artificially created epiphytotic condition during *kharif* 2013 to 2015 (three years). Out of them, 47 lines exhibited multiple disease resistance. The entry wise disease reactions are enumerated below in Table 5.

Table 5. Identified stable sources of resistance to major diseases

Genotype	Resistant	Moderately resistant
HKI 1105	MLB, RDM, CLS	C.ROT
HKI 1344	CLS	MLB, C.ROT, FSR
CM 212	-	C.ROT, FSR, CLS
CML 446	FSR	MLB, TLB, BLSB, C.ROT,CLS
HKI Talar	MLB, FSR, RDM, CLS	TLB, BLSB, P.RUST
EI 670	MLB, FSR,	TLB, BLSB, C.ROT, RDM
EI 708	-	MLB, TLB, C.ROT, FSR, RDM, CLS
EI 561	FSR, CLS	MLB, TLB, C.ROT, RDM
BML 8	FSR, CLS	MLB, TLB, C.ROT
G18seqcef 74-2-1	FSR	MLB, TLB, C.RUST, C.ROT, RDM
WSC Shrunken X MUS MADHAU	-	C.ROT
CM 117-3-2-1-1-1-2-1	-	MLB, TLB, BLSB, FSR
CM 129	-	FSR
CM 132	FSR	MLB, TLB, C.ROT
CM 105	FSR	MLB, TLB, C.ROT, CLS
CM 123	-	MLB, TLB, C.ROT, FSR, CLS
CM 128	FSR, CLS	MLB, TLB, C.ROT
CM 149	-	MLB, TLB, C.RUST, C.ROT, FSR, CLS
CML 451(P2)	FSR,	MLB, TLB, BLSB, CLS
CUBA 377	MLB, FSR	TLB, BLSB, C.ROT, RDM, CLS
IIMR QPM-03-124	C.RUST,	MLB, P.RUST, C.ROT, FSR, CLS
IIMRQPM 03-113	FSR	MLB, TLB, BLSB
DMSC 20	-	FSR
DMSC 36	-	MLB, BLSB, C.ROT, FSR, CLS
DMSC 1	CLS	TLB, FSR,
DMSC 6	CLS	MLB, TLB, FSR
DMSC 8	-	MLB, FSR, CLS
HKI 164-7-6 x 161	-	MLB, TLB, FSR, CLS
HKI 164-D-3-3-2	-	MLB, TLB, BLSB, C.ROT, FSR,
HKI 226	FSR	MLB, TLB, C.ROT, CLS
HKI 31-2	C.RUST	MLB, TLB, C.ROT, CLS
HKI-2-6-2-4(1-2)-4	FSR	MLB, TLB, C.ROT, RDM, CLS
Hyd05R/204-1	CLS	MLB, TLB, BLSB, C.RUST, C.ROT, FSR
POBLAC61C4	-	MLB, TLB, BLSB, C.RUST, C.ROT, FSR
SHD-1 ER6	-	BLSB, C.ROT
SKV 18	FSR	TLB, P.RUST, C.ROT,
Temp.HOC 15	-	TLB, BLSB, C.ROT, FSR
CML 451Q	FSR, RDM	MLB, TLB, C.RUST, C.ROT, CLS
CML165	RDM	MLB, TLB, BLSB, C.ROT, FSR
CML 3	CLS	MLB, TLB, C.ROT, FSR
CML 321	FSR,	MLB, TLB, BLSB, C.ROT, CLS
IIMRQPM 58	-	C.ROT, FSR, CLS
DMSC 16-1	CLS	MLB, TLB, BLSB, C.ROT, FSR
DTPWC 9-F31-1-1-3	MLB, CLS	TLB, C.RUST, C.ROT, FSR
HKI 141	CLS	MLB, TLB, BLSB, C.RUST, C.ROT, FSR
HKISCST	-	MLB, FSR, CLS
KML 3-3	-	MLB, TLB, C.RUST, C.ROT, FSR, RDM, CLS

TLB – Turciuum leaf blight; MLB- Maydis leaf blight; BLSB- Banded leaf and sheath blight; C.ROT- Charcoal Rot; FSR- Fusarium stalk rot; RDM- Rajasthan downy mildew; CLS-Curvularia leaf spot; C.RUST- Common rust; P. RUST- Polysora rust.

Entomology

Identification of Multiple Borer Resistant Genotypes in artificial infestation

Among 38 genotypes were screened against *Chilo partellus*, of them in ten lines AEB (Y) C534-1-1(2.17), EC646047 (2.17), ACC No.573120 (2.20), WNZPBTL 9 (2.24), WNZPBTL 8 (2.35), EC440415 (2.39), EC598465 (2.48), E63 (2.48), BCK/BC4 (2.57) and EC 618222 (2.61) recorded LIR less than resistant check CM 500 (2.72). Another 25 genotypes were moderately resistant. One hundred and twenty-one early lines were screened against *Chilo partellus*, lines CM 212(2.22), NAI 147(2.25), HEY Pool 2011-12-5SC-3-1-1(2.29), CML 9(2.33), HEY Pool 2011-5-4-1-1-2-1(2.4), HEY Pool 2011-5-4-1-2-2-1(2.4),CM 137(2.5), CML 13(2.5), VQPM1-2-1(2.5), and HEY Pool 2011-12-1-2-1-1-1(2.6) recorded LIR less than resistant check CM 500 (2.66).

One hundred and twelve early maturing lines were screened against Pink stem borer, only four lines *viz*., CML 202, CML 9, V 353 and HEY Pool 2011-54-1-2-1-1 recorded LIR <3.0. A total of 35 lines were screened continuously in second year, against Pink stem borer and LIR were recorded <3.0 in only three lines EC 440415 (2.4) IIMR PBT Pool (2.70) and BCK/BC4 (2.7).

Screening of shoot fly under natural infestation

During spring 2016 sixty-six lines were evaluated against shoot fly, *Atherigona soccata* at Delhi for the third year, inbred line WS2 was most promising as no dead hearts were formed on this line, however <10% dead hearts were formed in PFSR5106/1(8.33), CM117-3-4-1(8.33), WINPOP-8 (8.33) and HKI1831(9.09)

A total of 32 lines were screened against shoot fly, *A. soccata* in Delhi for the first year, only one line AEB (Y) C5 34-1-1 (8.33) was recorded with <10% dead hearts.

Management of *Sitophilus oryzae* and *Sitotroga cerealella* infesting stored maize through Host plant resistance and Plant origin pesticides:

Screening of inbred lines against *Sitophilus oryzae*

A total of 43 inbred lines were screened for *S. oryzae* and the promising lines *viz*., PFSR5106/1⊗⊗⊗⊗, EC 646016, DPCL 125-2 were moderately resistant based on Dobie's index (4-7). Rest 26 lines were susceptible (8-10) against *S. oryzae*.

Evaluation of natural available plants for insecticidal activities against *S. oryzae*

Ethyl acetate and hexane extracts of *Tinospora cordifolia* and the solvent eluted fractions were evaluated against *S. oryzae*. Among all the fractions, TCH 25% and TCH 50% at 1% concenteration exhibited highest repellency of 86.22 and 79.11%, respectively towards *S. oryzae*. Hexane, ethyl acetate and methanol plant extracts from leaves of *Strychnos nux-vomica* were evaluated against *S. oryzae*. All the plant extracts were repellent at 78.4 and 235.8 µg/cm^2 after 1, 6, 24, 48 and 72 h exposure. Ethyl acetate extract of S. *nux-vomica* was most active compared to hexane and methanol extracts at all concentrations.

4

Extension and Outreach

Agricultural extension strengthens the people's capacity to innovate by providing access to knowledge and information. Agricultural production, profitability, and sustainability depend on the farmers to adopt innovative technologies, organizational approaches, management systems, institutions, and availability of resources. The services provided by IIMR include advisory and dissemination of improved production and management practices, communication and networking services, farm inputs and capacity building activities/ trainings. Farmers get better services/technology and quality inputs to enhance the maize productivity through dissemination of technology by conducting various training programmes and exhibitions.

Front Line Demonstrations

The Indian Institute of Maize Research is providing extension services to the nation through organizing Frontline Demonstrations (FLDs), field days, trainings etc. The demonstrations on maize production technology were organized at farmer's field by 14 AICRP centres in 13 states. Demonstrations were undertaken on 28.8, 9.6 and 119.8 hectares area during *rabi* 2014-15, spring 2015 and *kharif* 2015 seasons, respectively (Table 6). Under FLDs, increase in maize yield ranged between 43.2 to 148.7% during *rabi* (Fig 31) season and 7.5 to 227.5% during *kharif* (Fig 30) season over state yield (Fig 32). In spring season, yield enhancement was 100.8% under FLD over state yield (Table 1). Overall average grain yield of 5,003 kg/ha was recorded in FLDs, which showed 95.6 per cent increase over all India average yield of maize. All promising technologies *viz*. Production technologies for hybrid maize, nutrient management, pest management, weed management, seed production technology, seed treatment with bio fertilizers and plant protection chemicals, quality protein maize etc were demonstrated (Table 7). Demonstrations on intercropping of fenugreek in baby corn; and soybean and pigeon pea in maize were also conducted. The findings under FLDs highlight the potentials of further enhancing the yield levels of maize across the country. Two field days in Andhra Pradesh and Odisha, one kisan gosthi in Gujarat and one training programme in Karnataka were also organised by AICRIP centres.

Table 6. Details of FLDs conducted during different seasons in 2014-15 under NFSM

States	No. of FLDs (ha)	Range of average yield (kg/ha)	% increase over state average yield
***Rabi*- 2014-15**			
Bihar, Gujarat, Tamil Nadu	28.8	4,166 – 8,353	43.2 – 148.7
Spring-2015			
Punjab	9.6	7,329	100.8
***Kharif*-2015**			
Andhra Pradesh, Bihar, Chhattisgarh, Delhi, Gujarat, Jammu & Kashmir, Jharkhand, Karnataka, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh	119.8	2,347 – 6,318	7.5 – 227.5

Table 7. Technology demonstrated under Front Line Demonstrations

Technology demonstrated	FLDs (ha)	State
***Rabi*, 2014-15**		
Hybrid	18.8	Bihar, Tamil Nadu
Quality protein maize	10.0	Gujarat
Spring, 2015		
Production technology of spring maize	9.6	Punjab
***Kharif*, 2015**		
Production technology (Seed treatment with thiram, weed management, stem borer control, spacing, nutrient management)	42.0	Andhra Pradesh, Gujarat, Jammu and Kashmir, Karnataka
Hybrid	40.2	Bihar, Chhattisgarh, Punjab, Odisha, Tamil Nadu
Maize + Fenugreek/Arhar/Soybean intercropping	27.3	Rajasthan, Uttar Pradesh, NCR Delhi
Quality protein maize	10.3	Jharkhand

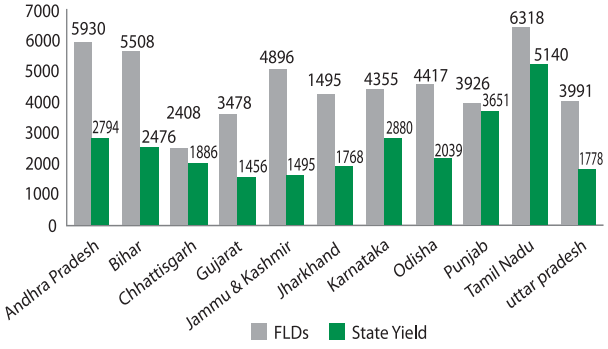


Figure 30. Comparision of grain yield of maize under FLDs with state average yield during *kharif*, 2015

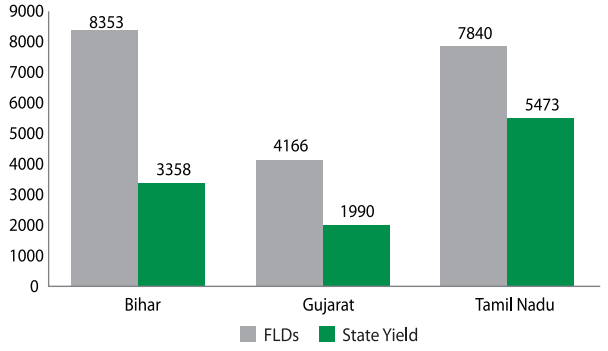


Figure 31. Comparision of grain yield of maize under FLDs with state average yield during *rabi* season, 2014-15

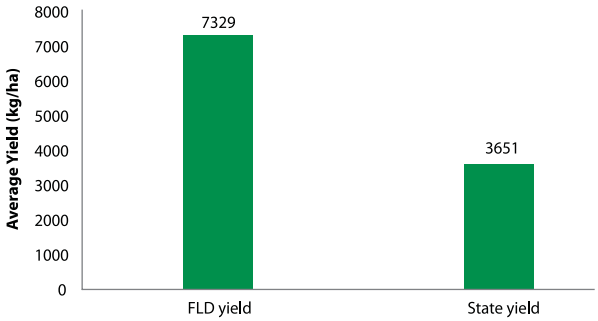


Figure 32. Comparision of grain yield of maize under FLDs with state average yield during spring, 2015

Tribal Sub Plan scheme (TSP)

Under TSP scheme, 209 hectares demonstration were carried out at tribal farmer's field by IIMR through its AICRP centres in different states of Assam, Andhra Pradesh, Chhattisgarh, Jharkhand, Karnataka, Madhya Pradesh, Odisha, Rajasthan and Uttar Pradesh. The average yield under the demonstration varied from 3,441 kg/ha to 7,500 kg/ha with 12.0% to 34.6% increase over state average yield during *rabi*, 2014-15 and 2,420 kg/ha to 5,090 kg/ha with 39.1% to 186.3% increase over state average yield during *kharif*, 2015. Four hectares FLDs in spring 2015 were conducted on baby corn cultivation in Ranchi, Jharkhand and average yield of 5,230 kg/ha husked baby corn was obtained (Table 8).

The Institute organized six National Level Training programmes on *Makka Aadharit Utpadan Pranali Avam Mulya Sanvardhan ki Naveentam Pradyogikiya* for tribal farmers to enrich their skills in respect of latest technologies in maize. In these trainings, 224 tribal farmers from ten states *viz.* Assam, Chhattisgarh, Gujarat, Jammu and Kashmir, Jharkhand, Odisha, Madhya Pradesh, Rajasthan, Uttar Pradesh and Telangana were trained. AICRP centres on maize conducted 17 Regional training programmes and 17 field days in Assam, Andhra Pradesh, Chhattisgrah, Gujarat, Jharkhand, Jammu and Kashmir, Karnataka, Madhya Pradesh, Manipur, Odisha, Rajasthan, Tamil Nadu and Uttar Pradesh wherein more than 2,300 tribal farmers were exposed to latest technologies (Table 9). To uplift the economic conditions of the farmers seed of improved maize hybrid, maize sheller, literature, biofertilizer, vermicompost, seed storage bin, Line Marker, Kunte, Tarapaulins, knapsack sprayer were provided to them.

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

To promote improved maize production technologies in the North Eastern Himalayan Region (NEHR) of India, different activities like demonstrations, trainings, farm input distribution were organized in four districts of Manipur *viz.* Chandel, Churachandpur, Tamenglong and Ukhrul in collaboration of ICAR Research complex for NEH Region, Manipur. The demonstrations were undertaken on 60 ha area and number of beneficiaries was 59. Six trainings on various aspects before sowing and during crop growing stage in selected district were also conducted and 276 persons were trained. The critical inputs were also distributed to the farmers for demonstrations. The composite varieties production varied from 2.9 to 3.4 t/ha and hybrid production varied from 3.5 to 4.1 t/ha. The net returns varied from Rs 31,600 to 41,100 in composite and RS 43,000 to 54,400 in hybrid as compared to state average net returns RS 20,010/ha.

Participation in exhibitions

The IIMR participated in India International Trade Faire in *Pragati Maidan*, New Delhi from 14th to 27th November, 2015. More than 500 visitors visited the exhibition and enriched with the maize production, protection and value addition knowledge. Exhibition was also organised during *kisan vaigyanik sanvad divas.* IIMR also exhibited their technologies during *Krishi Unnati Mela* organised in Pusa campus from 19 to 21 March, 2016 (Table 10).

Table 8. Field demonstrations on maize under TSP scheme

Season	FLDs (ha)	Average yield (kg/ha)	Percent increase*	State
Rabi, 2014-15	8.8	5,655	121.1	Assam, Andhra Pradesh
Spring, 2015 (BC)	4.0	5,230	---	Jharkhand
Kharif, 2015	195.8	3,820	49.4	A.P., Jharkhand Chhattisgarh, Karnataka, M.P., Odisha, Rajasthan, U.P.
Total	208.6	3898	52.4	

Table 9. Trainings/Field days organized by IIMR and AICRIP centers

Trainings/Field days	No. of trainings/Field days	Beneficiaries
National level trainings	6	224
Regional level trainings (in NEH region)	6	276
Field days	6	224
Trainings/Field days by AICRIP centres		
Regional level trainings	17	2,300
Field days	17	

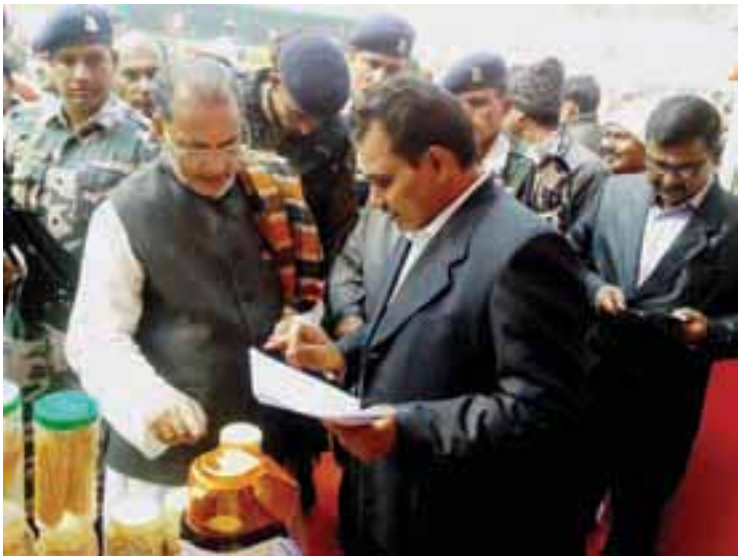
Table 10. Participation in Exhibitions/Mela/fair

Exhibitions	Date	Place
India International Trade Fare	14th-27th November, 2015	Pragati maidan, New Delhi
Exhibition during *Kisan Vaigyanik Sanvad*	25th December, 2015	Pusa Campus, New Delhi
Krishi Unnati Mela	19th to 21st March, 2016	Pusa Campus, New Delhi

Kisan Vaigyanik Sanvad

In view of lab to land technologies from agricultural scientists *"Kisan Vaigyanik Sanvad'* was organized by the eight institutions on the birth day of Hon'able former prime minister Sh. Atal Bihari Vajpayeeji and to remember the contributions of Hon'able former Prime Minister Chaudhary Charan Singhji on 25 December, 2015. Indian Institute of Maize Research was one of the institutes among the eight institutions who celebrated the function jointly. The main aim of the function was to have the interaction between scientists and the farmers to discuss the latest technologies and to solve the problems of the farmers. Hon'able minister of state of agriculture Dr Sanjeev Kumar Balyan inaugurated the function. The progressive farmers were also awarded on this occasion by the Hon'able minister and a show case of the latest technologies available was also displayed in an exhibition.

Inauguration of Kisan Vaigyanik Samvad



Hon'ble Agriculture Minister Sh. Radha Mohan Singh, visited IIMR, stall

IIMR Participation in Agra Exhibition

Extension training programm at IIMR

Director, IIMR at Krishi Unnati Mela

Input Distribution in TSP Programme

TSP Programme at Aterna village, Haryana

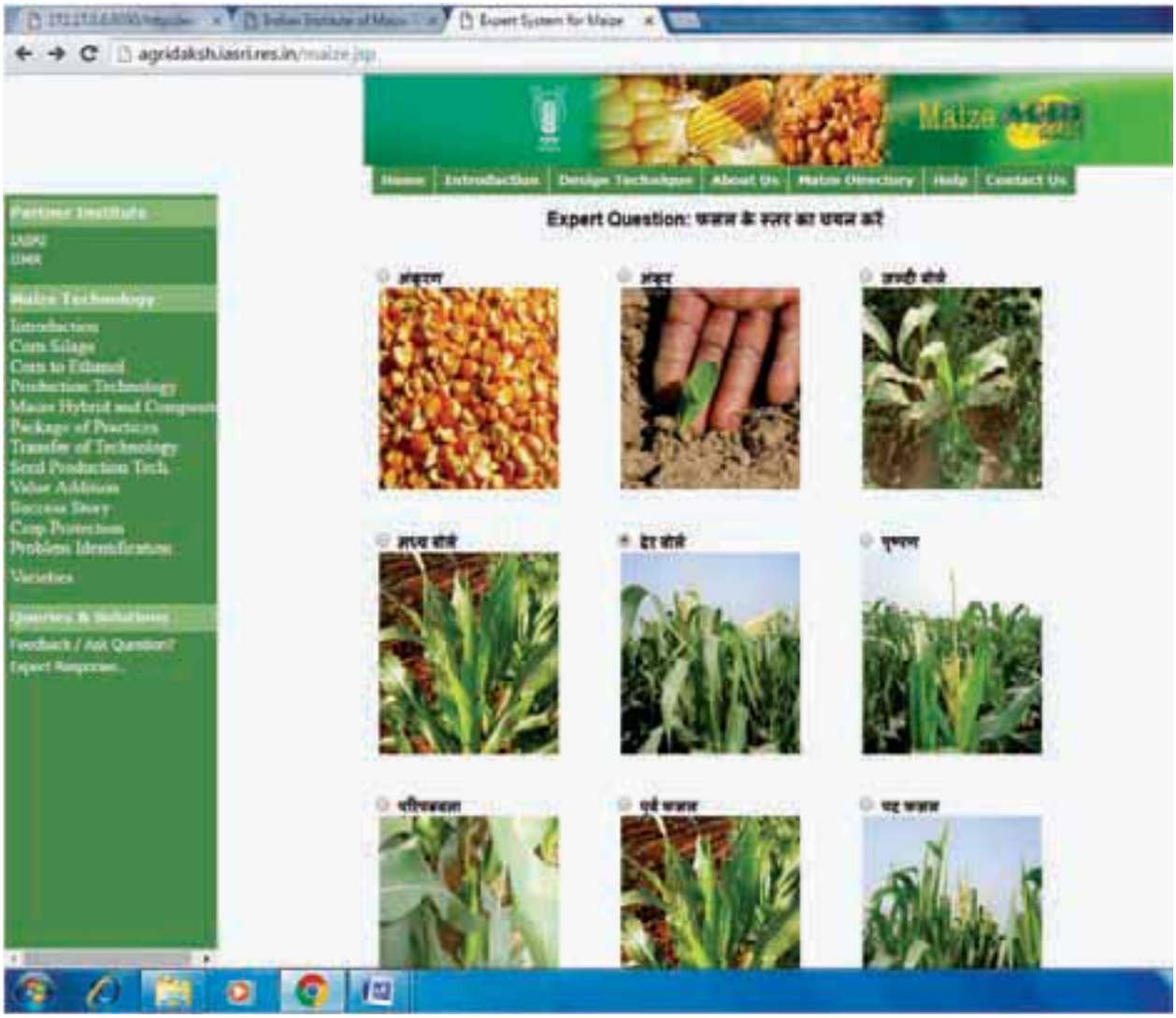
A View of Field day

TSP Certificate Distribution Ceremony

TSP Training and field visit at Manauli village, Haryana

Strengthening and Refinement of Maize AgriDaksh

Problem Identification (समस्या की पहचान) Module developed. The database of hybrids and varieties updated and improved with new features. A screen shot of the system is shown below.



5

All India Coordinated Research Project (AICRP)

In 1957, first co-ordinated programme in India was started in maize crop with the objective to develop and disseminate superior cultivars and production/ protection technologies. All India coordinated Research Project (AICRP) is an oldest co-ordinated research system in India for varietal testing across different agro-climatic zones.

Based on agro-climatic conditions, country has been demarcated into five zones (Fig. 33) constituting 30 centres (Table 11) 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.

Table 11. 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	33°22' N	77°0' E	1090	Grey wooded Podzolic soil
		Himachal Pradesh Krishi Vishvidhyala, Dhaulakuan	30 ° 30' N	77 °20' E	468.0	Brown alluvial and grey brown podzolic soil
		CSK, Himachal Pradesh Krishi Vishvidhyala, Kangra	32°6' N	76 °16' E	2404	
	Jammu and Kashmir	Sher-e-Kashmir University of Agricultural Science and Technology of Jammu, Udhampur, Jammu	32°56' N	75°8' E	2480	Sandy loam
	Uttarakhand	Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora	29°37' N	79°40' E	1650	Clay loam
	North Eastern States	ICAR Research Complex for NEH region, Barapani	25°70' N	91°97' E	1500	Sandy loam
		Assam Agricultural University (AAU), Jorhat, Assam	26°45' N	94°13' E	91.0	Sandy loam
NWPZ	Punjab	Punjab Agricultural University, Ludhiana	30°54' N	75°51' E	247	Sandy, clay loam
	Punjab	Indian Institute of maize Research Ludhiana	30°54' N	75°51' E	247	Sandy, clay loam
	Haryana	Chaudhary Charan Singh, Haryana Agricultural University, Uchani, Karnal	29°41' N	76°59' E	257	Loamy soil

	Delhi	Indian Institute of Maize Research, IARI, Delhi	28°39' N	77°13' E	228	Loam to sandy loam
	Uttar Pradesh	Chandra Shekhar Azad University of Agricultural and Technology, Kanpur	26°28' N	80°21' E	125	Sandy loam
	Uttarakhand	Govind Ballabh Pant University of Agriculture and Technology.	29°6' N	79°30' E	243	Clay loam
NEPZ	Bihar	Rajendra Agricultural University, Dholi	25°54' N	85°36' E	51.8	Sandy loam
	Jharkhand	Bisra Agricultural University, Ranchi	23°21' N	85°20' E	652	Sandy loam
	Orissa	Orissa University of Agriculture and Technology, Bhubaneswar	20°14' N	85°50' E	45	Clay loam
	Eastern Uttar Pradesh	Banaras Hindu University, Varanasi	25°20' N	83°0' E	128.93	Sandy loam
		Narendra Dev University of Agriculture and Technology, Bahraich	27°35' N	81°36' E	130	Sandy loam
PZ	Karnataka	University of Agricultural Sciences, Bangalore, Mandya	12°33'N	76°54' 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	Acharaya N G Ranga Agricultural University, Hyderabad	17°23'N	78°29' E	530	Black Clay loam
		ANGRAU, Karimnagar	18°26'N	79°9' E	869	Red sandy-loamy
	Tamil Nadu	Tamil Nadu Agricultural University, Coimbatore	11°0'N	76°58' E	411.5	Black
		TNAU, Vagarai	10° 35' N	77° 34' E	926	Black
	Maharashtra	Kolhapur	21°0' N	77°52' E	574	Light to medium black
CWZ	Rajasthan	Maharana Pratap University of Agriculture and Technology, Banswara	23°33' N	74°27' E	218	Red loam
		MPUA &T, Udaipur	24°35' N	73°41' E	572	Loam to sandy loam
	Gujarat	Anand Agriculture University, Godhra	22°45' N	73°38' E	119.4	Sandy loam
	Madhya Pradesh	Jawaharlal Nehru Krishi Viswa Vidyalaya, Chhindwara	22° 4' N	78° 56' E	682	Medium clay
		Rajmata Vijayaraje Scindia Krishi Viswa Vidyalaya, Jhabua	22°46' N	74°36' E	318	Clayey to Sandy
	Chhattisgarh	Ambikapur	23°7' N	83°12' E	1978	Sandy loam

Figure 33. Agro-climatic zones of India

AICRP trials conducted during the year

AICRP *kharif* 2015

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. During *kharif*, 343 maize entries were evaluated in all India coordinated trials. Of 343 entries, 219 entries were evaluated in national initial varietal trial (NIVT), 40 in advance varietal trial-I (AVT-I), 18 in advance varietal trial-II (AVT-II), 30 entries in quality protein maize (QPM), and 36 in specialty corns trials (17 in baby corn, 10 in sweet corn, and 9 in popcorn trials).

Of total entries received, 221 contributed by public and 122 by the private sector. Fifteen breeding trials (four each of NIVT, AVT-I, specialty corns and three of AVT-II) were constituted for evaluation at 64 locations (33 regular and 31 volunteers) across country. Data received from 54 locations, were reviewed, analyzed for yield and related traits and performance of varieties compared with respective checks. Based on superiority, 24.1% (76 out of 315) entries were promoted to their advance stage. Further four essentially derived

varieties (EDV) of QPM *viz.*, AQH8 (PZ), AQH4 (NWPZ), AQH9 (NEPZ) and APQH9 (NHZ, PZ) developed by marker assisted selection (MAS) were tested in final year trial.

AICRP *rabi* 2014-15 & 2015-16

During *rabi* 2014-15, a total of 128 maize entries were evaluated in 9 different breeding trials at 17 locations across four zones and 103 entries were promoted. In 2015-16 a total of 51 test entries were promoted for their advance generation in addition to that, 112 entries were received for testing in AICRP and 63 entries were received in NIVT, 24 in AVT-I, 23 in AVT-II, and 2 entries were in QPM trials. Further, in total, 35 were contributed from public sector and 77 from private partners. All trials are under testing at 17 locations across country.

Agronomy

The major agronomic research trial were focused on nutrient and planting density 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, and enhancing water-use efficiency in rainfed maize. There were 11 Maize Agronomy Trials constituted. The trial-wise highlights are as follows:

Evaluation of pre-release genotypes under varying planting density and nutrient levels; A total of eight pre-release early maturing genotypes were evaluated under different nutrient levels (150:50:60, 200:60:80 N: P_2O_5: K_2O kg/ha) in NHZ, PZ and CWZ. Best genotypes at high nutrient level and 50x20 cm planting density, were FH-3626, FH-3605 and Bio-9720 at Almora (NHZ); FH-3664 and FH-3605 at Dharwad and Karimnagar (PZ) and FH-3664 at Udaipur (CWZ). In medium maturity, DKC9144 (IM8478) & HTMH-5402, performed best at low nutrient levels and high planting density (50x20 cm). Genotype X35D601 at Ludhiana (NWPZ), Vagarai (PZ) and DKC9141 (IM8539) at Banswara (CWZ) were best at high nutrient levels (250:80:100 N:P_2O_5:K_2O kg/ha) and 50x20 cm plant density.

Popcorn, KDPC-2 performed best at high nutrient level (200:60:80 N: P_2O_5: K_2O kg/ha) and plant density (50x20 cm) at Almora and Bajaura (NHZ); Ambikapur (NEPZ); Hyderabad and Karimnagar (PZ). However at Ludhiana and Godhra (CWZ) it yielded maximum but could not surpass best check in similar conditions. VL popcorn-2 performed best at similar conditions at Baharaich and Bhubneshwar (NEPZ).

Sweet corn ADVSW-1 gave higher yield at nutrient levels (200:60:80 N: P_2O_5: K_2O kg/ha) and plant density (50x20 cm) at Almora; Delhi; Hyderabad and Karimnagar and Godhra. Whereas ADVSW-2 and FSCH-41 were found best at Almora, Bajaura; Hyderabad and Karimnagar under similar nutrient and plant density.

QPM genotypes performed well at different nutrient levels (150:50:60 and 200:60:80 N: P_2O_5: K_2O kg/ha) at Bajaura, (200:65:80 and 250:80:100 N: P_2O_5: K_2O kg/ha) at Ludhiana, Karnal and Ranchi whereas at (150:65:65, 200:80:80 and 250:95:95 N: P_2O_5: K_2O kg/ha) at Vagarai.

Nutrient management in maize-wheat-greengram cropping system under different tillage practices

Under this experiment, 3.3-42.8% higher yield over conventional tillage was achieved under zero tillage, at Karnal, Pantnagar, Dholi and Banswara. However, the conventional tillage planting gave 9.6% higher yield at Udaipur. SSNM gave higher yield at Banswara and Dholi, while farmer's fertilization practices (FFP) gave higher yield at Karnal and (Recommended Dose of Fertilizer) RDF at Udaipur and Pantnagar

Nutrient management in maize-chickpea/mustard cropping systems under different tillage practices

Zero tillage planting gave 6.52-19.3%, higher yields over conventional tillage at Srinagar and Delhi. However, conventional tillage performed well at Chhindwara. SSNM gave higher yield at Srinagar and Chhindwara, and remained higher with 100% RDF in Delhi.

Nutrient management for maize genotypes under different cropping systems

In this trial SSNM based decision support system gave 42.0, 63.3, 3.6, 17.4, 20.5, 44.9, 51.0, 83.8, 1.8, 5.0, 32.5 and 50.2% higher yield over recommended fertilizer practices

(RDF) at Bajaura, Srinagar, Karnal, Ludhiana, Pantnagar, Ambikapur, Bahraich, Ranchi, Hyderabad, Karimnagar, Chhindwara, and Udaipur, respectively. However, RDF resulted better at Dharwad. Significantly higher yield was obtained in hybrids K-25 Gold at Bajaura, HQPM-1 at Srinagar and Dharwad, PHM-3 at Karnal, Karimnagar, Bahraich and Chhindwara, PMH-1 at Ludhiana and Pantnagar, NK-30 at Ambikapur, CMH-08-350 at Ranchi, CMH-08-292 at Hyderabad and Udaipur.

Effect of planting density and nutrient management practices on the performance of hybrids in *kharif*

Popular maize hybrids responded well to high density at Bajaura (60x15cm^2), Ludhiana, Pantnagar (67.5x15cm^2), Bhubneshwar, Coimbatore, Banswara (50x20cm^2) and Udaipur (60x20 cm^2) with yield enhancement by 9.4, 6.2, 13.8, 8.3, 15.4, 14.7 and 11.1% higher over normal density, respectively. However, these genotypes responded well in normal density at Srinagar, Karnal, Ambikapur, Bahraich, Dholi, Ranchi, Dharwad, Hyderabad, Karimnagar, Chhindwara and Godhra. SSNM practices were best at Srinagar, Ludhiana, Ambikapur, Bahraich, Banswara and Chhindwara while Soil test crop response (STCR) was superior at Bajaura, Karnal, Pantnagar, Bhubaneswar, Dholi, Ranchi, Hyderabad, Karimnagar, Godhra and Udaipur, respectively. However RDF proved better at Coimbatore and Dharwad.

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

The experiment initiated in *kharif* 2014 at Pantnagar and this year higher yield (5.65 t/ha) was obtained with 100% RDF + 5,000 kg/ha FYM. However, 100% RDF was at par with 100% RDF + 5kg Zn/ha application. Economic analysis showed a new path for organic cultivation of maize and it was found that maize + cowpea as intercrop with FYM 10 t/ha + Azotobacter resulted in highest net returns and B: C ratio.

Weed management in maize systems

Experiments conducted at 19 locations with 10 treatments *viz.*, T1-Control (weedy check), T2-Weed free, T3-Atrazine @1.5* kg/ha preemegence, T4-Atrazine (750g/ha) + Pendemathalin (750ml/ha) preemegence, T5-Atrazine (750g/ha) + 2, 4-D Amine (500g/ha) at 25 DAS as PoE, T6-Halosulfuron 60 g/ha at 25 DAS, T7-Atrazine @1.5 kg/ha preemegence fb Halosulfuron 60 g/ha 25 DAS, T8-Tembotrione (Laudis) 120 g/ha PoE at 25 DAS, T9-Pendemathalin (1000 ml/ha) preemegence fb Atrazine (750 g/ha) + 2,4-D Amine (500 g/ha) at 25 DAS as PoE and T10-Atrazine @1.5 kg/ha preemegence fb Tembotrione (Laudis) 120 g/ha PoE at 25 DAS. Only T9 and T10 were the best at nine locations *viz.*, Bajaura, Ludhiana, Pantnagar, Ambikapur, Kalyani, Ranchi, Coimbatore and Hyderabad; however maximum yield was recorded under weed free (T2) treatment at 16 locations, except at Bahraich, Bhubaneswar and Vagarai.

Enhancing water-use efficiency in rainfed maize

Rainfed hybrids responded to zero tillage + mulch at Srinagar, Hisar, Dholi, Karimnagar and Chhindwara with yield enhancement by 9.7, 111.1, 26.5, 2.2 and 18.1% higher over conventional tillage without mulch, respectively. The response to conventional tillage with mulch was observed at Bhubaneswar. Hydrogel @5.0 (kg/ha) resulted yield increment by 3.0, 11.4, 13.2, 5.0, 0.4 and 5.3% at Srinagar, Hisar, Dholi, Karimnagar and Chhindwara centers, respectively over control.

Agronomy salient achievement of *rabi* 2014-15

Among thirteen pre-release late maturity; genotypes IL8212, IL8534, DKC 9120, P 3533 and X35C357, Bisco x 6573; in PZ; IL8212, IL 8534, PMH 2277, Ivori, KMH 2589, X35C537, KMH 2589, P3533, and Bisco x 6573; in NWPZ and Venus, Bisco x 6573 and P 3533 in CWZ, were best at high plant density (60x15 cm2). In medium maturity AHT–II year, genotypes DKC 9155, DKC 9142 and PMH 2246 gave higher yield at Banswara and Arbhavi. At Pantnagar, DKC 9135, DKC 9155, PMH 2246 and MKM 325 were best. In early maturity genotypes KHK 25, HKH 329, and HKH 330 gave higher yield at Arbhavi, Karimnagar; Ludhiana, Pantnagar and Karnal; while HKH 329 at Banswara, at high plant density (1lakh/ha).

Planting of popular maize hybrids in high density gave higher yield at Dholi (10.0 t/ha) and Banswara (8.8 t/ha). The application of nutrients based on soil test crop response (STCR) based equations gave higher yield at Dholi, Karimnagar

and Banswara (9.0 t/ha) while at Vagarai SSNM was effective. In maize-wheat-mungbean system; adoption of permanent raised beds (PB) at Dholi and flat zero tillage (ZT) at Banswara was effective over conventional tillage (CT), while CT was superior over CA practices at Pantnagar. In maize-chickpea cropping system, zero tillage gave higher yield and SSNM also better over farmer's fertilization practices (FFP) and RDF at Banswara. In Pantnagar and Banswara SSNM responded well at maize-wheat-mungbean system over FFP while at Dholi; FFP gave higher yields over RDF and SSNM. Highest (10.2 t/ha) productivity of maize-wheat system was recorded with 100% RDF + FYM @ 5 t/ha.

Pathology

Survey and surveillance of maize diseases

Maize disease survey and surveillance was undertaken in maize growing areas of Punjab; Himachal Pradesh; Karnataka; Rajasthan and Gujarat, covering 6, 3, 13, 20, 6 and 10 locations respectively during *Kharif* 2015. Banded leaf and sheath blight (BLSB) was the most important disease noticed from Punjab, H.P., Gujrat and Rajasthan with incidence form moderate to high, 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. In rest diseases were common in their respective areas. Based on the survey surveillance a disease map was updated (Fig. 34)

Coordinated trials

During the reporting period a total of 17 disease evaluation trials were conducted under artificially sick 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 411 hybrids in both seasons and 231 inbred lines (*kharif*) were screened against Maydis leaf blight, Turcicum leaf blight, Banded leaf and sheath blight, Sorghum downy mildew (SDM), Rajasthan downy mildew (RDM), Curvularia leaf spot, Post-flowering stalk rots (PFSR), Common rust, Polysora rust, Bacterial stalk rot (BSR) and Cyst nematode. The summarized results of various AICRP pathology trials conducted at respective centers are in Table 12.

Table 12 Promising genotypes in *kharif* with combined diseases resistance

Major Diseases	Promising entries with multiple disease resistance
IVT (late maturity) -	Genotypes
Trial 61A	
MLB, C.RUST, SDM, BSR	JKMH 4153
MLB, TLB, C.RUST	BRM 12-1
MLB, C.RUST, RDM	PM15104L
MLB, TLB, C.RUST, RDM	HT 515387
TLB, C.RUST, FSR	PM15105L
Trial 61B	
C.RUST, FSR, RDM	HM15313
MLB, TLB, C.RUST, FSR	IIMRNH 2015-7
MLB, TLB, C.RUST, RDM	JH 13346
MLB, TLB, C.RUST	RMH-748
TLB, C.RUST, FSR	CMH12-686
MLB, C.RUST, RDM	PM15103L
MLB, C.RUST, RDM	ZASL-986
MLB, TLB, C.RUST, RDM	HT 515169
MLB, C.RUST, RDM	KMH-2852
MLB, TLB, C.RUST	DH-295
MLB, TLB, C.RUST, FSR, RDM	DKC8144 (IM8479)
MLB, TLB, FSR, RDM	IIMRNH 2015-6
MLB, TLB, RDM	BRM 12-6
MLB, C.RUST, RDM	BL 108
MLB, TLB, C.RUST, RDM	MAH-K14-3(CAHCM1473)
MLB, C.RUST, FSR, RDM	DKC9164 (IP9002)
MLB, C.RUST, RDM	RMH-726
IVT (medium maturity)	**Genotypes**
MLB, TLB, C.RUST, RDM	BRM 12-3
MLB, TLB, C.RUST	CMH11-620
MLB, TLB, C.RUST	CMH12-699
MLB, TLB, C.RUST, RDM	RCRMH1 (HTMR1)
FSR, RDM, BSR	LMH 615

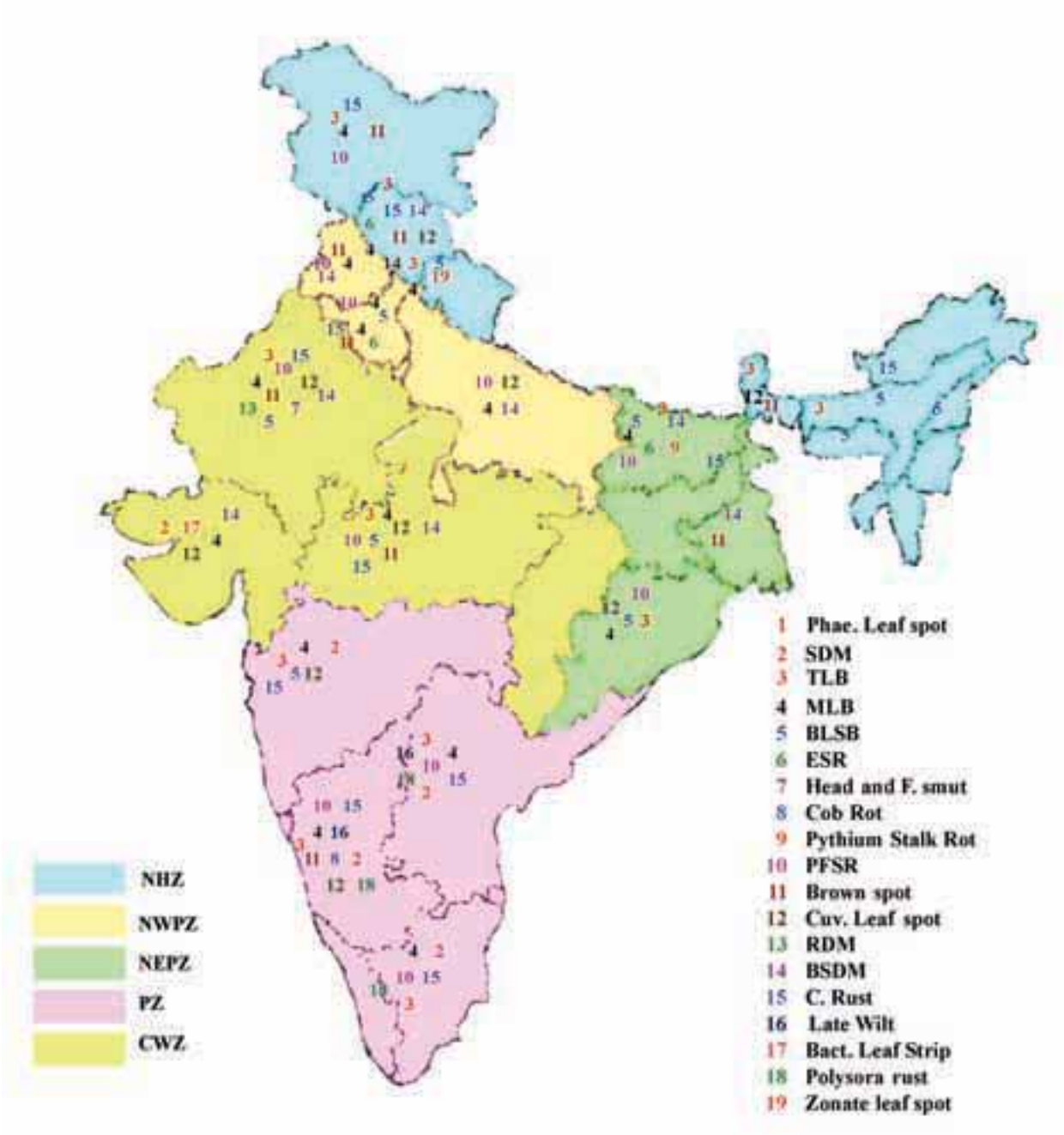


Figure 34. Disease distribution map based on disease survey *kharif* 2015

MLB, C.RUST, RDM	OMH 14-64(CAH 1532)
TLB, FSR, RDM	NMH 109
MLB, C.RUST, FSR	JH 13347
TLB, C.RUST, FSR	DAS-MH-309
MLB, TLB, RDM	KNMH-4508
MLB, TLB, C.RUST, FSR, RDM	LMH 1015
MLB, C.RUST, RDM, BSR	HT 515349
MLB, FSR, RDM	JH 31820
TLB, C.RUST, RDM	OMH 14-7(CAH 1538)

MLB, C.RUST, FSR, RDM	BIO 274
MLB, FSR, RDM	RMH-301
MLB, FSR, RDM	AH7009
MLB, C.RUST, RDM	BGMH2 (CAH1454)
IVT early & extra early maturity Genotypes	
FSR, RDM, BSR	AH1402
C.RUST, FSR, RDM	LMH 1315
FSR, RDM, BSR	NMH-51
MLB, FSR, RDM	KMH-5510
MLB, C.RUST, RDM	FH 3754

MLB, RDM, BSR	CMH12-700
AVT I & AVT II (late maturity) Genotypes	
AVT- I	
MLB, TLB, C.RUST, FSR	HT 51412616
MLB, TLB, BSR	DAS-MH-106
MLB, C.RUST, BSR	CMH 10-555
MLB, TLB, C.RUST, RDM, BSR	CMH 11-618
MLB, C.RUST, RDM, BSR	Gold 1166
FSR,RDM, BSR	HT 51412607
FSR, FSR, BSR	ADV 0990296
MLB, C.RUST, RDM	NMH-1247
MLB, C.RUST, BSR	Super-1177
MLB, C.RUST, FSR, RDM	KMH-3981
MLB, C.RUST, FSR, BSR	GK3118
MLB, C.RUST, RDM	KH-2192
MLB, C.RUST, RDM, BSR	DMRH1308
AVT- II	
MLB, C.RUST, RDM	DKC9133
MLB, FSR, RDM	DKC9141 (IM8539)
MLB, FSR, RDM	IM8556
MLB, C.RUST, RDM	PRO-392
MLB, C.RUST, RDM	DAS-MH-105
MLB, C.RUST, FSR, RDM	CP.999
AVT I & AVT II (medium maturity) Genotypes	
AVT-I	
MLB, FSR, RDM, BSR	BH 412084
MLB, FSR, RDM	JH 31605
MLB, C.RUST, RDM, BSR	HT 51412182
MLB, TLB	DAS-MH-306
C.RUST, RDM, BSR	JKMH 4848
MLB, FSR, RDM, BSR	HT 51412607
AVT-II	
MLB, FSR, RDM	HTMH 5402
MLB, C.RUST, RDM	DKC9144 (IM8478)

During *rabi* a total of 140 genotypes were evaluated under artificial conditions for charcoal rot, common rust, turcicum leaf blight and sorghum downy mildew. In IVT late and medium maturity 9 &10; AVT Ist and IInd late maturity 4 & 5; AVT-I and AVT-II Medium maturity 4 & 2 respectively; AVT-II, and QPM I-II Early maturity two genotypes in each were resistant to TLB

Nematology

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

A total of 388 maize hybrids from different maturity groups were screened for *H. zeae*. Of them, 23 entries *viz.*; OMH 14-27(CAH 153), PM15105L, QMH-1231, JH 13336, JH 13208, JH 13348, JH 13347, BIO 509, RCRMH2 (HTMR2), PM15107M, PMH-4-C, JKMH 4222, PRMH-189, KMH-3981, X35D601, HT 51412182, HTMH 5402, CMH 10-531, IMHB 1529, IMHB 1531, IIMRQPMH 1502, BQPMH 36, and HQPM 4-C exhibited moderately resistant reaction

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

Occurrence of maize cyst nematode was recorded in maize growing areas of Rajasthan. Maximum occurrence (100.00%) was observed in Durga Kund village of Rajsamand district followed by Salumber (Udaipur) and Gomti (Rajsamand) villages (80.00%). Minimum occurrence recorded in Sikhrani village of Ajmer (50.00%). On the whole, occurrence was estimated 70.83% in surveyed areas

Evaluation of AICRP entries against spotted stem borer *Chilo partellus*

A total of 193 hybrids, specialty corn, QPM and inbreds screened against *C. Partellus* under artificial infestation condition at NWPZ (Delhi, Karnal and Ludhiana), NEPZ (Dholi), PZ (Kolhapur, Hyderabad) and CWZ (Udaipur). Of them entries CMH10-555, ADV0990296, PRMH-189, ADV1190384, 115-08-01, Siri-4527 in NWPZ, DAS-Mh-106, PM14101L, GK3118, Siri-4527, PMH-3-C and Bio9681-C in CWZ were least susceptible in full season maturity whereas in medium maturity BH412084, JH31605, CP.201, DKC9144 (IM8478) and HM9-C in NWPZ and BH412084, BL897 and HT51412607 in CWZ; in early maturity GYH-0656, FH3605, FH3664 and CMH10-531 in NWPZ and FH3605, FH 3664, PMH-5-C in CWZ, were least susceptible. In extra early maturity Vivek Hybrid 21-C and Vivek Hybrid 43-C were selected for least susceptible reaction.

During *rabi* 2014-15, the entries X35F880 (2.5) and Rasi 950 (2.9) in full season; DKC 9155 (2.9)

in medium and PMH 2246 (2.4) in early maturity-QPM were selected for least susceptibility against *C. partellus* at Kolhapur.

Speciality Corn

Popcorn entries with least susceptibility against *C. Partellus* in NWPZ were SJPC1, MPC-1-15 and VL pop corn-C; DMRHP 1402 IMHP 1540, HPC1, VL Popcorn-2 (Re-testing), KDPC-2 (Pop corn), IMHP 1535 and VL Pop corn-C in NEPZ and VL Popcorn-2(Re-testing) and SJPC1 in CWZ.

Sweet corn entries FSCH 75, QMHSC-1182, BSCH 6, SJSC1, ASKH1, FSCH 41 and ASKH4 in NEPZ, QMHSC-1182 in CWZ: FSCH 55 in CWZ and NWPZ.

Baby corn genotypes with least susceptibility were Vivek MH 27(R-Testing), IMHB 1531, HKH 425 and HM4-C in NWPZ; IMHB 1538, IMHB 1539, MBC-11-15, IMHB 1537, ABH9001, DMRH 1305, IMHB 1531, IMHB 1532, GAYMH-1, IMH 1525, BAUM-3, ASKBH1 and HM4-C and IMHB 1529, IMHB 1539, BAUM-3 and HM4-C were in CWZ.

QPM entries EHQ-64, BQPMH-18, IIMRQPMH1510 and IIMRQPMH in NWPZ; All entries except IIMRQPMH1510 in NEPZ; IIMRQPMH1507, IIMRQPMH1508, LQPMH 415, APQH9(EDV), IIMRQPMH1504, BQPMH-18, IIMRQPMH1505, FQH 106, LQPMH 115, LQPMH 315, DHM 117-C and HQPM1-C in PZ and AQH4 (EDV), APQH9 (EDV), HM4-C and HQPM 5-C in CWZ were least susceptible.

Inbred lines

Inbred lines with least susceptibility against *C. Partellus* are Entries-ACC.NO571611, ACC. NO. 584542 and AEB(Y) C534-1-2 in NEPZ (Zone III); and ACC.No.565880, ACCNo.565881, AEB(Y) C534-1-2, EC4400415, E 62 and KDM895A were least susceptible in CWZ (Zone V) out of forty two lines screened. A total of 9 inbreds in early maturity *viz.*, HEY Pool -2011-12-1-2-1-1-1(2.6), CM-212(2.22), HEY POOL-2011-12-5SC-3-1-1(2.29), CML 9(2.33), HEY Pool -2011-5-4-1-1-2-1(2.4), HEY Pool -2011-5-4-1-2-2-1(2.4), CM-137(2.5), CM-13(2.5) and VQPM9-1-2-1(2.5) were selected based on LIR (Leaf injury rating) less then R Check CM 500(2.66)

Monitoring of *Helicoverpa armigera* by pheromone traps

The moths (*H. armigera*) first appeared in second week of September and continue till first week of October at Delhi with maximum population *i.e.* 7.5/trap/week in first week of October. Moths also appeared at Karnal in the same metrological period, whereas at Ludhiana from first week of May to second week of June, with maximum population (64.5/trap/3 days) in mid June. At Udaipur it observed in the second fortnight of September with maximum activity (5 moths /trap) during the last week of September. Activity period of moths varied from 15 days (Udaipur) to 30 days (Delhi and Karnal). The cob infestation was 27.5, 3.9, 0.5 and 6.8% at Delhi, Karnal, Hyderabad and Udaipur respectively.

Evaluation of biocontrol agents, egg and larval parasitoids

Egg parasitoids

The parasitization was recorded on the freshly laid eggs by *C. partellus* by artificially releasing the adults on HQPM1 and PMH1 at 12 DAG and no parasitization was observed at Karnal, Kolhapur, Ludhiana and Udaipur, while 2.66 and 2.96 percent parasitization by *Trichogramma* was recorded at Delhi and Hyderabad respectively.

Larval parasitoids

The larvae collected from infested maize plants when reared in laboratory, resulted in 37.5, 6.1, 5.6, 8.6, and 4.8 percent parasitization by *Cotesia flavipes* at Delhi, Karnal, Hyderabad, Ludhiana and Udaipur respectively. In all centres, mean larval incidence suggested *Cotesia* activated during 30-60 DAG with maximum incidence (22.3%) at 40 DAG and starts decreasing till 60 DAG. No parasitized larvae recovered from the plants dissected at 70 DAG at any of the centre.

Evaluation of insecticides against stem borers

The efficacy of four insecticides *viz.*, Chlorantraniliprole 18.5 SC, Flubendiamide 480 SC, Novaluron 10 EC and Deltamethrin 2.8 EC were evaluated at AICRP centres during *kharif*, 2015. The insecticides Flubendiamide 480 SC @

0.2ml/litre followed by Chlorantraniliprole 18.5 SC @0.4ml/litre were most effective based on leaf injury rating and also resulting in maximum yield return as compared to other treatments

Evaluation of inbred lines against Shoot fly *Atherigona Spp.*

A total of 71 inbred lines were evaluated at Delhi and Ludhiana under natural infestation during spring 2015 and the lines recorded <10.0% dead hearts were CML420 (8.3), ACC No. 263214 (9.1), WINPOP 8 (9.1) AEB (Y) (10.0%) and CML49 (10.0)

Evaluation of entries against Pink stem borer, *Sesamia inferens*

During 2014-15, out of 39 entries screened against *Sesamia inferens* at Hyderabad under artificial infestation in late maturity, only one entry Venus (2.5) was least susceptible in late maturity. In the medium and early maturity, none of the entries were promising whereas entry BL 798(6.7) in medium and DKC9155 (6.6) and DKC 9135(6.2) were highly susceptible in early maturity.

Evaluation of inbred lines against Pink stem borer, *Sesamia inferens* under artificial infestation during *rabi* 2014-15

Continuously three years screening of fifteen inbred lines against *S. inferens* at WNC, Hyderabad resulted in identifying two least susceptible genotypes, WNZ EXOTIC POOLDC2 (2.6) and WNZPBTL 6 (3.0).

Relationship between LIR and Yield for *S. inferens*

There was reduction in yield at each LIR when the yield at LIR 2 - 9 compared against LIR 1. Reduction of 13.7 and 87.3 percent in grain yield was observed at LIR 2 and 9 respectively as against LIR 1.

During *rabi* 2014-15, the entries X35F880 (2.5) and Rasi 950 (2.9) in full season; DKC 9155 (2.9) in medium and PMH 2246 (2.4) in early maturity-QPM were selected for least susceptibility against *C. partellus* at Kolhapur.

6

Significant Events

ICAR-IIMR celebrated its first foundation day

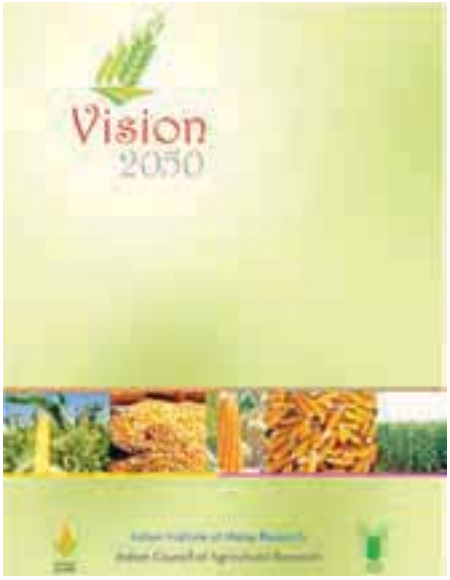
ICAR-Indian Institute of Maize Research celebrated its first Foundation Day on 14th November 2015 after being rechristened as IIMR from the erstwhile Directorate of Maize Research. Dr. BM Prasanna, Director of the Global Maize Program, CIMMYT & CGIAR Research Program, MAIZE delivered the First Foundation Day Lecture on "Doubling Maize Production of India by 2025". Dr. JS Sandhu, DDG (Crop Sciences), Chief Guest at this occasion, emphasized role of maize in developing climate resilient agriculture and called upon maize scientists to make sombre efforts to bridge the gap between achievable and realized maize yields at farmer's field especially in rainfed farming system of *kharif* season.

On this occasion, a documentary 'Amazing Maize – The Story of IIMR' and 'IIMR Newsletter' was released. Scientists, institute employees, progressive maize farmers and Entrepreneurs were felicitated for their significant contribution.

Glimpses of ICAR-IIMR Foundation Day Celebrations

Vision 2050 of ICAR- IIMR released

The Vision 2050 of ICAR- Indian Institute of Maize Research was released on 25th July 2015 during 87th Foundation Day and ICAR Award Ceremony at Patna by Hon'ble Prime Minister of India, Shri Narendra Modi along with all other ICAR institutes. The Hon'ble Prime Minister called upon agricultural scientists and planners to design second green revolution with new vision, dimensions and objectives to address the agricultural challenges in this modern era. In his message for the IIMR Vision 2050, the Hon'ble Minister of Agriculture and Farmer Welfare, Government of India and President of ICAR, Shri Radha Mohan Singh emphasized that we can certainly imagine a better agricultural scenario in future by learning lessons from past practices and for this we have to assess various technological models and prepare a blueprint for the future. The complete Vision 2050 document is available at www.iimr.res.in and www.icar.org.in



Vision 2050 of IIMR released along with Vision 2050 document of ICAR by Hon'ble Prime Minister Sh. Narendra Modi

58th Annual Maize Workshop Organized

The ICAR-Indian Institute of Maize Research (IIMR), the Punjab Agricultural University (PAU) and the Crop Improvement Society of India jointly organized the 58th Annual Workshop of AICRP on maize at Ludhiana during 4-6th April, 2015. Dr. Gurbachan Singh, Chairman, Agricultural Scientists' Recruitment Board was the Chief Guest on the occasion. The Guest-of-Honour on the occasion, Dr. J.S. Sandhu, Deputy Director General (Crop Sciences), highlighted that hybrid breeding needs greater focus, and research on suitable maize germplasm with tolerance to both drought and water-logging conditions is required. Dr. B.S. Dhillon, Vice-Chancellor, PAU presided over the inaugural function

Publication released during 58th Annual Maize Workshop

AICRP Coimbatore Centre received best Centre award during 58th Annual Maize Workshop

Brainstorming workshop on "Upscaling Quality Protein Maize for Nutrition Security" organized

A two-day brainstorming workshop on "Upscaling Quality Protein Maize for Nutrition Security" was organized during May 20-21, 2015, at National Agricultural Science Centre Complex, New Delhi. It was jointly organized by the Indian Council of Agricultural Research (ICAR), Trust for Advancement of Agricultural Sciences

(TAAS), National Academy of Agricultural Sciences (NAAS), Indian Institute of Maize Research (IIMR), International Maize and Wheat Improvement Centre (CIMMYT), Borlaug institute for South Asia (BISA) and Indian Society of Genetics and Plant Breeding (ISGPB). During the workshop eight technical sessions were organized in which all aspects to promote and further improve QPM were discussed in order to identify the gaps in adoption and to prepare a roadmap to further upscale QPM. More than 100 participants from public as well as private sector, government agencies, progressive farmers, seed producing agencies etc. attended the workshop.

Glimpses of Brainstorming Workshop an Up scaling QPM for Nutrition Security

World Soil Day Celebrated by ICAR-IIMR

The World Soil Day was celebrated by ICAR-Indian Institute of Maize Research on 5 December, 2015 at various places to make awareness amongst farmers in the country. A total of 260 soil health cards were distributed on this occasion.

Glimpses of World Soil Day Celebration

Maize Technologists Association of India (MTAI) is registered as national level society

Maize Technologists Association of India (MTAI) located at Cummings' Laboratory, IARI, Pusa, New Delhi, has been granted registration as a 'society' under Societies Registration Act, 1860. The registration certificate to this effect was issued by Registrar of Societies, Government of NCT of Delhi on 27th November 2015. MTAI was founded as a society of people associated with maize research and related industries in 2011.

CERTIFICATE OF REGISTRATION
UNDER SOCIETIES REGISTRATION ACT XXI OF 1860

Registration No. S/ND: 225/2015

I hereby certify that " MAIZE TECHNOLOGISTS ASSOCIATION OF INDIA " Located at Cummings Laboratory IARI Pusa New Delhi, has been registered" under SOCIETIES REGISTRATION ACT, 1860.

Given under my hand at Delhi on this 27th day of November Two Thousand Fifteen.

Fee of Rs. 50/- Paid

(S KRISHNA CHAITANYA)
REGISTRAR OF SOCIETIES
GOVT. OF NCT OF DELHI
DELHI

Registrar of Societies
New Delhi District

" This document certifies registration under the Society Registration Act, 1860. However, any Govt. department or any other association/person may kindly make necessary verification (on their own) of the assets and liabilities of the society before entering into any contract/assignment with them.

NOTE: The society shall not be entitled to use its translated/abbreviated/acronym name and shall use the original name only. It shall show the same with the caption that it is governed by private body/society and not by government and name of the society shall not be used for any commercial purpose or trade or business or profession, certification affiliation/recognition by other organization etc.

Registration Certificate of MTAI

Four new research grants to boost IIMR's research efforts

The research efforts of IIMR got a major funding boost with initiation of 4 new network projects in 2015-16:

1. **National Innovations in Climate Resilient Agriculture:** In this project the main focus of work will be on location specific evaluation and genetic enhancement of maize to drought and heat in collaboration with involving AICRP network.
2. **Consortium Research Platform on Agrobiodiversity:**

   The project is aimed at evaluating over 7500 maize germplasm in collaboration with its AICRP centres located at MPUA&T, Udaipur and CSKHPKV, Bajaura etc. during 2014- 17.
3. **Consortium Research Platform on Biofortification:**

   Identification and development of maize germplasm with improved levels of micro nutrients *viz.*, betacarotene, Fe, Zn, low phytic acid, and lysine/ tryptophan have been envisaged under the project.
4. **Incentivizing Research in Agriculture:**

   In this project, IIMR is going to play a major role in understanding the molecular and physiological basis of nitrogen use efficiency in maize.

IIMR wins a major competitive grant from NASF

IIMR has been awarded with a major competitive grant from National Agricultural Science Fund on "Genetic Transformation and Development of Elite Transgenic Maize (*Zea mays* L.) for Biotic and Abiotic Stresses Tolerance". International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi and ICAR-Vivekanand Partvatiya Krishi Anusandhan Santhan (VPKAS), Almora are collaborating centres of the project. The collaborative project aims at deploying the futuristic CRISPR/Cas9 based genome editing technologies to engineer herbicide tolerance trait in maize. Other objectives are to engineer Bt mediated insect resistance and to understand the role of miRNAs in phosphorus physiology.

Research Advisory Committee (RAC) meeting

The meeting was held on 25-26 May, 2015 under the chairmanship of Dr. S.K. Sharma. It was attended by Scientsts, IIMR, AICRP centres (Almora, Varansi, Hyderabad and Udaipur), and members of RAC (Dr. R.K. Malik, Dr. B.L. Jalali, Dr. S.K. Sharma, and Dr. I.S. Solanki). The presentation on the action taken report of the previous RAC and research progress made during 2014-15 were made by different sections

namely Crop Improvement, Crop Protection, Crop Production, Outreach and Computer Application and Biotechnology, Biochemistry, Plant Physiology. In addition, AICRP centres were also presented centre's progress. The several recommendations were come out but the most important one was to provide the required number of technical staff with a ratio of Scientist: Technical Officer ::1:1.3 for smooth and continuous functioning of research programmes.

Institute Research Council (IRC) Meeting

The meeting was held under the chairman ship of Dr. O. P. Yadav, Director, IIMR New Delhi. Dr. B. M. Prasanna, Director, CRP MAIZE, was invited as an external expert. The scientists of the institute presented the progress made during 2014-15 under different institutional projects. Several suggestions were come after critical assessment of progress; one of the important recommendation came out was to establish a system of coding or naming an inbred line and also to relate codes or names given to an inbred line.

Institutional Biosafety Committee Meetings

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 first IBSC meeting of the year was held on 7th August 2015 in which, the IBSC approved execution of two new projects at the institute that involve use of Living Modified Organisms (LMO)/recombinant DNA products. The second IBSC meeting was held on 19th February 2016, in which the IBSC approved inter-institutional movement of four gene editing constructs from ICGEB, New Delhi to, IIMR.

हिंदी भाषा के कार्यान्वयन से संबंधित गतिविधियां

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

1. हिन्दी "राज भाषा कार्यान्वयन समिति" की बैठक दिनांक 30 मई, 2015 को सम्पन्न हुई।
2. दिनांक 26 जून, 2015 को उपरोक्त बैठक का कार्यवृत्व प्रेषित किया गया।
3. उक्त कार्यवृत्त की समीक्षा परिषद के जन संख्या रा० भा० 13–7–2013 हिन्दी दिनांक 9 जुलाई, 2015 को प्राप्त हुई।
4. दिनांक 3 अगस्त, 3 सितम्बर 2015 एवं 30 जनवरी 2016 को संस्थान में "राज भाषा कार्यान्वयन सीमित" की बैठक सम्पन्न हुई।
5. दिनांक 21 मार्च 2016 को संसदीय राजभाषा समिति की दूसरी उपसमिति ने काम काज में हिन्दी राजभाषा के प्रयोग में हुई प्रगति का निरीक्षण किया गया।
6. दिनांक 18 मार्च, 2016 कार्यशाला का विषय धारा 3 (3) का अनुपालन व हिन्दी मे पत्राचार/टिप्पणियाँ इत्यादि सम्पन्न हुई।
7. समीक्षा और विशलेषण, परिजन संख्याः 2091/2 दिनांक 23–3–2016 को संस्थान में हिन्दी में किए गये कार्यों की समीक्षा व विशलेषण" के सम्बंध में कार्यशाला आयोजित की गयी।
8. दिनांक 31–3–2016 को हिन्दी बैठक में निर्णय लिया गया कि प्रशासनिक वर्ग को कार्यालय में शत प्रतिशत कार्य हिंदी में करना है।
9. दिनांक 12–5–2016 को प्रातः 11:00 बजे तिमाही बैठक में समीक्षा/विशलेषण किया गया।

7

Awards and Recognitions

Award

- **Dr. S.B. Singh** received "Innovative Scientist of the Year Award-2015" for Genetics and Plant Breeding at International Conference on Innovative Approaches in Applied Sciences and Technologies held at Faculty of Science, Kasetsart University, Bangkok, Thailand, February 01-05, 2016.

Dr. S.B. Singh received Innovative Scientist of the Year Award-2015

- **Dr. S.B. Singh** received Outstanding Achievement Award of Society for Scientific Development in Agriculture & Technology during National Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences, (GRISAAS-2015) held at Rajmata Vijayaraje Scindia Krishi Viswa Vidyalaya, Gwalior, December 12-13, 2015.

Dr. S.B. Singh received Outstanding Achievement Award

- **Dr. C.M. Parihar** received Young Scientist Award of ICAR-Indian Institute of Maize Research at 1st Foundation Day of ICAR-Indian Institute of Maize Research on November 13, 2015.
- **Dr. C.M. Parihar** received Outstanding Research Contribution Award of ICAR-Indian Institute of Maize Research at 1st Foundation Day of ICAR-Indian Institute of Maize Research on November 13, 2015.

Dr. C.M. Parihar received Silver Medal in Badminton Singles (Men) in ICAR Inter Zonal Sports Tournament at ICAR-CAZRI, Jodhpur, Rajasthan

Dr. C.M. Parihar received Young Scientist and Outstanding Research Contribution Award of ICAR-Indian Institute of Maize Research, New Delhi

- **Dr. C.M. Parihar** received Silver medal in Badminton singles (Men), ICAR Zonal Sports Tournament (Central Zone) held at ICAR-Central Arid Zone Research Institute, Jodhpur from February 8-12, 2016
- **Dr. Bhupender Kumar** received Young Scientist Award of Society for Scientific Development in Agriculture & Technology

for significant contribution in field of Genetics and Plant Breeding at RVS Krishi Vishwa Vidyalaya, Gwalior on December 13, 2015.

Dr. Bhupender Kumar received Young Scientist Award of Society for Scientific Development in Agriculture & Technology

Dr. Bhupender Kumar received an appreciation certificate for contribution in Coordinated Research Program

- **Dr. Bhupender Kumar** received an appreciation certificate for recognition of significant contribution in all India coordinated research programme on occasion of ICAR-IIMR 1st Foundation day celebration on November 13, 2015.
- **Dr. Nirupma Singh** received **Best Poster Award** for "Role of 27-kDa gamma zein in kernel vitreousness in quality protein maize" by **Nirupma Singh and R. Ambika Rajendran** in National Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences, Rajmata Vijayaraje Scindia Krishi Viswa Vidyalaya, Gwalior, December 12-13, 2015.
- **Dr. Nirupma Singh** received **Best Poster Award** for "Evaluation of hybrids for yield and resistance to post flowering stalk rot in maize" by **Nirupma Singh, Meena Shekhar, R. Ambika Rajendran and Ram Babu** in 6th International Conference "Plant, Pathogens and People", New Delhi, February 23-27, 2016.
- **Dr. S.L. Jat** received **Best Poster Award** for "Redefining nitrogen management in conservation agriculture for enhancing resource-use efficiency and soil health in intensified maize systems" by **S.L. Jat, C.M. Parihar, A.K.Singh, D. Saveipune, Sandhya and B. Singh** in National Seminar on Integrating Agri-Horticultural and Allied Research for Food and Nutritional Security in the Era of Global Climate Disruption, Imphal, Manipur, March 4 - 6, 2016.

Dr. S.L. Jat received Best Poster Award by DDG (Animal Sciences) in National Seminar at Imphal, Manipur

Recognitions

- **Dr. K.S. Hooda** awarded Endeavour Research Fellowship (Post Doctoral Research) 2016 by Australian Government, w.e.f. November 01, 2016 for 6 months at Murdoch University, Murdoch, WA, Australia.
- **Dr. S.B. Singh** appointed as Chief Guest in "National Children Science Congress 2015" for Bihar region held at Jawahar Navodaya Vidyalaya, Begusarai, September 30, 2015.
- **Dr. Suby S.B., Kumar P., Sekhar J.C., Lakshmi Soujanya P. 2015.** Dynamic Volatile Collection System: 'Dynamic Volatile Collection System' filed for patenting. Application no. 1235/DEL/2015

Annexure 1

Maize Hybrids Identified

At the 58th Annual Maize Workshop held at Punjab Agricultural University, Ludhiana from April 4-6, 2015, Variety Identification Committee identified seven new hybrids of different maturity groups for cultivation in varied production ecologies of the country.

Hybrid	AICRP Centre/ Company	Pedigree	Public /Private	Area of adaptation		Av. yield (t/ha)	Maturity	Other characteristics	Season
				Zone	States				
LTH-22 (Laxmi 3636)	Yaaganti Seeds Pvt. Ltd., Hyderabad	(YM-2 X YM-212) X YM-3	Private	4	Andhra Pradesh, Telangana, Maharashtra, Tamil Nadu and Karnataka	9.06	Late	Orange yellow, semi-dent	*Kharif*
Bio-237 (Bio 9782)	Bioseed Research India, a Division of DCM Shriram Ltd., Hyderabad	BY778-nm (CI462 P) X CZ172-nm (BI OPOP 9026F)	Private	3 & 5	Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	10.27	Late	Orange yellow, semi-dent	*Rabi*
KMH-7148	Kaveri Seed Company Ltd., Secunderabad	KML-2817 X KML-5165	Private	2	Punjab, Haryana, Delhi and Western Uttar Pradesh	10.09	Late	Orange yellow, dent to semi dent with bold kernels	*Rabi*
NMH 1247	Nuziveedu Seeds Ltd., Hyderabad	NM-183 X NM-199	Private	2	Punjab, Haryana, Delhi and Western Uttar Pradesh	9.97	Late	Bright yellow semi-dent bold kernels with orange tinge	*Rabi*
DKC-9145 (IJ8533)	Monsanto India Ltd., Bangalore	DT834Z X H1620Z	Private	2	Punjab, Haryana, Delhi and Western Uttar Pradesh	8.96	Medium	Yellow orange, semi-dent	*Kharif*
FSCH-18 (Central Maize VL Sweetcorn 1) (Sweet Corn)	VPKAS, Almora	VSL 16 X VSL 4	Public	1,2,4 & 5	Jammu & Kashmir, Uttarakhand, Himachal Pradesh, NE hills, Delhi, Punjab, Haryana, Western Uttar Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Rajasthan, Gujarat, Chhatisgarh and Madhya Pradesh	10.84	Early	Plant sturdy, medium in height with large open tassel, glume and silk green, anther yellow, husk cover good and green, TSS 16%	*Kharif*
KSCH 333 (Candy) (Sweet Corn)	Kaveri Seed Company Ltd., Secunderabad	KSCL-869 X KSCL-870	Private	1,2,4 & 5	Jammu & Kashmir, Uttarakhand, Himachal Pradesh, NE hills, Delhi, Punjab, Haryana, Western Uttar Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Rajasthan, Gujarat, Chhatisgarh and Madhya Pradesh	11.88	Early	Yellow juicy, flint, medium bold kernels and stable sweetness	*Kharif*

Annexure 2

Maize cultivars notified

Fourteen cultivars have been notified by Central Sub-Committee on Crop Standard and Notification for different agro-climatic conditions of the country. Among these, seven public-bred and seven are proprietary cultivars. Of them, six are late, one medium and three in early maturity group. Further four cultivars are state released and cultivars namely KMH7148, BIO9782 (BIO237), Dragon (NMH-1247) are released for *rabi* season.

Cultivar	Pedigree	Name of centre/ company	Notification details	Area of adaptation	Maturity	Average yield (t/ ha)	Characteristics	Cropping season
P 3580 (X-35A180)	PHM6T X PH1DVA	Pioneer Overseas Corporation, Chikkaballapur	07/05/2015 1228(E)	Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra	Late	9.92	Orange, semi-flint	*Kharif*
*PHM-12 (JPMH 4)		SKUAST, Srinagar	07/05/2015 1228(E)	Jammu and Kashmir				
BPCH-6	BPCL-3 X BPCL-6	Acharya N. G. Ranga Agricultural University, Hyderabad	01/10/2015 2680 (E)	All zones across the country	Early	3.2	Orange, flint	*Kharif*
Palam Sankar Makka 1 (EHL 162508)	HKI 1040-7 X BAJIM 09-64	CSK, HPKV, Hill Agricultural Research and Extension Centre, Bajaura, Kullu (H. P.)	01/10/2015 2680 (E)	Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Late	5.3	Yellow, flint	*Kharif*
KMH-7148	KML-2817 X KML-5165	Kaveri Seed Company Limited, Secundrabad	01/10/2015 2680 (E)	Punjab, Haryana, Delhi, Western Uttar Pradesh	Late	10.09	Orange yellow, dent to semi dent with bold kernels	*Rabi*
CANDY (KSCH-333)	KSCL-869 X KSCL-870	Kaveri Seed Company Limited, Secundrabad	01/10/2015 2680 (E)	Jammu & Kashmir, Himachal Pradesh, Assam, Meghalaya, Tripura, Arunachal Pradesh, Nagaland, Manipur, Sikkim, Punjab, Haryana, Delhi, Uttar Pradesh, Andhra Pradesh, Telangana, Karnataka, Maharashtra, Tamil Nadu Madhya Pradesh Rajasthan, Gujarat and Chhattisgarh	Early	11.88	Yellow juicy, flint, medium bold kernels and stable sweetness	*Kharif*
D2244 (DAS-MH-501)	NTC6 X NTC8	DOW Agro Sciences India Pvt. Ltd., Mumbai	13/01/2016 112 (E)	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)		SKUAST, Srinagar	13/01/2016 112 (E)	Jammu and Kashmir/2013				
*Shalimar Maize Composite-6 (KDM-322)		SKUAST, Srinagar	13/01/2016 112 (E)	Jammu and Kashmir/2013				
*Shalimar Maize Composite-7 (KDM-72)		SKUAST, Srinagar	13/01/2016 112 (E)	Jammu and Kashmir/2013				
LAXMI 3636 (LTH 22)	(YM-2 X YM-212) X YM-3	Yaaganti Seeds Pvt. Ltd., Hyderabad	13/01/2016 112 (E)	Andhra Pradesh, Telangana, Karnataka, Maharashtra and Tamil Nadu	Late	9.06	Orange yellow, semi-dent	*Kharif*
BIO 9782 (BIO 237)	BY778-nm (CI462 P) X CZ172-nm (BI-OPOP9026F)	Bioseed Research India a Division of DCM Shriram Ltd., Hyderabad	13/01/2016 112 (E)	Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Late	10.27	Orange yellow, semi-dent	*Rabi*
Dragon (NMH-1247)	NM-183 X NM-199	Nuziveedu Seeds Limited, Hyderabad	13/01/2016 112 (E)	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 x LM 20	Punjab Agricultural University, Ludhiana, Punjab	13/01/2016 112 (E)	Punjab	Medium	8.3	Yellow-orange, flint	Spring

*State released data not available

Annexure 3

Varietal Registration

New Applications Filed

Applications pertaining to eight hybrids have been filed under PPVFR& Act, 2001. The details are given below:

S. No.	Hybrids	Name of centre	Date of filing	Acknowledgement no.
1	DHM 121	P JTSAU, Hyderabad	22/07/2015	REG/2015/1445
2	Vivek Maize Hybrid 47	ICAR-VPKAS, Almora	22/07/2015	REG/2015/1444
3	Vivek Maize Hybrid 53	ICAR-VPKAS, Almora	22/07/2015	REG/2015/1443
4	Vivek Maize Hybrid 51	ICAR-VPKAS, Almora	22/07/2015	REG/2015/1442
5	CoH (M)7	TNAU, Coimbatore	30/12/2015	REG/2015/2090
6	CoH (M)8	TNAU, Coimbatore	30/12/2015	REG/2015/2091
7	CoH (M)9	TNAU, Coimbatore	30/12/2015	REG/2015/2089
8	CoH (M)10	TNAU, Coimbatore	30/12/2015	REG/2015/2088

DUS testing

During *kharif* 2015, 167 entries including 33 Farmers varieties have been characterized as per DUS descriptors. Of these, 46 candidate entries completed two years DUS testing and eligible for registration. Nine cultivars (seven in first year and two in second year) are from public organizations. Details of the candidate entries are given below:

Hybrid DUS trial 2015	Inbred DUS trial 2015	Variety of Common Knowledge	Farmer Varieties (grow out test)
2nd year Testing **Public –bred hybrids (25)** NMH 920, NMH-1247, TMMH 809, TMMH 801, TMMH 802, KMH-1411, KMH-3110, KMH-6681, GK 3090, KING II, PAC 753, PAC 751, RMH 3033, TMMH805, BIO 9211, Bio 032, MM 2100, Bio 719, Bio 605, Bio 237, P 3546, P 3533,P 3542, D 4141, NMH-803 **Proprietary hybrids (3)** PMH 3, HTMH 5101 SONA, , TNAU Maize Hybrid Co6 **OPVs (1)** Pratap Kanchan -2 **1st Year Testing** **Public –bred hybrids (5)** Vivek Maize Hybrid 45, Shaktiman 5, Pratap QPM Hybrid 1, Pant Sankar Makka1, HM 12 **Proprietary hybrids (38)** LG 32.81, LG 34.02, LG 34.03, LG 33.01, LG 32.01, PHSAB,PH1NOV, PH1BFW, PH23FC, PHM6M, PH1NO6, P3007,P 3401, P1855, P3596, P1844, PHYOR,PH1WGS, PH23F9, DKC 9135, DKC 9142, 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, KMH -7021, GK 3118, TMMH 826 **OPVs(2)** Shalimar Maize Composite 4, BAJAURA MAKKA	**2nd year Testing** **Proprietary Inbreds (17)** PH7PH, PH1BFR, PHBFE, PH15K0, PH1WA2, BIO 82015HI, BY778-nm, PHBET, PH17H, KML 2078, KML 2006, KML 5253, NM 183, NM 250, NM 199, CZ 170-nm, PH 9 JM **1stYear Testing** **Proprietary Inbreds (8)** BLI 108, AT 226, BLI 107, MZ14SO14N, MZ14SO13N, MHC4T007, MZYA090069, AT 69	**One year Testing** **Proprietary Hybrids (17)** PH234, DKC 9120, DKC9126, Laxmi 4959, DON1588, SINGHAM, D2244, **Proprietary Inbreds (3)** NM71, GPM27,GPM28	Makai Wazej (Turch) ,Wazej Makai(Babgund), Safed Makai, Double Khachar, Gurez Local Maize / Mewar, Kapsho, Tharathei Katika, Marencomte, Motso, Umom Tsungaro, Echungta Tsungharo, Pukazo -2, Ram Makka, Pila Makka, Dhanush Makka, Bhadore Jonar, Chutri Makai, Desi Riddhi , Chota Kanchan-1, G.D.Bad, Madhur Makka, Gauran Makki White, Makka Dhebri, Desi Suman, Bad (Makai), Kanchanpur Makai, Jinnor Makai, Sunahari, Desi Makka -2, Dehati Makka -1, Chotki Makka, Desi Makka Chota, Piyaka Makai

Hybrids/ varieties Registered

In the year 2015-16, six cultivars including four hybrids and two OPVs have been registered under PPV&FR Act, 2001. The information of the cultivars along with period of protection is given below:

S. No.	Hybrids/OPVs	Name of centre	Period of protection
1.	DHM 117	ANGRAU, Hyderabad	April 8, 2015 to April 7, 2030
2.	PMH 4	PAU, Ludhiana	April 27, 2015 to April 26, 2030
3.	Vivek Maize Hybrid 39	VPKAS, Almora	February 1, 2016 to January 31, 2031
4.	Vivek Maize Hybrid 43	VPKAS, Almora	February 1, 2016 to January 31, 2031
5.	Vivek Sankul Makka 37	VPKAS, Almora	April 7, 2015 to April 6, 2030
6.	Jawahar pop corn-11	JNKVV , Chhindwara	October 26, 2015 to October 25, 2030

Additional testing locations

Additional DUS testing / grow-out sites have been identified by PPVFR Authority, New Delhi. Besides, IIMR, New Delhi and SRTC, Hyderabad, tests have been conducted at VPKAS, Almora, ICAR Research Complex, Umiam, MPKV, Kolhapur, MPUA&T, Banswara, AAU Gossaigaon and PAU Ludhiana, respectively.

Annexure 4

Breeder seed production

A total of 65.96 quintals of breeders' seed has been produced against the indent of 103.91quintals during *kharif* 2015.Of these, breeder seed production of five OPVs and 16 parental lines of eight hybrids has been taken up in *rabi* 2015-16.

Centre-wise/ variety- wise breeders' seed production of parental lines of maize hybrids and OPVs

Parental Lines	Year of notification	DAC Indent	Indent-Allocation BSP1	Actual production BSP-4	Surplus/ deficit	Remarks
MPUAT, Udaipur						
Pratap QPM H-1 (HKI193-1)	2013	7.08	7.08			Indent withdrawn
Pratap QPM H-1 (DMRQPM-106)		14.20	14.20			Indent withdrawn
Pratap Hybrid3 (M)	-	3.00	3.00	3.00		Hybrid not notified
Pratap Hybrid3 (F)		6.00	6.00	6.00		Hybrid not notified
CCSHAU , Karnal						
HQPM4 -(F) HKI193-2	2010	4.00	4.00	-	-	*Rabi* 2015-16
HQPM4 -(M) HKI161		2.00	2.00	-	-	*Rabi* 2015-16
HM10 - (F) HKI193-2	2008	0.22	0.22	-	-	*Rabi* 2015-16
HM10 -(M) HKI1128		0.08	0.08	0.15	(+) 0.07	Surplus
HQPM7- (M) HKI161	2008	0.12	0.12	-	-	*Rabi* 2015-16
HQPM-7 (F) HKI 193-1		0.34	0.34	0.25	(-) 0.09	Deficit, *Rabi* 2015-16
HQPM-5 (F) HKI163	2007	0.45	0.45	0.30	(-) 0.15	Deficit, *Rabi* 2015-16
HQPM-5 (M) HKI161		0.15	0.15	-	-	*Rabi* 2015-16
HQPM-1-(F) HKI193-1	2007	1.30	1.30	-	-	*Rabi* 2015-16
HQPM-1-(M) HKI 163		0.40	0.40	-	-	*Rabi* 2015-16
VPKAS, Almora						
Vivek Maize Hybrid-17 (F) CM153	2005	0.07	0.07	0.07		Carry-over from 2013 *kharif* with 90% germination
Vivek Maize Hybrid-17 (M) CM 212		0.03	0.03	0.03		Carry-over from 2013 *kharif* with 90% germination
IARI , Delhi						
Pusa Extra Early Hybrid Makka -5 (AH-421) - (F) CM150	2004	0.16	0.16	0.16		
Pusa Extra Early Hybrid Makka -5 (AH-421) - (M) CM151		0.08	0.08	0.08		
PEHM-2 (F) CM137		0.22	0.22	0.22		
PEHM-2 (M) CM 138		0.11	0.11	0.11		
RAU, Dholi						
Shaktiman-2 (F) CML176	2004	0.06	0.06	0.60	(+)	Surplus
Shakhiman-2 (M) CML186		0.07	0.07	0.25	(+)	Surplus
ANGRAU, Hyderabad						
DHM-117 (F) - BML6	2010	6.12	6.12	3.00	(-) 3.12	Deficit, *Rabi* 2015-16
DHM-117 (M) –BML7		3.06	3.06	1.0	(-) 2.06	-do-

Parental Lines	Year of notification	DAC Indent	Indent-Allocation BSP1	Actual production BSP-4	Surplus/ deficit	Remarks
ANGRAU, Karimnagar						
DHM-121 (F) BML45	2014	0.05	0.05	0.10	(+) 0.05	Surplus
DHM-121 (M) BML6		0.03	0.03	-	-	*Rabi* 2015-16
MPKV, Kolhapur						
Rajashree (F) –GPM-456		0.10	0.10	4.50	(+) 4.40	Surplus
Rajashree (M) – GPM-342		0.05	0.05	3.00	(+) 2.95	Surplus
TNAU, Coimbatore						
COHM-8 (F) UMI 1201	2014	0.05	0.05			*Rabi* 2015-16
COHM-8 (M) UMI1230		0.03	0.03			*Rabi* 2015-16
COHM-9 (F) UMI 1205	2014	0.05	0.05			*Rabi* 2015-16
COHM-9 (M) UMI 1230		0.03	0.03			*Rabi* 2015-16
TOTAL :		**49.71**	**49.71**	**22.82**		
Variety (OPVs)						
MPUAT, Banswara						
Pratap Kanchan-2 WC-236(Y)	2009	1.20	1.20	-	-	*Rabi* 2015-16
MPUAT , Udaipur						
Pratap Makka-3		0.20	0.20	-	-	*Rabi* 2015-16
GBPUAT ,Pant nagar						
Pant Sankul Makka-3 (D131)	2008	0.20	0.20	1.74	(+)1.54	Surplus
VPKAS, Almora						
Vivek Sankul Makka-31(VL-103)	2008	0.60	0.60	1.20	(+) 0.60	Surplus
CSUAT, Kanpur						
Azad Kamal (R 9803)	2005	0.20	0.20	0.20		
IARI, Delhi						
Pusa Composite-3 (Composite-85134)	2005	3.40	3.40			*Rabi* 2015-16
Pusa Composite-4(Composite-8551)	2005	0.40	0.40			*Rabi* 2015-16
JNKVV, Chhindwara						
Jawahar Makai -216 (JM-216)	2002	38.50	38.50	40.00	(+) 1.50	
Gwalior						
JVM-421		2.20	2.20			No report
UAS , Mandya						
NAC 6004	2001	7.00	7.00			*Rabi* 2015-16
BAU, Ranchi						
Birsa Makkai-1	1996	0.30	0.30			Production taken up in *kharif* 2015 but report awaited
TOTAL :		**54.20**	**54.20**	**43.14**		
Grand total				**65.96**		

Annexure 5

Human Resource Development

A. Training attended

Name	Programme	Venue	Date
Dr. Bhupender Kumar	Technologies for tropical maize improvement	CIMMYT HQ-El batan, Mexico	August 31 -September 11, 2015
Dr. Ishwar Singh	Competency Development for Human Resource Development Nodal Officers of ICAR	NAARM, Hyderabad	February 10-12, 2016
Dr. KS Hooda	Science Governance and Management	Administrative Staff College of India, Hyderabad	February 29 – March 04, 2016
Dr. Krishan Kumar	Orientation Training	IIMR, Pusa Campus, New Delhi	October 9 - November 9, 2015
	Professional Attachment Training	ICGEB, New Delhi	December 2- February 28, 2016
Dr. P. Lakshmi Soujanya	Pest Risk Analysis	National Institute of Plant Health Management (NIPHM), Hyderabad	September 3-8, 2015
Dr. Pranjal Yadava	91st DAE/BRNS/IANCAS National Workshop on Radiochemistry and Application of Radioisotopes	GBPUA&T, Pantnagar	February 22-27 , 2016
Dr. Ramesh Phagna	Mendelian Genetics to Molecular Genetics in Relevance to Plant Breeding	PAU , Ludhiana	August 6-26, 2015

B. Trainings conducted

Name	Programme	Venue	Date
Course Director (Dr. Ashok Kumar) and course co-coordinators (Drs C.M. Parihar and S.L. Jat)	Eight days model training course on "Production, protection and value addition for maize based production systems" sponsored by Directorate of Extension, Ministry of Agriculture, Government of India	ICAR-Indian Institute of Maize Research, New Delhi	September 16 -23, 2015
Course Director (Dr. Ashok Kumar) and course co-coordinator (Dr C.M. Parihar)	National Level Training for Tribal Framers on "Recent technologies of maize based production systems and value addition" funded by Tribal Sub Plan, ICAR, New Delhi.	ICAR-Indian Institute of Maize Research, New Delhi	October 7 - 9, 2015 March 8 -10, 2016
Course Director (Dr. Ashok Kumar) and course co-coordinator (Dr S.L.Jat)	National Level Training for Tribal Framers on "Recent technologies of maize based production systems and value addition" funded by Tribal Sub Plan, ICAR, New Delhi.	ICAR-Indian Institute of Maize Research, New Delhi	October 27 - 29, 2015 March 15-17, 2016 September 29- October 01, 2015 February 16-18, 2016
Dr. Ashok Kumar	Farmers training (Inter-state) on Integrated Crop Management in Maize under Agricultural Technology Management Agency (ATMA) Ramanthpurum Districts , Tamil Nadu	ICAR-Indian Institute of Maize Research, New Delhi	February 9-11, 2016
	Farmers training (Inter-state) on Integrated Crop Management in Maize under Agricultural Technology Management Agency (ATMA) Dindugali District ThoppamPATY, Tamil Nadu	ICAR-Indian Institute of Maize Research, New Delhi	March 01, 2016
Dr. K.P. Singh	कम्प्यूटर पर हिंदी प्रयोग सम्बन्धी कार्यशाला	भारतीय मक्का अनुसंधान संस्थान	December 21, 2015
	Seminar on "Data digitization and research data repository for knowledge management"	ICAR-Indian Institute of Maize Research, New Delhi	February 23, 2016
	Training on FMS/MIS for processing of different bills for administrative and account staff	ICAR-Indian Institute of Maize Research, New Delhi	March 26, 2016
Dr. Pranjal Yadava	Orientation Training under Foundation Course for Agricultural Research Services (FOCARS) for newly recruited Scientist (Agricultural Biotechnology)	ICAR-Indian Institute of Maize Research, New Delhi	October 9- November 9, 2015

C. Participation in Conferences/ Seminars/ Workshops

Name	Programme	Venue	Date
Dr. A.K. Singh	58th Annual Maize Workshop	PAU, Ludhiana	April 4 - 6, 2015
	Annual NICRA Workshop	CMFRI, Kochi	August 14, 2015
	Brainstorming Workshop on "Up-scaling Quality Protein Maize (QPM) for Nutrition Security"	NASC, New Delhi	May 20-21, 2015
Dr. Ambika Rajendran	National Seminar on Global Research Initiative for Sustainable Agriculture & Allied Sciences	RVS Krishi Vishwa Vidyalaya, Gwalior	December 12-13, 2015
Dr. Ashok Kumar	National Seminar on Innovative Approaches for Sustainable Agriculture, Livelihood and Environment Security	GMV, Rampur Maniharan (Saharanpur)	November 7, 2015
Dr. Bhupender Kumar	National Seminar on Integrating Agri-Horticultural and Allied Research for Food and Nutritional Security in the Era of Global Climate Disruption	ICAR-Research Complex for NEH Region, Imphal	March 4 - 6, 2016
	National Conference on Global Research Initiatives for Sustainable Agriculture and Allied Sciences	RVS Krishi Vishwa Vidyalaya, Gwalior	December 12 - 13, 2015
	58th Annual Maize Workshop	PAU, Ludhiana	April 4 - 6, 2015
Dr. C.M. Parihar	58th Annual Maize Workshop	PAU, Ludhiana	April 4 - 6, 2015
	Brainstorming Workshop on "Up-scaling Quality Protein Maize (QPM) for Nutrition Security"	NASC Complex, New Delhi	May 20-21, 2015
	National Dialogue on "Efficient Nutrient Management for Improving Soil Health"	New Delhi, India	September 28 - 29, 2015
	National Seminar on Integrating Agri-Horticultural and Allied Research for Food and Nutritional Security in the Era of Global Climate Disruption	ICAR-Research Complex for NEH Region, Imphal	March 4 - 6, 2016
Dr. D. P. Chaudhary	National Conference on Global Research Initiatives for Sustainable Agriculture and Allied Sciences	RVS Krishi Vishwa Vidyalaya, Gwalior	December 12 - 13, 2015
	103rd Indian Science Congress	University of Mysore, Mysore	January 3-7, 2016
	Brainstorming Workshop on "Up-scaling Quality Protein Maize (QPM) for Nutrition Security"	NASC Complex, New Delhi	May 20-21, 2015
Dr. Ishwar Singh	3rd International Plant Physiology Congress on "Changes and Strategies in Plant Biology Research	JNU, New Delhi	December 11-14, 2015
	National Seminar on "Challenges in Plant Sciences: Now and Then"	CCS University, Meerut	December 8-10, 2015
	9th Annual Review Meeting of "ICAR-Network Project on Transgenics in Crops"	NRCPB, New Delhi	November 7, 2015
Dr. K.P. Singh	First Workshop of Nodal Officers of ICAR Research Data Repository for Knowledge Management initiative	NASC Complex, New Delhi.	August 04-05, 2015
	8th GCRA International Conference on "Innovative Digital Applications for Sustainable Development"	UAS, Bengaluru	January 5-7, 2016
	58th Annual Maize Workshop	PAU, Ludhiana	April 4-6, 2015
	3rd International Conference on Nanostructured Materials and Nanocomposites	Hindustan College of Science and Technology, Farah, UP	December 12-14, 2015
	8th Bangalore India Nano International Conference	Lalit Ashok , Bengaluru	March 3-5, 2016
Dr. K.S. Hooda	IPS 6th International Conference on "Plant, Pathogens and People"	NASC Complex, New Delhi	February 23-27, 2016
	Delhi Zone Annual Meeting & National Symposium on "Biosecurity in Food Value Chain"	Dr. B.P. Pal Auditorium, ICAR-NBPGR, New Delhi	February 20, 2016
Dr. Meena Shekhar	IPS 6th International Conference on "Plant, Pathogens and People"	NASC Complex, New Delhi	February 23-27, 2016
	Delhi Zone Annual Meeting & National Symposium on "Biosecurity in Food Value Chain"	Dr. B.P. Pal Auditorium, ICAR-NBPGR, New Delhi	February 20, 2016
	Brainstorming Workshop on "Up-scaling Quality Protein Maize (QPM) for Nutrition Security"	NASC, New Delhi	May 20-21, 2015
Dr. Nirupma Singh	Winter School on "Genomics and Phenomics Assisted Crop Breeding: Principles and Practices"	Division of Genetics, ICAR-IARI, New Delhi	November 18- December 08, 2015
	National Seminar on Global Research Initiative for Sustainable Agriculture & Allied Sciences	RVS Krishi Vishwa Vidyalaya, Gwalior	December 12-13 , 2015

Name	Programme	Venue	Date
	IPS 6th International Conference on "Plant, Pathogens and People"	NASC Complex, New Delhi	February 23-27, 2016
Dr. N. Sunil	One-day workshop of Agro-climatic Zone-X of Southern Plateau and Hill Region	Indian Institute of Oilseeds Research, Hyderabad	October 21 , 2015
	One -day workshop on "Strengthening of Access & Benefit Sharing and use of Biological Resources in Research & Development'	NAARM, Hyderabad	November 24 , 2015
Dr. P. Lakshmi Soujanya	National Conference on "Botanicals: Efficacy and challenges in stored maize pest management.	Punjabi University, Patiala, Punjab	October 29-30, 2015
	Entomology for sustainable Agriculture and gave oral presentation on "Potentiality of various extracts of *Ixora coccinea* and its major component tanacetene from Rubiaceae family towards storage pest of maize"	Punjab Agricultural University, Ludhiana, Punjab	April 16 -17, 2015
	Three day orientation training programme	CRIDA, Hyderabad	January 6-8, 2016
Dr. Pranjal Yadava	7th Indo-Global Summit and Expo on Food and Beverages (Food India-2015)	Radisson Blu Hotel, New Delhi	October 8-10, 2015
	3rd International Plant Physiology Congress on "Changes and Strategies in Plant Biology Research	JNU, New Delhi	December 11-14, 2015
	Workshop on Refuge Strategies for Biotech Crops- Adoption, Challenges & Alternatives towards achieving technology sustenance	NASC Complex, New Delhi	December 8, 2015
	Review Meeting of XII Plan ICAR scheme 'Incentivizing Research in Agriculture'	IARI, New Delhi	October 28, 2015
	Review Meeting of ICAR- Network Project on Transgenics in Crops	NRCPB, New Delhi	November 7, 2015
	58th Annual Maize Workshop	PAU, Ludhiana	April 4-6, 2015
Dr. Ramesh Kumar	National Conference on Intellectual Property Rights in Agriculture: Needs and Future Prospects	Sabour, Bhagalpur (Bihar)	Dec 22-23, 2015
	National Seminar on Global Research Initiative for Sustainable Agriculture & Allied Sciences	RVS Krishi Vishwa Vidyalaya, Gwalior	Dec.12-13 , 2015
Dr. S.B. Singh	Brainstorming Workshop on "Up-scaling Quality Protein Maize (QPM) for Nutrition Security"	NASC Complex, New Delhi	May 20-21, 2015
	National Seminar on Global Research Initiative for Sustainable Agriculture & Allied Sciences	RVS Krishi Vishwa Vidyalaya, Gwalior	December 12-13, 2015
	International Conference on Innovative Approaches in Applied Sciences and Technologies	Faculty of Science, Kasetsart University Bangkok, Thailand	February 01-05, 2016
	National Symposium on Genomics & Molecular Breeding and Alumni Meet	CCS University, Meerut	March 28-29, 2016
	X Annual Review Meeting of ICAR Seed Project- "Seed Production in Agricultural Crops"	ICAR Research Complex, Goa	August 24-25, 2015
	58th Annual Maize Workshop	PAU, Ludhiana	April 4 - 6, 2015
	Scientist-Farmers Interaction cum- Exhibition	Town Hall Distt. Motihari (Bihar)	December 25, 2015
	One day workshop on Farmer Producer Organization	Town Hall, Ghandhi Maidan Motihari.	December 24, 2015
Dr. S.L. Jat	58th Annual Maize Workshop	PAU, Ludhiana	April 4 - 6, 2015
	Brainstorming Workshop on "Up-scaling Quality Protein Maize (QPM) for Nutrition Security"	NASC Complex, New Delhi	May 20-21, 2015
	National Dialogue on "Efficient Nutrient Management for Improving Soil Health"	New Delhi, India	September 28 - 29, 2015
	National Seminar on Integrating Agri-Horticultural and Allied Research for Food and Nutritional Security in the Era of Global Climate Disruption	ICAR-Research Complex for NEH Region, Imphal	March 4 - 6, 2016
Dr. Vinay Mahajan	58th Annual Maize Workshop	PAU, Ludhiana	April 4 - 6, 2015
	National Conference on De-polluting Indian Cities	India International Centre ,New Delhi	September 18-19, 2015
	103rd Indian Science Congress	University of Mysore, Mysore	January 3-7, 2016
	Brainstorming Workshop on "Up-scaling Quality Protein Maize (QPM) for Nutrition Security"	NASC, New Delhi	May 20-21, 2015

Annexure 6

Lectures/ Radio/ Television talks Delivered

Scientist	Topic	Programme	Venue	Date
Dr. Ambika Rajendran	Evaluation of grain maize for dual utility	National Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences	Rajmata Vijayaraje Sciendia Krishi Viswa Vidyalaya, Gwalior	December 12-13, 2015
	Value addition in maize	Farmers training (Inter-state) on Integrated Crop Management in Maize under Agricultural Technology Management Agency (ATMA)	ICAR-IIMR, New Delhi	February 09 & March 01, 2016
Dr. A. K. Singh	Maize production & improved agriculture techniques for higher income	Farmers training for Purnea (Bihar) farmers	CATAT, New Delhi	July 13, 2015
	Television talk on "*Rabi* main Makka ki Kheti"	"Hello Kisan"	DD Kisan channel	October 14, 2015
Dr. Bhupender Kumar	Performance of quality protein maize (QPM) hybrids versus normal maize a case study for assessment of grain yield penalty in QPM genotypes	National Conference on Global Research Initiatives for Sustainable Agriculture and Allied Sciences	RVS Krishi Vishwa Vidyalaya, , Gwalior	December 12 -13, 2015
	Efficacy of selection indices and AMMI analysis to identify stress resilient Maize cultivars for tropical environments	National Seminar on Integrated Agri-Horticultural and Allied Research for Food and Nutritional Security in the Era of Global Climate Disruption	ICAR-RCNEH	March 4 - 6, 2016
	Association mapping in plants: A powerful approach to dissect the complex traits in plant sciences	National Conference on Global Research Initiatives for Sustainable Agriculture and Allied Sciences	RVS Krishi Vishwa Vidyalaya, Gwalior	December 12 -13, 2015
Dr. C. M. Parihar	Conservation agriculture	Television Talk	ICAR-Indian Institute of Maize Research, New Delhi	November 30, 2015
	मक्का की नवीनतम् सस्य विद्धियाँ	National level training programme on "Recent tecnologies of maize based production systems and value addition" for tribal farmers under Tribal Sub Plan of ICAR.	ICAR-Indian Institute of Maize Research, New Delhi	March 14 and08, February 16, 2016 October 7, 2015 September 29, 2015
	Mechanization in maize production systems	Delivered a lecture in model training course on "Production, Protection and Value Addition Technologies for Maize Production systems.	ICAR-Indian Institute of Maize Research, New Delhi	September, 18, 2015
	Seven year of conservation agriculture and diversified cropping systems: Effects on yield, economics and soil health in a semi-arid environment	National Seminar on Integrating Agri-Horticultural and Allied Research for Food and Nutritional Security in the Era of Global Climate Disruption	Imphal, Manipur	March 4 - 6, 2016
Dr. Ishwar Singh	Molecular mechanism of brassino-steroids mediated abiotic stress tolerance in plants	National Seminar on "Challenges in Plant Sciences: Now and Then"	CCS University, Meerut	December 10, 2015
Dr. Jyoti Kaul	Maize and its scientific production technologies	Model training course on "Practices for conservation agriculture and climate resilient maize systems"	ICAR-Indian Institute of Maize Research, New Delhi	August 30, 2014
	Conservation agriculture: Principles, practices and environmental benefits	Model training course on "Practices for conservation agriculture and climate resilient maize systems"	ICAR-Indian Institute of Maize Research, New Delhi	September 05, 2014
	Makka ki navintam shasya vidhiya	National Training Programme under TSP for tribal farmers	ICAR-Indian Institute of Maize Research, New Delhi	September 24, 2014

Scientist	Topic	Programme	Venue	Date
Dr. K.P. Singh	Maize AgriDaksh-An Expert System	Model Training Course on "Production, Protection and Value Addition for Maize based Production Systems"	ICAR-Indian Institute of Maize Research, New Delhi	October 07-09, 2015
	मेज एग्रीदक्ष– एक बहुउपयोगी प्रणाली"	Training programme on "Recent technologies of maize based production systems and value addition" for tribal farmers	ICAR-Indian Institute of Maize Research, New Delhi.	October 07-09, 2015
	मेज एग्रीदक्ष– एक बहुउपयोगी प्रणाली	Training programme on "Recent technologies of maize based production systems and value addition" for tribal farmers	ICAR-Indian Institute of Maize Research, New Delhi	February 16-18, 2016
	मेज एग्रीदक्ष– एक बहुउपयोगी प्रणाली"	Training programme on "Recent technologies of maize based production systems and value addition" for tribal farmers	ICAR-Indian Institute of Maize Research, New Delhi	March 8-10, 2016
Dr.K.S. Hooda	*Rabi* makka mein samekit fasal prabandhan	Krishi Darshan, Delhi Doordarshan	ICAR-Indian Institute of Maize Research, New Delhi	April 8, 2015
Dr. Nirupma Singh	Kernel Vitreousness : Validation of 27-kDa Zein Subunit in Indian QPM Hybrids	National Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences	Rajmata Vijayaraje Sciendia Krishi Viswa Vidyalaya, Gwalior	December 12-13, 2015
	विशिष्ट मक्का व उत्पादन तकनीकी	Training on "Recent technologies of maize based production systems and value addition" for tribal farmers	ICAR-IIMR, New Delhi	September 29 & October 27, 2015 February 16, March 08 & 24, 2016
	Role of speciality corns and their specific production technologies to enhance farmer's income	Model training course on " Production and value addition technologies for maize production"	ICAR-IIMR, New Delhi	September 19, 2015
	Speciality corn and its production technology	Farmers training (Inter-state) on Integrated Crop Management in Maize under Agricultural Technology Management Agency (ATMA)	ICAR-IIMR, New Delhi	March 01, 2016
Dr. Pranjal Yadava	Maize: An amazing system for fundamental and applied plant biology research	PMB Invited talk series	International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi	May 4, 2015
	GM food labeling: The science, sense and stewardship of it	7th Indo-Global Summit and Expo on Food and Beverages (Food India-2015)	Radisson Blu Hotel, New Delhi	October 8-10, 2015
Dr. Ramesh Kumar	Progression of concept of Heterosis and recent approaches	Training "Mendelian Genetics to Molecular Genetics in Relevance to Plant Breeding"	PAU, Ludhiana	August 6-26, 2015
	Intellectual Property Rights in Agriculture with special reference Farmer's Rights	National Conference on Intellectual Property Rights in Agriculture: during Needs and Future Prospects	Sabour, Bhagalpur(Bihar)	December 22-23, 2015
Dr. S. B Singh	Enhancing waterlogging tolerance in maize- Mechanism, Breeding and Molecular Approaches	National Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences, (GRISAAS-2015)	Rajmata Vijayaraje Sciendia Krishi Viswa Vidyalaya, Gwalior	December 12-13,2015
	Breeding approaches for improving waterlogging tolerance in maize	International Conference on Innovative Approaches in Applied Sciences and Technologies	Kasetsart University Bangkok, Thailand	February 01-05, 2016

Scientist	Topic	Programme	Venue	Date
Dr. S.B. Suby	Major insects of maize in different ecosystems and their control measures	Model training course on Maize production systems for improving resource use efficiency and livelihood security	Indian Institute of Maize Research, New Delhi	September 22, 2015
	Identification of maize insects-Visit of maize entomology laboratory	Model training course on Maize production systems for improving resource use efficiency and livelihood security	Indian Institute of Maize Research, New Delhi	September 22, 2015
Dr. S.L. Jat	बसंत ऋतू की मक्का की खेती	Live Hello Kisan programme	DD Kisan	February 9, 2016
	रबी मक्का में समसामयिक क्रियाए	Krishi Darshan	DoorDarshan	February 9, 2016
	रबी मक्का की खेती	Live Hello Kisan programme	DD Kisan	September 28 , 2015
	खरीफ मक्का में समसामयिक क्रियाए	Krishi Darshan	DoorDarshan	September 8, 2015
	मक्का के विभिन्न उपयोग	National level training programme on "Recent tecnologies of maize based production systems and value addition" for tribal farmers under Tribal Sub Plan of ICAR.	ICAR-Indian Institute of Maize Research, New Delhi	March 08 ,14 and 16, 2016
	मक्का – एक बहुपयोगी फसल	National level training programme on "Recent tecnologies of maize based production systems and value addition" for tribal farmers under Tribal Sub Plan of ICAR.	ICAR-Indian Institute of Maize Research, Pusa Campus, New Delhi	September, 29, October 7 and 27, 2015
	Diversified uses of maize	Model training course on "Production, Protection and Value Addition Technologies for Maize Production systems.	ICAR-Indian Institute of Maize Research, New Delhi	September, 18, 2015
	Seed production technology in maize	Training "Seed production & improved Agricultural Technologies for higher income"	CATAT, IARI	May01, 2015
	Precision nutrient management strategies for higher yield, nutrient productivity and economics of maize hybrids in various agro-ecologies of India.	National Seminar on Integrating Agri-Horticultural and Allied Research for Food and Nutritional Security in the Era of Global Climate Disruption	Imphal, Manipur	March 4 - 6, 2016
Dr. Vinay Mahajan	Breeding Approaches for Sustainable Maize Production under Climate change scenario of North-East Region	Training on "Diversification of Hill Agriculture: An Approach for Climate Change Adaptation and Mitigation' at	ICAR Research Complex for NEH Region, Tadong, Sikkim	
	Strategies for Genetic Articulation of Early Maize Hybrids for Changing Climatic conditions	103rd Indian Science Congress	University of Mysuru, Mysuru	January 3-7, 2016
	Genetic basis of selection in cross-pollinated crops	Training programme "Mendelian Genetics to Molecular Genetics in Relevance to Plant Breeding"	PAU, Punjab	August 19, 2015
	Strategic technologies for peri-urban agriculture	National Conference on De-polluting Indian Cities	India International Centre, New Delhi	September 18-19, 2015
	Seed Production Technology of Single Cross Hybrids		IIMR, New Delhi.	September 21, 2015

Annexure 7

Research Papers

1. Agrawal P.K., Gupta H.S., Jha S.K., Mahajan V., Bhatt J.C., Bisht G.S. and Pant M.C. 2015. Vivek maize Hybrid 47 (FH 3513). Notification of crop varieties and registration of germplasm. Indian Journal of Genetics & Plant Breeding, 75(1): 150-153
2. Agrawal P.K., Jha S.K., Mahajan V., Gupta H.S., Bhatt J.C., Bisht G.S. and Pant M.C. 2015. Vivek Maize Hybrid 53 (FH 3556). Notification of crop varieties and registration of germplasm.Indian Journal of Genetics & Plant Breeding, 75(1): 150-153
3. Agrawal V.K., Singh R.M., Shahi J.P., Agrawal R.K. and Chaudhary D. P. 2015. Inheritance of kernel quality attributes in quality protein maize (*Zea mays* L.). Indian Journal of Genetics & Plant Breeding, 75: 201-207.
4. Amrita, Singh O. and Singh K.P. 2016. Analysis of Ground Water Level Trend in Kurukshetra District of Haryana: 1990-2013. Environmental Pollution Control Journal, 19(2): 23-31.
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Extended summary / Abstract /Conference Paper

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1. Kumar A., Jat S.L. and Parihar C. M .2016. Production, protection and value addition for maize based production system. Indian Institute of Maize Research, New Delhi-110012. 146 pp.

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5. साई दास, सी.एम.परिहार, एस.एल.जाट, वी. के. यादव, एम.आर.यादव एवं वंदना चौधरी सितम्बर 2015. बेबीकॉर्न की खेती। *कृषि* जागरण: 65-68.

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1. Mahajan V., Kumar P., Yadav O.P., Kumar B., Chikkappa G.K., Kaul J., Singh A.K., Parihar C.M., Jat S.L., Sekhar J.C., Shekhar M., Hooda K.S., Paul D., and Singh K.P. 2015. Annual Progress Report *Kharif* Maize 2015. All India Coordinated Research Project on Maize. ICAR-Indian Institute of Maize Research (IIMR), Pusa Campus, New Delhi-110 012, India, 999 pp.

2. Yadav O.P., Kumar B., Chikkappa G.K., Kaul J., Singh A.K., Parihar C.M., Jat S.L., Kumar P., Shekhar M., Hooda K.S., Paul D., and Singh K.P. 2014-15 . Annual Progress Report *Rabi* Maize 2014-15. All India Coordinated Research Project on Maize. ICAR-Indian Institute of Maize Research (IIMR), Pusa Campus, New Delhi-110 012, India, 242 pp.

3. Shekhar M., Singh N., Yadava P and Chikkappa G.K. 2014-15.Annual report. ICAR-Indian Institute of Maize Research ,Pusa Campus, New Delhi, India, 100pp.

Annexure 8

Institute Research Projects

S. No.	Title of the project	P.I.	Co-P.I.s	Duration	
				Start	End
	Plant Breeding				
1	Genetic enhancement of early maturing maize	Dr. Vinay Mahajan	Dr. Avinash Singode * Dr. Meena Shekhar Dr. J.C. Sekhar Dr. Ashok Kumar	April 2012	March 2017
2	Development and enhancement of Quality Protein Maize Germplasm	Dr. Jyoti Kaul	Dr. Ramesh Kumar Dr. Dharam Paul Dr. N. Sunil	May 2012	April 2017
3	Development of maize hybrids for eastern India	Dr. S.B. Singh	Dr. Avinash Singode* Mr. Yatish Kumar Dr. Ganpati Mukri* Dr. N. Sunil	Oct 2014	Sept.2019
4	Breeding for tolerance to abiotic stress in maize	Dr. Ramesh Kumar	Dr. Nirupma Singh Dr. Manivannan* Dr. Avinash Singode* Dr. Ishwar Singh Dr. G.K. Chikkappa Dr. Bhupender Kumar	Aug 2014	July 2019
5	Characterization and diversification of maize germplasm	Dr. G.K. Chikkappa	Dr. Jyoti Kaul Dr. Bhupender Kumar Dr. Vinay Mahajan Dr. K. S. Hooda Dr. Nirupma Singh Dr. Ganpati Mukri* Mr. Vishal Singh Mr. Yatish Kumar Dr. S.B. Singh Dr. N. Sunil	June 2014	May 2019
6	Genetic enhancement of maize for starch, oil, methionine and pro-vitamin A	Mr. Vishal Singh	Mr. Yatish Kumar Dr. Dharam Paul Dr. Pranjal Yadava	Aug.2014	July 2019
7	Development of high yielding maize hybrids for different ecologies	Dr. Bhupender Kumar	Dr. Avinash Singode* Dr. Manivannan* Dr. Chikkakpa G.K. Mr. Vishal Singh Mr. Yatish Kumar Dr. Ganpati Mukri* Dr. Nirupma Singh Dr. Ramesh Kumar Dr. S.B. Singh Dr. K.S.Hooda	June 2014	May 2019
	Plant Pathology				
8	Development of IDM strategy for major diseases of maize with available effective tools	Dr. K.S. Hooda	Dr.(Mrs.) Jyoti Kaul Dr. Amrender Kumar	April 2016	March 2021
9	Studies of host-Pathogen interaction between *M. phaseolina & F. moniliforme* (stalk rot pathogens) in maize and Identification of sources of resistance	Dr. Meena Shekhar	Dr. Nirupma Singh	Jan 2013	Dec 2018

S. No.	Title of the project	P.I.	Co-P.I.s	Duration	
				Start	End
	Agricultural Entomology				
10	Study on biochemical basis of resistance against major pests of maize	Ms. Suby S.B./ (20.01.2015) P. Kumar from 5.8.11	Dr. P. Kumar Dr. J.C. Sekhar Aditi Kundu	April 2010	March 2015 Extended upto March 2016
11	Development of management tools for maize pests	Dr. P. Kumar	Dr. P. L. Soujanya Dr. Subey S.B. Dr. Amrender Kumar	January 2014	Dec. 2019
12	Identification of Multiple Borer Resistant Genotypes in Maize	Dr. J.C. Sekhar	Dr. P. Kumar Dr. P. L. Soujanya Dr. N. Sunil	June 2012	May 2017
13	Management of Sitophilus oryzae (L) and Sitotroga cerealella (Oliv) infesting stored maize through Host Plant resistance and Plant origin pesticides"	Dr. P. L. Soujanya	Dr. J.C. Sekhar	June 2012	April 2017
	Agronomy				
14	Evaluating conservation tillage practices for Improving resources use efficiency in maize based cropping system	Dr. C.M. Parihar	Dr. S.L. Jat Dr. A. K Singh	July, 2008 July,2013	June 2013 (extended June 2018)
15	Diversified maize based cropping system for higher productivity and sustained soil health	Dr. Ashok Kumar	Dr. C.M. Parihar	July, 2011	June 2016
16	Site specific nutrient management in maize based cropping system	Dr. Aditya Kumar Singh	Dr. S.L. Jat Dr. Ashok Kumar	June 2012	June 2017
17	Nitrogen Management under Conservation Agriculture in Maize Based Cropping System	Dr. S.L. Jat	Dr. A. K Singh Dr. C.M. Parihar Dr. Ashok Kumar	June 2012	June 2017
	Plant Physiology				
18	Physilogical and molecular basis of heat tolerance in maize	Dr. Ishwar Singh	Dr. Pranjal Yadava Ms. Avni	Oct. 2014	Sept. 2017
	Agricultural Biochemistry				
19	Biochemical Characterization of Normal and Speciality Corn Germplasm	Dr. Dharam Paul	-	April 2012	March 2017
	Agricultural Extension				
20	Strengthening and Refinement of Maize AGRIdaksh	Dr. Virendra Kumar Yadav/Dr. K.P.Singh as PI from June 2014	-	April 2011	March 2016
	ARIS Cell				
21	Data mining and management of data generated through AICRP on maize	Dr. K. P. Singh	Dr. Vinay Mahajan Dr. Meena Shekhar	April 2012	March 2017
22	Cloning and characterization of abiotic stress regulated genetic elements from maize	Dr. Pranjal Yadava	Dr. Ishwar Singh Dr. Avinash Singode*	Sept.2012	Sept.2017

* Scientist transfered

Externally Funded Projects

S. No.	Funding agency	Title of the Project	From	To	P.I./Mentor
1	ICAR- Network Project	Development of Maize Transgenic for Stem Borer Resistance	2012	2017	Dr. Pranjal Yadava
2	ITMU-IIMR	Institute Technology Management Unit	2007	On going	Dr. J. Kaul
3	PPV&FRA	Strengthening DUS test centres for effective implementation of PVP legislation	2004	On going	Dr. J. Kaul
4	ICAR (NBPGR)(CRP)	CRP on Maize Agro-biodiversity	2014	2017	Dr. J. Kaul
5	ICAR	Genetic enhancement for low moisture stress tolerance in maize	2016	2017	Dr. J. Kaul
6	DSR/ICAR	Mega seed project	2007	On going	Dr. S.B.Singh
7	ICAR- Network Project	Functional genomics of drought tolerance in maize	April 2012	March 2017	Dr. Ishwar Singh
8	DST	Study of host pathogen interactions as affected by extra chromosal factors dsRNA and DNA Plasmids in Rhizoctonia sp"	April 2014	May 2017	Dr. Vimla Singh/ Dr. K.S. Hooda As Mentor
9	ICAR (CRP)	National Initiative on Climate Resilient Agriculture (NICRA) at CRIDA	April 2012	March 2017	Dr. A.K. Singh
10	ICAR (CRP)	Consortia for Research Platform (CRP) in Biofortiification in selected crops or nutritional security	April 2014	March 2017	Dr. Bhupender Kumar
11	ICAR (Incentivizing Research in Agriculture)	Genetic modifications to improve biological nitrogen fixation for augmenting nitrogen needs of cereals	2015	2017	Dr. Pranjal Yadava
12	ICAR	Genetic Transformation and Development of Elite Transgenic Maize (Sea Mays L.) for Biotic and Abiot8ic Stresses Tolerance (NASF)	2015	2018	Dr. Pranjal Yadava
13	ICAR	Molecular breeding for improvement of tolerance to biotic and abiotic stresses, yield and quality traits in crops	2015	2017	Dr. Chikappa G. Karjagi

Annexure 9

Important Committees

Research Advisory Committee

Dr. S.K Sharma	CSIR- Emeritus Scientist	Chairman
Dr. R.K Malik	Ex. Director Extn, CCSHAU	Member
Dr. B.L Jalali	Ex. Director of Research, HAU	Member
Dr. R.P. Dua	Ex. ADG (FFC)	Member
Dr. Himanshu Pathak	Professor, Division of Environmental Sciences	Member
Dr. I.S. Solanki	ADG (FFC)	Member
Dr. Vinay Mahajan	Director, ICAR-IIMR	Member
Dr. K. S. Hooda	Principal Scientist, ICAR-IIMR	Member Secretary

Institute Research Council

Dr. Vinay Mahajan	Director, ICAR-IIMR	Chairman
All PI/Section Incharge	Head of Division / Section	Member
All Scientist	ICAR-IIMR	Member
ADG(FFC)	ICAR	Member
Dr. K. S. Hooda	Principal Scientist	Member Secretary

Prioritization Monitoring and Evaluation Cell

Dr. K. S. Hooda	Principal Scientist	Chairman
Dr. Ishwar Singh	Principal Scientist	Member
Dr. A. K. Singh	Principal Scientist	Member
Dr. K. P. Singh	Senior Scientist	Member
Dr. R. Ambika Rajendran	Scientist	Member
Dr. Shankar Lal Jat	Scientist	Member

Institute Technology Management Unit

Dr. Jyoti Kaul	Principal Scientist	Nodal Officer
Dr. Meena Shekhar	Principal Scientist	Member
Dr. Ishwar Singh	Principal Scientist	Member
Dr. K. P. Singh	Senior Scientist	Member
Dr. Usha Nara	Research Associate	IPR

Committee for Awarding Incentives to Meritorious Wards

Dr. Meena Shekher	Pr. Scientist	Chairperson
Dr. A. K. Singh	Pr. Scientist	Member
Administrative Officer	Officer	Member Secretary
Dr. K. P. Singh	Sr. Scientist	Member
Dr. Nirupma Singh	Scientist	Member
Mrs. Kamlesh Malik	Asstt.	Member
Sh. Ram Kishan	SSS	Member

Institute Biosafety Committee

Dr. P. Kumar	Principal Scientist	Chairman
Dr. Jyoti Kaul	Principal Scientist	Member
Dr. Meena Shekhar	Principal Scientist	Member
Dr. Amar Kumar	External Expert, Delhi University	Member
Dr. Amrita Srivastava	Doctor (IARI Dispensary)	Member
Dr. Pranjal Yadava	Scientist	Nodal Officer

Staff Welfare Committee

Dr. K. P. Singh	Senior Scientist	Chairman
Dr. A. K. Singh	Principal Scientist	Member
Dr. Nirupma Singh	Scientist	Member
Smt. Kamlesh Malik	Assistant	Member
Sh. Amar Nath	SSS	Member
Administrative Officer	A. O.	Member

Foreign Deputation Committee

Dr. K. S. Hooda	Principal Scientist	Chairman
Dr. Ishwar Singh	Principal Scientist	Member
Dr. Jyoti Kaul	Scientist	Member
Administrative Officer	A. O.	Member Secretary

Tender Opening Committee

Dr. K. S. Hooda	Pr. Scientist	Chairman
Dr. K. P. Singh	Sr. Scientist	Member
Dr. Pranjal Yadav	Scientist	Member
Indenter	-	Member
Sh. H. C. Ghildiyal	A. O.	Member Secretary
Dr. S. L. Jat	Scientist	Member

Annual Report Editorial Committee

Dr. Meena Shekhar	Principal Scientist
Dr. Nirupma Singh	Scientist
Dr. Chikkappa G Karjagi	Scientist
Dr. Pranjal Yadava	Scientist

Condemnation Committee

Dr. K. S. Hooda,	Pr. Scientist	Chairman
Dr. Chikkappa G. K.	Scientist	Member
Dr. Nirupma Singh	Scientist	Member
Dr. Bhupender kumar	Scientist	Member
Administrative Officer	Officer	Member Secretary

Local Purchase committee for IIMR, PAU Campus, Ludhiana

Dr. Dharma Paul	Sr. Scientist & Incharge	Chairman
Dr. Ramesh Kumar	Sr. Scientist	Member
Sh. Vishal	Scientist	Member
Indenter	-	Member

Local Purchase committee for WNC, Hyderabad

Dr. J. C. Shekar	Pr. Scientist	Chairman
Dr. N. Sunil	Sr. Scientist	Member
Dr. P. Lakshmi Soujanya	Scientist	Member Secretary
One representative from ANGRAU		Member

Biometric Attendance Control System (BACS)

Dr. Ishwar Singh	Principal Scientist	Nodal Officer
Dr. K.P. Singh	Senior Scientist	Co- Nodal Officer

Contractual Services Advisory Committee

Dr. K. S. Hooda	Principal Scientist	Chairman
Dr. Ashok Kumar	Principal Scientist	Member
Dr. C. M. Parihar	Scientist	Member
Dr. Bhupender Kumar	Scientist	Member
Dr. Jyoti Kaul	Scientist	Member
Administrative Officer	A. O.	Member Secretary

Women Complaint Committee

Dr. Meena Shekhar	Pr. Scientist	Chairperson
Dr. K.P. Singh	Sr. Scientist	Member
Sh. Raj Kishor Singh	T-II	Member
Smt. Kamlesh Malik	Assistant	Member Secretary

Institute Local Purchase Committee for IIMR, New Delhi

Dr. Ashok Kumar	Pr. Scientist	Chairman
Dr. Meena Shekhaer	Pr. Scientist	Member
Dr. C. M. Parihar	Scientist	Member
Indenter	-	Member
Sh. H. C. Ghildiyal	A. O.	Member Secretary

Local Purchase committee for RMR & SPC, Begusarai

Dr. S. B. Singh	Pr. Scientist	Chairman
Sh. Rahul	T-3	Member
Sh. Kamal Vats	T-3	Member
Sh. Sameer Kumar Rai	T-3	Member

Institute's Result Framework Document Committee

Dr. O.P. Yadav	Director	Chairman
Dr. Ishwar Singh	Principal Scientist	Nodal Officer
Dr. S. L. Jat	Scientist	Co-Nodal Officer
Dr. P. Kumar	Principal Scientist	Ex-officio member (I/c PME)
Dr. A.K. Singh	Principal Scientist	Member
Administrative Officer	A.O.	Member

Human Resource Development

Dr. Ishwar Singh	Principal Scientist	Nodal Officer

Annexure 10

Personnel

Name	Designation	Discipline
Indian Institute of Maize Research, Pusa Campus, New Delhi		
Dr. Vinay Mahajan	Director (Acting) 01-03-2016 onwards	Plant Breeding
Dr. Jyoti Kaul	Principal Scientist	Plant Breeding
Dr. K. S. Hooda	Principal Scientist	Plant Pathology
Dr. Ishwar Singh	Principal Scientist	Plant Physiology
Dr. Aditya Kr. Singh	Principal Scientist	Agronomy
Dr. Ashok Kumar	Principal Scientist	Agronomy
Dr. Meena Shekhar	Principal Scientist	Plant Pathology
Dr. M. L. Jat*	Senior Scientist	Agronomy
Dr. K. P. Singh	Senior Scientist	Computer Application
Dr. Nirupma Singh	Scientist	Plant Breeding
Dr. C. M. Parihar	Scientist	Agronomy
Dr. Chikkappa G. Karjagi	Scientist	Plant Breeding
Dr. A. Manivannan	Scientist	Genetics
Dr. Suby S. B.	Scientist	Entomology
Dr. R. Ambika Rajendran	Scientist	Plant Breeding
Dr. Shankar Lal Jat	Scientist	Agronomy
Ms. Sapna***	Scientist	Biochemistry
Dr. Bhupender Kumar	Scientist	Plant breeding
Dr. Pranjal Yadava	Scientist	Agricultural Biotechnology
Ms. Avni	Scientist	Agricultural Biotechnology
Dr. Krishan Kumar	Scientist	Agricultural Biotechnology
Mrs. Seema Khatter	PS	
Mrs. Kamlesh Malik	Assistant	
Ms. Chinkey Aggarwal	Assistant	
Mr. Dharambir Singh	Sr. Clerk	
Mr. Ajay Kumar Singh	T-2	
Mr. Raj Kishor Singh	T-2	
Mr. Amar Nath	SSS	
Mr. Anwar Ali	SSS	
Mr. Ram Kishan	SSS	
Winter Nursery Centre, Hyderabad		
Dr. J. C. Sekhar	Principal Scientist	Entomology
Dr. N. Sunil	Senior Scientist	Genetics & Plant Breeding
Dr. P. L. Soujanya	Scientist	Entomology
Regional Maize Research and Seed Production Centre, Kushmahout Farm, Begusarai (Bihar)		
Dr. S. B. Singh	Principal Scientist	Plant Breeding
Mr. Samir Kumar Rai	T-3	
Mr. Rahul	T-3	
Mr. Kamal Vats	T-3	

Name	Designation	Discipline
Indian Institute of Maize Research, PAU Campus, Ludhiana (Punjab)		
Dr. Dharam Paul	Senior Scientist	Biochemistry
Dr. Ramesh Kumar	Senior Scientist	Plant Breeding
Sh. Vishal Singh	Scientist	Plant Breeding
Sh. Yatish K. R. ***	Scientist	Genetics
Mr. Abhijit Kumar Das***	Scientist	Plant Breeding

*On Deputation ***On study leave

Staff position of the ICAR-IIMR as on March 31, 2016

Type of Posts	Approved by D/o expenditure	In Position	Vacant
Scientific	40	28	12
Technical	05	05	0
Administrative	13	05	08
Supporting	03	03	0
Total	61	41	20

Superannuation

Dr. Pradyuman Kumar	Director (Acting) 19-12-2015 to 29-02-2016 & Principal Scientist, Entomology	Superannuated on 29.02.2016

Transfers

Name	Date of Transfer from IIMR	Transferred to
Dr. Manivannan	28-4-2015	CICR, Coimbatore
Dr. Avinash Singode	02-6-2015	ICAR-IIMR, Hyderabad
Dr. O. P. Yadav	18-12-2015	CAZRI, Jodhpur
Dr. Ganpati Mukri	31-12-2015	IARI, New Delhi

New Joining

Name	Date	Place	From
Sh. H. C. Ghildiyal, A.O.	13-10-2015	ICAR-IIMR	IARI, New Delhi
Sh. Krishan Kumar, Scientist	09-10-2015	ICAR-IIMR	New ARS Joining

Annexure 11

Financial Expenditure for Annual Report 2015-16

Sanctioned Budget (Rs in Lakhs)					2015-2016 Expenditure (Rs in Lakhs)				
Head of Account	**Plan**	**Non-Plan**	**AICRP on Maize**	**Total**	**Head of Account**	**Plan**	**Non-Plan**	**AICRP on Maize**	**Total**
Grant in Capital	50.00	19.00	—	69.00	Grant in Capital	49.71	14.38	—	64.09
Grant in salary	—	482.30	1648.60	2130.90	Grant in salary	—	482.14	1648.60	2130.74
Grant in General	377.00	193.70	279.00	849.70	Grant in General	376.98	188.19	279.00	844.17
TSP	23.00	—	71.00	94.00	TSP	23.00	—	71.00	94.00
Total	450.00	695.00	1998.60	3143.60	Total	449.69	684.71	1998.60	3133.00

Resource Generation

Particular	Funds (Rs Lakh)
FLD	15.00
DUS Testing	19.05
Transgenic Project	19.19
Plan scheme	194.91
Total	248.15

Funds Received for Externally Funded Projects

Particular	Rs. (Rs In Lakh)
Sale of farm produce	29.85
Standard License Fee	0.80
Analytical and Testing Fee	120.00
Receipts from Services Rendered	0.07
Income generated form IRG	12.32
Total	163.04

Annexure 12

Results-Framework Document (RFD)

for

Indian Institute of Maize Research

(2014-2015)

Section 1:

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

Mission

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

Objectives

1. Germplasm enhancement and development of improved cultivars
2. Development and identification of appropriate crop production and protection technologies
3. Technology dissemination and capacity building

Functions

1. To carry out basic, strategic and applied research aimed at enhancement of production and productivity of maize in the country.
2. To conduct and coordinate multi-disciplinary and multi-location research to identify appropriate technologies for varied agro-climatic conditions in different parts of India
3. Germplasm collection, evaluation, maintenance and its enhancement.
4. To develop specialty corn cultivars such as Quality Protein Maize, baby corn, sweet corn, bio-fuel etc for diverse uses.
5. To conduct training, frontline demonstrations and on-farm research to maximize and accelerate adoption of research findings and innovative technologies.
6. To serve as core centre for maize research material and information
7. To develop linkages with national, international and private sector for collaborative research program.
8. To provide consultancy services and undertake contractual research

Section 2:

Inter se Priorities among Key Objectives, Success Indicators and Targets

S. No.	Objective(s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target/Criteria value				
							Excellent	Very Good	Good	Fair	Poor
							100%	90%	80%	70%	60%
1	Genetic enhancement and development of improved cultivars	**50**	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	20	1320	**1100**	880	660	440
				Entries tested in AICRP trials for multi-location testing	Number	10	288	**240**	196	152	108
				Lines identified for unique traits	Number	5	13	**11**	9	7	5
			Development of improved cultivars	Entries contributed for AICRP multi-location trial	Number	5	146	**122**	98	74	50
				Varieties identified for release	Number	5	5	**4**	3	2	1
			Seed production programme	Breeder seed produced	Weight (Quintals)	5	66	**55**	44	33	22
2	Development and identification of appropriate crop production and protection technologies	**15**	Development and testing of new technologies	New technologies tested	Number	8	6	**5**	4	3	2
				Technologies recommended	Number	7	3	**2**	1	0	0
3	Technology dissemination and capacity building	**15**	Demonstrations conducted	Front line demonstrations conducted	Number	5	180	**150**	120	90	60
			Farmers/ Extension officials training programmes organized	Trainings organized	Number	10	8	**7**	6	5	4
*	Publication / Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3	4	**3**	2	1	0
			Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	2	30.06. 2014	**02.07. 2014**	04.07. 2014	07.07. 2014	09.07. 2014
*	Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	2	98	**96**	94	92	90
*	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD for 2014-2015 for Approval	On-time submission	Date	2	May 15, 2014	**May 16, 2014**	May 19, 2014	May 20, 2014	May 21, 2014
			Timely submission of Results for 2013-2014	On-time submission	Date	1	May 1 2014	**May 2 2014**	May 5 2014	May 6 2014	May 7 2014

S. No.	Objective(s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target/Criteria value				
							Excellent	Very Good	Good	Fair	Poor
							100%	90%	80%	70%	60%
*	Enhanced Transparency / Improved Service delivery of Ministry/ Department	3	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	2	100	**95**	90	85	80
			Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	1	100	**95**	90	85	80
*	Administrative Reforms	7	Update organizational strategy to align with revised priorities	Date	Date	2	Nov.1 2014	**Nov.2 2014**	Nov.3 2014	Nov.4 2014	Nov.5 2014
			Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC)	% of implementation	%	1	100	**90**	80	70	60
			Implementation of agreed milestones for ISO 9001	% of implementation	%	2	100	**95**	90	85	80
			Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	2	100	**90**	80	70	60

*Mandatory objective(s)

Section 3:

Trend Values of the Success indicators

S. No.	Objective	Actions	Success Indicator	Unit	Actual Value for FY 12-13	Actual Value for FY 13-14	Target Value for FY 14-15	Projected Value for FY 15-16	Projected Value for FY 16-17
1.	Genetic enhancement and development of improved cultivars	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	2985	1298	1100	1200	1300
			Entries tested in AICRP trials for multi-location testing	Number	349	298	240	250	260
			Lines identified for unique traits	Number	2	10	11	12	13
		Development of improved cultivars	Entries contributed for AICRP multi-location trial	Number	192	156	122	124	126
			Varieties identified for release	Number	6	10	4	5	6
		Seed production programme	Breeder seed produced	Weight (Quin-tals)	108	65.5	55	60	65

S. No.	Objective	Actions	Success Indicator	Unit	Actual Value for FY 12-13	Actual Value for FY 13-14	Target Value for FY 14-15	Projected Value for FY 15-16	Projected Value for FY 16-17
2.	Development and identification of appropriate crop production and protection technologies	Development and testing of new technologies	New technologies tested	Number	3	5	5	6	7
			Technologies recommended	Number	1	3	2	3	4
3.	Technology dissemination and capacity building	Demonstrations conducted	Front line demonstrations conducted	Number	75	550	150	175	200
		Farmers/ Extension officials training programmes organized	Trainings organized	Number	7	7	7	8	9
*	Publication/ Documentation	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3	3	3	4	5
		Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	-	-	02.07.2014	-	-
*	Fiscal resource management	Utilization of released plan fund	Plan fund utilized	%	100	96	96	97	98
*	Efficient Functioning of the RFD System	Timely submission of Draft RFD for 2014-2015 for Approval	On-time submission	Date	-	-	May 16, 2014	-	-
		Timely submission of Results for 2013-2014	On-time submission	Date	-	-	May 2, 2014	-	-
*	Enhanced Transparency / Improved Service delivery of Ministry	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	-	-	95	-	-
		Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	-	-	95	-	-

S. No.	Objective	Actions	Success Indicator	Unit	Actual Value for FY 12-13	Actual Value for FY 13-14	Target Value for FY 14-15	Projected Value for FY 15-16	Projected Value for FY 16-17
*	Administrative Reforms	Update organizational strategy to align with revised priorities	Date	Date	-	-	**Nov.2, 2014**	-	-
		Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC).	% of implementation	%	-	-	**90**	-	-
		Implementation of agreed milestones for ISO 9001	% of implementation	%	-	-	**95**	-	-
		Implementation of milestones of approved Innovation Action Plans (IAPs).	% of implementation	%	-	-	**90**	-	-

*Mandatory objective(s)

Section 4 (a):

Acronyms

S. No.	Acronym	Description
1	AICRP	All India Coordinated Research Project
2	DAC	Department of Agriculture and Cooperation
3	FLDs	Front Line Demonstrations

Section 4 (b):

Description and Definition of Success Indicators and Proposed Measurement Methodology

Sl No.	Success Indicator	Description	Definition	Measurement	General Comments
1	Breeding and germplasm lines evaluated	Source material for the improved cultivars to be evaluated	Material generated from source germplasm	Number of accessions/ lines evaluated	
2	Entries tested in AICRP trials for multi-location testing	Entries contributed for multi-location at different level of testing through All India Coordinated Research Project on Maize	Relative performance of entries	Number	
3	Lines identified for unique traits	Basic germplasm is evaluated for traits like biotic and abiotic stress resistance/tolerance	Resistant/ tolerant lines identified for use in breeding program	Number of lines identified	
4	Entries contributed for AICRP multi-location trial	Newly developed on-station hybrids evaluated in AICRP multi-location testing	Relative performance of experimental hybrids	Number of entries contributed	
5	Varieties identified for release	Newly developed hybrids along with checks in multi-location trials through All India Coordinated Research Project on Maize	Best performing entries identified for release	Number of such hybrids identified	Identification of varieties/ hybrids depend upon the availability of superior material with respect to yield, biotic and abiotic resistance/tolerance over the existing hybrids

Sl No.	Success Indicator	Description	Definition	Measurement	General Comments
6	Breeder seed produced	Produce from nucleus and breeder seed is the starting point in the seed chain of producing quality seed for farmers	Breeder seed is the starting point in the seed chain which is multiplied/converted into foundation/ certified seed	Quantity produced	Quantity may vary as per indent of DAC
7	New technologies tested	Testing of newly developed production and protection technologies for improving maize productivity	Better crop management	Number	
8	Technologies recommended	Tested production and protection technologies recommended to farmers	Crop management for enhanced productivity	Number	
9	Front line demonstrations conducted	Demonstrations conducted for technology testing and providing the technology potential production	Frontline demonstration is the field demonstration conducted on farmers field under the close supervision of the scientists	Number	Number may vary as per approval of DAC
10	Trainings organized	Capacity building activities related to knowledge and skill improvement/ development programmes conducted for farmers, rural youth and extension personnel	Training is a process of acquisition of new skills, attitude and knowledge in the context of improving productivity in an organization	Number	

Section 5:

Specific Performance Requirements from other Departments that are critical for delivering agreed results

Location Type	State	Organization Type	Organization Name	Relevant Success Indicator	What is your requirement from this organization	Justification for this requirement	Please quantify your requirement from this Organization	What happens if your requirement is not met
Central Government		Departments	Department of Agriculture and Cooperation	Breeder seed produced	Indent for quantity of breeder seed	Hybrid wise indent of breeder seed	Quantity of breeder seed is produced as per indent	Less or more quantity of breeder seed will be produced
Central Government		Departments	Department of Agriculture and Cooperation	Front line demonstrations conducted	Timely allotment of funds/ FLDs	Agency wise distribution	FLDs are conducted as per allotment	Less number of FLDs will be conducted

Section 6:

Outcome/Impact of activities of Department/Ministry

S. No.	Outcome/ impact	Jointly responsible for influencing this outcome/ impact with the following department(s)/ organization(s)/ ministry(ies)	Success Indicator(s)	Unit	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
1.	Enhanced maize productivity	DAC, Planning commission, Ministry of Environment & Forests, Ministry of Rural development and state Governments	Increase in maize productivity (Base year 2010-11)	%	1.7	2.4*	2.2	2.4	2.6

*Based on 3rd advance estimate

Annual (April 1, 2014 to March 31, 2015) Performance Evaluation Report of RFD 2014-2015 of RSCs *i.e.* Institutes

Name of the Division : Crop Science

Name of the Institution : Indian Institute of Maize Research

RFD Nodal Officer of the RSC : Dr. Ishwar Singh

S. N.	Objectives	Weight	Action (s)s	Success Indicator (s)	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.	*Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100 %	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw score	Weighted score		
1.	Genetic enhancement and development of improved cultivars	50	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	20	1320	1100	880	660	440	1339	100	20	121.7	The ongoing research projects were able to generate more number of segregating lines
				Entries tested in AICRP trials for multi-location testing	Number	10	288	240	196	152	108	471	100	10	196.3	More experimental hybrids were contributed by the institute
				Lines identified for unique traits	Number	5	13	11	9	7	5	13	100	5	118.2	This is equivalent to achievements mentioned in 100% column
			Development of improved cultivars	Entries contributed for AICRP multi-location trial	Number	5	146	122	98	74	50	256	100	5	209.8	There was better response from AICRP partners
				Varieties identified for release	Number	5	5	4	3	2	1	11	100	5	275.0	Superior material was available over the existing hybrids
			Seed production programme	Breeder seed produced	Weight (Quinta ls)	5	66	55	44	33	22	66	100	5	120.0	This is equivalent to achievements mentioned in 100% column
2.	Development and identification of appropriate crop production and protection technologies	15	Development and testing of new technologies	New technologies tested	Number	8	6	5	4	3	2	6	100	8	120.0	This is equivalent to achievements mentioned in 100% column
				Technologies recommended	Number	7	3	2	1	0	0	2	90	6.3	100.0	NA
3.	Technology dissemination and capacity building	15	Demonstrations conducted	Front line demonstrations conducted	Number	5	180	150	120	90	60	188	100	5	125.3	There was better response from the farmers
			Farmers/ Extension officials training programmes organized	Trainings organized	Number	10	8	7	6	5	4	8	100	10	114.3	This is equivalent to achievements mentioned in 100% column

S. N.	Objectives	Weight	Action (s)s	Success Indicator (s)	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.	*Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100 %	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw score	Weighted score		
*	Publication/ Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3	4	3	2	1	0	14	100	3	466.7	-
			Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	2	30.06.2014	02.07.2014	04.07.2014	07.07.2014	09.07.2014	27/06/2014	100	2	-	-
*	Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	2	98	96	94	92	90	94.8	84	1.68		-
*	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD for 2014-2015 for Approval	On-time submission	Date	2	May 15, 2014	May 16, 2014	May 19, 2014	May 20, 2014	May 21, 2014	15/05/2014	100	2	-	-
			Timely submission of Results for 2013-2014	On-time submission	Date	1	May 1, 2014	May 2, 2014	May 5, 2014	May 6, 2014	May 7, 2014	01/05/2014	100	1	-	-
*	Enhanced Transparency / Improved Service delivery of Ministry/ Department	3	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	2	100	95	90	85	80	100	100	2	-	-
			Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	1	100	95	90	85	80	100	100	1	-	-
*	Administrative Reforms	7	Update organizational strategy to align with revised priorities	Date	Date	2	Nov. 1, 2014	Nov. 2, 2014	Nov. 3, 2014	Nov. 4, 2014	Nov. 5, 2014	01/11/2014	100	2	-	-
			Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC).	% of implementation	%	1	100	90	80	70	60	100	100	1	-	-

S. N.	Objectives	Weight	Action (s)s	Success Indicator (s)	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.	*Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100 %	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw score	Weighted score		
			Implementation of agreed milestones for ISO 9001	% of implementation	%	2	100	95	90	85	80	100	100	2	-	-
			Implementation of milestones of approved Innovation Action Plans (IAPs).	% of implementation	%	2	100	90	80	70	60	100	100	2	-	-

Total Composite Score: 98.98

Rating: Excellent

ANNEXURE-I

Actual Scientific Staff in position in the Institute and their research articles publications published in International and National Journals having NAAS rating 6.00 or more during April 1, 2014-March 31, 2015

Name of the Division : Crop Science

Name of the Institute Name : ICAR- Indian Institute of Maize Research

S. No.	Category of Scientific Staff	Actual Scientific Staff in position (Nos.)	Research articles publications as first /corresponding author (Nos.)	Publication productivity (Number of research articles publications divided by number of Scientists)
1.	Principal Scientist	**11**	**4**	**0.36**
2.	Senior Scientist	**04**	**3**	**0.75**
3.	Scientist	**13**	**7**	**0.54**
Total		**28**	**14**	**0.50**


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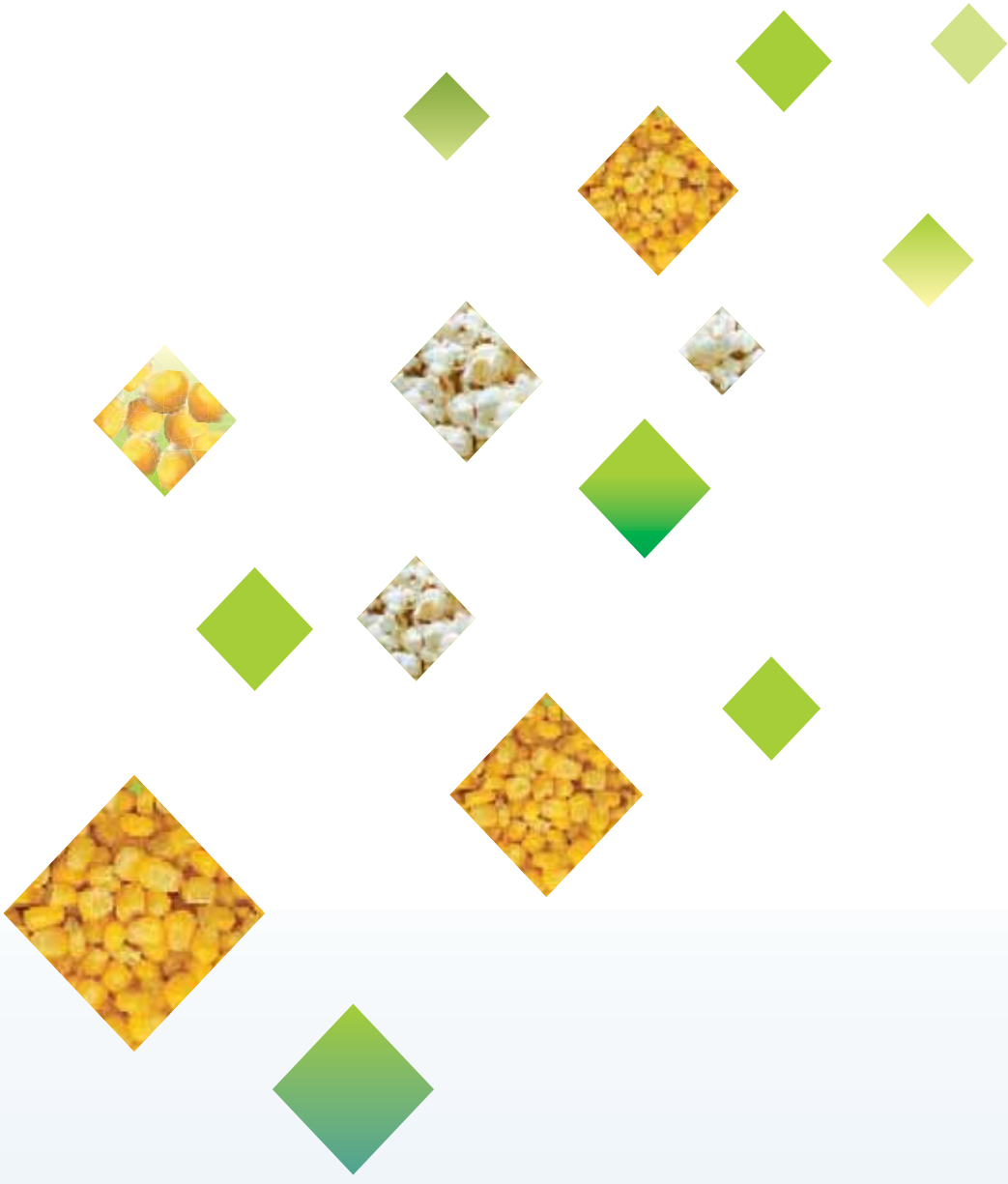

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किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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