ANNUAL REPORT
2014-15

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

Annual Report

2014-15

ICAR-Indian Institute of Maize Research

Pusa Campus, New Delhi -110012, India

Correct Citation:

ICAR-IIMR (2015). Annual Report 2014-15, ICAR-Indian Institute of Maize Research, Pusa Campus, New Delhi – 110012, pp 100.

Editorial Team : Meena Shekhar
Nirupma Singh
Pranjal Yadava
Chikkappa G Karjagi

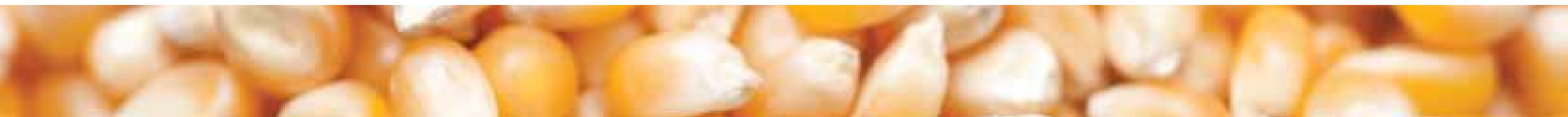
Cover Page Legend : Harvest from ICAR-Indian Institute of Maize Research experimental field, *Kharif* 2014.

Cover page photography & design by : Meena Shekhar, Nirupma Singh

Published by : Director
ICAR-Indian Institute of Maize Research
Pusa Campus, New Delhi - 110012 (India)
Ph. : 91-11-25841805, 25842372, 28549725; Fax 91-11-25848195
Email: pdmaize@gmail.com
Website: www.iimr.res.in

Layout design & printed by:
M/s. Royal Offset Printers, A-89/1, Naraina Industrial Area, Phase-I, New Delhi-110028

Contents



Preface

The year 2014-15 was a landmark year in the history of maize research in India. In a significant development that clearly underscores the rising importance of maize in the Indian economy, the government approved the upgradation of the erstwhile Directorate of Maize Research into a full-fledged institute with the name of ICAR-Indian Institute of Maize Research (IIMR). The upgradation into an institute would not only strengthen the infrastructure for maize research, but it would also lead to better organizational management. The genesis of the present day IIMR lies in the historic event of establishment of the All India Coordinated Maize Improvement Project (AICMIP) way back in 1957. The establishment of the AICMIP was a pioneer idea, which spurred the creation of several other coordinated projects in different commodities- a unique feature of the Indian National Agricultural Research System. The Project was upgraded into Directorate of Maize Research (DMR) on 28th January 1994. After more than 20 years of relentless service to the nation, the Directorate was upgraded into an institute on 13th November 2014. IIMR is the only institute in the country which is exclusively mandated for maize research. The institute is devoted for conducting basic, strategic and applied research aimed at enhancing production, productivity and utilization of maize in India.

Another significant event of the year that would further catalyze the maize research scenario is the approval of the XII Five Year Plan (2012-2017) of the institute. The implementation of XII Five Year Plan is enabling the institute to augment its research infrastructure, execute its flagship and other prioritized programmes, as well as strengthen the All India Coordinated Research Project (AICRP) on Maize. Under the XII Plan, five new AICRP centres are being opened, taking the total number of AICRP Maize centres to 32. The intensified focus and investment would lead to better outcomes in 'public good' maize research and enable us to engage our stakeholders in a more entrenched manner.

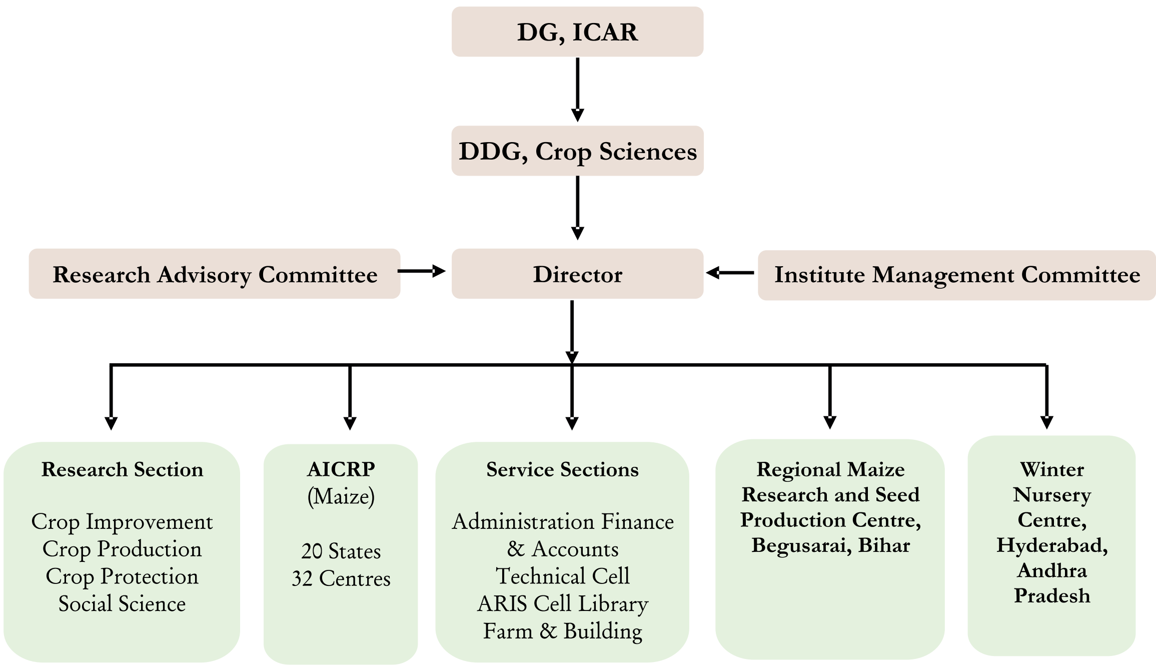
This year, we have been successful in implementing major reforms in our varietal testing system. These efforts are directed towards expansion in number of test locations, enhancing operational efficiencies, and achieving greater data accuracy. In view of expansion of maize cultivation in newer ecologies, and the need to test the material in these ecologies, 30 new volunteer centres were added to our network. This has resulted in more rigorous testing, especially in the Advance Varietal Trials. During *kharif* 2014, 414 new maize hybrids were evaluated in coordinated trials, which is the highest ever figure of entries received for AICRP testing. This highlights the robustness of the testing system and confidence of the stakeholders in our system. This year, 17 new maize hybrids were released by the Central Sub- Committee on Crop Standard and Notification of Varieties for different agro-climatic conditions of the country.

As a result of the coordinated interventions, the maize production and productivity of the country is continuing to rise. The estimates of 2014-15 have indicated an increase in maize production over last two years and it has touched 24.35 million tonnes, which is the highest so far in the history of maize production in India. This year till January 2015, India had already exported 2.6 million tonnes of maize grains worth Rs 3654 crores. While, the maize production and export is increasing, there is a need to promote domestic utilization of maize, especially in the industrial processes. A sustained domestic demand coupled with stable export demand is critical in assuring remunerative prices to the maize farmers.

IIMR is committed to strengthen its research priorities towards secondary agriculture to ensure effective utilization of the increased maize production. At the same time, we shall continue our research aimed at crop improvement and management. Through the intensified focus on single cross hybrid research during last decade, we have achieved a very high genetic yield potential (12-14 tonnes/ha) as seen in yields obtained in experiment stations. However, this yield level is achievable only when the crop is grown under stress-free conditions. At the farmer's field, even one third of this yield potential is hardly achieved due to the incidence of various biotic and abiotic stresses. Therefore, there is a need to focus improvement and management towards mitigating theses biotic and abiotic stresses.

I am thankful to Dr. S. Ayyappan, Secretary, DARE and DG ICAR, Dr. J.S. Sandhu, DDG (CS), Prof. S.K. Datta, former DDG (CS), Dr. I.S. Solanki, ADG (FFC) and Dr. R.P. Dua, former ADG (FFC) for their erudite guidance and generous support for maize research. I also deeply acknowledge the sincere efforts of our scientists, staff, partners and all the stakeholders for making the maize sector one of the most vibrant facet of the Indian agriculture.

(O.P. Yadav)


DG, ICAR
DDG, Crop Sciences
Research Advisory Committee
Director
Institute Management Committee
Research Section
Crop Improvement
Crop Production
Crop Protection
Social Science
AICRP
(Maize)
20 States
32 Centres
Service Sections
Administration Finance
& Accounts
Technical Cell
ARIS Cell Library
Farm & Building
Regional Maize Research and Seed Production Centre, Begusarai, Bihar
Winter Nursery Centre, Hyderabad, Andhra Pradesh

ICAR-IIMR at a glance

- In 1957, with the motive of intensifying maize research, All India Coordinated Research Project- Maize (AICRP) was initiated
- AICRP (Maize) is the oldest co-ordinated research system in India for varietal testing across different agro-climatic zones
- Upgraded to Directorate of Maize Research (DMR) in January 1994
- Upgraded to the Indian Institute of Maize Research (IIMR) on 13 November 2014 to strengthen and fortify the maize research programme
- IIMR is a crop based institute, working under the umbrella of the Indian Council of Agricultural Research
- Mandate of IIMR is to organize, conduct, coordinate and generate improved maize technology for continuous enhancement of maize productivity
- Indian Institute of Maize Research with its head quarter in New Delhi carries out its research under four divisions/sections *viz.*, Crop Improvement, Crop Production, Crop Protection and Social Sciences
- Institute's research activities are planned under the guidance of Research Advisory Committee and Institute Research Council while the progress is critially evaluated by the Quinquiennial Review Team
- Based on agro climatic conditions, country has been demarcated into five zones constituting 32 centres for varietal testing
- Winter Nursery Centre, Hyderabad, Regional Maize Research and Seed Production Centre, Begusarai and Regional Unit Ludhiana cater significantly the multi location research, off-season and seed production requirements of IIMR.

Executive Summary

ICAR-Indian Institute of Maize Research (IIMR) is mandated to carry out basic, strategic and applied research aimed at enhancing production, productivity and sustainability of maize as a crop. The research programmes of the institute are built around two major theme areas- Crop Improvement and Crop Management. The institute also coordinates maize research programmes at many agricultural universities and also supports extension and outreach programmes. During 2014-15, the institute made significant research achievements in different areas of maize research.

Crop improvement

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

Introduction and characterization of base germplasm

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, the institute procured, maintained and advanced 620 new maize germplasm lines obtained through the National Bureau of Plant Genetic Resources. The institute also took initiative to assess genetic diversity in existing inbred lines. During 2014-15, a total of 793 inbred lines were maintained during *kharif* 2014 and the same numbers of inbred lines were being maintained during *rabi* 2014-15 at Regional Maize Research and Seed Production Centre (RMR&SPC), Begusarai. The data on grain characteristics like grain texture, grain colour, kernel cap colour, ear shape, shank colour of the inbred lines were recorded and classified. Another important aspect for increasing the efficiency of hybrid development is grouping inbred lines into different heterotic groups based on the combining ability. In continuation of efforts made to group inbred lines into different heterotic groups during 2012-14, a set of 64 inbred lines derived from HEY pool were test crossed with two diverse testers.

Germplasm for combating biotic stresses

In order to identify superior germplasm that is intrinsically resistant to various biotic stress, extensive screening of material was conducted. During *rabi* 2014-15, 91 inbred lines were evaluated for resistance to different diseases *viz.,* Turcicum leaf blight (at Mandya) and post-flowering stalk rot (at Hyderabad and Ludhiana). In addition, a set of 29 agronomically superior early maturing inbred lines were screened for resistance to Turcicum leaf blight. In an effort to identify genomic regions linked to Maydis leaf blight disease, the institute has developed a recombinant inbred line (RIL) population. The population was advanced from F_4 to F_5 during *kharif* 2014 at New Delhi and F_5 to F_6 during *rabi* 2014-15 at Begusarai. In another experiment, a total of 124 maize lines were evaluated against major diseases at different hot spot locations under artificially inoculated diseased condition in *kharif* 2014. Of them, 56 lines exhibited multiple disease resistance. Similar screening for finding genetic resistance to postflowering stalk rot resistance was also carried out. To study the biology of stalk rot fungus in greater detail, the stalk rot pathogens *i.e. Macrophomina phaseolina* and *Fusarium verticilloides* were isolated, purified and established in culture. Presence of stalk rot pathogens in symptomless plants was authenticated by extensive histopathological studies and pathogen induced cellulase, pectinase and protease activities were characterized. In order to develop insect resistance germplasm, the institute is extensively screening maize germplasm for resistance to stem borers, i.e *Chilo partellus and Sesamia inferens* and stored grain insects, i.e. *Sitophilus oryzae and S. cerealella.* After three years screening under artificial infestation, two lines *viz*., BCK/BK8 and DC2 were identified least susceptible to *Chilo partellus*, out of 37 lines screened. Similarly, six inbred lines were found promising against *S. inferens* out of 34 lines screened. A total of 26 inbred lines were screened and a few lines were identified that were tolerant to *S. oryzae* and *S. Cerealella.*

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. Trials were constituted to identify released commercial hybrids with moisture stress tolerance. During *kharif* 2014, 38 maize cultivars were evaluated in ten environments (five each of rainfed and irrigated). Further, a set of 37 inbred lines were evaluated under managed drought, cold and heat stress separately at different locations *viz*., Biloda and Udaipur for drought and Delhi and Ludhiana for cold and heat stress during *rabi* 2014-15. During this year, 70 inbred lines especially developed for abiotic stress tolerance (29 uniform and established, 41 at different developmental stages; F_4 to F_7) was maintained and advanced to the next stage. Further, two maize inbred lines, i.e HKI 335 and LM 17, have been identified which exhibit pronounced drought and heat tolerance trait, respectively. In order to map the genomic regions that contribute to drought and heat tolerance in these lines, two mapping populations [HKI 335 (highly drought tolerant) × MGUD 22 (highly drought susceptible) and LM 17 (highly heat tolerant) × HKI 1015-wg8 (highly heat susceptible), have been developed. These mapping populations have been advanced from F_7 to F_8 generation during *kharif* 2014. A total of 150 test-crosses (67 for drought and 83 for heat) were generated by crossing the F_{6-7} generation of these two populations with two testers, namely LM13 and LM14 for extensive screening under drought and heat stress. In order to delineate molecular mechanisms for drought tolerance trait, the parents of one of this population, i.e. HKI-335 (drought tolerant) and MGUD-22 (drought susceptible) were chosen for cloning and characterizing their antioxidant genes. Twelve different antioxidant genes viz. *Sod 2, Sod 4, Sod 9, Fe- Sod, Mn-Sod, Apx 1, Apx 2, Apx 3, Apx 8, Cat 1, Cat 2,* and *Cat 3* have been cloned, sequenced and submitted for registration at GenBank.

Germplasm for enhanced quality

Apart from building biotic and abiotic stress tolerance in maize germplasm, another goal of the institute is genetic improvement of maize quality for nutritional and industrial traits. Maize cultivars that have high usable protein quality are termed Quality Protein Maize (QPM) and development of such hybrids is a major focus area of the institute. During 2014-15, 55 elite inbred lines of QPM and 168 newly developed QPM lines were evaluated. Around 130 QPM lines were identified as potential hybrid parental lines. Further, a multi-location QPM hybrid trial consisting of 235 entries was conducted at five locations (Ludhiana, Udaipur, Karnal, Bhubaneswar and Bajaura) during *kharif* 2014. QPM development requires continuous monitoring of protein quality and thus needs a strong biochemistry support. During 2014-15, around 1050 samples were analyzed for protein quality. Apart from QPM, inbred lines which are to be used as donor parents for high pro-vitamin A were maintained and screened with gene specific markers to ascertain the presence of desirable allele. Similarly, during 2014-15, 98 samples were analyzed for sugar content, 149 for starch profile, and 66 for oil content to support the respective breeding programmes.

Hybrid development and evaluation

Development of new improved hybrids is the ultimate aim of the the entire crop improvement programme. As a precursor to hybrid development, the institute also undertook evaluation of experimental cross-combinations and hybrids. During *kharif* 2014, three trials comprising 37, 16 and 37 early maturing single-cross hybrids, respectively were evaluated at different locations. This year, the institute also contributed 27 hybrids for multi-locational coordinated testing. During *rabi* 2013-14, 8 single cross experimental hybrids of the institute were tested under nationwide coordinated testing system. Of the eight, five entries were promoted for next stage of testing and they were under testing during *rabi* 2014-15, whereas the entries which were promoted from *kharif* 2014 would be tested during *kharif* 2015.

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 and disease management on the other hand.

Tillage and nutrient management

The institute is evaluating the long term effects of various tillage practices, viz. permanent bed, zero tillage flat and conventional till. The results indicate that conservation tillage practices, i.e. zero tillage and permanent bed, help in reducing the production cost and enhancing the net returns over the conventional tillage. In general, an increase in the net profits to the tune of 29 to 40 % as compared to conventional tillage was observed. The institute is also evaluating different nitrogen management practices in different cropping systems and residue management scenario. The combined analysis of three years data revealed that the one-time neem coated urea application was beneficial under conservation agriculture. The maize yield increased slightly only, but the agronomic nitrogen-use efficiency was increased by 15.7% over prilled urea application. In addition, the residue retention of mungbean crop also enhanced maize yield by 10% over no residue application. Further, the cropping system also affected maize yield in *kharif* season, with the maize-wheat-mungbean cropping system being best in achieving higher maize yields (4.5t/ha). In another programme, the institute is investigating the suitability of site specific nutrient management, in scheduling fertilizer doses for optimum productivity and profitability. Over last three years, the results have shown that site specific nutrient management remained at par with following recommended dose of fertilizer application in terms of achieving maize grain yield. However, accounting other crops in rotation, the site specific nutrient management gave 6% higher system productivity (12.5 t/ha) as compared to applying generally recommended fertilizer dosage (11.8 t/ha). Experiments on potassium management and effect of nitrification inhibitors on productivity and nitrogen use efficiency were also carried out. The system productivity was found best (5.5 t/ha) on integrating 3/4 of recommended dose of potassium, with crop residue incorporation along with fungal consortia. Similarly, neem oil coated urea in 700 ppm concentration recorded the highest grain yields of both maize (7.3 t/ha) and wheat, when applied at 100% nitrogen level, as compared to 100% nitrogen application in the form of urea alone.

Insect and disease management

Crop management practices have a profound impact on incidence of insects and diseases. Insects and diseases can be agronomically managed though various interventions. Habitat management including cowpea as intercrop and sorghum as trap crop in maize for stem borers was practiced at IIMR farm, Ladhowal, Ludhiana. *Sesamum* and marigold were raised as alternate source of pollen, nectar and shelter for adult parasitoids. Maize with *Sesamum* and marigold was found best agronomic option. Intercropping of sorghum with marigold on borders of maize crop was found the next best treatment. The institute also studied the oviposition behaviour of shoot fly under field conditions. On farm crop loss assessment due to pests is an important objective for devising strategies to minimize production losses. The crop loss in maize due to *C. partellus* was estimated in 17 plots using the formula generated during *kharif*, 2013. The average total yield loss was observed at 20.43 % out of which 6.39 % loss was caused due to *Chilo* infestation and 14.04 % loss was due to other biotic and abiotic factors. The maximum numbers of eggs were found to be laid from 11-13 days after germination and decrease thereafter. No egg laying was noticed at 23 days after germination. The data will help the farmers to plan the sowing of maize in a way that asynchrony occurs between the pest and susceptible age of the plant. The institute also carried out biological and molecular typing of virulence among isolates of pathogen *Rhizoctonia solani*, for exploitation as potential biological control agents. Biological characterization of 62 *Rhizoctonia* isolates representing five agro ecological zones was conducted by cultural, morphological and pathogenic means. The results showed narrow diversity across the different maize cropping zones indicating that the pathogen may perhaps belong to a single race. Two isolates showed presence of M2 dsRNA and diminished virulence. These can be further examined for exploring the prospects for development of bio-rationals and composts as disease suppressive alternatives to pre- plant fumigation.

AICRP on maize

Apart from its core research activities, the institute also supports and coordinates maize research programmes various agricultural universities through All India Coordinated Research Project on Maize (AICRP-Maize). Based on the data generated by AICRP-Maize, 17 new maize cultivars were notified by the Central government, thereby expanding the choice of hybrids for different ecologies. During *kharif* 2014, 414 new maize hybrids were evaluated in coordinated trials, which is the highest ever figure of entries received for AICRP testing. Of 414 genotypes, 297 entries were evaluated in initial varietal trial (IVT), 67 were under advance varietal trial-I (AVT-I), 10 in advance varietal trial-II (AVT-II), 12 entries in quality protein maize, 13 in sweet corn, 8 in popcorn and 7 in baby corn trials. Total 15 breeding trials (four each of IVT, AVT-I, specialty corns and three of AVT-II) were constituted for evaluation at 59 locations (29 regular and 30 volunteers) across country. The trial data received from 53 locations were reviewed and analyzed critically for yield and related traits. The test entries were promoted from IVT to AVT-I and AVT-I to AVT-II, based on the 5% superiority (in late maturity, QPM, sweet corn, popcorn and baby corn trials) and 10% superiority (in medium, early and extra early trials) over the best check for grain yield in respective zones. In order to further strengthening the development of hybrid-oriented breeding material, 61 nurseries and trials were grown at 22 centres under collaborative trails with International Wheat and Maize Improvement Centre (CIMMYT). The institute also provided Winter Nursery support to the AICRP centres by advancing a total of 1244 accessions provided by 29 centres. A total of 27.68 quintals of breeder has been produced till March, 2015 by the institute and its AICRP centres. 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. During the *kharif* 2014, *rabi* 2013-14 and spring 2014 seasons 1405, 1488 and 566 such demonstrations were conducted. The institute has established special programmes for the tribal farmers of the country. During 2014-15, 171 demonstrations were carried out at tribal farmer's field and 10 training programmes exclusively for tribals were conducted. The institute also participated in various exhibitions, farmer's fairs, trade fairs etc. The year was also marked with various activities and events organized by the institute.

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

Research Achievements

1

Crop Improvement

Maize in India is emerging as one of the important crop due to its increased trend in area, production and productivity in recent years. 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 pro vitamin A in order to make maize cultivation more profitable to farmers. The salient research highlights of above aspects are summarized below.

Characterization, diversification and genetic enhancement

Procurement and maintenance of new germplasm

Induction of new germplasm is one of the important process to diversify the existing germplasm base to continuously support the inbred-hybrid development programme. Indian Institute of Maize Research participated in the maize germplasm day organized by NBPGR, New Delhi and CIMMYT India, Hyderabad to procure new maize germplasm. During 2014, IIMR has obtained 620 new maize germplasm; the details of the germplasm procured from different institutes are given below (Table 1).

The maintenance and adaptation of new germplasm is the first step before actual utilization in the breeding programme. Out of 620 new maize germplasm procured, 231 lines were maintained by selfing during *kharif* 2014 at New Delhi. Since there was severe water stress during *kharif* 2014 at New Delhi, many of the germplasm did not even reach the reproductive stage. However, anticipating the possible water stress during the season, about 20 seeds of each germplasm were kept as back-up. Thus by using the remnant seed, 612 germplasm lines are being maintained during *rabi* 2014-15. In addition, six populations/pools *viz*., 10309-K pool, C-2 pool, C11 pool, Pote yellow, Pote brown, HEY pool were maintained through chain crossing.

Table 1. Maize germplasm received and maintained through selfing at IIMR, New Delhi during 2014-15

Source of Material	Indenter	Number	Description of Material
CIMMYT, Hyderabad	AICRP/ IIMR	588	Germplasm displayed during IMIC-Asia Maize Field Day, which included diverse kinds of material *viz.*, advanced and early generation abiotic (drought and heat) and biotic (BLSB and DM) stress tolerant lines/synthetics/populations
CIMMYT, El Batan, Mexico	IIMR	2	Haploid inducer lines and the hybrid
Switzerland through NBPGR, New Delhi	Unknown	30	Maize core collections i.e. EC808940 to EC808969 from Switzerland under SMTA and designated by Switzerland under MLS of ITPGRFA

Assessment of genetic diversity in existing inbred lines

The initiative was taken to develop association mapping panel/diversity panel with sufficient genetic diversity to study economically important traits. In this regard the germplasm available with different breeders at IIMR as well as germplasm procured from different centres across India and abroad were pooled during *kharif* 2014 for comprehensive characterization under new project "Characterization and Diversification of Maize Germplasm". During 2014-15, a total of 793 inbred lines were maintained during *kharif* 2014 and the same numbers of inbred lines are being maintained during *rabi* 2014-15 at Regional Maize Research & Seed Production Centre (RMR&SPC), Begusarai. The observation on grain characteristics like grain texture, grain colour, kernel cap colour, ear shape, shank colour of the inbred lines were recorded and classified (Figure 1a) and grouped by using DARwin 5 software (Figure 1b) to assess the diversity. However, additional information generation on days to 50% flowering, plant height, ear height etc. for all the inbred lines is being carried out.

Similarly the germplasm available at Winter Nursery Centre, Hyderabad are classified by considering grain colour and texture along with origin of the germplasm (Figure 2). There is still some overlapping in the germplasm being maintained at IIMR, New Delhi; Regional Unit, IIMR, Ludhiana; RMR&SPC, Begusarai and WNC, IIMR, Hyderabad. However, efforts are on to remove duplicates by assessing similarities and uniformity at different stages of growth and development.

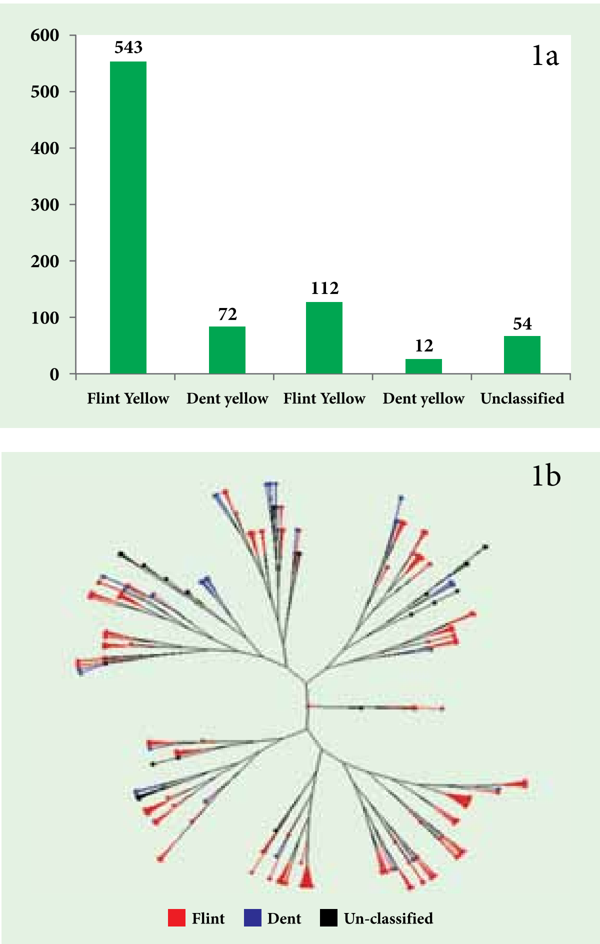


Figure 1. Classification and grouping of maize inbred lines available at Indian Institute of Maize Research, New Delhi.

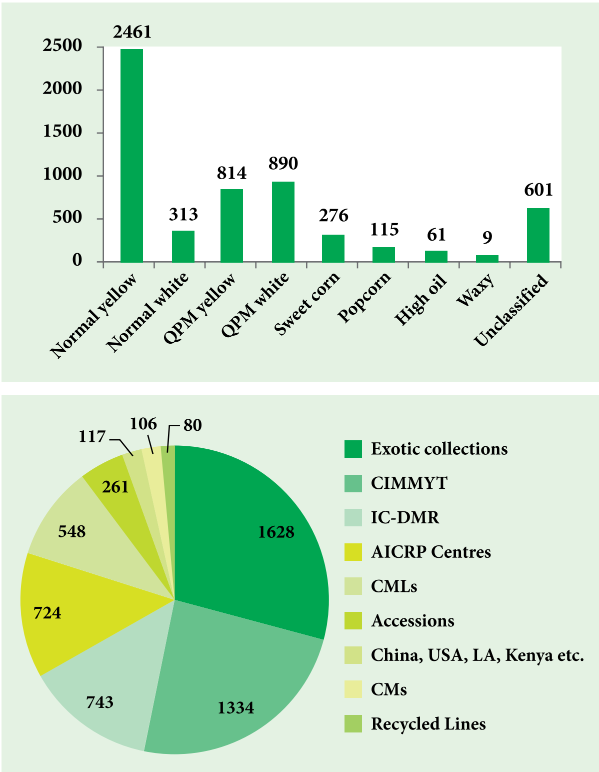


Figure 2. Classification of maize germplasm available at Winter Nursery Centre, Hyderabad

Development of new inbred lines and advancement of segregating germplasm

Development of new inbred lines is a continuous process. The main base material from which inbred lines being developed was commercial hybrids. In addition, local land races like HEY pool, Indigenous/Exotic (I/E) collections are also being used to derive new inbred lines. In total 799 segregating material is being advanced through selfing from $F_{3/7}$ generation to $F_{4/8}$ generations; out of which 545 were derived from commercial hybrids, 118 from HEY pool, and 254 are either from land races or I/E collections. Among 799 segregating germplasm, 150 and 16 lines are in F_7 and F_8 stage respectively with almost uniform at morphological level. However, evaluation and characterization of such inbred lines will be undertaken for their subsequent effective utilization in the breeding programme.

Heterotic grouping of maize germplasm

Identification of inbred lines with good *per se* productivity and combining ability play an important role in selecting inbred lines to utilize them in hybrid development. The inbred line yield trial comprising 91 inbreds was conducted at two locations namely Hyderabad and Begusarai during 2014-15 to assess their productivity level. The second important aspect for increasing the efficiency of hybrid development is grouping inbred lines into different heterotic groups based on the combining ability. In continuation of efforts made to group inbred lines into different heterotic groups during 2012-14, a set of 64 inbred lines derived from HEY pool were test crossed with two diverse testers CML474 (SW92145-2EV-13-1-BB) and V373 (JKMH-175-4 (O.P.) Ä-16-7-12-1- Äb-#-#-Äb-#-Äb-Äb) during *kharif* 2013. Test-crosses were evaluated at six locations in 'Zone I' as well as at Delhi (Zone 2). The Line x Tester (LxT) analysis was performed without parents. Inbred line giving positive SCA effect with CML474 was placed in Heterotic group 'B' vice versa. Fifteen inbred which performed well with tester V373 are grouped with CML474, while fourteen inbred which performed well with tester CML474 are grouped with the V373 (Table 2). Based on the positive SCA effect for yield, the lines were grouped into two heterotic groups 'A' and 'B'. In addition, a set on 91 elite inbred lines were used to develop around 600 test-crosses with nine testers during *rabi* 2014-15.

Table 2. Line with high *per se* performance in LxT crosses and positive GCA effects and SCA effects for yield

Line (Female)	Tester (Male)		GCA effect	SCA effect	
	CML474	V373		CML474	V373
DE13001	48.33	37.50	0.125	0.115	-0.115
DE13005	43.33	58.75	0.320	-0.200	0.200
DE13006	41.67	73.33	0.475	-0.395	0.395
DE13007	62.92	56.67	0.530	0.060	-0.060
DE13013	32.92	58.33	0.190	-0.320	0.320
DE13017	44.58	40.00	0.110	0.040	-0.040
DE13018	43.75	47.08	0.185	-0.055	0.055
DE13019	52.92	27.92	0.065	0.285	-0.285
DE13021	50.00	30.83	0.065	0.215	-0.215
DE13032	35.00	48.33	0.095	-0.175	0.175
DE13034	33.75	51.25	0.115	-0.225	0.225
DE13036	53.33	45.42	0.280	0.080	-0.080
DE13042	43.75	49.17	0.210	-0.080	0.080
DE13043	119.58	44.17	1.060	0.890	-0.890
DE13045	45.83	40.83	0.135	0.045	-0.045
DE13056	55.42	31.67	0.140	0.270	-0.270
DE13057	42.08	60.42	0.325	-0.235	0.235
DE13063	40.83	50.00	0.185	-0.125	0.125
DE13065	79.17	56.67	0.725	0.255	-0.255
DE13067	52.50	49.58	0.320	0.020	-0.020
DE13068	38.33	46.67	0.115	-0.115	0.115

Line (Female)	Tester (Male)		GCA effect	SCA effect	
	CML474	V373		CML474	V373
DE13069	41.67	55.83	0.265	-0.185	0.185
DE13073	55.83	53.75	0.410	0.010	-0.010
DE13074	55.83	42.08	0.270	0.150	-0.150
DE13077	34.58	45.42	0.055	-0.145	0.145
DE13097	39.58	38.75	0.035	-0.005	0.005
DE13099	46.67	43.75	0.180	0.020	-0.020
DE13116	50.83	58.75	0.410	-0.110	0.110
DE13118	32.08	78.33	0.420	-0.570	0.570

Germplasm supplied to AICRP Centres

In order to strengthen maize breeding programme of different AICRP centres, 979 (3103) maize accessions were supplied to 31 AICRP centres as per their indent given during the germplasm day (Table 3).

Germplasm registration

During the year 2014-15, three inbred lines DMR E63 (WN2P BTL 9) (for source of resistance to pink borer), DMR QPM-03-124 (medium maturity QPM) and DMR QPM 58 (early maturing QPM) registered with NBPGR. The IC (INGR) number of the registered line are IC 0594373 (14014), IC 0694271 (14013) and IC 0594368 (14012) respectively.

Development of new maize hybrids

Evaluation of experimental cross-combinations/ hybrids

During *kharif* 2014, three trials 14A, 14B and 14C comprising 37, 16 and 37 early maturing single-cross hybrids respectively were evaluated along with checks (Vivek QPM 9 and Vivek Maize Hybrid 43) at different locations. Trial 14A at five locations *viz.*, Srinagar and Udhampur (Jammu and Kashmir), Bajaura (Himachal Pradesh), Sikkim and Barapani (Meghalaya) in 'Zone-1', trial 14B at Manipur and Sikkim and trial 14C at Srinagar were evaluated. The objective was to identify the heterotic superiority of the new cross-combinations over the best check and understand the relationship of yield with other agronomic characters in maize. The data was recorded for grain yield (GY), shelling percent (SP), plant (PH) and ear height (EH), ratio of ear height to plant height (EHPH), ear leaf area (ELA), days to anthesis (DA), silk (DS) and maturity (DM), anthesis-silk interval (ASI), grain filling period (GFP), rows per ear (RE), grains per row (GR), ear length (EL), ear diameter (ED), grain length (GL) and width (GW).

Table 3. Germplasm distributed to various AICRP centres

Centre	No. of accessions provided	Centre	No. of accessions provided	Centre	No. of accessions provided
Raichur	55	CRIDA, Hyderabad	37	UAS, Dharwad	72
MRC, Hyderabad	214	IARI RS, Dharwad	108	Dholi	218
Varanasi	43	Karnal	115	Bhiloda	158
Ranchi	213	Kolhapur	125	Ambikapur	43
Srinagar	55	Arbhavi	91	IARI, Breeding	84
AICRP, Mandya	46	Udhampur	34	UAS, Bengaluru	45
Udaipur	88	Godhra	89	Bajaura	42
Coimbatore, TNAU	57	Pantnagar	73	Almora	87
Ludhiana	219	Bhubaneswar, Odisha	52	IIMR/DMR	493
Begusarai	107	IARI, Pathology	32	VC Farm, Mandya	08

The test entry, DE14067 in trial 14A was significantly superior over the best check across three locations (Sikkim, Srinagar and Meghalaya) with heterosis ranging from 8.31 to 11.35 and at Delhi DE14163 exhibited 34.7% heterosis over the best check. In addition, there were eight other entries *viz.,* DE14121, DE14017, DE14162, DE14163, DE14167, DE14042, DE14217 and DE14226, which performed significantly superior to the best check at minimum two locations. The significant grain yield heterosis at these location ranged from 8.57 to 14.18 (Bajaura), 8.03 to 8.31 (Sikkim), 8.46 to 11.59 (Srinagar), 9.32 to 10.51 (Udhampur) and 10.42 to 14.17 (Barapani). In trial 14B, DE14005 exhibited 15.02% heterosis over the best check with an average grain yield of 7.02 t/ha whereas in trial 14C, five SCH *viz.,* DE14173, DE14037, DE14045, DE14151, DE14044 showed more than 10% heterosis over the best check. Further, approximately 614 new cross combinations in the form of experimental hybrids which were developed during *kharif* 2014 are being evaluated under station trial either at one-or multi-locations during *rabi* 2014-15. In addition six other experimental hybrids trials comprising >1000 crosses were also conducted at New Delhi and Ludhiana. The superior entries based on the higher grain yield over checks have identified.

Hybrids under testing in AICRP on maize coordinated trials

Single cross experimental hybrids in the form of test entries were contributed for testing under AICRP on maize for multi-location and multi-disciplinary coordinated trials during *rabi* 2014-15 and *kharif* 2014 (Table 4).

The total numbers of experimental hybrids in the form of test entries contributed for different trials during *kharif* 2014 were 27 and two hybrids *viz.,* DMRH1413 and DMRH1416 were tested under both late and medium maturity group trials.

Table 4. The details of test entries contributed for testing under AICRP

Maturity / Type	Stage	Experimental hybrids/test entries	
		Number	Name
Rabi 2014-15			
Late	IVT	1	DMRH1423
	AVTI	1	DMRH1308
Medium	IVT	5	DMRH1422, DMRH1419, DMRH1420, DMRH1410, DMRH1421
	AVTI	4	DMRH1301, DMRH1302, DMRH1306, DMRH1307
Kharif 2014			
Late	IVT	6	DMRH1308, DMRH1409, DMRH1411, DMRH1413, DMRH1415, DMRH1416
Medium	IVT	18	DMRH1301, DMRH1302, DMRH1308, DMRH1402, DMRH1410, DMRH1412, DMRH1413, DMRH1416, DMRH1417, DMRH1418, DH1401, DH1403, DH1405, DH1411, DH1413, DH1415, DH1429, DMRH-12-110
Early	IVT	1	DMRE1403
QPM	IVT	1	DMRQPM1401
Popcorn	IVT	2	DMRHP1401, DMRHP1402

Hybrids promoted from IVT to AVT-1 in All India Coordinated Research Programme

During *rabi* 2013-14, eight single cross experimental hybrids in the form of test entries (DMRH1301 to DMRH1308) were tested, out of which DMRH1302 and DMRH1306 were tested under IVT-Late and IVT-Medium whereas DMRH1303 and DMRH1305 were tested under IVT-Medium and IVT-Early. Of the eight test entries tested five entries were promoted for next stage of testing and they are under testing during *rabi* 2014-15, whereas the entries which are promoted from *kharif* 2014 will be tested during *kharif* 2015 (Table 5).

Table 5. The details of the experimental hybrids/test entries which were promoted

Name of test entry	Stage-Maturity	Promoted to	Zone
Promoted from *rabi* 2013-14 to *rabi* 2014-15			
DMRH1302	IVT-Late, IVT-Medium	AVTI-Medium	III, IV
DMRH1308	IVT-Late	AVTI-Late	III, V
DMRH1301	IVT-Medium	AVTI-Medium	III, IV, V
DMRH1306	IVT-Medium	AVTI-Medium	III
DMRH1307	IVT-Medium	AVTI-Medium	III, IV
Promoted from *kharif* 2014 to *kharif* 2015			
1. IVT L-AVT- I- Late (DMRH13080) 2. PCI –PCII- (DMRHP140), DMRHP1402			

Development of new cross combinations

Ten diverse inbred lines *viz*., CML470, Indimyt 300A, CML338, V373, VQL2, CML422, CM 212, CM502, V409 and V411 were used to generate new cross combinations in half diallel fashion.

National Demonstration

Maize hybrids comprising both notified as well as hybrids under pipeline were evaluated in large plot [18 m^2 area] under high management condition at New Delhi during *kharif* 2013 and 2014. The total numbers of hybrids, contributed by both public and private partners were 106 (2013) and 131 (2014). Based on the observation, sufficient variation was recorded for different traits like flowering, maturity, plant height, ear height/placement, yield and its components (Table 6). Though national demonstrations were conducted under stress-free, well-managed conditions but due to high-vapour pressure deficit due to prolonged high temperature coupled with low rainfall (~451mm) during growing season (July to October) in 2014 affected the overall growth and development of hybrids resulting in low biological yield and high CV as compared to the 2013.

Table 6. Summary of descriptive statistics of different phenotypic traits based on hybrids evaluated during *kharif* 2013 and *kharif* 2014

	Kharif 2013				*Kharif* 2014			
Variable	Min.	Max.	Mean	CV (%)	Min.	Max.	Mean	CV (%)
Days to anthesis	42	55	50±2	5	39	61	50±4	7
Days to silking	44	58	52±3	5	41	63	53±4	7
Days to maturity	82	119	107±6	6	78	110	92±6	7
Grain filling duration (hrs)	38	66	55±5	9	24	56	40±6	15
Plant height (cm)	154	268	207±20	10	117	214	164±20	12
Ear height placement (cm)	67	149	111±15	14	52	128	90±14	16
Cob length (cm)	10	23	17±2	12	9	22	16±2	13
Cob girth (cm)	4	6	5±0.3	8	2.7	5.2	4±0.4	9
Kernel rows per cob	10	18	15±2	10	9	18	14±2	11
Kernels per row	24	48	35±4	12	12	45	32±5	16
Test weight (100 gm. seeds)	19	40	31±4	14	15	37	28±4	14
Shelling %	61	89	77±7	9	55	90	83±5	6
Grain yield (kg/ha)	3668	9971	6868±1436	21	663	10473	5837±1700	29
Biological yield (kg/ha)	15028	35263	24569±4022	16	2891	29214	16774±4314	26
Harvest index	0.20	0.34	0.3±0.01	9.10	0.20	0.50	0.3±0.10	20

Correlation studies were carried out between yield and its related traits during *kharif* 2013 and 2014 (Table 7). Among all traits, few traits have showed statistically significant positive correlation with high correlation coefficient (>0.6) between them in both the years. For example, days to maturity and grain filling duration; kernel per row and cob length; biological yield and yield; harvest index and yield; days to anthesis and days to silking and plant height and ear height.

In addition significant correlations between several other traits with low correlation coefficient (<0.5) were also observed (Table 7), for example plant height was positively correlated with biological and grain yield during both year. Further, grain filling duration was positively correlated with grain yield only during *kharif* 2013, however there was no correlation observed during *kharif* 2014, indicated that prolonged grain filling duration may contributed for increase of grain yield when there are sufficient moisture available.

Some of the better performing hybrids under national demonstrations were PMH 1, PMH 3, PMH 6, CMH 08-287, CMH 08-292, NK 6217, CP 828, FCH 184, DKC 9150, RMH 4726, DKC 9144, PAC 745, PAC 740 etc. in late and medium and Prakash, Vivek Hy 45, DMRH 1417, DH 1411, DMRH 1305, EHL 162508, Vivek Maize Hybrid 43, Vivek QPM 9 etc. in early and extra early maturity.

Breeding for biotic stresses

Evaluation of inbred lines

In order to characterize maize germplasm for different traits, a multi-location and multi-year evaluation/screening covering different discipline is essential. During *kharif* 2014, 91 inbred lines are selected based on different cob traits like grain texture, ear shape, cob length, tip filling etc. to evaluate at hot-spot locations for different diseases *viz.*, turcicum leaf blight (Mandya), post-flowering stalk rot (Hyderabad and Ludhiana) under artificial inoculation during *rabi* 2014-15. In addition a set of 29 agronomically superior early maturing inbred lines were screened for resistance to turcicum leaf blight.

Assessment of disease resistance linked markers in mapping population

Recombinant Inbred Lines (RILs) population is being developed to undertake genetic mapping of resistance loci for MLB resistance were advanced from F_4 to F_6 during *kharif* 2014 (F_4 to F_5) at New Delhi and *rabi* 2014-15 (F_5 to F_6) at Begusarai. Belcher et al (2011) reported several genomic regions in a series of mapping studies for MLB resistance in different genetic background other than Indian adapted germplasm. Therefore, an attempt was made to validate the molecular markers linked to MLB resistance in Indian genetic background. In this regard, six simple sequence repeats (SSRs) markers, three from bin location 3.04 (umc2000, umc1920 and bnlg602), two from 9.04 (phi022 and umc1571) and one from 6.06 (umc1520) which have explained 8-23% of total variation for MLB resistance (Balint-Kurti et al, 2006) were used for validation in Indian germplasm based populations using BSA. However, none of the SSR markers selected from reported genomic regions (bin location 3.04, 9.04 and 6.06) could differentiate between resistant and susceptible plants through BSA, which implies that either different genomic regions other than the regions represented by these six loci, may be responsible for the expression of MLB resistance in Indian maize germplasm and/or recombination might have broken the linkage of the said markers with QTLs. In addition, initiatives have been taken to constitute an association mapping panel for study of useful markers-traits association in maize. Maximum efforts are put to make panel as diverse as possible by including lines of different genetic background *viz.*, CMLs, CMs, LMs, DMLs, DQLs, UMI, PC, HKIs etc.

Breeding for abiotic stresses

Development of source germplasm tolerant to abiotic stresses

Abiotic stresses like drought and heat stress severely compromise plant physiological processes leading to reduction in yield and quality. In this regard, 70 inbred lines are being developed for abiotic stress tolerance (29 uniform and established, 41 at different developmental stages; F_4 to F_7).

Table 7. Correlation studies for yield and its components recorded during *kharif* 2013 (lower half) and 2014 (upper half) in 106 and 131 test entries respectively

	DTA	DTS	DTM	GFD	PHT	EHT	CBL	CBG	RPC	KPR	TSWT	SHL	YLD	BI	HI
DTA		0.98**	0.25**	-0.31**	0.14	0.23**	-0.03	-0.06	-0.01	-0.04	-0.07	-0.01	0.08	0.04	-0.01
DTS	0.93**		0.27**	-0.31**	0.16	0.22**	0.00	-0.03	0.00	-0.03	-0.08	-0.03	0.10	0.06	-0.01
DTM	0.51**	0.46**		0.83**	0.24**	0.40**	0.13	0.10	-0.08	0.03	0.09	-0.20*	0.07	0.22**	-0.13
GFD	0.10	0.01	0.89**		0.15	0.26**	0.13	0.12	-0.08	0.05	0.17*	-0.18*	0.01	0.18*	-0.12
PHT	0.33**	0.30**	0.21*	0.08		0.80**	0.24**	0.17*	-0.01	0.13	0.17*	0.02	0.37**	0.50**	-0.01
EHT	0.45**	0.43**	0.21*	0.01	0.74**		0.22**	0.12	-0.02	0.13	0.10	-0.02	0.28**	0.49**	-0.13
CBL	0.09	0.15	0.21*	0.16	0.07	0.02		0.41**	0.11	0.70**	0.31**	0.12	0.40**	0.37**	0.18**
CBG	0.09	0.11	0.04	0	-0.13	-0.15	0.15		0.61**	0.47**	0.11	0.22**	0.50**	0.40**	0.30**
RPC	0.07	0.1	-0.07	-0.13	-0.06	-0.11	0.13	0.39**		0.19*	-0.22**	0.17*	0.20*	0.07	0.24**
KPR	-0.07	-0.03	0.05	0.031	-0.01	-0.05	0.60**	0.13	0.15		0.06	0.24**	0.38**	0.38**	0.15
TSWT	0.09	0.06	0.31**	0.31**	0.04	0.05	0.08	0.11	-0.32**	-0.01		0.03	0.32**	0.29**	0.16
SHL	-0.01	-0.01	-0.03	-0.02	0.11	0.11	0.04	-0.02	-0.14	-0.01	0.04		0.41**	0.14	0.43**
YLD	0.27**	0.19*	0.26**	0.39**	0.29**	0.23*	0.09	0.21*	-0.12	0.03	0.13	0.51**		0.73**	0.62**
BI	0.36**	0.27**	0.34**	0.25**	0.37**	0.32**	0.12	0.19*	-0.25**	0.03	0.20*	0.31**	0.91**		-0.05
HI	-0.04	-0.06	-0.04	-0.014	0.04	-0.01	0.01	0.15	0.05	0.02	-0.06	0.65**	0.68**	0.33**	

DTA-Days to anthesis; DTS-Days to silking; DTM-Days to maturity; GFD-Grain filling duration; PHT-Plant height; EHT-Ear height/ placement; CBL-Cob length; RPC-Kernel rows per cob; TSWT-Test weight; SHL-Shelling percentage; YLD-Yield; BI-Biological yield; HI-Harvest index

Evaluation of inbred lines for drought stress tolerance

A set of 37 inbred lines are being evaluated under managed drought, cold and heat stress separately at different locations namely Biloda and Udaipur for drought and Delhi and Ludhiana for cold and heat stress during *rabi* 2014-15.

Development of RILs for drought and heat stress

Two maize inbred lines, i.e. HKI 335 and LM 17, exhibited pronounced drought and heat tolerance traits, respectively when subjected to physiological screening. In order to map the genomic regions that contribute to drought and heat tolerance, two RILs mapping populations are developed using the single seed descent method. A set of 209 RILs derived from the cross HKI 335 (highly tolerant) x MGUD22 (highly susceptible) and another set of 221 RILs derived from the cross LM 17 (highly tolerant) x HKI 1015-wg8 (highly susceptible) have been advanced from F_7 to F_8 generation during *Kharif* 2014. These RILs mapping populations will now be used for quantitative trait loci mapping for drought and heat stress, respectively. RILs derived from HKI 335 x MGUD22 were phenotyped for major morpho-physiological traits (like plant height, leaf area index, relative water content, canopy temperature, root length, root volume, root biomass, leaf senescence, anthesis-silking-interval, cob position and grain yield) to study the phenotypic behavior of the mapping population. Significant variations were recorded among the different lines with respect to major drought adaptive traits like root length, leaf senescence score, anthesis-silking-interval, cob position and grain yield.

Since inbred lines are highly sensitive to drought and heat stress, 150 test-crosses [67 for drought and 83 for heat] were generated by crossing F_{6-7} RILs generated for drought and heat stress during *kharif* 2014 with two testers, namely LM13 and LM14 for identification of relatively drought and heat stress tolerant RILs via screening test-crosses under drought and heat stress condition. In addition, another set of RILs population have been generated to understand and map the loci responsible for drought adapted traits. The RILs were advanced from F_3 to F_5 during *kahrif* 2014 and *rabi* 2014-15. The populations will be used for development of immortal populations for fine mapping of various contrasting traits.

Further, two contrasting maize inbred lines, *viz.* DTPYC9F119 (heat-tolerant) and K64R (heat-susceptible) were functionally analyzed for photosynthetic efficiency at normal (25/20°C) and heat-stress (38/28°C) during flowering stage under controlled environment conditions. Genotype DTPYC9F119 had a significantly higher photosynthetic rate (44.3 µmol $CO_2 m^{-2} s^{-1}$ than KR64R (36.7 µmol $CO_2 m^{-2} s^{-1}$) under normal green house conditions. The heat-stress imposed at reproductive stage had an adverse effect on photosynthetic efficiency of both the genotypes, however the effect was more pronounced in KR64R. Exposure to one week heat- stress at flowering days caused a reduction in net photosynthetic rate by 22.9 and 47.8 % in genotypes DTPYC9F119 and K64R, respectively (Figure 3).

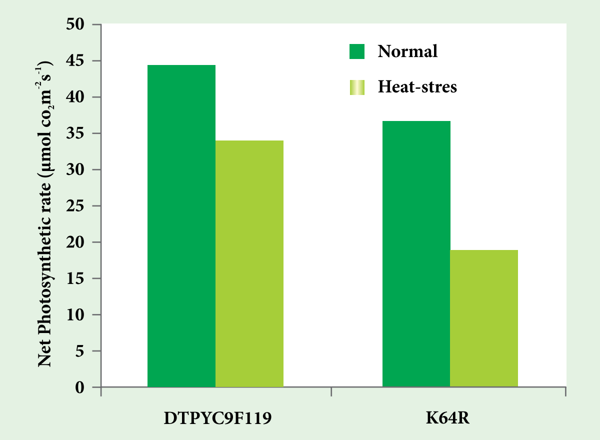


Figure 3. Effect of reproductive stage heat-stress on net photosynthetic rate of two maize genotypes

Cloning and characterization of abiotic stress regulated genetic elements from maize

Drought is a major environmental stress factor that limits agricultural production worldwide. Plants exposed to biotic and abiotic stresses generate more reactive oxygen species (ROS) than their capacity to scavenge them. Plants have evolved defence systems, consisting of antioxidative enzymes and low-molecular-weight antioxidants to scavenge ROS. Superoxide dismutase (SOD), catalase (CAT), peroxidase (POD), ascorbate peroxidise (APX), and glutathione reductase (GR) are important parts of the antioxidative enzyme system. Plants employ complex mechanisms of gene regulation in response to drought stress. Drought induces up-regulation and down-regulation of numerous genes. A detailed study on the differential expression pattern of different antioxidant genes in response to drought in the Indian maize genotypes would help in developing better yielding varieties under abiotic stress.

Two maize genotypes, HKI-335 (drought tolerant) and MGUD-22 (drought susceptible) were chosen for cloning and characterizing their antioxidant genes. Twelve different antioxidant genes *viz, Sod 2, Sod 4, Sod 9, Fe-Sod, Mn-Sod, Apx 1, Apx 2, Apx 3, Apx 8, Cat 1, Cat 2, and Cat 3* were chosen for detailed characterization. Total RNA was isolated from both the genotypes and quantified using Nanodrop. Complementary DNA (cDNA) was further synthesized from appropriate quantity RNA. This cDNA was used for standardizing different polymerase chain reactions (PCR) with gene specific primers of the selected antioxidant genes in both the genotypes. The resident level of some of these genes was found to be different in the two inbred lines used for the study. The PCR products were cloned in the novel positive selection cloning vector pJET 1.2/blunt and then transformed into DH5-alpha competent *E. coli* cells to generate cDNA libraries. Plasmids were then sent for sequencing. Sequencing results were confirmed using Basic Local Alignment Search Tool (BLAST) with reference genomic sequences of *Zea mays*. Using the BankIt software, these gene sequences have been submitted and registered with GenBank, which is a part of the International Nucleotide Sequence Database Collaboration (INSDC), comprising the DNA DataBank of Japan (DDBJ), the European Molecular Biology Laboratory (EMBL), and GenBank at National Centre for Biotechnology Information (NCBI). NCBI has allotted following unique accession numbers to the submitted gene sequences: KR105967, KR136339, KR136340, KR136341 and KR136342. Other submissions are presently under review. We have observed subtle sequence polymorphisms (SNPs etc.) between the sequences of antioxidant genes cloned from drought tolerant and drought susceptible genotypes, which could be the key to unraveling the tolerance mechanism (Figure 4). The cloned genes are being further characterized through bioinformatics, homology modeling and transgenic over-expression.

```
HKI             -CATGGTGAAGGCTGTTGCTGTGCTTGGTAGCAGCGATGGTGTCAAGGGCACCATCTTTT 59
MGUD            ACATGGTGAAGGCTGTTGCTGTGCTTGGTAGCAGCGAGGGTGTCAAGGGCACCATCTTCT 60
                 ************************************ ******************** *

HKI             TCACCCAAGAGGGAGATGGCCCTACCGCTGTCACCGGAAGTGTCTCTGGCCTCAAGCCTG 119
MGUD            TCACCCAAGAGGGAGATGGCCCTACCACTGTCACTGGAAGTGTCTCTGGCCTCAAGCCTG 120
                ************************** ******* *************************

HKI             GCCTCCATGGGTTCCATGTACATGCACTTGGTGACACCACCAATGGATGCATGTCAACTG 179
MGUD            GCCTCCATGGGTCCCATGTGCATGCACTTGGTGACACCACCAATGGCTGCATGTCAACTG 180
                ************ ****** ************************** *************

HKI             GACCACACTACAATCCTGCGAGCAAGGAGCATGGGGCACCAGAAGATGAGAACCGCCATG 239
MGUD            GACCACACTACAATCCTGCGAGCAAGGAACATGGAGCACCAGAAGATGAGAACCGCCATG 240
                **************************** ***** *************************

HKI             CTGGTGATCTTGGAAACGTGACAGCTGGAGCAGATGGTGTTGCTAATATCAATGTCACTG 299
MGUD            CCGGTGATCTTGGAAATGTGACAGCTGGAGCAGATGGTGTTGCAAACATTAATGTTACCG 300
                * ************** ************************** ** ** ***** ** *

HKI             ACAGCCAGATCCCACTGACTGGGCCAAACTCAATCATTGGCAGAGCTGTTGTTGTTCACG 359
MGUD            ACAGCCAGATCCCACTGACTGGGCCAAACTCAATCATTGGCAGAGCTGTTGTTGTTCACG 360
                ************************************************************

HKI             CTGATCCTGATGATCTTGGAAAGGGTGGGCACGAGCTGAGCAAGAGCACTGGAAACGCCG 419
MGUD            CTGATCCTGATGATCTTGGAAAGGGTGGGCACGAGCTGAGCAAGAGCACTGGAAACGCCG 420
                ************************************************************

HKI             GTGGCCGTGTTGCTTGTGGATCATCGGACTCCAGGGCTGAA 461
MGUD            GTGGCCGTGTTGCTTGTGGATCATCGGACTCCAGGGCTGAA 462
                *****************************************
```

Figure 4. Nucleotide sequence of *sod 9* gene of HKI 335 and MGUD 22 genotypes, indicating sequence polymorphism between these two contrasting lines.

Identification of released commercial hybrids with abiotic stress tolerance

Developing drought tolerant genotypes for different agro-climatic zone of the country is highly challenging due to lack of suitable methods for selection of drought tolerant genotypes. However, it needs a long-term strategy but in short-term, it is possible to identify the existing cultivars which can perform relatively better with acceptable yield under moisture stress. In this regard, a multi-location trial comprising commercial hybrids were constituted and executed across ten locations during *rabi* 2013-14 and *kharif* 2014. During *rabi* 2013-14 two trials namely early and medium comprising eight and thirteen commercial hybrids respectively were evaluated under stress-free conditions as well as managed stress conditions by imposing stress at flowering and grain-filling stage. The best performing hybrids under different condition were identified (Table 8).

The per cent yield penalty was calculated by comparing the yield level under stress *vis-à-vis* stress-free condition and the percentage of penalty on hybrids under stress varied among the entries. The hybrids VaMH 08015 and MMH 13-12-13 have showed least penalty with 12.4 and 19.9 under flowering and 25.3 and 32 per cent under grain-filling stress respectively. Based on the results, CSM 2 and Bio 9637 in medium maturity and Vivek QPM 9, Prakash and IH072 in early maturity were considered as hybrids with relative tolerance to drought stress.

During *kharif* 2014 thirty-eight maize cultivars were evaluated in ten environments (five each of rainfed and irrigated). Genotypes, environments

Table 8. Best performing hybrids under normal conditions, flowering stress and grain filling stress

Condition	Medium maturity		Early maturity	
	Name	Yield (t/ha)	Name	Yield (t/ha)
Stress-free	Bio 9637 EH 1974	8.00 7.26	IH 072 Prakash	5.05 5.02
Flowering stress	CSM 2 Bio 9637	5.54 5.43	Vivek QPM 9 Prakash	2.71 3.43
Grain filling stress	CSM 2 Bio 9637	4.85 4.86	IH 072 Vivek QPM 9	2.94 2.71

and their interactions effects were significant and explained 6-10%, 71-79% and 15-19% of total grain yield variation respectively, under rainfed and irrigated conditions. Eight selection indices *viz*., stress susceptibility index (SSI), stress tolerance index (STI), harmonic mean (HM), geometric mean productivity (GMP), yield stability index (YSI), drought resistance index (DI), Yield index (YI) and drought response index (DRI) for each genotypes were studied and correlated with Ys and Yp. Grain yield reduction due to moisture stress was ranged from 25 to 69% with average of 52% across environments. HM, GMP and STI were identified with strong positive correlation with Ys and Yp. DRI, YSI and DI were strongly correlated positively with Ys and among each other, indicated that they are suitable selection indices in stress environments. SSI correlated negatively with Ys, so could be used as selection index in combination with yield under stress. Cultivars, CMH 08-292, CMH 10-473, PMH4, JH 31470, Vivek Hybrid 21 and FH 3556 were identified with high GMP, YSI, DRI and STI and high average grain yield under stress (>4.4 t/ha) as well as non-stress (>6.3 t/ha). Efficacy of selection indices was confirmed using multivariate analysis.

Breeding for special traits and quality

Quality Protein Maize (QPM)

Improving nutritional quality in cereal crops is particularly important as the benefits can easily spread to hundreds of millions of people in a most rapid and effective manner without changing the traditional food habits. A significant human population consumes maize as a staple food, worldwide, the nutritional quality of which in turn depends upon the chemical composition of various components of its kernel. The nutritional quality of maize protein is poor because of the limiting quantities of two essential amino acids lysine and tryptophan. The discovery of association of high lysine and tryptophan with *opaque-2* maize endosperm opened up new vistas in improving the protein quality of maize. This paved the way for genetic manipulation in breeding to improve the nutritional quality of maize endosperm protein. Over the time, the consistent efforts of plant breeders and biochemists led to the development of present day quality protein maize. 55 elite inbred lines of QPM (HKIs, CMLs, DMRQPMs) were evaluated and maintained at Delhi (*kharif* 2014). 168 newly developed lines (from commercial QPM hybrids *viz*., HQPM1, HQPM5, HQPM7, Vivek QPM9) were evaluated for uniformity out of which 130 were identified as potential lines (*kharif* 2014, *rabi* 2014-15) at Delhi. The performance of select lines is given in Table 9. In addition, 30 lines were developed from exotic QPM introductions (*kharif* 2014, *rabi* 2014-15) at Delhi/Ludhiana. The performance of the selected lines is given in Table 10. Further, 210 lines developed from selfing and advancing of segregating lines from HQPM4 (*kharif* 2014; *rabi* 2014-15) at Hyderabad. The performance of selected lines is given in Table 11.

Evaluation of QPM experimental hybrids

A multi-locations QPM hybrid trial consisting of 235 entries was conducted at five locations (Ludhiana, Udaipur, Karnal, Bhubaneswar and Bajaura) in augmented design during *kharif* 2014. The best hybrids based on average yield across locations having higher yield over the best check (HQPM-5) are given in Table 12.

Table 9. The performance of newly developed promising QPM lines at Delhi (*kharif* 2014)

Line	Source Germplasm	DA (50%)	DS (50%)	ASI (days)	Protein (%)	Trp (%)
DQL 783-31-1	Vivek QPM9	50	52.5	2.5	9.06	0.70
DQL 593-2-4	HQPM7	52	54.0	2.0	9.17	0.99
DQL -596 -2-1-3	HQPM7	54	56.0	2.0	9.32	0.95
DQL 596-2-1-1	HQPM7	54.5	61.0	6.5	9.54	0.90
DQL 505-3 (y)-1	Vivek QPM9	55.5	57.0	1.5	9.66	0.75
DQL 660-1-2	HQPM5	59	61.0	2.0	9.69	0.90
DQL 619-5-5	HQPM7	56.5	58.5	2.0	9.98	0.86
DQL 690-2-8	HQPM5	56.5	58.0	2.5	10.04	0.76
DQL 799	HKI164-7-6XHKI 131	60.5	62.0	1.5	10.06	0.76
DQL 602-7-2	HQPM7	59	61.5	2.5	10.21	0.77
DQL 689-1-1	HQPM5	65.5	67.0	1.5	10.48	0.82
DQL 598-1-2	HQPM7	57	58.5	1.5	10.73	0.74
DQL 659-4-2	HQPM5	57.5	59.0	1.5	11.06	0.95
DQL 644-4-6	HQPM7	55	57.0	2.0	12.77	0.73
HKI193-1	(check)	59	63.5	4.5	10.50	0.72
HKI161	(check)	58.5	61.5	3.0	10.70	0.71

DA (50%): Days to 50% anthesis; DS (50%): Days to 50% silking; ASI: Anthesis-silking interval; Trp: Tryptophan

Table 10. The performance of QPM lines developed from exotic germplasm at Ludhiana (*kharif* 2014)

Inbred line	Source Germplasm	DA (50%)	DS (50%)	ASI (days)	Trp (%)
DQL 2159	CLQRCY 47-B-6-1	53	55	2	0.62
DQL 2163	CLQRCY 42	51	53	2	0.65
DQL 2164	P 70CO-BBB-8-BBB	53	56	3	0.68
DQL 2165	su2su2o2o2Comp-BBB-8-BBB	50	52	2	0.62
DQL 2166	Temp. X Temp (HO)QPM-BBB-18-BBB-1	50	52	2	0.78
DQL 2182	P 65 C6-BBB-21-BBB	56	58	2	0.69
DQL 2187	S00TLYWQH4-BBB-35-B-1	48	50	2	0.72
DQL 2188	P 65 C6-BBB-9-BBB	50	52	2	0.71
DQL 2189	S99S1YQ-BBB-14-BBB	50	52	2	0.72
DQL 2206	P61C1-BBB-42-BBB-1-1	56	58	2	0.60
DQL 2222	P66CO-BBB-7-BBB-1-4	53	55	2	0.62
DQL 2228	G25QC23-BBB-20-BBB-1	49	51	2	0.64
DQL 2253	Temp. x Trop (HO)QPM-BBB-68-BBB-1-3	50	52	2	0.63
DQL 2254	Temp. x Trop. (HO)QPM-BBB-74-BBB-1-1	47	49	2	0.61
DQL 2257	Hybrid 9415-BBB-18-BBB-1-3	59	60	1	0.70
DQL 2264	CML 187-BBB-1-1	59	61	2	0.66
HKI 193-1	Check	58	59	1	0.70

DA (50%): Days to 50% anthesis; DS (50%): Days to 50% silking; ASI: Anthesis-silking interval; Trp: Tryptophan

Table 11. The performance of newly developed lines at Hyderabad (*rabi* 2014-15)

Lines *	DA (50%)	DS (50%)	ASI (days)	PH (cm)	EH (cm)	Kernel Characteristics
Line 1	49	52	3	120	30	OF
Line 2	49	51	2	145	55	OF
Line 3	62	64	2	170	70	OF
Line 4	49	51	2	150	50	YD
Line 5	50	51	1	95	55	YF
Line 6	52	57	5	145	55	OF
Line 7	56	57	1	115	40	YF
Line 8	50	51	1	100	50	OF
Line 9	60	62	2	75	30	OF
Line 10	60	62	2	180	95	YD
Line 11	52	54	2	140	50	OD
Line 12	50	51	1	95	55	YF
HKI 161 (check)	58	62	4	120	55	OF
CM300 (check)	63	65	2	120	50	WF
DMRE9 (check)	61	63	2	125	50	YD

*source germplasm: HQPM4

DA (50%): Days to 50% anthesis; DS (50%): Days to 50% silking; ASI: Anthesis-silking interval; Trp: Tryptophan; EH: Ear height; PH: Plant height

Table 12. Comparison of experimental hybrids with best check

Entries	Yield (t/ha)
DQL 2082 X CLQRCY 40	7.49
DQL 2072 X HKI 193-1	5.82
DQL 2072 X CML 165	6.13
DQL 2075 X CLQRCY 40	6.16
BGS 155 X CLQRCY 40	7.17
WNL 19082 X HKI 193-1	6.47
WNL 19082 X CML 165	6.19
DQL 2104-1 X CLQRCY 40	6.64
DQL 2076 X CLQRCY 40	6.11
DQL 2068 X CLQRCY 40	6.88
DQL 2104 X CLQRCY 40	6.06
DQL 2042 X CML 161	6.06
DQL 2034 X CML 161	6.05
DQL 2018- X CML 163	6.30
DQL 2039-1 X HKI 163	6.40
DQL 2038-1 X CML 165	5.92
DQL 2020 X HKI 163	5.83
DQL 2018 X CLQRCY 40	5.87
CHECK HQPM-5	5.84

Provitamin A

Inbred lines which are to be used as donor parents for high provitamin A were maintained and screened with gene specific markers to ascertain the presence of desirable allele. Crosses between donor and recipient parents were attempted and F_1 seeds were planted at Begusarai.

Starch and Oil

To assess the G x E interactions, a multi-location trial comprising 20 hybrids of both released and notified as well as pipeline hybrids was conducted during *rabi* 2013-14 at Delhi, Begusarai and Hyderabad. The selfed seed from five random plants were harvested and the biochemical analysis is being undertaken.

Biochemical analysis of maize germplasm

A large number of samples received from different centres were analyzed for various quality parameters *viz.*, protein, tryptophan, lysine, oil, sugar, starch, etc. Around 1050 samples for protein quality, 98 for sugar, 149 for starch, 66 for oil content, 80 for starch profile i.e. amylose and amylopectin content and 80 for resistant starch content were analyzed. In quality protein maize analysis, the kernels were first screened on the basis of opaqueness to select the representative sample containing 25-30% opaqueness. Out crossed as well as non uniform kernels were discarded. The endosperm was separated, defatted and processed for protein quality. Germplasm having threshold concentrations of protein quantity (≥ 9% protein) along with quality (≥ 0.6 % tryptophan and ≥ 2.50 % lysine in the endosperm protein) was selected and identified as promising quality protein maize material.

A total of 590 yellow inbred lines (introduction nursery) received from Winter Nursery Center, Hyderabad were analyzed for protein quality. The range of protein was 7.27 to 13.33 per cent with lowest and highest values being exhibited by the genotypes S00TLYQ-HG-BBB-9-BBB and P66C0-BBB-45-BBB, respectively. The range of tryptophan was 0.30 {S99TLYQ-HG-AB*4-17-BBB} to 0.78 {S99TLYQ-HG-AB*4-7-BBB} per cent.

In addition 453 inbreds received from different breeders from the Indian Institute of Maize Research, were screened on the basis of kernel opaqueness and out of 453, 215 samples were found to possess some opaqueness and therefore analyzed for protein quality analysis. In the third set of experiment, a panel of 35 elite inbreds was analyzed for protein, starch, tryptophan and lysine content. Starch and protein are analyzed in the whole kernel, whereas, only endosperm protein is measured in the samples analyzed for protein quality. A total of 8 lines showed higher starch content (>70%) for the consecutive two years, whereas 2 lines *viz.*, DML-281 and DML-301 are identified as high protein (≥ 13%).

Further, a set of 80 selfed maize seeds, mostly hybrids of public as well as private sector obtained from the Indian Institute of Maize Research, were analyzed for carbohydrate profile such as sugar, starch, amylose, amylopectin and resistant starch content. The results revealed that significant variation exists in the carbohydrate and resistant starch (RS) content among the diverse maize hybrids. Resistant starch is the part of the starch which is not digested in the small intestine. Many health benefits such as improved cholesterol metabolism and reduced risk of type II diabetes and colon cancer have been associated with the consumption of RS. Some hybrid viz., Pratap QPM Hybrid, HQPM 7, DHM 119 and HQPM 1 were found better with respect to sugar, starch amylose and resistant starch content.

Finally, inbred lines developed for high oil were also analyzed for oil concentration in the whole kernel. A total of 13 quality protein white maize and 19 quality protein yellow maize inbreds were evaluated for total oil content. Five inbreds yielded more than 5% of oil (Table 13).

Table 13. Promising lines for oil content

PEDIGREE	OIL (%)
TLWQ(H0)QPMC15-BBB-55-BBB	5.07
TLWQ(H0)QPMC15-BBB-64-BBB	5.51
TempxTrop(H0)QPM-BBB-69-BBB	6.00
TempxTrop(H0)QPM-BBB-73-BBB	5.56
TempxTrop(H0)QPM-BBB-100-BBB	5.82

Hybrid seed production of experimental hybrids

Seed multiplication of the single cross hybrids submitted to the IVT trials was also attempted during *kharif* 2014. The crosses were 'CML338 x CML422', 'DMRN6 x CML470' and 'CML470 x V373'. In addition attempts were also made to produce seed for IVT of *kharif* 2015. The hybrid seed production of the test entries were produced during *kharif* 2014 as well as *rabi* 2014-15.

2

Production System and Technology

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

In recent years Indian agriculture is facing the problems of declining water table, escalating fuel prices, labour shortage, deteriorating soil health along with frequent climatic extremes leadings to higher production cost and lower economic returns. In order to ensure future food security, practicing conservation agriculture (CA) in principle is essential to bridge management yield gaps, sustain natural resources and also to address the above problems. Therefore, an attempt was made to develop and evaluate the performance (as individual crop productivity, system productivity and monitory returns) of different tillage and crop establishment practices [permanent bed (PB), zero tillage (ZT) flat and conventional till (CT)] under four intensified irrigated maize based cropping systems in cropping seasons *kharif-rabi*-summer [maize-wheat-mungbean (MWMb), maize-chickpea-*Sesbania* (MCS), maize-mustard-mungbean (MMuMb) and maize-maize-*Sesbania* (MMS)] by conducting long-term experiment [2008-till date] at fixed site.

The observation were recorded on rainfall and temperature and the total rainfall in *rabi* 2013-14 (November to April) was 169.1 mm and during *kharif* 2014 (July to October) was 451 mm. The mean range of monthly minimum and maximum temperature during *rabi* 2013-14 and *kharif* 2014 were 18.6-34.8°C and 33.2-35.9°C, respectively. The performance (in terms of grain/seed yield) of all the *rabi* crops grown during *rabi* 2013-14 in rotation with *kharif* maize was maximum under ZT flat planting except wheat, where PB plots gave maximum grain yield. The grain/seed yield of maize, chickpea and mustard was 22.13, 20.47 and 20.03 per cent higher under ZT flat planting over the CT flat, respectively whereas the wheat grain yield was 21.43% higher in PB plots over the CT plots (Figure 5). During *kharif* 2014, the maize grain yield was 14.21% higher under ZT flat over the CT flat (Figure 6). Further, the *kharif* maize grain yield differed significantly in different cropping systems and the highest yield was recorded in MCS system which was 4.93, 8.44 and 12.43 per cent higher over to MWM, MMuMb and MMS systems, respectively (Figure 7). The higher system productivity (in terms of maize equivalent yield) was recorded under ZT plots (12854 kg ha^{-1}) and the lowest (10687 kg ha^{-1}) was under CT plots in 2013-14 (Figure 8). However, among the cropping sequences, the systems productivity (13446 kg ha^{-1}) was highest in MMuMb cropping system (Figure 9). The synergistic effect (in terms of higher productivity) of summer season legumes (mungbean and *Sesbania*) was observed under CA based crop management practices in traditional cereal based systems. The CA based management practices (ZT flat and PB) also helped in reducing the production cost and enhancing the net returns over the CT flat system. In general, an increase in

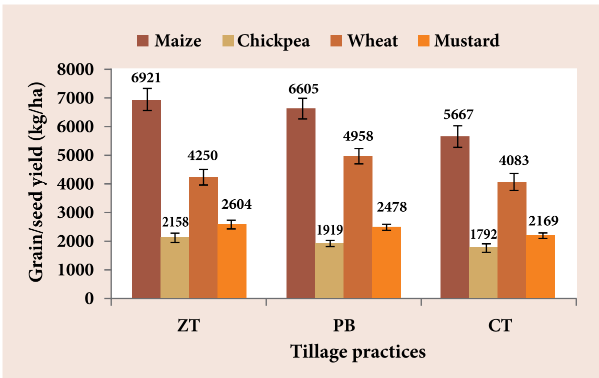


Figure 5. The productivity (kg ha-1) of *rabi* crops under different tillage practices during 2013-14 in different maize based cropping systems.

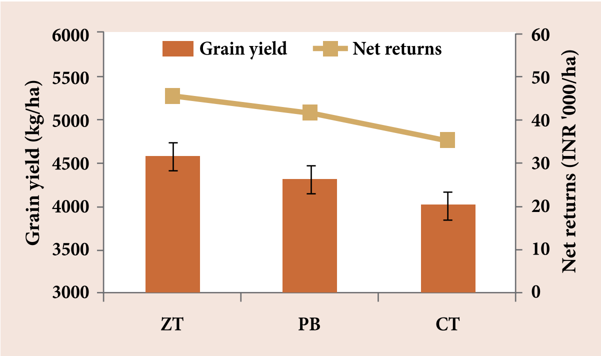


Figure 6. The average *kharif* maize grain yield (kg ha-1) and net returns (INR '000 ha-1) under different tillage practices during 2014.

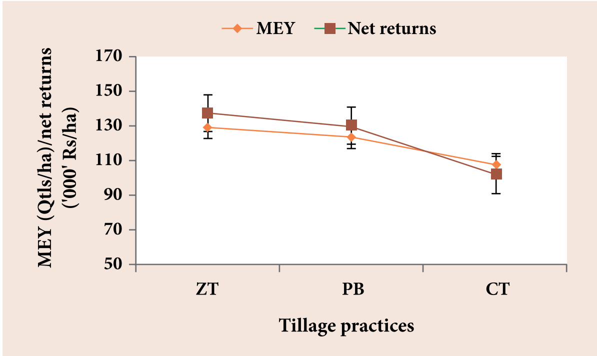


Figure 8. The average maize equivalent yield (kg ha^{-1}) and net returns (INR '000 ha^{-1}) across maize based cropping systems under different tillage practices.

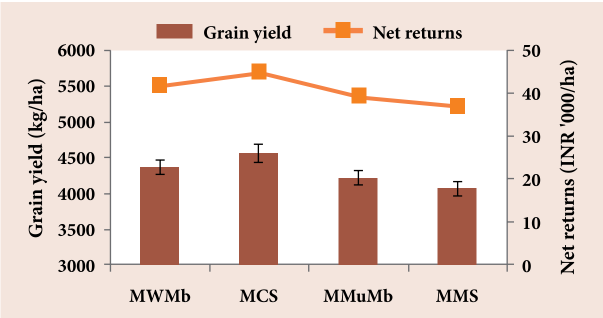


Figure 7. The average *kharif* maize grain yield (kg ha^{-1}) and net returns (INR '000 ha^{-1}) in different maize based cropping systems during 2014.

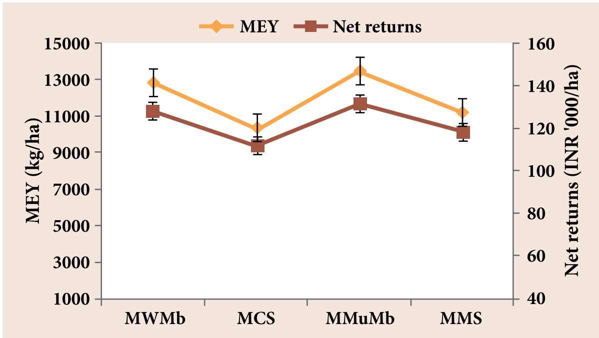


Figure 9. System productivity (kg ha^{-1}) and net returns (INR '000 ha^{-1}) in different maize based cropping systems across tillage practices.

the net profit from 29 to 40 per cent as compared to CT flat planting (Figures 6) was observed in different crops planted in maize sequences under CA based tillage practices (ZT flat/PB). Among the different maize based cropping systems, the maximum net profit was observed with MMuMb system (Figure 7, 8 & 9).

Nitrogen management under conservation agriculture in maize-based cropping systems

Conservation agriculture (CA) practices are proving better for enhancing returns from agriculture besides improving soil health for sustainable crop production. The adoption of proper nutrients management practices may further enhance the benefits of CA. In fact they can become a driving force for accelerating adoption of CA. Nitrogen, one of the important nutrient element when applied in splits stay in/on the crop residues and causes volatilization and immobilization losses in CA. In order to explore the feasibility of one time application of coated nitrogen fertilizer under CA in intensified maize-based systems, an experiment started during July 2012.

Effect on *kharif* crops yield

The combined analysis of three years data revealed that the one-time *neem* coated urea (NCU) application was beneficial under CA. The maize yield increased slightly but the agronomic nitrogen-use efficiency has increased by 15.7% over prilled urea (PU) application (Figure 10). In addition, the residue retention (WR) of mungbean crop also enhanced maize yield by 10% over no residue application (WoR). Further, the cropping system (CS) also affected maize yield in *kharif* season, the maize-wheat-mungbean (MWMb) CS has improved the maize yield slightly over maize-mustard-mungbean (MMuMb) system.

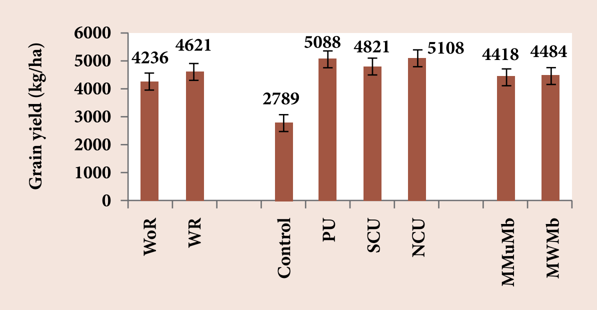


Figure 10. The mean *kharif* maize productivity (2012-14) under different nitrogen management practices in different cropping systems and residue management scenario

Effect on *rabi* crops yield

The combined analysis of two year data (2012-13) revealed that the *rabi* crops productivity also improved with the coated fertilizer application. However, a marginal improvement was noticed with residue application (Figure 11). The mustard yield was highest under one time SCU application which was 14% higher over the conventional PU whereas wheat yield was highest with NCU application which was 7% higher over PU application. The residue retention lead to 10 and 13% yield enhancement in mustard and wheat, respectively over without residue.

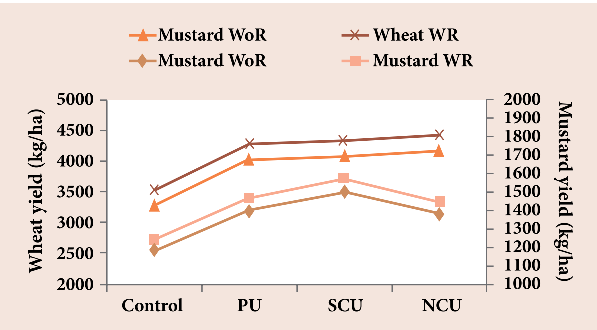


Figure 11. The mean (2012-13) productivity of mustard/ wheat with different nitrogen management practices under different residue management scenario

Effect on system productivity

The system productivity in terms of maize equivalent yield was 18% higher with MWMb compared to MMuMb sequence (Figure 12). The residue retention helped in enhancing maize yield by 5% over WoR. However, there was not much difference in terms of systems productivity due to coated fertilizer application as NCU was best under MWMb while SCU was better under MMuMb system which indicates different

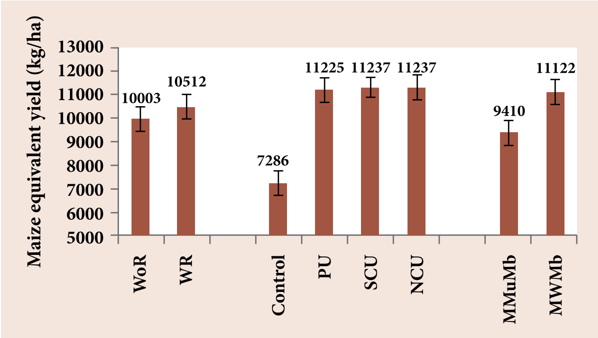


Figure 12. The mean (2012-13) system productivity under different nitrogen management practices in maize systems under conservation agriculture.

cropping systems requires different coated fertilizer under CA.

Site specific nutrient management in maize based cropping systems

All crop plants generally respond in terms of yield to nutrient status of soil, which depends upon soil supplying capacity and preceding crop (cropping system). The rate of nutrient application either through organic or inorganic sources depends mainly on soil nutrient status/balance and cropping system. However, in order to obtain desirable yields, the doses of nutrients applied should match with plant demand. In this context, site specific nutrient management (SSNM), which follows specific principles, provides decision tools and guidelines for farmers and extension workers for optimally supplying nutrients. 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. Hence, experiments on site specific nutrient management were initiated during *kharif* 2012.

SSNM under different tillage practices

The productivity of the system mainly depends on proper nutrient and moisture management practices. An experiment was undertaken to identify the best combination of tillage and nutrient management practice under maize-wheat-green gram cropping system. The data revealed that during first year [2012] different tillage systems didn't influence the maize yield (Figure 13). However, in 2013 and 2014 both the permanent beds and zero tillage system increased maize yield significantly higher over conventional tillage practices. While in case of wheat significantly higher grain yield was obtained in both the years (2012-13 and 2013-14) under permanent beds over conventional tillage and zero tillage systems.

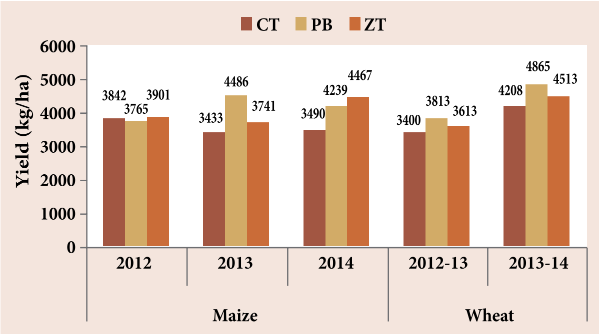


Figure 13. Effect of site specific nutrient management on maize and wheat yield under different tillage practices

Effects of nutrient management treatments on crop yield

Amongst different nutrient managemnet treatments, SSNM improved maize grain yield in all the three years (2012, 2013, 2014) over absolute control and 50% RDF/FFP (Figure 14). However, SSNM remained at par with 100% RDF during all the three years. While in case of wheat significantly higher yield was obtained with SSNM over all nutrient management treatments *viz.*, absolute control, 100% RDF and 50% RDF/FFP.

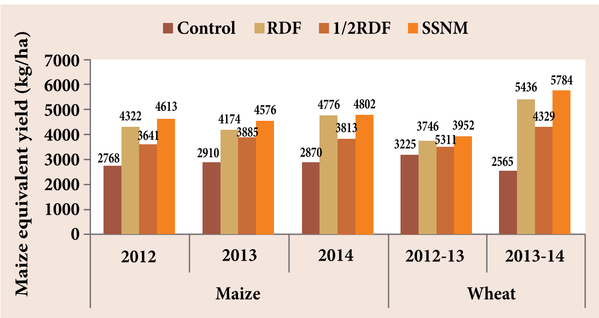


Figure 14. Effect of nutrient management treatments on maize and wheat yield.

Effects of nutrient management on system productivity

The system productivity in terms of maize equivalent yield didn't differ significantly (Figure 15) during first year (2012-13) under different tillage practices. However, during second year (2013-14) significantly higher system productivity by 18.64 and 7.53% was obtained by permanent beds over conventional tillage and zero tillage, respectively. Amongst nutrient management practices significantly higher system productivity was obtained with SSNM which was 44.4, 6.1 and 18.6 per cent higher over absolute control, 100% RDF and 50% RDF, respectively.

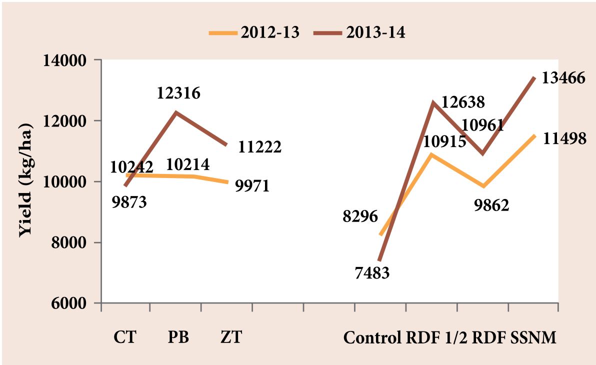


Figure 15. Effect of nutrient management treatments on system productivity and under different tillage practices (Maize equivalent yield)

Effect of SSNM on yield of different maize hybrids

The Nutrient Expert - Decision Support System provides decision support on SSNM. It is a software programme (Nutrient Expert) which estimates the nutrient requirements for achieving realistic target yields. The system selects the adequate and least costly combination of quality fertilizer sources by matching with nutrient requirement of crop. It also takes into consideration the split application of fertilizer and also estimates the profit gained from improved nutrient and crop management. During *kharif* 2014, SSNM showed

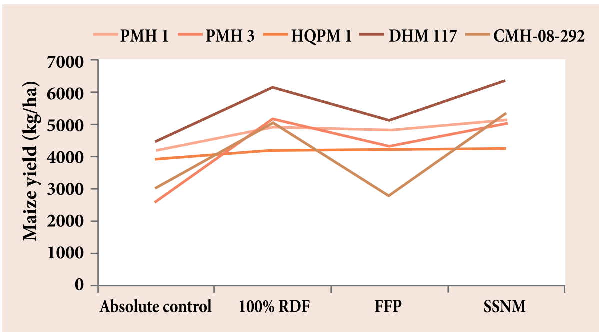


Figure 16. Interaction effects of nutrient management practices on the grain yield of maize hybrids (LSD 0.05=849.67).

significantly higher maize yield over absolute control and FFP (Figure 16). Amongst genotypes DHM-117 showed significantly higher yield by 13.54, 22.64, 25.4 and 27.0% over PMH-1, PMH-3, HQPM-1 and CMH-08-292, respectively.

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

The crop residue incorporation of previous crop with the application of fungal consortia (*Aspergillus awamori, Trichderma viride, Phanerochaete clirysosporium, Aspergillus nidulans*) in maize-wheat-mungbean cropping sequence substantially improved the yield of maize, wheat and mungbean. The per cent improvement in yield with incorporation of previous crop with the application of fungal consortia of maize, wheat and mungbean were 14.16 and 7.5 and 24.16 and 13.3, 39.0 and 10.3 0 over no crop residue incorporation and crop residue incorporation treatments, respectively (Table 14). Maize and wheat recorded the highest yields with the application of recommended dose of potassium, but when recommended dose of potassium was reduced to its ¾ level coupled with KSB, the yield of wheat remained similar to recommended dose of potassium. The system productivity in terms of maize equivalent revealed that integration of ¾ of recommended dose of potassium, KSB and crop residue incorporation along with fungal consortia in maize and wheat proved the best combination (Figure 17). The residual content of potassium in soil after the cropping systems was also the maximum in crop residue + fungal consortium treatment that the recommended dose of potassium.

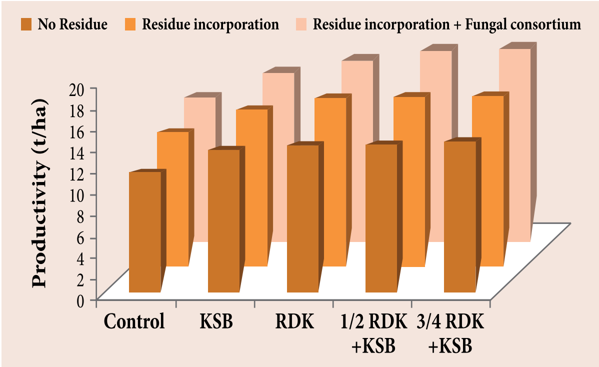


Figure 17. Productivity of maize-wheat-mungbean cropping system under different crop residue and potassium management practices

Table 14. Productivity of different crops and residual content of available potassium in soil as affected by crop residue and potassium management treatments in maize-wheat- mungbean cropping system

Treatment	Productivity (t/ha)			Available (kg/ha)
	Maize	Wheat	Mungbean	
Control	4.87	4.80	1.00	192.5
Residue incorporation	5.17	5.26	1.26	198.1
Residue incorporation + fungal consortium	5.56	5.96	1.39	211.7
C D (P=0.05)	0.22	0.17	0.18	1.49
Control	4.51	4.23	1.13	178.7
KSB	4.85	4.47	1.21	158.8
RDK	6.13	6.17	1.23	222.6
1/2 RDK* + KSB**	5.15	5.70	1.25	205.1
3/4 RDK +KSB	5.35	6.13	1.28	211.6
C D (P=0.05)	0.23	0.21	0.12	2.55

*RDK-recommended dose of potassium was 60 and 50 kg/ha in maize and wheat, respectively
**KSB-Potassium Solublizing Bacteria

Effect of nitrification inhibitors on productivity and nitrogen use efficiency of maize-wheat cropping system

An experiment with different nitrification inhibitors in varying concentration at 75% and 100% of the recommended dose of nitrogen were conducted in maize-wheat cropping sequence. Neem oil coated urea (NOCU) in 700 ppm concentration recorded the highest grain yields of both maize (7.33 t/ha) and wheat (6.7 t/ha), when applied at 100% nitrogen level, which were significantly higher over remaining treatments including 100% N application in the form of urea (Table 15). Meliacin coated urea (MCU) in 350 ppm and Dicyandiamide (DCD) in 5% concentration recorded the maize yield similar to NOCU 700 ppm treatment at 100% recommended dose of nitrogen level, while in case of wheat DCD at 5% concentration remained at par to NOCU. It is important to note that increasing concentration of MCU from 350 to 750 ppm and DCD from 5 to 10% reduced yield of both maize and wheat, however significant differences were noticed at DCD in maize and at MCU and DCD in wheat. Agronomic nitrogen use efficiency (ANUE) was also highest with application of NOCU in 700 ppm at 100% recommended nitrogen level and no marked differences were noticed in case of all nitrogen inhibitors between 75% and 100% levels of nitrogen. However, increasing concentration in MCU and DCD reduced the ANUE considerably. The maize equivalents of maize-wheat cropping system also resulted in similar trend both in terms of productivity and ANUE (Figure 18).

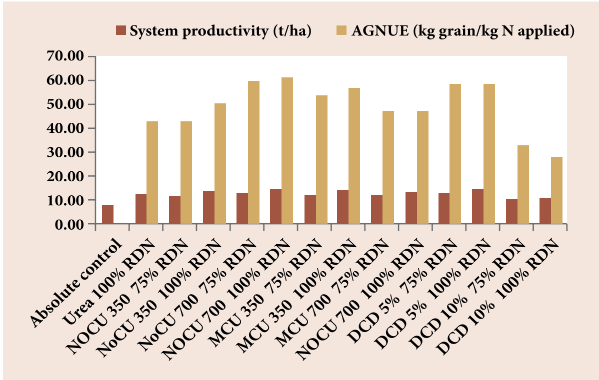


Figure 18. Productivity and agronomic nitrogen use efficiency of maize-wheat cropping system

Table 15. Productivity and agronomic use efficiency of maize and wheat grown in sequence

Treatment	Maize Grain yield (t/ha)	AGNUE of maize (kg grain/kg N applied)	Wheat grain yield (t/ha)	ANUE of wheat (kg grain/kg N applied)
Absolute control	3.8	0.0	3.2	0.00
Urea (100% RDN)	6.37	14.28	5.5	19.17
NOCU 350 ppm (75% RDN)	5.68	13.93	5.0	20.00
NOCU 350 ppm (100% RDN)	6.68	16.00	6.1	24.17
NOCU 700 ppm (75% RDN)	6.15	17.41	6.0	31.11
NOCU 700 ppm (100% RDN)	7.33	19.61	6.7	29.17
MCU 350 ppm (75% RDN)	6.24	18.07	5.4	24.44
MCU 350 ppm (100% RDN)	7.25	19.17	6.3	25.83
MCU 700 ppm (75% RDN)	6.10	17.04	5.0	20.00
MCU 700 ppm (100% RDN)	6.76	16.44	5.7	20.83
DCD 5% (75%RDN)	6.47	19.78	5.6	26.67
DCD 5% (100%RDN)	7.21	18.94	6.5	27.50
DCD 10% (75% RDN)	5.46	12.30	4.4	13.33
DCD 10% (100% RDN)	5.64	10.22	4.6	11.67
CD (P=0.05)	0.6		0.27	

3

Crop Protection

Maize occupies a pivotal role in economy and is being traded all over world widely. A wide array of diseases and pest have been known to attack maize crop throughout the country, its cultivation is limited by diseases which cause grain loss of about 13% of the total production. We incur heavy economic losses every year due to major diseases. Various research approaches to combat the losses are being carried out.

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

Post flowering stalk rot of maize is a globally important destructive disease. The disease caused by soil borne pathogens and disease incidence recorded in India ranged from 10 to 42% occurs both in winter & rainy crop seasons.

Collection and establishment of stalk rot pathogens

Stalk rot pathogens *i.e. Macrophomina phaseolina* and *Fusarium verticilloides* were isolated, purified and established on Potato Dextrose Agar (PDA) medium separately.

Figure 19. Seedling 7-10 old (Uninoculated)

Histopathological study

Studies conducted on two contrast genotypes resistant CM 123 and susceptible BML 6. Seed planted in paper cups aseptically (Figure 19). Seedlings (10 days after germination) were transferred in large pots containing inoculated soil with stalk rot pathogens separately and in combination. Experiment was carried out in glasshouse under controlled condition (Figure 20). None of the plants exhibited any symptoms even after 30 days of germination/inoculation. Histopathological studies of these plants were carried out.

Figure 20. Asymptomatic plant (30 days old) planted in artificially inoculated soil

Histopathological study of 30 days old asymptomatic resistant (CM 123) and susceptible (BML 6) genotypes planted in inoculated soil –

There was no fungal growth/mycelium observed in uninoculated (control) plant when studied under microscope. All the tissues of root *viz.*, cortex endodermis, xylem, phloem and pith were clear without any infection (Figure 21 A). In stem both conducting and cortex tissues were without any infection and fungal growth (Figure 22 B).

Transverse section of un inoculated root and stem (control)

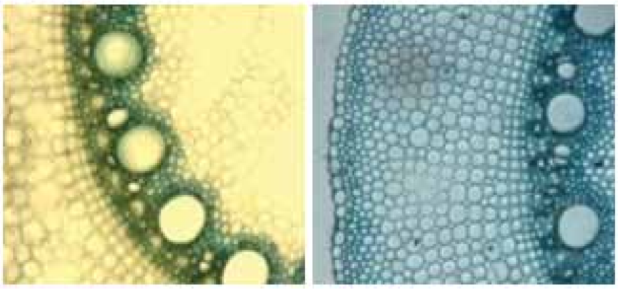


Figure 21. A T. S. of Root

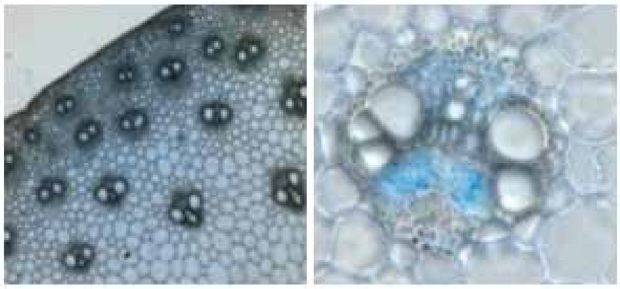


Figure 22. B Stem showing Vascular bundle

Histopathology of root and stem of soil inoculated, susceptible (asymptomatic) genotypes after 48-72 hours of inoculation

Root of susceptible plant exhibited fungal growth of *F. verticilloides* colonized over the epidermal layer of root (Figure 23A) and start invading the cortex cells through epidermis.

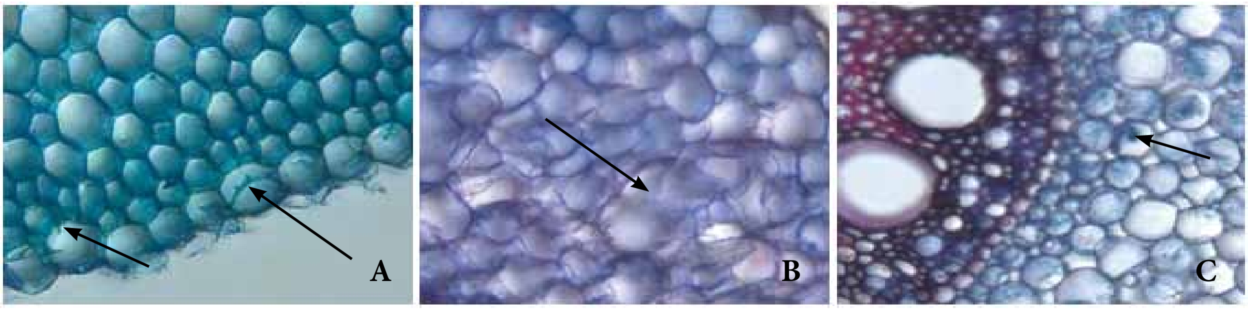


Figure 23.
(After 48 Hrs) (After 48 Hrs) (After 72 Hrs)

A. Fungal hyphae of *F. verticilloides* colonizing over the epidermis of root and invading epidermal layer and cortex tissues and approaching cortex.

B. Total disintegration of ground tissues is clearly visible which is due to production of cellulases and proteases enzyme

C. Tissues of cortex in root showing heavily colonized with hyphae and approaching towards endodermis and vascular bundles

Disintegration of ground tissues (Figure 23B) were clearly observed in root of susceptible plant which is due to production of enzyme cellulases and proteases. Cortex tissues of root showing heavily colonized with hyphae that approaching towards endodermis and vascular bundle (Figure 23C).

Histopathology of root and stem of soil inoculated resistant (asymptomatic) genotypes after 72 hours of inoculation

Histopathology of root of resistant plant studied under microscope at 72 hrs after inoculation. Stained Transverse Section (T.S.) of resistant root showed acidic-neutral carbohydrates (red-violet), polyphenolic substances (blue green) and unstained substances (yellow), when challenged with both fungi (*M. phaseolina* and *F. verticilloides*) together, as a part of host defense reaction after 72 hours of inoculation (Figure 24 A & B).

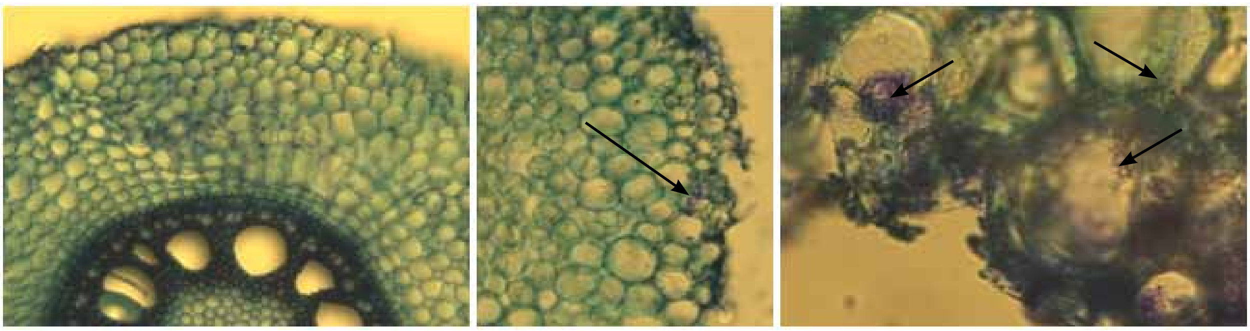


Figure 24. T.S. of resistant plant (A. Root under 10X) (B. under 20X and zoom in)

Gum and gel like depositions were also observed in ground tissue of stem in resistant plant after 48 hours of inoculation which is also part of defense reaction in resistant plants (Figure 25 A, B C). observed in histopathological studies. Further confirmation of pathogen in the plants was done by isolation of pathogenic fungi from host plants to prove Koch's Postulates (Figure 26 & 27).

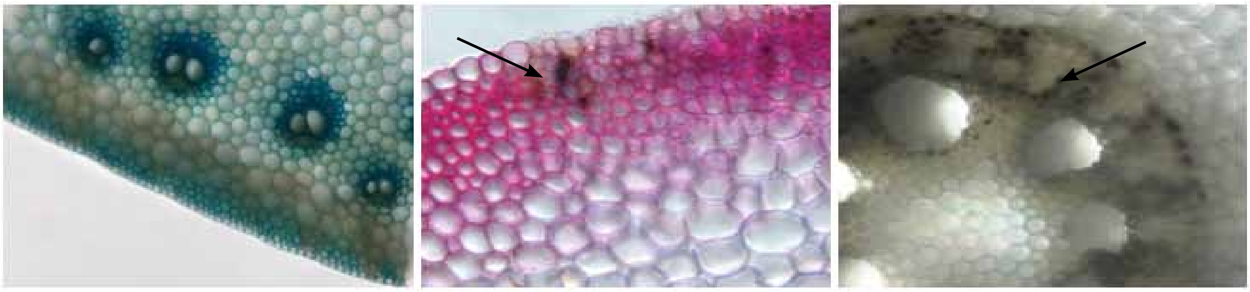


Figure 25. (A) (B) (C)
Dark brown coloured gum & gel like deposits in ground tissues of resistant plants

Confirmation and re isolation of pathogens from asymptomatic 30 days old maize plant

Thirty days old plant planted in inoculated soil did not exhibit any symptoms. Presence of pathogen inside the susceptible plant was

In-vitro studies of enzymatic activity in stalk rot pathogens;

Enzymatic activity such as pecitnase, lipase, cellulases, and proteases was studied in stalk rot pathogens i.e. *M. phaseolina* and *F. verticilloides*

Figure 26.

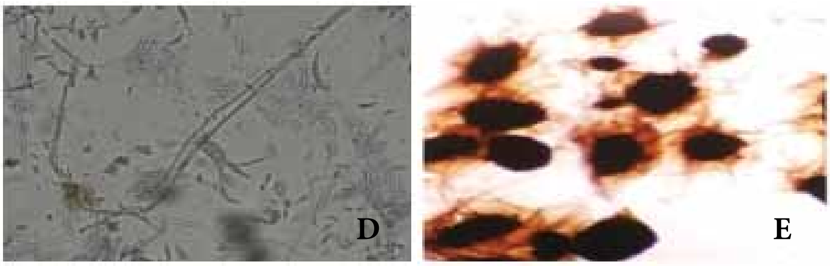


Figure 27.

A. Isolation of surface sterilized tissue from asymptomatic plant in PDA
B. Fungal growth of *F. verticilloides* on culture plate
C. Growth of *M. phaseolina* on culture plate
D. Microconidia of *F. verticilloides* under 10X
E. E. Microsclerotia of *M. phaseolina* under 10X

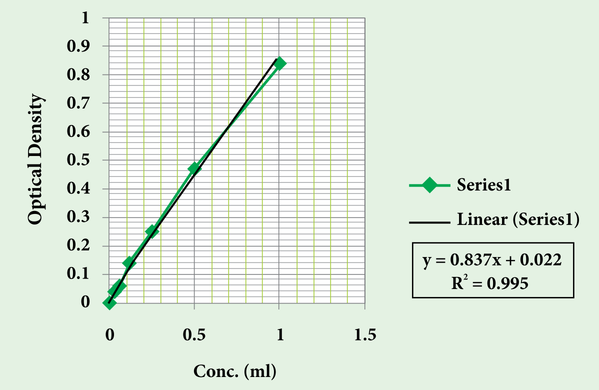


Figure 28. Standard Glucose curve at 600 nm

in vitro. It was observed that pectinase was the most important enzyme in initiating the process of cell wall degradation as it showed highest activity at 48 hrs whereas cellulases and proteases were more active at 72 hrs and high activity of lipase was observed at 96 hrs. (Figure 28). These enzymes degrade the cell membrane of host plant and consequently the pathogen spread inside the host tissue up to the maximum limit, causing destruction of soft tissue where individual cells decomposed. It has also explained the reason for lodging and banding of plants and it is significantly correlated with cellulase production.

- Presence of stalk rot pathogens in symptomless plant was authenticated by extensive histopathological studies.
- The pathogen penetrates from root of the host and develops further systemically with inter-and intracellular colonization in vascular bundles and adjacent tissues, including protoxylem lacuna, xylem vessels and metaxylem.
- Both the pathogens i.e. *M. phaseolina* and *F. verticilloides* are able to invade root of both the resistant and susceptible maize cultivars, indicating that resistance is tissue specific.
- Pathogen exhibited highest pectinase activity at 48 hrs - it is the time when process of cell wall degradation is initiated.
- Cellulase and protease were more active in both pathogens at 72 hrs whereas lipase was more active at 96 hrs–help in degradation of cell membrane consequently pathogen spared to the maximum limit, causing destruction of soft tissue

Screening/evaluation of maize germplasm to identify resistant sources against PFSR under artificial inoculation conditions

A total of 99 maize genotypes were evaluated under artificial toothpick inoculation condition in IIMR experimental field during 2015 *kharif*. The experiment planted with 3 m. row length x 75 cm plant to plant space with two replications. The expression of disease was not much as there was rainy spell at post flowering stage of crop which is unfavorable condition for disease development, however based on disease reaction 90 genotypes selected which has been planted at Hyderabad winter nursery for evaluation and seed multiplication.

Screening of genotypes against PFSR at four hot spot locations under artificial inoculated condition;

A total of 60 genotypes were screened for charcoal rot disease under artificial epiphytotics in three identified hot spot locations *viz.*, Ludhiana, Delhi and Hyderabad, of them a total of 26 lines were identified resistant on 1-9 rating scale. These promising lines are enumerated below (Table 16);

Table 16. Genotypes resistant to PFSR on a score of 1-9 disease rating scale at three hot spot locations

Pedigree	Disease score (1-9 scale)		
	Ludhiana	Delhi	Hyderabad
TL02A-1184A-32-1-3-1-2-1-1	3.0	2.5	1.5
TL02A-1184A-32-1-3-1-2-1-2	3.4	2.5	1.5
TL02A-1184A-32-4-1-1-2-1-1-1	3.3	1.5	1.3
TL02A-1184A-32-4-1-1-2-1-1-2	3.4	2.0	1.2

Pedigree	Disease score (1-9 scale)		
	Ludhiana	Delhi	Hyderabad
AF -04-B-5779-22-3–3-2-2-1-1-1	4.4	2.0	1.6
AF-04-B-5796-A-7-1-2-2-1-2-1-1-2	3.8	3.8	3.9
PFSR (Y)-C0-1-Ä-4-1Ä-1-1-1-3Ä-1-1-1-1-2	3.2	4.5	2.0
V406 -2 Ä-1-1-1-1-1	3.3	4.0	2.3

Pedigree	Disease score (1-9 scale)		
	Ludhiana	Delhi	Hyderabad
V338 -1Ä-1-1-1-1-1	3.5	2.5	3.3
PFSR (Y)-C0-3Ä-1-1-1-1-1	3.0	2.1	2.7
PFSR (Y)-C0-3Ä-1-1-1-1-2	3.4	1.5	2.7
Indimyt-345-3Ä-2-1-3	4.2	2.6	1.9
PFSR (Y)-C1-A-A1 Pink heart Bold grains-2Ä-1-2-1-1-1	4.7	3.4	2.8
CML 27-1-1-1-1	3.0	3.8	4.8
North east 4-1 (N)-Ä -1-1-3	4.5	2.9	4.4
NEH (W) -1 (N)-1-2	3.8	1.6	1.5
NEH (W) -2 (N)-1-1	4.7	3.0	1.9

Pedigree	Disease score (1-9 scale)		
	Ludhiana	Delhi	Hyderabad
CML 389-1-1-1-1	5.2	2.5	2.7
CML 342 – 1-1-1	3.0	2.4	1.9
CML 342 – 1-1-2	3.0	1.2	1.5
PFSR (Y)-C1-B Ä-1-1-1-1	3.7	1.6	4.1
PFSR (Y)-C1-B Ä-1-2-1-1	4.0	2.5	3.1
PFSR (Y)-C1-B Ä-2-1-1-1	3.4	1.8	1.9
PFSR (Y)-C1-B Ä-2-2-1-1	3.6	2.6	3.7
PFSR (Y)-C1-B Ä-2-2-1-2	4.4	2.7	4.7
PFSR (Y)-C0 Ä-2-1-1-1	3.0	2.5	3.5

Identification of stable sources of resistance to major diseases of maize

A total of 124 maize lines were evaluated against major diseases at different hot spot locations under artificially inoculated diseased condition in *kharif* 2014. Of them, 56 lines exhibited multiple disease resistance. The entry wise disease reactions are enumerated below in Table 17.

Table 17. Promising inbred lines exhibiting resistance to one or more diseases

Genotype	Resistant	Moderately resistant
HKI163	C.ROT, FSR, CLS	MLB
HKI 193-1	MLB, C.ROT, FSR	TLB
HKI 1105	BLSB, C.ROT	
HKI 1344	C.ROT, FSR, CLS	MLB
CM 212	FSR	C.ROT
CM 117-3-2-1-1-1-2-1	RDM, BSR	MLB, TLB, BLSB, FSR
CM 129	-	C.ROT
CM 132	C.ROT, FSR, BSR	TLB
CM 501	FSR, CLS	MLB, TLB, C.ROT
CM 502	FSR, BSR, CLS	TLB, C.ROT
CM105	CLS	MLB, TLB, C.ROT, FSR
CM123	FSR, CLS	MLB, TLB, C.ROT
CM128	FSR, CLS	MLB, C.ROT
CM149	-	MLB, TLB, C.ROT, FSR, BSR

Genotype	Resistant	Moderately resistant
CML 451(P2)	FSR	C.ROT, BSR
CML446	MLB, C.ROT, FSR	TLB, BLSB, CLS
CUBA 377	MLB, FSR, RDM, CLS	TLB, C.ROT, BSR
IIMR QPM-03-124	MLB, C.RUTS, C.ROT	P. RUST, FSR, CLS
IIMRQPM 03-113	FSR	MLB, C.ROT
DMSC 20	FSR	BLSB
DMSC 36	FSR	C.ROT
DMSC1	FSR	MLB, BLSB, C.ROT, CLS
DMSC6	FSR	MLB, TLB, BLSB, C.ROT
DMSC8	FSR, CLS	MLB
HKI 1040-11-7	C.ROT, CLS	MLB, FSR
HKI 1128	FSR	MLB
HKI 164-7-6 x 161	MLB	FSR, CLS

Genotype	Resistant	Moderately resistant
HKI 164-D-3-3-2	FSR, CLS	MLB, TLB, BLSB, C.ROT, BSR
HKI 193-2-2-1	C.ROT, FSR, BSR	MLB, TLB
HKI 226	C.ROT, FSR, RDM	MLB, TLB, BSR
HKI 31-2	C.ROT, FSR, CLS	MLB, TLB, BSR
HKI 323	MLB, FSR	BLSB, CLS
HKI Talar	MLB	TLB, BLSB, P.RUST, CLS
HKI-2-6-2-4(1-2)-4	C.ROT, CLS	MLB, TLB, BLSB, BSR
HKIMBR139-2	C.ROT, CLS	MLB, TLB, FSR, BSR
HYD05R/204-1	MLB, C.ROT,FSR, CLS	TLB, BLSB, C.RUST
JCY2-7-2-1-1-B-1-2-1-1	MLB, FSR, CLS	TLB, BLSB, C.ROT, BSR
JCY-3-7-1-2-1-B-2-3-2-1-3-2	CLS	MLB, TLB, C.ROT, FSR
POBLAC61C4	-	MLB, TLB, BLSB, P.RUST, C.ROT
SHD-1 ER6	-	BLSB, C.ROT
SKV18	FSR	TLB, BLSB, P.RUST, C.ROT
Temp.HOC15	C.ROT, FSR, BSR	TLB
WS KHOTHAI-1-WAXY-1-1	FSR, CLS	TLB, C.ROT
EI 670	FSR, BSR	MLB, TLB, BLSB, C.ROT
EI 708	SDM, FSR	MLB, TLB, C.ROT, CLS
EI 561	FSR, CLS	MLB, TLB, BLSB, C.ROT
BML13	FSR, BSR	MLB, TLB, BLSB, C.ROT
BML15	BSR, CLS	MLB, TLB, FSR
BML8	FSR, CLS	MLB, BLSB, C.ROT
CM 111	CLS	MLB, C.ROT, FSR
CM 115	FSR	TLB, C.ROT
CM119	FSR	BLSB, C.ROT, CLS
CM130	FSR	C.ROT
CM145	FSR	MLB, C.ROT
CM202	BSR, CLS	MLB, TLB, C.ROT, FSR
CM500	C.ROT, FSR, CLS	MLB, TLB, BLSB
CML 451Q	C.ROT, FSR, RDM, CLS	MLB, TLB, BLSB

Genotype	Resistant	Moderately resistant
CML 44	C.ROT, FSR, CLS	MLB, TLB
CML117-3-4-1-1-4-1	C.ROT, FSR, BSR	MLB, TLB, BLSB
CML161	FSR	MLB, TLB, C.ROT, RDM
CML165	C.ROT, FSR	MLB, TLB, BLSB, RDM
CML175	C.ROT	TLB, BLSB, C.RUST
CML287	FSR	MLB, C.ROT, BSR
CML3	C.ROT, CLS	MLB, FSR, BSR
CML321	FSR	MLB, TLB, BLSB, C.ROT, BSR
CML33	C.ROT	MLB, TLB, FSR, BSR
IIMRQPM 58	C.ROT	MLB, FSR
DMSC 16-1	C.ROT, FSR, CLS	MLB, TLB
DTPWC9 -F31-1-1-3	C.ROT, FSR	MLB, TLB, RDM, CLS
G18seqcef74-2-1	-	TLB, C.ROT, FSR, RDM
Gen 6033	C.ROT	MLB, TLB, FSR, BSR
HKI 141	CLS	MLB, TLB, C.RUST, C.ROT
HKI 164-3 (2-1)-1	FSR	MLB, TLB, C.ROT
HKI 586-1 WG'33	FSR	MLB, C.ROT
HKI C 322	FSR, CLS	MLB, TLB
HKI PC8	MLB, C.ROT, FSR, RDM	TLB
HKI141	FSR,	MLB, TLB, C.ROT, CLS
HKI164—4(1-3)	C.ROT, FSR, CLS	TLB, BSR
HKI-164-7-4-2	FSR, CLS	MLB, TLB, BLSB, C.RUST, C.ROT, RDM, BSR
HKI191-1-2-5	FSR, RDM, BSR	MLB, TLB, BLSB, CLS
HKI-484-5	MLB, C.ROT	TLB, BLSB, C.RUST, FSR, BSR, CLS
HKIC78	C.ROT, BSR	MLB, TLB, FSR
HKISCST	-	FSR, CLS
ITNA04	CLS	MLB, FSR
JCY2-2-4-1-1	FSR, RDM, BSR, CLS	MLB,TLB, BLSB, SDM, C.ROT
KML 3-3	FSR, RDM, CLS	MLB,TLB, C.ROT, BSR

Genotype	Resistant	Moderately resistant
La Posta Seq C7-F10-3-1-2-3-B-B-B-B-B-B	CLS	TLB, C.ROT, FSR, RDM
LM5	C.ROT, BSR, CLS	MLB, BLSB, FSR,
P390AM/ CMLC 4F230-B-2-1	C.ROT	MLB, FSR, BSR, CLS
P3C45SB- 33-##-11	-	MLB, C.ROT, FSR, BSR
P72c1Xbrasil 1177-2	FSR	BLSB, BSR
SC24-(C12)- 3-2-1-1	FSR	
SC7-2-1-2-6-1	CLS	C.ROT, FSR
Tempx Trop(H0) QPM-B-B-B-57-B-B	MLB, SFSR, CLS	TLB, C.ROT, RDM, BSR
TS2TR1107	C.ROT, FSR, CLS	MLB, TLB, BLSB, BSR
V334	FSR	MLB, TLB, BLSB, C.ROT, CLS
WINPOP2	FSR	TLB, C.ROT
WINPOP-43	C.ROT, FSR, BSR	MLB, TLB
WSCShrunken X MUS MADHAU	FSR, BSR	C.RUST, C.ROT, CLS
DQL 2006	-	MLB, TLB, BLSB
DQL 2008-1	-	MLB, TLB, BLSB
DQL 2009	BLSB	MLB, TLB, C.ROT
DQL 2010	-	MLB, TLB, BLSB
DQL 2015	-	MLB, TLB

Genotype	Resistant	Moderately resistant
DQL 2019	MLB	TLB
DQL 2024	-	MLB, TLB
DQL 2025	BLSB	MLB, TLB
DQL 2028	-	MLB, TLB, BLSB, C.ROT
DQL 2031	-	MLB, TLB, BLSB, C.ROT
DQL 2034	-	MLB, TLB
DQL 2038	TLB	MLB, C.ROT
DQL 2039	TLB	MLB
DQL 2048	-	MLB, TLB, BLSB, C.ROT
DQL 2054	-	MLB, TLB, BLSB
DQL 2055	-	MLB, TLB
DQL 2071	-	MLB, BLSB
DQL 2068	-	MLB, TLB, C.ROT
DQL 2057	BLSB	MLB, TLB
DQL 2046	-	MLB, TLB
DQL 2157	-	MLB, TLB
DQL 2111	BLSB	MLB, TLB, C.ROT
DQL 2113	TLB	MLB, BLSB
DQL 2104	TLB	MLB, BLSB, C.ROT
DQL 2105-1	MLB, TLB, BLSB	C.ROT

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; BSR–Bacterial stalk rot; C. RUST–Common rust; P. RUST– Polysora rust.

Biological and Molecular Typing of Virulence/Hypo virulence among isolates of *Rhizoctonia solani* infecting maize, for exploitation as potential biological control agents (Project Funded by: DST)

The project is completed and report has been submitted, salient achievements of this project are:

- Biological characterization of 62 *Rhizoctonia* isolates, from five agro ecological zones was accomplished by cultural, morphological and 8 pathogenic characters showed narrow diversity (Figure 32 & 33) which perhaps may belong to a single race indicating close similarity which may be sharing a common gene pool.
- Molecular typing by Sequence alignment and phylogenetic analysis of the ITS 5.8S rDNA region revealed that 61 isolates fall in AG 1-1A group. A remarkable variability in virulence was shown by 22 of the 62 isolates due to the compensatory base changes found in the secondary structure of ITS-2. Only 6 isolates showed diminished virulence (Figure 34)
- A new isolate of *Waitea spps*. from Barapani (Meghalaya) was characterized.

Two isolates (*HR-Ymn* and *MH-Klp*) showed presence of M2 dsRNA and diminished virulence. These can be further examined for exploring the prospects for development of bio-rationals and composts as disease suppressive alternatives to pre- plant fumigation.

	Rs-P-Knp	MG-Bpn	HR-Dbw	RJ-Ftn	HR-Ymn	UP-Cnd	MH-Klp	HR-Tck	HR-Pti	HR-Jhk	HR-Kou(M)
Rs-P-Knp	C3	C0	C0	C0	C0	C0	C0	C0	C0	C0	C0
MG-Bpn		C3	C0	C0	C1	C0	C1	C0	C0	C0	C0
HR-Dbw			C3	C2	C2	C2	C2	C2	C3	C2	C2
RJ-Ftn				C3	C2	C2	C2	C2	C2	C2	C2
HR-Ymn					C3	C2	C2	C2	C2	C2	C2
UP-Cnd						C3	C2	C2	C2	C2	C2
MH-Klp							C3	C2	C2	C2	C2
HR-Tck								C3	C3	C3	C2
HR-Pti									C3	C2	C2
HR-Jhk										C3	C2
HR-Kou(M)											C3

Figure 29. Compatibility reaction of 9 isolates of *Rhizoctonia* solani with tester strain Rs-P-Knp from AG-4

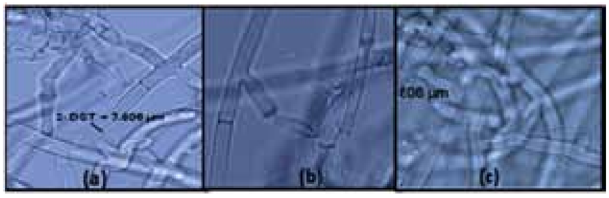


Figure 30. Types of anastomosis reactions observed (in agreement with McNish *et al.*, 1977). Microscopic interactions between hyphae of different isolates of *Rhizoctonia solani* (a) C_1 (hypha contact only); (b) C_2 (killing reaction); (c) C_3 (perfect fusion)

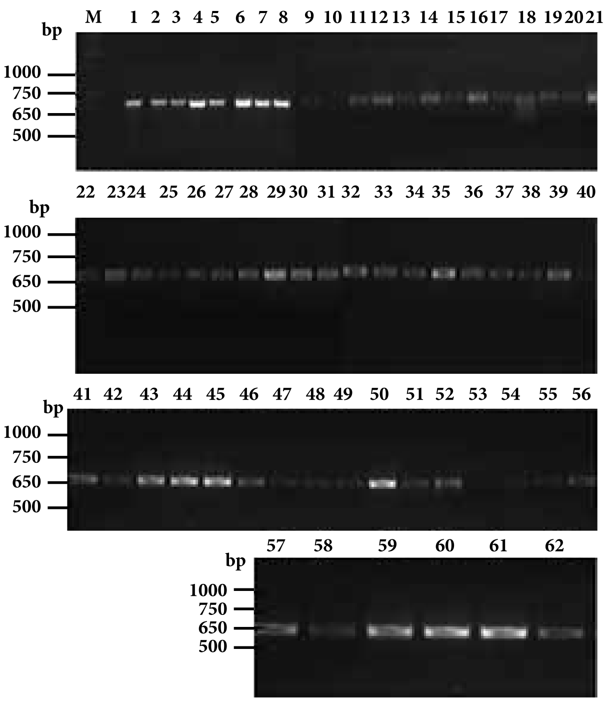


Figure 31. Agarose gel electrophoresis of the product of PCR amplification using primers ITS-1 and ITS-4 (White *et al.*, 1990) A single product of 650-750 bp was produced in all the isolates tested between hyphae of different isolates of *Rhizoctonia solani* (a) C_1 (hypha contact only); (b) C_2 (killing reaction); (c) C_3 (perfect fusion)

Study of host-pathogen interactions as affected by extra-chromosomal factors- dsRNAs and DNA plasmids in *Rhizoctonia solani*

This is ongoing project started on 28/05/2014. The Salient achievements of the project are;

- Screening of *Rhizoctonia* isolates for presence of hypo/hyper virulent dsRNA was conducted.
- The results revealed the presence of M1 dsRNA (partial fragment) in two of the 62 isolates (Figure 32).
- A faint amplification of a small fragment was observed in 3 isolates. These isolates showed very weak symptoms on the test plants (Figure 33).
- The isolates showing presence of dsRNA are of interest for studies on interaction of dsRNA with host pathogenicity.

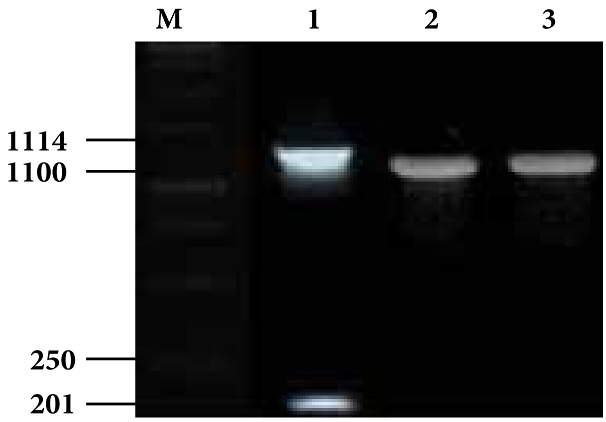


Figure 32. Gel banding patterns of dsRNAs partial resolution visible Lane 1 is positive control for M2 dsRNA; Lane 2 and 3 are test samples

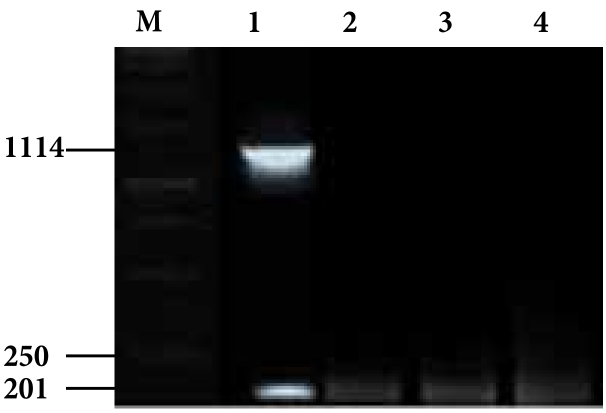


Figure 33. Gel banding patterns of dsRNAs partial resolution visible Lane 1 is positive control for M2 dsRNA; Lane 2, 3 and 4 partially resolved fractions

- The isolates showing presence of dsRNA are of interest for studies on interaction of dsRNA with host pathogenicity.

Identification of multiple Borer resistant genotypes in Maize

Screening for *Chilo partellus* resistance

After three years screening under artificial infestation, two lines *viz*., BCK/BK8 and DC2 were identified least susceptible to *Chilo partellus*, out of 37 lines screened.

Screening for *Sesamia inferens* resistance

During *rabi*, second years screening six inbred lines *viz*., WNZPBTL 9 (3.2), WNZPBTL 8 (3.5), CML 338 (3.6), WNZ EXOTIC POOL DC2 (3.1), CML 424 (3.2), WNZPBTL 9-1 (3.4) were promising over resistant check CM 500 (3.8) to *S. inferens* out of 34 lines screened.

Screening of maize inbred lines against *Sitophilus oryzae* and *S. cerealella*

A total of 26 inbred lines screened, of them the least susceptible lines with score of 0-3 identified, were: CM149, EC646015 and ENT 2-3 while LM10R, HKI 161 were moderately susceptible based on Dobie's index (4-7) rest 14 lines were susceptible (8-10) and 7 were highly susceptible (≥ 11) to *S. oryzae*. In screening for *S. cerealella*, moderately susceptible lines were WNC 10R NY5144, EC440608, HKI 1105, rest 16 lines were susceptible and 7 were highly susceptible.

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

Hexane, ethyl acetate and methanolic plant extracts of ten medicinal plants were tested in the laboratory at 5% (v/w) for their insecticidal and repellent effectiveness against rice weevil *Sitophilus oryzae*. Ethyl acetate extracts of *Erythrina indica* (80.0) followed by methanol extract of *Psoralea corylifolia* (76.7) and hexane extract of *E. indica* (63.3) showed maximum per cent mortality at 10 days of exposure. Maximum per cent repellency of *S. oryzae* was observed in ethyl acetate (90.0) and hexane extract (73.3) of *E. indica* followed by hexane extract of *P. corylifolia* (63.3).

Oviposition behavior of *Atherigona soccata* on maize

The oviposition behavior of shoot fly under field conditions was studied from 7 to 30 days after germination (DAG). The maximum number of eggs laid from 11-13 DAG and decrease thereafter. No egg laying was noticed 23 DAG. The data will help the farmers to plan the sowing of maize in a way that asynchrony occurs between the pest and susceptible age of the plant (Figure 34).

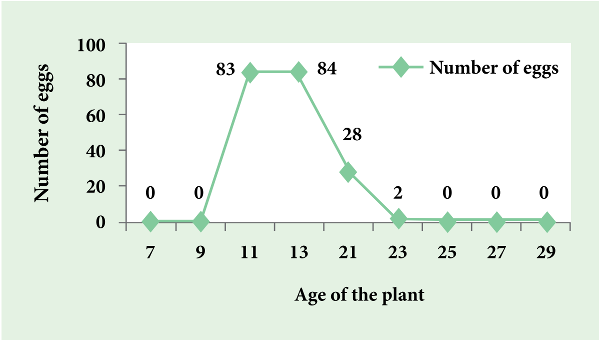


Figure 34. Trend of egg laying in relation to plant age (mean of 72 germplasm) Pest management in maize through habitat management

Habitat management including cowpea as intercrop and sorghum as trap crop in maize for stem borers was practiced at IIMR farm, Ladhowal, Ludhiana. *Sesamum* (T) and marigold (Mari) were raised as alternate source of pollen, nectar and shelter for adult parasitoids. Maize (M) with *Sesamum* and marigold was found best in terms of LIR (1.25) and percent dead hearts (0.01)

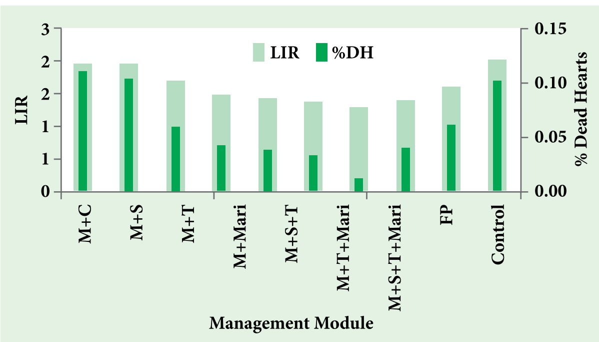


Figure 35. Leaf injury rating (LIR) and dead hearts (per cent) due to Chilo partellus in different management practices at IIMR farm, Ladhowal, Ludhiana

observed at 30 DAG. Intercropping of sorghum with marigold on borders of maize crop was found the next best treatment. The plant damage in the form of leaf injury and dead hearts was less than control in all the treatments (Figure 35). The results were compared with famer's practice (FP) and control.

Crop loss assessment due to *Chilo partellus*

The crop loss in maize due to *C. partellus* was estimated in 17 plots using the formula generated during *kharif*, 2013 (Table 18).

Table 18. Assessment of crop losses due to *Chilo partellus*

	Plot No.	Loss due to Chilo (%)	Estimated yield (t/ha)	Actual yield (t/ha)	Total loss (%)
Permanent Bed	1	4.11	5.95	4.00	15.60
	2	4.72	5.96	5.15	12.81
	3	2.29	6.06	3.71	40.29
Zero Tillage	4	1.54	6.11	4.25	38.00
	5	0.89	6.15	4.12	29.97
	6	0.39	6.18	4.44	32.68
	7	0.17	6.19	4.53	28.26
Conventional Tillage	8	0.55	6.17	3.88	26.89
	9	0.33	6.18	4.52	36.97
	10	0.43	6.18	3.69	26.89
	11	0.90	6.15	4.00	40.10
PMH1	12	13.48	4.55	4.38	3.18
	13	11.06	4.67	4.50	3.22
	14	19.56	4.23	4.00	4.25
	15	15.46	4.40	4.25	3.60
	16	22.86	4.05	4.00	0.93
DKC 9125	17	9.89	4.00	4.75	3.75

The average total yield loss of 17 locations was observed 20.43 percent out of which 6.39 percent loss was caused due to *Chilo* infestation and 14.04 percent loss was due to other biotic and abiotic factors.

4

Extension and Outreach

Agriculture extension is an essential pillar for rural upliftment and agricultural research and development. The dissemination of information including improved seeds, fertilizers, implements, pesticides, improved cultural practices, and livestock create awareness of improved agricultural technologies among the farmers. This leads to assessment, refinement and demonstration of technology/products by the scientists. Agriculture Extension Services focuses on enhancing farmers' knowledge about crop techniques and helping them to increase productivity through training courses, farm visits, front line demonstrations, kisan melas, kisan clubs, extension bulletins and the like.

Front Line Demonstrations

To demonstrate the latest technologies related to maize cultivation under ISOPOM programme, frontline demonstrations were conducted at farmers' level in each *rabi*, *kharif* and spring seasons. During the *rabi* 2013-14 and spring 2014 season 1488 and 566 demonstrations conducted covering the states *viz*., Andhra Pradesh, Assam, Bihar, Delhi, Gujarat, Maharashtra, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Tamil Nadu, Tripura and Uttar Pradesh; and Arunachal Pradesh, Bihar, Chhattisgarh, Delhi, Haryana, Punjab, Odisha, Rajasthan and Uttar Pradesh states, respectively under the Front Line Demonstrations scheme of Government of India. The beneficiaries belong to different communities to the tune of 37.3, 10.0, 31.5, 17.6 and 3.6 percent to general caste, schedule caste, schedule tribes, other backward caste and minority. Under the front line demonstrations, improved production technologies recommended for the different states were demonstrated *viz.*, latest hybrids, crop production and protection technologies, quality protein maize *etc.* during *rabi* 2013-14. The yield ranged from 2069 to 8376 kg/ha with the percent increase of 3.51 to 180.78 over state average yield in Mizoram and Andhra Pradesh, respectively While during spring 2014, average yield ranged between 4433 to 6846 kg/ha with 60.4 to 307.0 % increase state average of Chhattisgarh and Haryana, respectively.

Under the NFSM scheme of Government of India 1405 front line demonstrations were conducted during *kharif* 2014 in 13 states *viz.*, Andhra Pradesh, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh and Uttrakhand. The percentage of farmers belonging to different communities covered under front line demonstrations were 21.6, 11.3, 57.8 and 9.3 percent under general caste, schedule caste, schedule tribes and other back ward caste, respectively. The women farmers' percentage was 8.1% during this season (Table 19). The state specific improved production technologies *viz.*, hybrids cultivation, crop production and protection technologies, quality protein maize *etc.* were demonstrated. Compared to the state average yield, the percent increase in yield under front line demonstrations ranged from 3.19 to 233.4 with the minimum and maximum yield of 1648 to 6843 kg/ha.

Table 19. Season wise distribution, achievements and beneficiaries of frontline demonstrations on maize in India

No. of FLDs (acre)	Number of beneficiaries						Average yield range (t/ha)	% increase over state average	States covered
	General	SC	ST	OBC	Others	Total			
***Rabi*, 2013-14**									
1488	554	176	500	326	42	1598	3.68 – 8.38	3.5 to 180.8	Andhra Pradesh, Assam, Bihar, Gujarat, Maharashtra, Madhya Pradesh, New Delhi, Odisha, Tamil Nadu, Uttar Pradesh, Mizoram, Nagaland, Manipur, Tripura, Meghalaya
Spring, 2014									
566	257	43	188	57	36	581	4.43-6.80	60.4 to 307	Arunachal Pradesh, Bihar, Rajasthan, Uttar Pradesh, Haryana, Punjab, Odisha, Chhattisgarh, New Delhi
***Kharif*, 2014**									
1405	186	93	458	81	-	818	1.65 – 6.84	3.2 to 233.4	Andhra Pradesh, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand

Tribal Sub Plan scheme

To acquaint with the latest technologies and uplift the economic condition of tribal farmers, a scheme *viz.,* Tribal Sub Plan was launched by the Government of India. The Indian Institute of Maize Research implemented this scheme in various forms as, skill enrichment through trainings, field days and field visits, demonstration of technologies at farmers field; and supporting tribal farmers by providing various farm inputs like seed of hybrids, fertilizers, small farm implements *etc.*

During 2014, 171 demonstrations were carried out at tribal farmer's field by Indian Institute of Maize Research through its AICRIP centers in the states of Maharashtra, Karnataka, Uttar Pradesh, Odisha, Madhya Pradesh and Andhra Pradesh. The mean yield under the demonstration varied from 2875 to 6555 kg/ha with the % increase of 9.1 to 87.9 over average state yield in the state of Madhya Pradesh and Andhra Pradesh, respectively. The Indian Institute of Maize Research organized ten National level trainings comprised of three days at New Delhi and one Regional level training at RMR and SPC, Begusarai for tribal farmers of the different parts of the country. The tribal farmers belonging to Assam, Andhra Pradesh, Bihar, Chhattisgarh, Delhi, Gujarat, Jammu and Kashmir, Jharkhand, Madhya Pradesh, Odisha, Rajasthan and Uttar Pradesh states participated in these training programmes. The women participation in these training programmes was 7.4 %.

The trainings were conducted on various aspects of maize production system covering all the latest technologies related to production; protection and value addition (Table 20). The farmers were also exposed to preparation of various value added products at domestic level. They themselves prepared the different items under the guidance of scientists. The farmers were also benefited through visiting the National level Hybrid Demonstration Programme organized by the Institute. During the training programme farmers also visited the fields of progressive farmers located in National Capital Region and during these visits farmers were not only exposed to maize and specialty corn technologies but also the other technologies like poly house crop production techniques, mushroom cultivation and resource efficient technologies. The inputs like seed of latest hybrid and maize shellers were also distributed to the trainee farmers. The literature in the form of posters and booklets on covering all aspects of maize technologies were also provided to these farmers, so that they may teach other farmers in their villages.

Table 20. Tribal Sub Plan Training Programme, 2014-15

Date	Training	No. of farmers participated
National Training Programme conducted at ICAR- IIMR, Delhi		
September 10-12, 2014	Improved production and value addition technologies for specialty corn	49 farmers
September 17-19, 2014	Production system and value addition in maize	47 farmers
September 24-26, 2014	Maize production and value addition technologies increasing income of farmer	36 farmers
October 8-10, 2014	Improved production and value addition for technologies specialty corn	44 farmers
March 17-19, 2015	*Uttam Jivikoparjanan haitu makka parddat fasal sanghnikaran evam mulya sanvardhan*	22 farmers
March 24-26, 2015	*Makka utpadan evam mulya sanvardhan ki navintam prodhogiki*	38 farmers
March 26-28, 2015	*Vishist makka utpandan evam mulya sanvardhan*	40 farmers
Regional level Training		
October 17, 2014 RMR& SPC, Begusarai (Bihar)	Maize production technologies	59 farmers
December 12, 2014 Bordeivat, Abhona, Kalwan (Maharashtra Dist. Nasik)	Sweet Corn cultivation	25 farmers
December 17-19, 2014 RMR & SPC, Begusarai (Bihar)	*Purvi chetro mein makka ki vegyanik taknikiya*	

Dr. J.P. Sharma Joint Director (Extension), IARI, New Delhi distributing inputs to tribal farmers during training programme

Dr. D.P. Malik Additional Commissioner (Crops), Government of India distributing certificates to the tribal farmers

Field day under the TSP at Siru Vattukadu village in Dindigul district, Tamil Nadu

Visit at demonstration plot under TSP at Rangareddy district during *kharif* 2014.

Tribal farmers attending the training on value addition of maize

Tribal framers visited field of Regional Maize Research & Seed Production Centre, Begusarai

Participation in Exhibition/Kisan Melas/ Science Congress

In order to boost up farmers, youth and industry people to take up maize cultivation, seed production and value addition etc., IIMR actively participated in Kisan Melas and exhibitions by putting up their stalls. Technical bulletins both in Hindi and English were also distributed.

ICAR received the best stall award in International Agriculture and Horticulture Expo 2014 in which ICAR-IIMR participated from July 25-27, 2014 at Pragati Maidan, New Delhi

ICAR-IIMR participated in exhibition in “National symposium on agriculture diversification for sustainable livelihood and environmental security” at P.A.U. Ludhiana from November 18-20, 2014

ICAR-IIMR participated in 12th Agricultural Science Congress, India Expo held at NDRI Karnal from February 03-06, 2015

Strengthening and Refinement of Maize AgriDaksh

Database related to maize hybrid updated in regional languages Telugu, Urdu and Punjabi. The information and images of varieties, weeds and disorders of maize; static pages of pop corn and technical or popular articles in hindi were added in the knowledge base of the system. Farmer's or other user's questions were answered by maize Agridaksh Team.

All India Coordinated Research Project (AICRP)

5

All India Coordinated Research Project (AICRP)

All India Coordinated Maize Improvement Project (AICMIP) was initiated in 1957 with the objective to develop and disseminate superior cultivars and production/protection technologies. It is an oldest and first in a series of co-ordinated research under the ICAR system for varietal testing across different agro-climatic zones, presently known as AICRP on Maize. Based on agro-climatic conditions, country has been demarcated into five zones (Figure 36) constituting 30 centres (Table 21) 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 21. Locations and soil characteristics of the various AICRP Maize Research Centres of Indian Institute Maize Research

Zone	States	Centres	Latitude	Longitude	Altitude (masl)	Soil Type
Zone 1	Himachal Pradesh	CSK, Himachal Pradesh Krishi Vishwavidyalaya, Bajaura	33°22' N	77°0' E	1090	Grey wooded Podzolic soil
		Himachal Pradesh Krishi Vishwavidyalaya, 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), Gossain Gaon, Assam	26°45' N	94°13' E	91.0	Sandy loam
Zone II	Punjab	Punjab Agricultural University, 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 Agricultural Research Institute, Pusa, New 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, Pantnagar	29°6' N	79°30' E	243	Clay loam

Zone	States	Centres	Latitude	Longitude	Altitude (masl)	Soil Type
Zone III	Bihar	Rajendra Agricultural University, Dholi	25º54' N	85º36' E	51.8	Sandy loam
	Jharkhand	Bisra Agricultural University, Ranchi	23º21' N	85º20' E	652	Sandy loam
	Orissa	Orissa University of Agriculture and Technology, Bhubaneswar	20º14' N	85º50' E	45	Clay loam
	Eastern Uttar Pradesh	Banaras Hindu University, Varanasi	25º20' N	83º0' E	128.93	Sandy loam
		Narendra Dev University of Agriculture and Technology Bahraich	27º35' N	81º36' E	130	Sandy loam
Zone IV	Karnataka	University of Agricultural Sciences, Bangalore, Mandya	12º33'N	76º54' E	695	Light red sandy loam
		University of Agricultural Science, Dharwad, Arbhavi	16°13' N	74°48' E	640	Black soil; Medium black
	Andhra Pradesh	Professor Jayshankar Telangana State Agricultural University, Hyderabad	17º23'N	78°29' E	530	Black Clay loam
		Professor Jayshankar Telangana State, Karimnagar	18º26'N	79°9' E	869	Red sandy-loamy
	Tamil Nadu	Tamil Nadu Agricultural University, Coimbatore	11º0'N	76º58' E	411.5	Black
		TNAU, Vagarai	10°35' N	77°34' E	926	Black
	Maharashtra	Maharashtra Shahu Agricultural School Campus, Line Bazar Kasba- Bawada, Kolhapur	21º0' N	77º52' E	574	Light to medium black
Zone V	Rajasthan	Maharana Pratap University of Agriculture and Technology, Banswara	23º33' N	74º27' E	218	Red loam
		MPUA&T, Udaipur	24º35' N	73º41' E	572	Loam to sandy loam
	Gujarat	Anand Agriculture University, Godhra	22º45' N	73º38' E	119.4	Sandy loam
	Madhya Pradesh	Jawaharlal Nehru Krishi Viswa Vidyalaya, Chhindwara	22º4' N	78°56' E	682	Medium clay
		Rajmata Vijayaraje Scindia Krishi Viswa Vidyalaya, Jhabua	22º46' N	74º36' E	318	Clayey to Sandy
	Chhattisgarh	RMD College of Agriculture and Research Station, Ajirma, Ambikapur, - Surguja	23º7' N	83º12' E	1978	Sandy loam

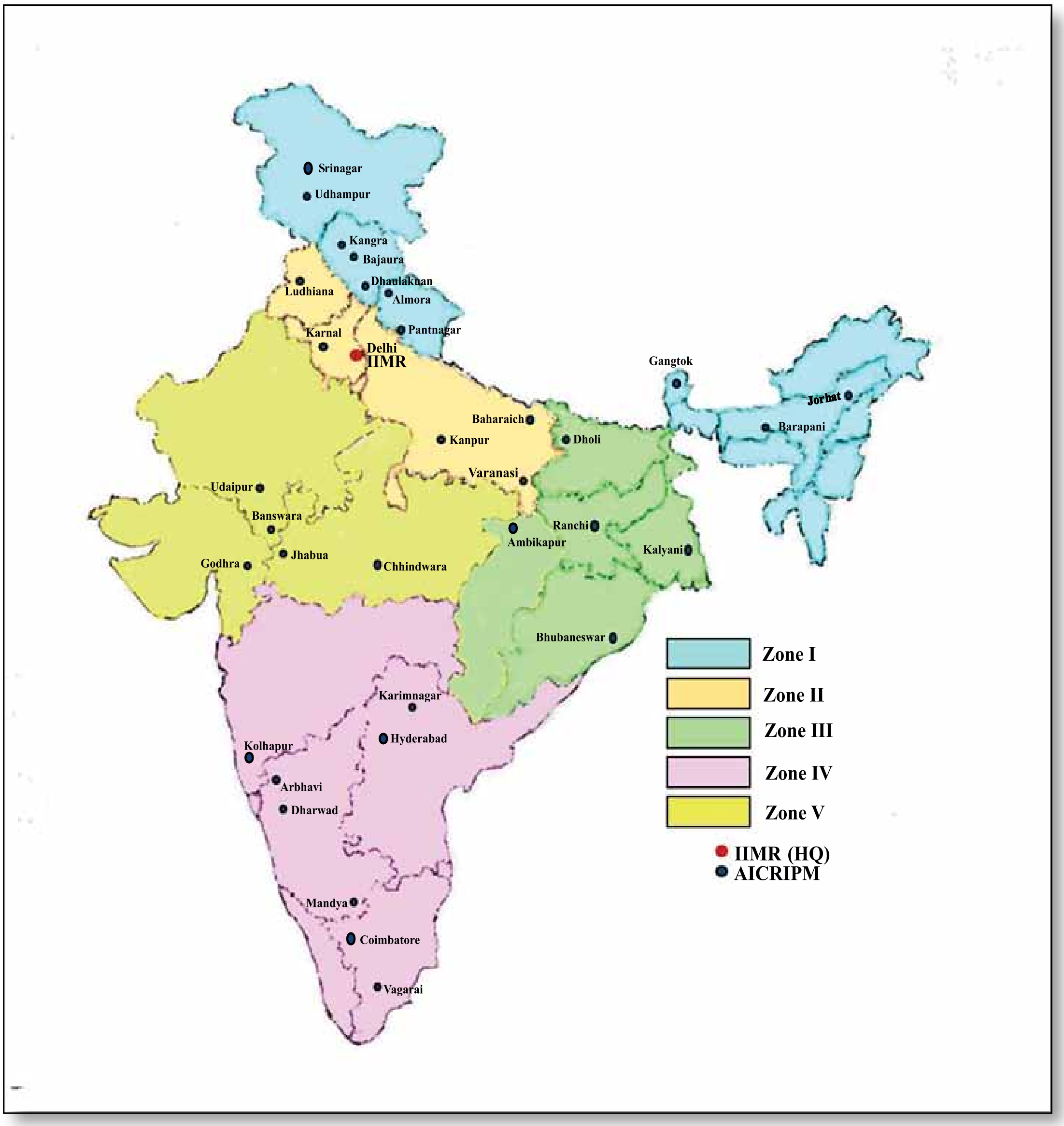


Figure 36. Existing Zones and Project centres of the Indian Institute of Maize Research

AICRP trials conducted during 2013-14

Breeding

Evaluation and Promotion of test entries of *rabi* 2013-14 trials

During *rabi* 2013-14, a total of 97 test entries were evaluated at eighteen locations across the country in nine different breeding trials. Data was recorded, reviewed and analyzed for yield and its related traits. Entries were promoted based on their performance with respect to best check in each zone. After review, a total of 56 hybrids were promoted for their advance stage of testing during *rabi* AICRP trials. Out of 56 entries, 34 were promoted from IVT to AVT-I, 21 from AVT-I to AVT-II and 1 from quality protein maize trial I (QPM-I) to quality protein maize trial II (QPM-II).

Constitution of AICRP *kharif* 2014 trials

During *kharif*, a total of 414 entries were evaluated in coordinated trials, of which, 261 entries were received from public and 153 were from private sector. Fifteen different breeding trials were constituted and were evaluated at 60 different locations across the country. Details of the entries (in number) belonging to different maturity groups are given in Table 22.

Table 22. Number of public/private maize hybrids received for testing in AICRP multi-location trial *kharif* -2014

Initial Varietal Trial (IVT)				
	Late Maturity	Medium Maturity	Early Maturity	Extra Early Maturity
Public	55	90	39	11
Private	60	35	7	0
Total	115	125	46	11
Advance Varietal Trial-I (AVT-I)				
	Late Maturity	Medium Maturity	Early Maturity	Extra Early Maturity
Public	1	11	15	2
Private	19	13	5	1
Total	20	24	20	3
Advance Varietal Trial-II (AVT-II)				
	Late Maturity	Medium Maturity	Early Maturity	Extra Early Maturity
Public	0	0	4	NIL
Private	3	2	1	NIL
Total	3	2	5	NIL
Specialty Corns Trials				
	QPM1-I-II-II	SC1-I-II-II	PC-1-II-II	BC-1-II-II
Public	12	8	8	5
Private	0	5	0	2
Total	12	13	8	7

Constitution of AICRP trials for multi-locations evaluation during *rabi* 2014-15

During *rabi*, a total of 128 entries were received from public and private sectors for multi-location testing in coordinated AICRP trials. Of 128 test entries, 47 were received from public and 81 from private sectors. A total of nine different breeding trials were constituted and allotted to the 18 co-ordinated centres across the four zones of the country. During the season only quality protein maize trials were conducted whereas extra early, specialty corns trials were not conducted. In zone -I which includes hill regions of the country, no trials were allotted there. From 2014-15 *rabi*, no early trials are allocated during *rabi* season because of less suitability of early and extra early hybrids and more suitability of late hybrids in production ecology of *rabi* season (Table 23).

Table 23. Number of public/private maize hybrids received for testing in AICRP multi-location trial *kharif* -2014

Initial Varietal Trial (IVT)			
	Late Maturity	Medium Maturity	Early Maturity
Public	8	23	NIL
Private	29	8	NIL
Total	37	31	NIL
Advance Varietal Trial-II (AVT-II)			
	Late Maturity	Medium Maturity	Early Maturity
Public	4	5	1
Private	17	6	0
Total	21	11	1

Advance Varietal Trial-II (AVT-II)			
	Late Maturity	Medium Maturity	Early Maturity
Public	1	1	2
Private	15	5	1
Total	16	6	3
Quality protein maize (QPM)-I-II-I			
	Public	Private	Total
	2	0	2

Agronomy

In *kharif*, agronomic research focused on nutrient application, planting density optimization of pre-released maize hybrids, identification of suitable intercrop/s, planting pattern in rainfed areas with residue management, site specific nutrient management (SSNM), tillage systems and organic manuring for maize production. In *rabi*, the work focused on pre released genotypic response to nutrient (NPK) levels, nutrient and tillage practices under various cropping system with maize.

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

A total of 17 pre-release hybrids of different maturity groups under AVT-2 were evaluated with 9 national checks under two densities (Normal and High) and two nutrient levels (N: P2O5: K_2O kg/ha) *i.e.* 150:50:60 and 200:60:80 for early maturity hybrids. Medium and late maturing hybrids evaluated with 200:65:80, 250:80:100 nutrient levels at 17 centers across the country. In *rabi* 2013-14, the pre-release late and medium maturing genotypes evaluated under different nutrient levels of (150:65:65, 200:80:80 and 250:95:95 N: P2O5: K_2O kg/ha) in zone II (Pantnagar, and Ludhiana), zone III (Bahraich and Dholi), zone IV (Arbhavi, Karimnagar and Vagarai) and zone V (Banswara).

Effect of planting systems and intercropping with and without residue retention under rain-fed condition

In order to find out suitable intercrop and residue management options for enhancing rainfed maize productivity, an experiment was conducted at seven locations during *kharif*. The retention of residue enhanced maize productivity at Bajaura, Ranchi, Ambikapur, and Banswara while there was no significant effect at Srinagar and Bhubneshwar. Residue retention @ 5 t/ha, enhanced maize yield by 9-29% at Ranchi and Bajaura respectively. Intercropping of maize with soybean or blackgram was effective at Bajaura, Ambikapur, Ranchi, Banswara and Udaipur while cowpea at Srinagar and groundnut was best intercrop at Bhubneshwar. Overall, the mean maize productivity gained in this situation to the tune of 7099 kg/ha. Planting of maize in paired row (84:50 cm) resulted higher yield by 5 to 11% at Ranchi, Ambikapur, Banswara and Udaipur while uniform row (67cm) planting was significantly superior with 7.6 to 29% yield increase at Srinagar and Bhubneshwar.

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

The experiments were conducted at five locations to find out effective SSNM and tillage practices for yield maximization in intensified cropping system. The zero tillage planting of maize resulted increase in yield by 8.0 and 17.5% over conventional tillage system, at Karnal and Banswara, respectively. However, the method of conventional tillage planting gave higher yield at Pantnagar and Udaipur. Among the nutrient management practices SSNM resulted in significantly higher yield at Pantnagar, Banswara and Chhindwara, while farmers fertilization practices (FFP) resulted significantly higher yield at Karnal and Udaipur.

Nutrient management in maize based rainfed cropping systems under different tillage practices

Effective SSNM and tillage practices for yield maximization in emerging cropping system were studied at four locations. Maize under zero tillage resulted 20.5, 12.1 and 10.3% significantly higher yields over conventional tillage system at Kashmir, Delhi and Banswara, respectively. However, the method of conventional tillage planting gave higher yield at Chhindwara. Amongst nutrient management practices SSNM resulted in significantly higher yield at Delhi, while it remained at par with 100% recommended fertilizer practices (RDF) at Kashmir, Banswara and Chhindwara.

Nutrient management for maize genotypes under different cropping systems

The trial was conducted at thirteen locations under maize-wheat system. Among the nutrient management practices, SSNM based on the nutrient expert gave 13.6, 4.5, 5.8, 12.8, 10.3, 22.1, 13.7, 22.9 and 9.0% higher yield of maize over recommended fertilizer practices (RDF) at Bajaura, Kangra, Ludhiana, Ranchi, Ambikapur, Banswara, Chhindwara, Jhabua and Udaipur, respectively. However, RDF resulted better at Kashmir and FFP resulted significantly better at Karnal (210:95:50 kg N: P2O5:K2O) and Hyderabad (215:90:50 kg N: P2O5:K2O) due to higher use of fertilizers by farmers. Among the various maize hybrids tested, significantly high yield of PMH-3 at Bajaura, Chhindwara, Jhabua and Ludhiana, PAC-740 at Kangra, DKC-7074 at Kashmir, CMH-08-292 at Karnal, Hyderabad, Banswara and Jhabua, CMH-08-350 at Ranchi, CMH-08-287 at Arbhavi and DHM-117 at Karimnagar was obtained over other hybrids.

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

This experiment conducted to maximize the yield of hybrids through planting density and nutrient management optimization at 17 locations. The hybrids responded to high density at Ludhiana, Bhubaneswar, Arbhavi, Banswara and Udaipur centre by 5.7, 6.2, 4.3, 13.8 and 11.2% higher yield over normal density, respectively. While at Pantnagar, Kashmir, Ranchi, Hyderabad, Karimnagar and Ambikapur they responded to normal planting density. Among various nutrient management practices SSNM resulted in significantly higher yield at Ludhiana, Kashmir, Dholi, Banswara and Chhindwara while STCR was found significantly superior at Karnal, Pantnagar, Bhubaneswar, Ranchi, Hyderabad, Godhra and Udaipur, respectively. However RDF proved better only at Bahraich centre.

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

In order to explore the possibilities of organic maize production, one long term experiment was initiated in *kharif* 2014. Significantly highest maize grain yield was obtained with 100% RDF + 5 t/ha FYM. However, 100% RDF was found at par with 10 t/ha FYM + *Azotobacter* application which show that the organic maize production can be possible in lower foothill Himalayas. Economic analysis showed a new path for organic maize cultivation and it was found that maize + cowpea as intercrop with FYM 10 t/ha + *Azotobacter* resulted in highest net returns with B: C ratio of four.

Pathology

Survey and surveillance of maize diseases

Maize disease survey and surveillance was conducted in maize growing areas of Bhubaneswar (Odisha), Ludhiana (Punjab), Almora, Pantnagar (Uttarakhand), Bajaura, Dhaulakuan, Sirmour, Solan, Bilaspur, Hamirpur, Kangra, Una (Himachal Pradesh), Arabhavi (Karnataka), Udaipur (Rajasthan) and in Gujarat during the cropping season 2014.

In Odisha a total of 4 places were covered, where disease Banded Leaf and Sheath Blight (BLSB) was most severe and Maydis Leaf Blight & Turcicum Leaf Blight (MLB & TLB) was moderate to traces. In Punjab a total of six areas were covered where BLSB, MLB, Bacterial Stalk Rot and Post Flowering Stalk Rot were recorded in low to moderate incidence. In Himachal Pradesh the incidence of BLSB, MLB and TLB were recorded in severe and Curvularia Leaf Spot (CLS), Brown spot and BSR was in traces from eighteen places. Incidence of MLB, TLB and BLSB was severe in Pant Nagar and Almora from Uttarakhand whereas CLS was in traces. In Rajasthan, a total of twelve places were covered where incidence of Rajasthan Downy Mildew, MLB and PFSR was recorded from moderate to severe. Based on the survey surveillance a disease map was updated (Figure 37).

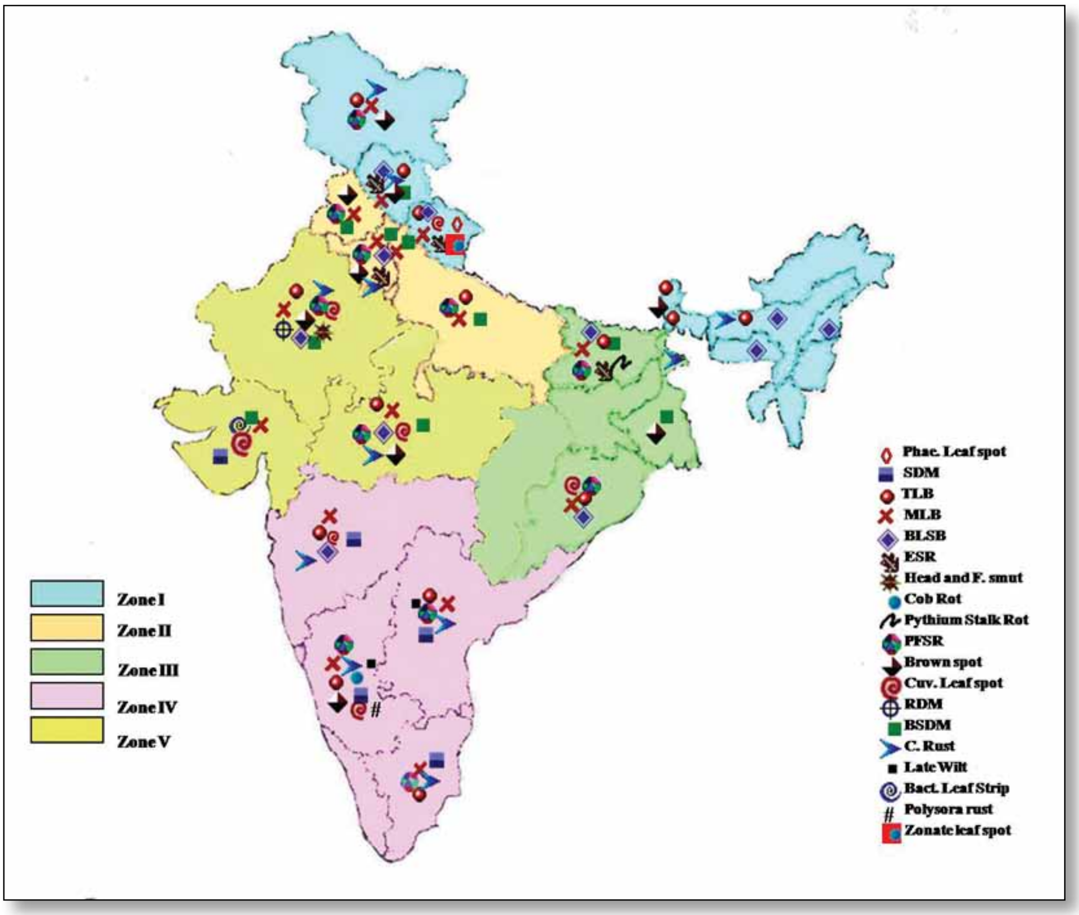


Figure 37. Disease distribution map based on disease survey 2014 *kharif*

Coordinated trials

During the reporting period a total of 18 disease evaluation trials (17 in *kharif* and 1 in *rabi*) were conducted under artificially epiphytotics at identified hot spot locations *viz.*, Bajaura, Almora, Dhaulakuan, Barapani (Zone I). Ludhiana, Delhi, Karnal, Pantnagar (Zone II). Dholi, Bhubaneswar, Midanapur (Zone III). Arbhavi, Coimbatore, Mandya Hyderabad (Zone IV) Udaipur (Zone V). A total of 551 hybrids in both seasons and 231 inbred lines (*kharif* only) 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 24.

During *rabi* a total of 96 genotypes were evaluated (Table) against major diseases of maize under artificially created epiphytotics at various hot spot locations i.e. sorghum downy mildew (SDM) at Coimbatore and Mandya; charcoal rot (C. Rot) at Arabhavi, Ludhiana and Hyderabad; banded leaf and sheath blight (BLSB) at Midnapur and turcicum leaf blight (TLB) at Dholi. The promising hybrids are enumerated below (Table 25):

Table 24. Promising genotypes with combined diseases resistance

Major Diseases	Promising entries with multiple disease resistance
IVT (late maturity) - 120	**Genotypes (96)**
MLB, C.ROT, FSR, RDM, CLS	IN 8569
MLB, TLB, RDM, CLS	HT 51412616
MLB, RDM, BSR, CLS	Proline-2404
MLB, C.ROT, RDM, BSR, CLS	PM 14101L
C.ROT, RDM, BSR, CLS	JH 12150
MLB, C.ROT, FSR, RDM	PMH 1-C
C.ROT, FSR, RDM, CLS	PMH 3-C
IVT (medium maturity) - 129	**Genotypes (116)**
C.ROT, FSR, RDM, BSR	JH 13172
C.ROT, FSR, BSR, CLS	DMRH 1417
MLB, FSR, RDM, BSR	HT 51412182
TLB, FSR, RDM, CLS	LMH 114
MLB, TLB, FSR, RDM	JH 13119
TLB, FSR, RDM, BSR, CLS	DMRH 1308
C.ROT, FSR, BSR, CLS	JH 13122
MLB, FSR, RDM, CLS	DMRH 1418
C.ROT, FSR, RDM, BSR, CSL	CMH 11-584
TLB, C.ROT, FSR, CLS	JH 13224
IVT (early maturity) - 51	**Genotypes (45)**
MLB, C. ROT, FSR, RDM	CMH 12-675
FSR, RDM, CLS	KMH 12-18, AH-1321
MLB, C. ROT, FSR, RDM, CLS	CMH 10-527
MLB, FSR, CLS	JKMH 4025, CMH 10-552
FSR, RDM, CLS	FH 3695, BH 412055
IVT (extra early maturity) - 13	**Genotypes (12)**
FSR, CLS	EH-2236, AH-1317
FSR, RDM	DH 287
FSR, RDM, CLS	Vivek Hybrid-43(C)
AVT I & AVT II (late maturity) - 27	**Genotypes (26)**
C.ROT, FSR, CLS	RMH-972
MLB, FSR, RDM, CLS	Siri 4527
MLB, FSR, CLS	JH 12247
FSR, CLS	Bio 032 (BB032)

Major Diseases	Promising entries with multiple disease resistance
MLB, C.ROT, FSR, RDM, BSR, CLS	CP.999
MLB, FSR, RDM, CLS	DAS-MH-105
MLB, FSR, RDM, CLS	IM 8556
MLB, C.ROT, FSR, RDM, CLS	PMH 1-C
AVT I & AVT II (medium maturity) - 31	**Genotypes (31)**
C.ROT, FSR, BSR	LG 32.82
FSR, RDM, CLS	CMH 10-547, DKC 9144 (IM8478), DKC 9149 (IM8581), FCH 11231, S-6750
C.ROT, FSR, RDM	HTMH 5402
FSR, RDM, BSR	EHL 3412
FSR, RDM, CLS	Bio -9637(C)
AVT I & AVT II (early maturity) - 26	**Genotypes (25)**
MLB, FSR, RDM	FH 3669
MLB, FSR, CLS	CMH 11-611, CMH 11-629
MLB, FSR, RDM, BSR, CLS	EH-2214
AVT I & II (extra early maturity) - 10	**Genotypes (9)**
FSR, RDM, CLS	KH-7502, Vivek Hybrid-43(C)
MLB, FSR, CLS	PMH-1-F
FSR, CLS	BIO 9681-F, HM 10-F
MLB, FSR, RDM, CLS	PMH3-F

Table 25. The promising hybrids identified for important diseases

Genotype	Disease	Reaction
A 7501, NMH-1247, PRO-385, X 35B349, GK 3149, Venus, Megan-G, PMH-189, X 35C537, DADA, CP-999, GK 3118, IM 8222, CSM 1, KMH-4210, Bio 9662, DMRH 1302, AH 1315, NMH-51, IM 8013, IL 8033, IH-061, DMRH 1304, AH 1313	TLB	Resistant
A 7501, X 35B349, GK 3150, NMH-51	SDM	Resistant
A 7501, Bisco X 5141, NMH-1247, PRO-385, X 35B349, Bisco X 6573, X-1228, KH-K25 Gold, II 8212, DKC 9120, IL 8534, X 35C537, P 3533, TH 22, CP-838, CP-999, CP-111, GK 3118, GK 3155, HTMH 5108, HTMH 5202, KH-2192, KMH-1411, IM 8226, Rasi 393, Rasi 950, VEH 13-1, CSM 1, JH 248, DMRH 1308, , KH-K26, IJ 8521, IL 8536, IL 8537, IJ8214, BL 798, BL 900, KH-517, IM 8303, VaMH 08015, CSM 2, DMRH 1301, DMRH 1302, DMRH 1306, DMRH 1307, AH 1314, AH 1315, B-52, IM 8013, IL 8033, IL 8235, IH-072, IH-061, IHQ-091, DMRH 1303, DMRH 1304, DMRH 1305, AH 1312, AH 1313, QPM-3, MMHQPM-6-12-13	C. Rot	Moderately Resistant

Nematology

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

A total of 455 maize hybrids belonging to different maturity groups of initial and advance trials were screened for cyst nematode (*Heterodera zeae*). Of them, 28 entries *viz*., ADV 0990293, IN 8570, VNR 4325, JKMH 4023, JH13094, JH 13270, RMH-726, CMH 11-593, LMH 314, HT 51412607, JH 13121, JH 31607, CMH 11-584, DH 1405, DH 1401, CMH 12-697, CMH 12-691, AH-1320, X 35D601, CP. 999, DAS-MH-105, CMH 11-582, CMH 11-617, CMH 11-629, EH-2214, VIVEK QPM9-C, VEHQ 14-1, and CMH 11-659 exhibited moderately resistant reaction to *Heterodera zeae*.

Occurrence of maize cyst nematode in Rajasthan

Occurrence of cyst nematode (*H. zeae)* was to the tune of 64.44% in maize growing areas. The maximum occurrence (75.00%) with highest population i.e. 10.33 cyst/plant, 12.67 cyst/100 cc soil and 520.00 larvae/100 cc soil was recorded from Gudli (Udaipur), whereas the minimum population (3.00 cyst/plant, 6.00 cyst/100 cc soil and 316.67 larvae/ 100 cc soil) with 75.00% occurrence recorded from Ramgarh (Ajmer). The other important plant parasitic nematodes like root lesion nematode (*Pratylenchus* spp.), lance nematode (*Hoplolaimus* spp.), stunt nematode (*Tylenchorhynchus* spp.) were also observed in the soil samples.

Identification of promising components for management of maize cyst nematode

Use of lantana leaf at 2 q/ha (*Lantana camara*) as organic amendment in soil is best option in reducing cyst nematode (*H. zeae)* population up to 28.35–41.75% followed by neem cake at 2 q/ha 31.35-45.26 per cent.

Effect of association of cyst nematode (*Heterodera zeae*) with Post flowering stalk rot pathogen (*Fusarium verticilioides*) and stem borer (*Chilo partellus*) in maize

Population of maize cyst nematode (*H. zeae)* is negatively correlated with stalk rot pathogens i.e. *Fusarium verticilloides* stem borer, *Chilo partellus.* Population of *H. zeae* declined from 11.60 to 15.18% when associated with *F. verticilloides,* whereas the population reduced from 31.11 to 34.51% when associated with *Chilo partellus*.

Entomology

Evaluation of germplasm from various maturity groups to identify resistance against *S. inference* and *Chilo partellus* under artificial infestation

A total of 44 maize germplasms screened against *Sesamia inferens* and *Chilo partellus* at Hyderabad and Kolhapur respectively in *rabi*. Of them entries A 7501, Bio 237 and X35B349 were promising to *S. inferens* and A 7501, Bisco X 5141, KMH-7148 and NMH-1247 to *Chilo partellus* by exhibiting LIR less than check in AVT II late maturity.

In AVT I-Late, entries GK 3149, GK 3150, X-1228, KH-K25 Gold, KMH-2589, IL 8534, Megan-G, Rasi-750, DADA and TH-2 were promising to *S. inferens* whereas Bisco X 6573, GK 3149, X-1228, KH-K25 Gold, II8212, IL 8534, Ivory, Megan G, Rasi 750, P 3533, DADA and TH 22 were promising to *C. Partellus.* In AVT II and AVT I medium, all the entries were promising as compared to check against *S. inferens* while, KH-K26 and KMH-4210 were promising to *C. partellus*. In AVT I-Early, KH-K25 was selected to *C. partellus,* while in QPM-3, VEHQ-11-1 was selected for both the stem borers.

A total of seventy-two germplasm were screened against shoot fly (*Atherigona soccata*) under natural infestation in spring. Of them fifty-seven genotypes were promising by exhibiting less than 3.0 percent dead hearts at 21 DAG, while genotypes S 58 (S87P66QBBB30), S 64 (DMSC28), S 65 (SC FEMALE) and S 67 (HKIPCBT3) were selected and being used for development of shoot fly tolerant hybrid at Ludhiana centre.

Screening of germplasm of different maturity groups

A total of 94 entries belonging to different maturity groups were evaluated against *C. partellus* under artificial infestation at Zone II and IV and V. The promising genotypes are enumerated in table 26.

Screening of inbred lines against *Chilo partellus* under artificial infestation

A total of 42 inbred lines were screened in Zones II, IV and V to identify resistant sources to *C. partellus,* exhibited variable reaction. In Zone I moderately susceptible (LIR=3.1-6.0) were 21 and same numbers were highly susceptible (LIR 6.1-9.0). In zone IV five genotypes *viz.,* WNZPBTL9, HKI 488 EARLY, CML 49, CML 482 and CML 227 were least susceptible (LIR ≤3.0) rest were susceptible. In Zone V: CML 49, Hybrid 9415-BBB-4, ABB CYC5342-1, P390AM/CMLC4F230 B2, AEBCYC534-3-1, HKI 326-3, CMl227, P63 C2-BBB 17B and CML 408 were found to be least susceptible whereas 24 moderately susceptible and nine highly susceptible

Multilocation testing of insecticides against *Chilo partellus*

In order to find out effective insecticides, four *viz.*, Chlorantriniliprole 20 SC, Flubendiamide 480 SC, Novaluron 10EC and Deltamethrin 2.8 EC were evaluated at five AICRP centres. Of them Flubendiamide 480 SC was most effective followed by Chlorantriniliprole 20 SC (Figure 38).

Evaluation of biocontrol agents against *Chilo partellus*

Egg parasitization; The parasitization was recorded on the freshly laid eggs by *C. partellus* by artificially releasing the adults on HQPM1 and PMH1 at 12 DAG covered by net cage Figure 39). The plants were harvested and the egg masses obtained were kept under ambient conditions for observing the emergence of parasitoids. No parasitization was observed at Delhi, Ludhiana, Karnal and Kolhapur while 1.32 percent parasitization by *Trichogramma* was recorded at Hyderabad this year.

Larval Parasitization The larvae collected from infested maize plants when reared in laboratory, resulted in 4.56, 2.95, 6.25 22.85, 35

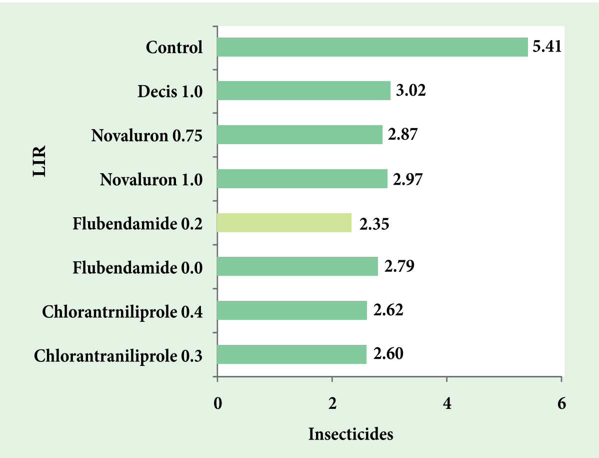


Figure 38. Leaf injury rating (LIR) observed against *Chilo partellus* in different treatments (mean of 5 locations)

Figure 39. Evaluation of biocontrol agents in maize ecosystem

Table 26: Entries with leaf injury rating (LIR) less than that of check

Maturity Group	Zone II	Zone IV	Zone V
Full Season	-	-	X35D601, DKC 9133(IM9133), DKC 9141 (IM8539), HTMH 5108, RMH 972, IM 8562, JANAHIT, PRO 392, PMH1-C and Bio 9681-C
Medium	S6750 TH38	-	DKC9149(IM8581), JKMH 4545, T 38, CMH 11-617, EH 2240, Bio 9637 (C) and HM8 C
Early maturity			LG31.81, MEH 1-12-13, CMH 11-6-11, EH 2214 and Prakash (C)
Extra Early			Vivek Hybreds 21 (C), Vivek Hybreds 43 (C) and Bio 9681-F

and 3.7 percent parasitization by *Cotesia flavipes* at Ludhiana, Karnal, Hyderabad, Delhi, Udaipur and Kolhapur respectively (Figure 40).

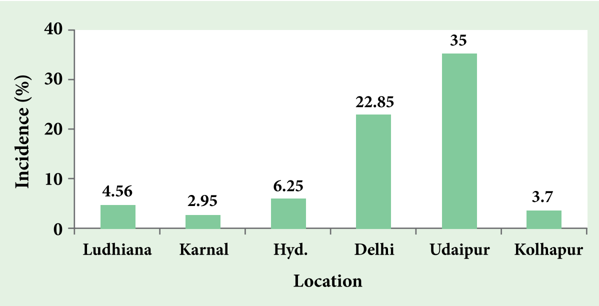


Figure 40. Percent incidence of *Cotesia* recorded at different locations

The incidence of *Cotesia* was found to be minimum 3.03 at 30 DAG crop while maximum larvae were found parasitized (18.42%) at 50 DAG maize crop (Figure 41). No parasitized larvae were recovered from dissected plants at 60 and 70 DAG.

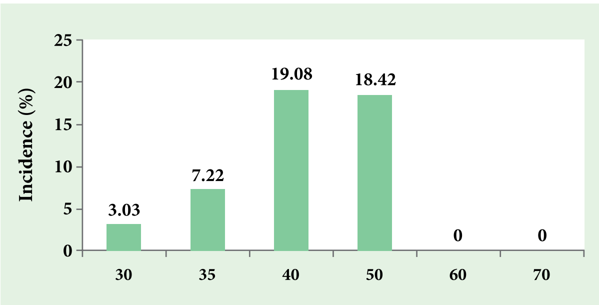


Figure 41. Incidence of Cotesia (%) at different plant age of maize (mean of 5 locations)

Cob borer complex

Insect and pests infestation in maize crop was monitored from tasseling to hard dough stage at various locations. Level of cob borer infestation was 16.93, 5.18, 2.0 and 1.14 and 26% at Ludhiana, Karnal, Hyderabad, Delhi and Udiapur respectively. The insects *viz.*, *Helicoverpa, Sesamia inferens, Spodoptera and Euproctis* were also observe in cobs. Varied incidence (33, 116, 50, 6.25 and 0.56%) of *Helicoverpa* infestation reported at Ludhiana, Karnal, Hyderabad, Delhi and Kolhapur respectively, whereas *Sesamia* noticed in Ludhiana with 13.6% infestation. At Hyderabad, infestation of cob with *Spodoptera* was 26% (Figure 42). Incidence of *Helicoverpa*,

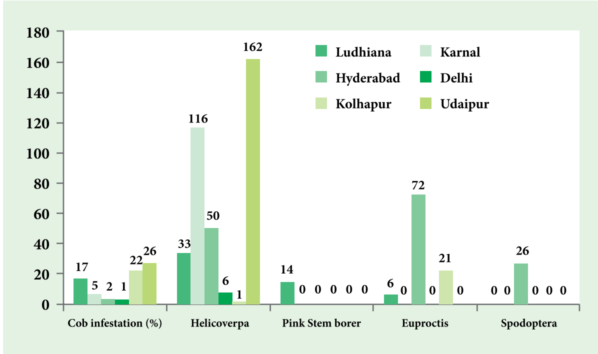


Figure 42. Cob borer complex and infestation level at six locations

Sesamia, Euproctis and *Spodoptera* was 61.27, 2.27, 16.47 and 4.33 percent respectively. Severe infestation of *Euproctis* (72%) was observed at Hyderabad while 21.23 and 5.6 % infestation was recorded at Kolhapur and Ludhiana respectively which is emerging as a potential cob borer other than *Helicoverpa* (Figure 43).

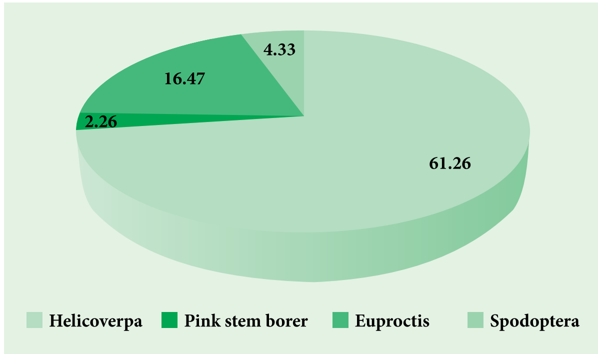


Figure 43. Percent incidence of different cob borers (mean of 6 locations)

Data mining and management of data generated through AICRP on maize:

Climate change and maize productivity in north-western plains regions of India

The full season maturity group grown during the monsoon (*kharif*) season in 'All India Coordinated Maize Improvement Project' trials from 1991 to 2012 in north western plains zone was analysed for grain yield for the best check and best entries. The rainfall trends were simultaneously analyzed in each month over years through Mann and Kendall approach. The total rainfall of the season averaged over 22 years for the maize crop season (July to October) in 'zone II' was from 511.2 mm.

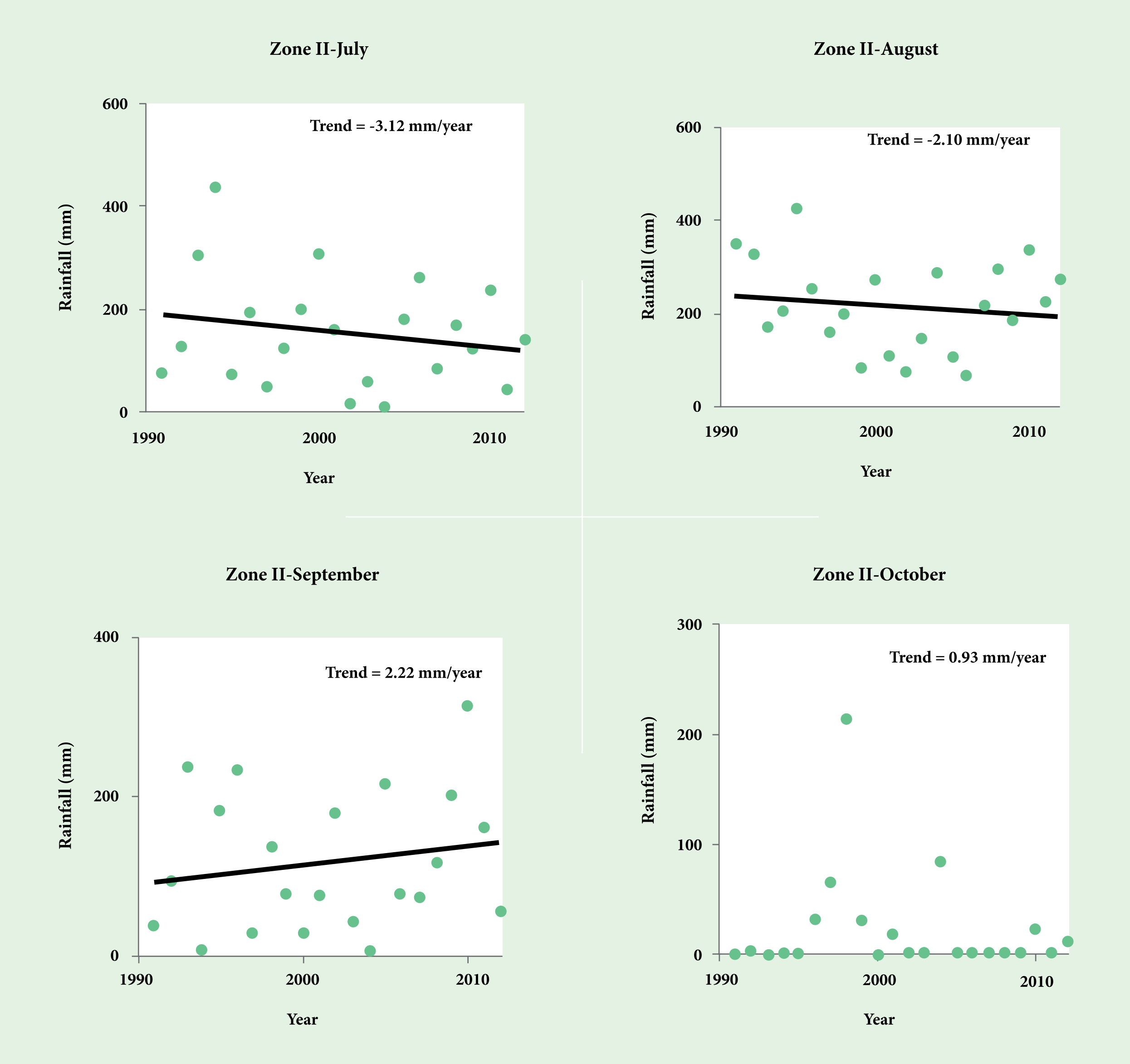


Figure 44. Rainfall trends in Zone II (North-Western Plains Zone) from July to October

In 'zone II', the monthly fluctuations in rainfall during maize cropping season are high during maize crop season and the trend was numerically decreased in all the months except for the month of September (Figure 44). Even though the increase or decrease in rainfall over years is not significant but the fluctuations in rainfall in each month over years was significant in all the months. In addition, there was increasing trend for maize yields since 1991 in 'zone II' as well as in Punjab state (Figure 45).

The new maize hybrids from AICMIP are superior even though there were wide and significant fluctuations in rainfall over years. Hence, AICMIP had an important contribution in overall increase in zonal yields of 'zone II' as well as Punjab state. The initial grain yield in zone II was higher than that in other zones but the yield gain was less in this zone in comparison to other zones. The yield gains in 'zone II' as expressed through trend was low i.e., 110.8 kg/ha/year. The yield fluctuation expressed for the best check was R2=0.384 and the best check was R2=0.469 in 'zone II'. In addition, the yield for the best entry was 6237.8±251.9 kg/ha and best check was 5798.7±248.7 kg/ha. On the other hand, the actual fluctuations and yield gains in Punjab and 'zone II' was given in Figure 2. There is need of more in order to achieve higher innovative technology in maize programme so as to break through in yield barrier in 'zone II' including Punjab state. In future, new innovative technology with more active maize improvement programme has a major impact in view of unpredictable rain patterns and changing climatic conditions.

Figure 45. Average productivity (kg/ha) of Punjab and Zone II (1990-91 to 2008-09)

6

Significant Events

Directorate of Maize Research upgraded to Indian Institute of Maize Research

In line with the rising importance of maize in the agricultural economy of the nation, the Central government has accorded its approval for up gradation of Directorate of Maize Research into a full fledged institute of ICAR with the name of **ICAR- Indian Institute of Maize Research**, with effect from 13.11.2014. The upgradation into an institute would not only strengthen the infrastructure for maize research, but it would also lead to better organizational management. Together with the upgradation, the XII Five Year Plan (2012-2017) of the institute has also been approved. The XII Plan would enable the institute to augment its research infrastructure, implement its flagship and other prioritized programmes, as well as strengthen the All India Coordinated Research Project (AICRP) on Maize. The intensified focus and investment would lead to better outcomes in 'public good' maize research and enable the institute to engage its stakeholder in a more entrenched manner. The genesis of the present day ICAR- Indian Institute of Maize Research lies in the historic event of establishment of the All India Coordinated Maize Improvement Project (AICMIP), way back in 1957. Being a pioneer project, the AICMIP (presently known as AICRP on Maize) holds a historical significance in the history of Indian agricultural research system. The Project was upgraded into Directorate of Maize Research on 28th January 1994. After more than 20 years of relentless service to the nation, the Directorate was upgraded into ICAR- Indian Institute of Maize Research on 13th November 2014.

57th Annual Maize Workshop

The erstwhile Directorate of Maize Research (DMR) and Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur, jointly organized the 57th Annual Maize Workshop at Udaipur from April 21-23, 2014. Dr. S.K. Datta, the then Deputy Director General (CS), who was the Chief Guest at the occasion, appreciated the efforts of maize researchers in developing high-yielding hybrids and production technology. He further said that India has still a long way to go to match the global productivity of 5.5 t/ha. He also highlighted the various challenges in the maize sector and extolled researchers not to shy away from using the best modern technologies for maize improvement. While throwing light on the global maize scenario vis-à-vis the Indian scenario, Prof. O.P. Gill, Vice-Chancellor who presided over the inaugural session stressed upon the need of genetic engineering and genomics for future maize improvement. Dr. R.P. Dua, the then Assistant Director General (Food and Fodder Crops) emphasized the need of maize based diversification of agriculture and also called for solving the weed problem in maize, especially during *kharif* season.

Dr. O.P. Yadav, Project Director reviewed the maize improvement work carried out during 2013-14 and informed that maize recorded

Dr. S.K. Datta, the then DDG (CS) addressing the 57th Annual Maize Workshop highest ever production of 22.23 million tonnes. Highlighting the flagship role played by the Directorate, he informed that this year a total of 651 germplasm lines were distributed by Directorate of Maize Research to various centres of the All India Coordinated Research Project on Maize.

The variety identification committee, which met during the workshop, identified 25 new hybrids of different maturity groups for cultivation in different seasons of various production ecologies in the country.

Dr. P.L. Maliwal, Director (Research) welcomed the delegates and presented a brief overview of research being undertaken at MPUAT. More than 200 delegates from different national and international research institutes, universities, government departments and seed industry participated in this workshop. On this occasion a

Release of CD on *Kharif* Progress Report during the workshop

CD on *Kharif* Progress Report and 4 other books were also released. The best performing maize research centres from public and private sectors were awarded.

Union Agriculture Minister visits Regional Maize Research and Seed Production Centre, Begusarai

The Union Agriculture Minister Sh. Radha Mohan Singh visited Regional Maize Research and Seed Production Centre (RMR&SPC) of the institute at Begusarai, Bihar on 14 September 2014. The Minister visited the seed production plots of maize and soybean and breeding block at Kusumahaut farm, 20 km away from Begusarai.

The Agriculture Minister closely observed the crossing experiments going on at RMR&SPC

Union minister appreciated the efforts of the institute in breeder seed production and its contribution in strengthening the seed chain to make improved seed available to farmers. He further emphasized the need to scale-up this activity so that fruits of research reach more number of farmers in a timely manner. Shri Singh called upon the scientists to strengthen research to develop climate-resilient maize to minimize the risk of crop production due to weather aberrations. He particularly emphasized development of drought tolerant maize for *kharif* season and highly productive maize hybrids for *rabi* season. Union minister interacted with farmers of regions and advised them to adopt improved cultivars and agro-techniques to raise the crop yields and net profit. He exhorted farmers to take care of soil health by adopting suitable and recommended doses of fertilizers and chemicals.

Project Director, DMR and In-charge RMR&SPC welcoming the Hon'ble Union Minister of Agriculture, Shri Radha Mohan Singh

Visit of Secretary, DARE & DG, ICAR to IIMR Ludhiana

The Director General (ICAR) and Secretary, Department of Agricultural Research and Education (DARE), Dr. S. Ayyappan visited IIMR labs and farm at Ludhiana. He assessed the progress made at experimental fields and store-cum field-lab at Ladhowal and appreciated the physical facilities created at IIMR transit camp in Punjab Agricultural University (PAU) campus. He was also apprised of the progress made in land transfer from State Government to ICAR. Dr. Ayyappan appreciated the developmental activities undertaken by IIMR scientists in initiating the conduct of experiments and commended PAU for providing the basic facility at farm and campus. Dr. B.S. Dhillon, Vice Chancellor, PAU also visited the IIMR labs.

Director General, ICAR and Former Director General, CIMMYT appreciated maize improvement programme

Dr S. Ayyappan, DG, ICAR and Dr Masa Iwanaga, President, Japan International Research Center for Agricultural Sciences (JIRCAS) and Former DG, CIMMYT and Dr SK Datta, DDG (CS), ICAR visited experiments and breeding nurseries at the institute during *kharif* 2014. Dr Ayyappan appreciated the efforts of the institute in developing the hybrids suitable for different ecologies of the country which have made a huge impact on crop productivity. He asked the scientists to scale up adoption of hybrids through public-private partnership which is a major strength of National Agricultural Research

Dr. S. Ayyappan, DG, ICAR, keenly observing experiments at the breeding nursery

Dr. S. Ayyappan, DG, ICAR visiting the lab facilities created at IIMR Ludhiana

Dr O.P. Yadav, Director IIMR explaining the ongoing experiments to Dr. Masa Iwanaga, President, JIRCAS and Dr S.K. Dutta DDG (CS) in the experimental field

Dr. S. Ayyappan, DG ICAR and Dr. B.S. Dhillon, VC, PAU at IIMR labs in PAU campus

Dr. S. Ayappan, DG, ICAR and Dr OP Yadav Director IIMR and scientists in the IIMR experimental field

System. He took keen interest in experiments on conservation agriculture being undertaken at the institute. While looking at 126 hybrids of maize showcased in a compact block, Dr Iwanga said that he was amazed by the variety of hybrids the institute and associated centres have provided to the Indian farmers. Dr SK Datta, DDG (CS) appreciated progress made in germplasm enhancement of maize to cater to the need of diverse ecologies in which maize is cultivated in India. Both improved cultivars and production technologies have to be integrated to meet the demand of maize for domestic as well as international markets, he further added. Drs KV Prabhu, JS Chauhan, BB Singh, S Muria, PK Chakrabarty and C Chattopdhyay also visited maize experiments.

IIMR staff participated in Clean India Mission

ICAR- Indian Institute of Maize Research participated hand in hand with ICAR and other sister institutes based at Delhi to the Swachchh Bharat Mission led by ICAR with the motive to intensify the ongoing cleanliness drive Government of India.

The whole staff of IIMR shouldered the responsibility of cleaning the premises and adjoining area of Pusa Campus. The staff offered *shramdan* with great zeal.

IIMR staff cleaning the Loha Mandi traffic junction

IIMR staff joined hands in cleaning the Loha Mandi area adjoining the Pusa Campus

Maize Germplasm Day organized to support national breeding programme and hybrid development

ICAR- Indian Institute of Maize Research organized a Maize Germplasm Field Day at its Winter Nursery Centre, Hyderabad on 14th March, 2015. A total of 862 maize accessions were grown in a compact block for assessment and selections by breeders, pathologists and entomologists from 19 AICRP centres from SAUs and ICAR institutes. The material included registered germplasm at NBPGR, inbred lines from CIMMYT and large segregating materials with tropical, sub-tropical and temperate background from IIMR. Thirty participants from AICRP, SAUs, ICAR institutes and CIMMYT participated in the field day. The field visit was followed by a discussion on various issues like development of drought and disease tolerant lines, importing of exotic material, strengthening of germplasm on speciality corns etc. Dr. K.S. Varaprasad, Director, Indian Institute of Oil Seeds

Participants at the Maize Germplasm Day

Breeders keenly observing the traits of germplasm lines exhibited during the germplasm day

Research (IIOR) who graced the occasion as Chief Guest emphasized the need for creation of variability through various means. He appreciated the initiative of IIMR of sharing the germplasm among the coordinating centres through Field Days at Winter Nursery Centre, IIMR. He also commended the maize programme in utilizing the registered germplasm in hybrid development. Dr. O.P. Yadav, Director, IIMR outlined the initiative taken by institute in strengthening the genetic base of AICRP and cooperating centres and also briefed the role of Winter Nursery to speed up the breeding programme and cultivar development. He emphasized the need for more sites for field days in different target areas and highlighted the supplementary role of Winter Nursery Centre for strengthening the germplasm base of the AICRP centres. He thanked the collaborators for their active participation in field day and also underlined the use of selected material from nursery for hybrid development.

Institute Technology Management Unit assesses consultancy and technology commercialization activities of the institute

Institute Technology Management Unit meetings were held three times on June 25 and September 3 during the year 2014 and January 23, 2015 to discuss on various issues viz., to provide contractual services regarding testing the nutritional quality parameters of maize hybrids to Hytech Seeds India Pvt. Ltd., to provide training to an entomologist of Syngenta Biosciences India Pvt. Ltd. on key corn pests rearing and filing of a new patent application. The committee members decided that the contractual services provided to the companies and filing of the application should be as per ICAR rules and guidelines.

Institutional Biosafety Committee takes stock of status of biosafety compliance at the institute

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 in the year 2010. 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. IBSC meetings are held twice a year in the institute. IBSC meetings were held on August 27, 2014 and March 3, 2015 to discuss the biosafety aspects of the ongoing projects of ICAR-IIMR. The agenda of the meeting was to review the biosafety aspects taken in research activities at the institute. The committee members discussed about the disposal facilities of laboratory waste. It was explained that the laboratory waste is now disposed after autoclaving. They also discussed that laboratory and field staff should use aprons during their work. The snake guard may be used while working in fields. The IBSC committee members discussed on other biosafety issues and they were satisfied as the officials were observing the required biosafety measures.

Research Advisory Committee meeting held

The meetings of the Research Advisory Committee (RAC) of the institute were held on 13-14 June, 2014. The committee assessed the various ongoing programmes of the institute and selected AICRP centres and suggested measures to further strengthen the programme.

Research Advisory Committee meeting of the institute was held on June 13-14, 2014

Institute Research Council assessed research progress of the institute

The Institute Research Council (IRC) meeting was held on May 02-03, 2014 under the Chairmanship of the Project Director, Dr. OP Yadav to discuss the research agenda of the institute. Dr. S. K. Vasal, a distinguished maize scientist from International Maize and Wheat Improvement Center (CIMMYT) was invited member of IRC. The Director presented the overview of activities carried out at the institute followed by presentation of all the projects by respective Principal Investigators. It was pointed out by several members and external expert Dr. Vasal that there exists a lot of duplication in various research projects, specifically in the activity of germplasm evaluation and characterization. The matter was deliberated at great length and in order to bring in cost effectiveness in the projects, to avoid duplicity and to improve the efficiency, various projects were merged. New projects were also presented and discussed by the members. It was decided to hold another meeting to discuss the new projects formed after merging them. The IRC met for the second time on 14th August, 2014 under the Chairmanship of Project Director, Dr. OP Yadav. Dr. KS Hooda presented the Guidelines of Madan Committee Report for the preparation of Research Project Proposals. The IRC members discussed on the issues related to institute and research projects. On the basis of recommendation of previous IRC held on May 2-3, 2014 the projects were converged and the Principal Investigators of all the newly formed four projects were asked to form their team as per the Madan Committee Guidelines.

Delegation from Vietnam visits Winter Nursery Centre, ICAR-IIMR, Hyderabad

An 8-member delegation from Ministry of Agriculture and Rural Development and National Agriculture Extension Centre, Vietnam, visited Winter Nursery Centre, ICAR- Directorate of Maize Research, Hyderabad and Maize Research Centre, Acharya N. G. Ranga Agricultural University on 9th September 2014. Dr. J.C. Sekhar, Principal Scientist and In-charge, Winter Nursery Centre, gave a brief overview of the maize research including various methods of technology transfer. He appraised the delegation about the All India Co-ordinated project on Maize, Winter Nursery Centre's mandate, Frontline Demonstrations and the Tribal Sub plan. Dr. N. Sunil, Senior Scientist, briefed them about the maize germplasm from the national gene bank that was being regenerated and characterized and Dr. Laxmi Soujanya, Scientist briefed about the entomology research. The delegation members keenly inquired about on maturity groups and high density planting.

The Vietnamese delegation with the IIMR staff at the Winter Nursery Centre, Hyderabad

Hindi Activities

To promote the progressive use of Rajbhasha Hindi, following events were organized at the institute:

- Workshop on "*Hindi Dasha Aur disha*" on 7 May, 2014 at IIMR, New Delhi
- Workshop on "*Rajbhasha hindi mein karya karane ki Abhiparerna*" on 29 November, 2014 at IIMR, New Delhi
- "*Hindi Chetna* Maas" for the year 2014 from 24-25 September, 2014. During the *Hindi Chetna Maas,* a number of events were organized in which the staff participated with great zeal. The Chetna Maas was concluded with distribution of prizes. The Hindi activities were also organized at IIMR Ludhiana.

Dr Prem Singh, Ex. Joint Director (Hindi), Government of India addressing in the workshop on "*Rajbhasha hindi mein karya karane ki Abhiparerna*" on 29 November, 2014 at IIMR, New Delhi

IIMR participated in *Ek divasiya hindi sangoshthi and hindi prakashan pradarsani* organized by ICAR and DKMA on September 26, 2014 (In the inset bulletins published by IIMR kept in exhibition.

7

Awards and Recognitions

Award

- **Dr. O.P. Yadav,** Director, ICAR-IIMR received Dr. R.K. Arora Best Paper Award by the Indian Society of Plant Genetic Resources, New Delhi

Dr. O.P. Yadav, Director, ICAR-IIMR receiving Dr. R.K. Arora Best Paper Award

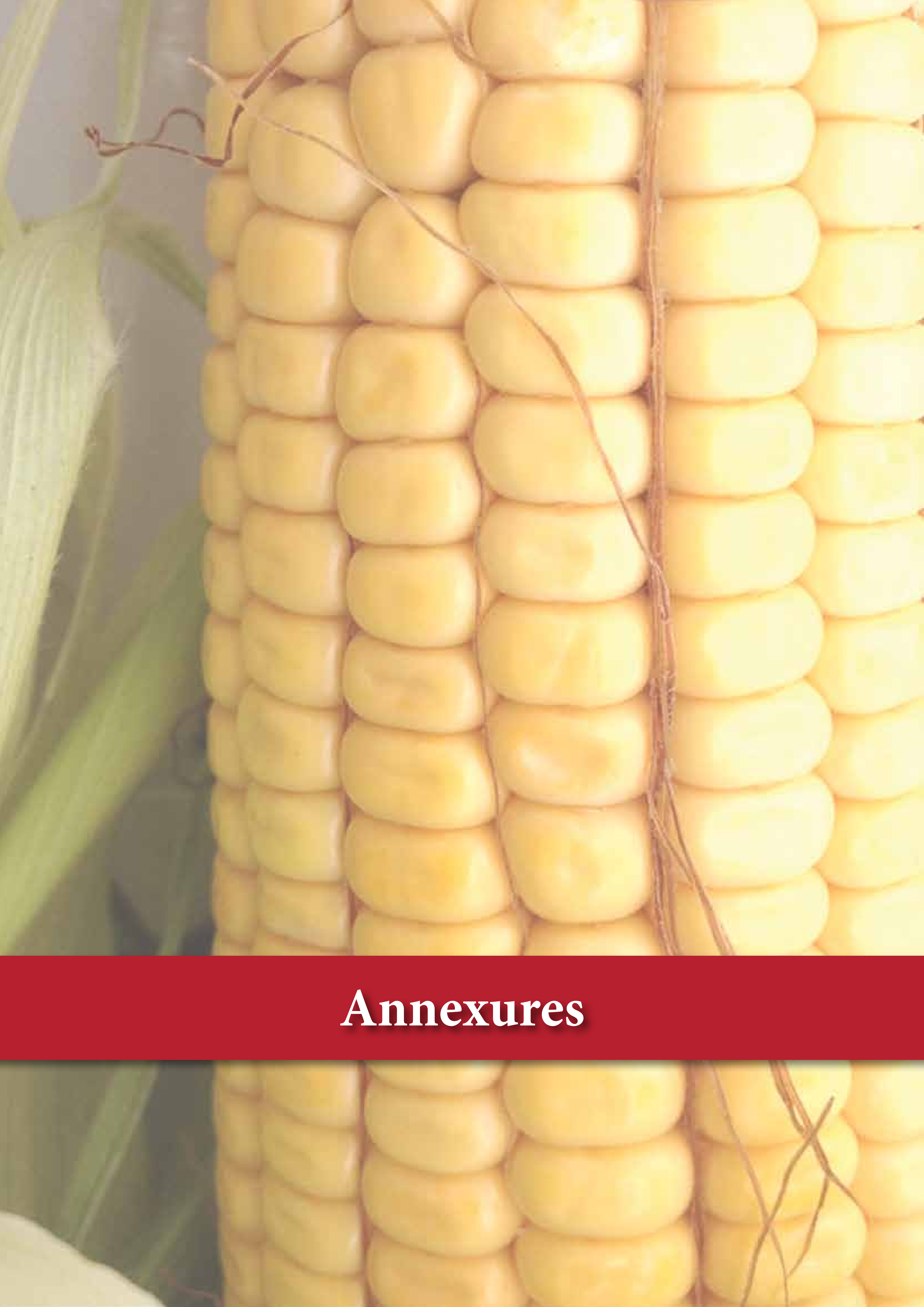
- **Dr. S.B. Singh** received Distinguished Scientist Award (Plant Breeding) by the Society for Scientific Development in Agriculture & Technology during National Conference on Emerging Challenges and Opportunities in Biotic and Abiotic Stress Management held at DRR, Rajendranagar, Hyderabad on December13-14, 2014.

Dr. S.B. Singh receiving Distinguished Scientist Award (Plant Breeding)

- **Best Poster Award for Paper entitled** "Stable sources of multiple disease resistance in maize" by Hooda K.S., Shekar J.C., Chikkappa G.K., Kumar B., Kaul J., Singode A., Dass S., Kumar R.S., Yadav O.P., Singh V., Kumar S., Khokar M.K., Sharma S.S., Kaur H., Sreerama Setty T.A., Pandurnge Gowda K.T., Gogoi R., Devlash R.K., Basandarai A., Chandraskehara C. and Kumar P. during 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security held at Bangkok, Thailand from 30 October to 01 November, 2014.
- **Best Poster Award for Paper entitled** "Nitrogen management under conservation agriculture for enhancing resource-use efficiency in intensified maize systems' by **S.L. Jat, C.M. Parihar, A.K. Singh, Ashok Kumar, Bahadur Singh and Savita Sharma** during 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security held at Bangkok, Thailand from 30 October to 01 November, 2014.
- **Best Oral Presentation Award to Paper entitled** "Biplot analysis in germplasm characterization of industrial legume – clusterbean (*Cyamopsis tetragonoloba* (L.) Taub.)" by **A. Manivannan, C. R. Anandakumar, R. Ushakumari, I. Yesu Raja and K. Balakrishnan** during National Seminar on Challenges and Innovative Approaches in Crop Improvement held at AC&RI, TNAU, Madurai on December 16-17, 2014.

Recognitions

- **Dr. K.S. Hooda** elected as President, Indian Phytopathological Society (Delhi Chapter), New Delhi for the year 2014.
- **Dr. S.B. Singh** appointed as Judge for "National Children Science Congress-2014" held at Jawahar Navodaya Vidyalaya, Begusarai on November 23-25, 2014.
- **Dr. S.B. Singh** nominated as member of State Standing Technical Committee (Bihar) of "National Mission for Sustainable Agriculture".



Annexures

Annexure 1

Maize Hybrids Identified

At the 57th Annual Maize Workshop held at Maharana Pratap University of Agriculture and Technology, Udaipur from April 21-23, 2014, Variety Identification Committee identified 26 new hybrids of different maturity groups for cultivation in varied production ecologies of the country.

Hybrid	Centre	Pedigree	Public/ Private	Area of adaptation		Av. Yield (t/ha)	Maturity	Characteristics	Season
				Zone	States				
P 3580 (X35A180)	Pioneer Overseas Corporation, Karnataka	PHM6T X PH1DVA	Private	4	Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	9.92	Late	Orange, semi-flint	*Kharif*
Pro385	Rasi Seeds (P) Ltd., Tamil Nadu	XCL10076 X BCL401	Private	4	Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	10.14	Late	Orange- yellow, semi-flint	*Kharif*
MCH 46 (DKC9126)	Monsanto India Ltd., Bangalore	H4858Z X D4121Z	Private	1 & 4	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, North East Hills, Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh	8.96	Late	Yellow-orange, semi-flint	*Kharif*
CoH (M) 13 (CMH 08-381)	TNAU, Coimbatore	UMI 1211 X UMI 1221	Public	3 & 4	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	9.35	Late	Orange yellow, dent, high starch (76.4%), high protein (10.57%) and high beta-carotene (0.47 mg/100g) with moderate level of fat (4.56%) and crude fibre (1.43%)	*Kharif*
CP 333	Charoen Pokphand Seeds (India) Pvt. Ltd., Bangalore	IFF018 X IFF019	Private	5	Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	6.64	Late	Orange yellow, semi-dent	*Kharif*
CoH(M) 15 (CMH 09-464)	TNAU, Coimbatore	(UMI 1200 X UMI 1210') X UMI 1223	Public	3	Eastern Uttar Pradesh, Bihar, Jharkhand and Odisha	8.32	Late	Orange yellow, dent, high starch (76.52%), high protein (11.51%) and high beta-carotene (0.48 mg/100g) with moderate level of fat (4.52%), crude fibre (1.44%), resistant to MLB, CLS, TLB, PFSR and RDM	*Kharif*
Pro 383	Rasi Seeds (P) Ltd., Tamil Nadu	BCX11109 X BCL301	Private	4	Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	9.65	Medium	Yellow, semi-dent	*Kharif*
EHL 161708	CSK, HPKV, HAREC, Bajaura, Kullu	BAJIM 08-26 X BAJIM 08-27	Public	1	Jammu & Kashmir, Himachal Pradesh, Uttarakhand and North East Hills	9.88	Medium	Yellow- orange, flint, moderate resistance to MLB and TLB	*Kharif*
Pratap Hybrid Maize-3 (EH 1974)	MPUAT, Udaipur	EI-586-2 X EI-670-2	Public	5	Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	5.59	Medium	Yellow, semi-dent, resistant to FSR, moderate resistant to CLS and RDM	*Kharif*

Hybrid	Centre	Pedigree	Public/ Private	Area of adaptation		Av. Yield (t/ha)	Maturity	Characteristics	Season
				Zone	States				
EHL 162508	CSK, HPKV, HAREC, Bajaura, Kullu	HKI 1040-7 X BAJIM 09-64	Public	1 & 5	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, North East Hills, Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	6..93	Early	Yellow- orange, semi-dent	*Kharif*
KNMH 4010141	ANGRAU, ARS, Karimnagar	KML-225 X BML-7	Public	4	Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	7.95	Early	Orange, semi-flint, moderate resistance to MLB, TLB, PFSR and CLS	*Kharif*
Vivek Maize Hybrid 49 (FH 3548)	VPKAS, Almora	V400 X V391	Public	4	Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	7.15	Early	Yellow, semi-flint	*Kharif*
DAS-MH-501 (D2244)	Dow Agro-Sciences India Pvt. Ltd., Mumbai	NTC6 X NTC8	Private	1, 4 & 5	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, North East Hills, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	7.09	Early	Yellow- orange, semi-dent	*Kharif*
Bisco 2238	Bisco Bio Sciences Pvt. Ltd., Andhra Pradesh	(BSI 235 X BSI 216) X BSI 238	Private	1 & 4	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, North East Hills, Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh	8.19	Early	Yellow, dent	*Kharif*
Vivek Maize Hybrid 51 (FH 3554)	VPKAS, Almora	V405 X V409	Public	1 & 5	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, North East Hills, Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	5.08 (for zone 5)	Extra-early	Yellow, semi-flint, moderate resistance to MLB, FSR, RDM and CLS	*Kharif*
Vivek Maize Hybrid 53 (FH 3556)	VPKAS, Almora	V407 X V409	Public	1, 3 & 4	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, North East Hills, Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	6.93	Extra-early	Yellow, semi-flint	*Kharif*
CoH (M) 11 (CMH-08-282)	TNAU, Coimbatore	UMI 1200 X UMI 1230	Public	4	Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	8.95	Late	Orange- yellow, semi-dent	*Rabi*
CoH (M) 12 (CMH-08-287)	TNAU, Coimbatore	UMI 1210 X UMI 1220	Public	4	Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	8.25	Late	Orange- yellow, dent	*Rabi*
KMH-25K45 (2700) (BUMPER)	Kaveri Seed Company Ltd., Andhra Pradesh	KML-5254 X KML-2286	Private	2, 4 & 5	Punjab, Haryana, Delhi, Western Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	9.01	Late	Yellow, semi-dent	*Rabi*
Bisco New 704	Bisco Bio Sciences Pvt. Ltd., Andhra Pradesh	(BS 240 X BSI 202) X BSI 264	Private	4	Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	7.51 (for zone 5 proposed)	Late	Yellow, semi-dent	*Rabi*

Hybrid	Centre	Pedigree	Public/ Private	Area of adaptation		Av. Yield (t/ha)	Maturity	Characteristics	Season
				Zone	States				
Bisco X 5129	Bisco Bio Sciences Pvt. Ltd., Andhra Pradesh	BS 251 X (BSI 226 X BSI 252)	Private	4	Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	9.47	Late	Yellow, semi-dent	*Rabi*
NMH 713	Nuziveedu Seeds Ltd., Hyderabad	NM-115 X NM-45	Private	3 & 4	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	9.49 (for zone 4)	Late	Yellow, dent	*Rabi*
NMH 731	Nuziveedu Seeds Ltd., Hyderabad	NM-206 X NM-85	Private	4	Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	9.77	Late	Yellow, semi-dent	*Rabi*
RJ 2020	RJ Biotech Ltd., Aurang-abad	RJ-126 X RJ-78	Private	5	Rajasthan, Gujarat, Chhattisgarh and Mad-hya Pradesh	8.43	Late	Yellow- orange, flint	*Rabi*
NMH 1242	Nuziveedu Seeds Ltd., Hyderabad	NM-161 X NM-250	Private	2, 4 & 5	Punjab, Haryana, Delhi, Western Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Rajasthan, Gu-jarat, Chhattisgarh and Madhya Pradesh	9.17 (for zone 4 & 5)	Medium	Yellow, dent	*Rabi*
BIO 9544 (BIO 151)	Bioseed Research India , DCM Shriram Ltd., Hyderabad	BY070-nm (BIOSEED KNPR-3) X BIO PCI001-nm (BIO PT963018)	Private	4 & 5	Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Rajasthan, Gu-jarat, Chhattisgarh and Madhya Pradesh	9.80 (for zone 4)	Medium	Orange- yellow, semi-dent	*Rabi*

Abbreviations: **MLB:** Maydis Leaf Blight, **TLB:** Turcicum Leaf Blight, **CLS:** Curvularia Leaf Spot, **PFSR:** Post Flowering Stalk Rot, **RDM:** Rajasthan Downy Mildew, **FSR:** Fusarium Stalk Rot

Annexure 2

Maize Hybrids Notified

Seventeen maize hybrids notified by Central Sub-Committee on Crop Standard and Notification of Varieties for different agro-climatic conditions of the country. Among these, eleven public-bred and six proprietary hybrids with six in late, seven in medium and two each in early and extra-early maturity group released for different production ecologies. Further, one hybrid GH0727 is a state release and six other hybrids, *viz.*, NMH-713, NMH-731, NMH-1242, P3522, Bio 9544 and KMH-25K45 been released for *rabi* season.

Cultivar	Pedigree	Name of centre/ company	Notification Details	Area of adaptation	Maturity	Av.Yield (t/ha)	Characteristics	Cropping season
CoH (M) 10 (CMH 08-433)	(UMI 1200 X UMI 1210) X UMI 1230	TNAU, Coimbatore	28/01/2015 268(E)	Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	Medium	7.2	Orange-yellow, semi-dent resistant to MLB, RDM and moderately resistant to common rust and TLB	*Kharif*
HM-13 (HKH-317)	HKI-488-1RG X HKI-193-1	CCSHAU, Karnal	28/01/2015 268(E)	Jammu and Kashmir, Himachal Pradesh and Uttarakhand	Early	6.6	Yellow with cap, flint and resistant to MLB, TLB, BLSB, C. rust and PFSR	*Kharif*
PMH 6 (JH 31292)	LM 13 X SE 546	PAU, Ludhiana	28/01/2015 268(E)	Bihar, West Bengal, Jharkhand, Odisha and Uttar Pradesh	Medium	6.3	Yellow, flint	*Kharif*
NMH-713	NM-115 X NM-45	Nuziveedu Seeds Limited	28/01/2015 268(E)	Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra	Late	9.49	Yellow, dent	*Rabi*
NMH-731	NM-206 X NM-85	Nuziveedu Seeds Limited	28/01/2015 269 (E)	Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra	Late	9.49	Yellow, dent	*Rabi*
KMH-25K45 (BUMPER)	KML-5254 X KML-2286	Kaveri Seed Company Ltd., Andhra Pradesh	28/01/2015 271 (E) and 30/07/2014 1919 (E)	Gujarat, Rajasthan Chhattisgarh, Madhya Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra	Late	5.4	Orange-yellow, semi-dent	*Rabi*
NMH-1242	NM-161 X NM-250	Nuziveedu Seeds Limited	28/01/2015 272 (E)	Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Punjab, Haryana, Delhi, Uttar Pradesh, Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh	Medium	7.3	Yellow, dent and moderately tolerant to MLB	*Rabi*
CoH (M)7 (CMH 08-287)	UMI 1210 X UMI 1220	TNAU, Coimbatore	30/07/2014 1919 (E)	Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Telangana, Tamil Nadu, Maharashtra and Karnataka	Late	7.8	Orange-yellow, dent and resistant to MLB, PR, TLB, BSDM, C. rust	*Kharif*
CoH (M)8 (CMH 08-292)	UMI 1201 X UMI 1230	TNAU, Coimbatore	30/07/2014 1919 (E)	Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh, Punjab, Haryana, Delhi and Maharashtra	Medium	7.1	Orange-yellow, semi-dent, resistant to MLB, TLB, RDM, DM and moderately resistant to PFSR and PR	*Kharif*

Cultivar	Pedigree	Name of centre/ company	Notification Details	Area of adaptation	Maturity	Av.Yield (t/ha)	Characteristics	Cropping season
CoH (M) 9 (CMH 08-350)	UMI 1205 X UMI 1230	TNAU, Coimbatore	30/07/2014 1919 (E)	Uttar Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	Medium	6.4	Orange-yellow, semi- dent, resistant to MLB, TLB, RDM, DM and moderately resistant to common rust and resistant against multiple diseases and cyst nematode	*Kharif*
DHM 121 (BH 41009)	BML 45 X BML 6	ANGRAU, Hyderabad	30/07/2014 1919 (E)	Odisha, Bihar, Jharkhand, West Bengal , Gujarat, Rajasthan, Chhattisgarh and Madhya Pradesh	Medium	5.4	yellow, semi-dent and tolerant to moisture stress conditions	*Kharif*
GH 0727* (Shrushti)	CI-4 x KDMI-15	ARS, Arabhavi	30/07/2014 1919 (E)	Karnataka	Late	7.5	Orange-yellow	*Kharif*
Vivek Maize Hybrid 47 (FH 3513)	Female-V373 (JKMH-175-4) Ä-16-7-12-1-Äb-#-#-Äb-#-Äb-Äb-#) Male-V391 (CML 471-F-7- Äb-#-b-#-b-#-b-b-#-#)	VPKAS, Almora	30/07/2014 1919 (E)	Uttarakhand, Himachal Pradesh, Jammu & Kashmir, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim	Early	6.9	Yellow with white cap, semi flint and moderately resistant to MLB and C. rust	*Kharif*
Vivek Maize Hybrid 53 (FH 3556)	V407 X V409	VPKAS, Almora	30/07/2014 1919 (E)	Uttarakhand, Himachal Pradesh, Jammu & Kashmir, Uttar Pradesh, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim	Extra-early	6.9	Yellow, semi-flint	*Kharif*
Vivek Maize Hybrid 51 (FH 3554)	V405 X V409	VPKAS, Almora	30/07/2014 1919 (E)	Gujarat, Rajasthan Chhattisgarh and Madhya Pradesh	Extra-early	5.1	Yellow, semi-flint, moderate resistance to MLB, FSR, RDM and CLS	*Kharif*
Bio 9544 (BIO151)	By070-nm (BIOSEED KNPR-3) X BIO PCI001-nm (BIO PT963018)	Bioseed Research India Pvt. Ltd.	30/07/2014 1921 (E)	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	Medium	7.3	Orange-yellow, semi- dent	*Kharif & Rabi*
P3522 (X35A019)	PH6MT X PH1SP	Pioneer Overseas Corporation, Karnataka	24/04/2014 1146(E)	Punjab, Haryana, Delhi, Uttarakhand, Uttar Pradesh, Bihar, West Bengal, Jharkhand, Orissa, Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Gujarat, Rajasthan, Madhya Pradesh and Chhattisgarh	Late	9.1	Yellow-orange, semi-flint	*Rabi*

MLB: Maydis Leaf Blight, **PR:** Polyspora Rust, **TLB:** Turcicum Leaf Blight, **BSDM:** Brown Spot Downy Mildew, **C. rust:** Common rust, **RDM:** Rajasthan Downy Mildew, **DM:** Downy Mildew,
PFSR: Post Flowering Stalk Rot, **FSR:** Fusarium Stalk Rot, **CLS:** Curvularia Leaf Spot

*state release

Annexure 3

Varietal Registration

New Applications Filed

During the year 2014-15, eight applications of maize varieties been filed under PPV&FR Act, 2001. The details are given below:

Hybrids/OPVs	Name of centre	Date of filing	Acknowledgement no.
PMH 9 (JH9144)	PAU, Ludhiana	29.12.2014	REG/2014/2520
PMH 8 (JH31244)	PAU, Ludhiana	07.07.2014	REG/2014/1306
PMH 7 (JH3956)	PAU, Ludhiana	07.07.2014	REG/2014/1307
Shaktiman-5	RAU, Dholi	07.07.2014	REG/2014/1308
Pant Sankar Makka-1	GBPUA&T, Pantnagar	07.07.2014	REG/2014/1309
PMH 6 (JH31292)	PAU, Ludhiana	07.07.2014	REG/2014/1310
Shalimar Maize Composite-3	SKUAST, Srinagar	15.09.2014	REG/2014/1906
Shalimar Maize Composite-4	SKUAST, Srinagar	15.09.2014	REG/2014/1907

DUS Testing

During *kharif* 2014, DUS testing was done at five locations namely ICAR-IIMR, New Delhi; SRTC, Hyderabad; VPKAS, Almora; PAU, Ludhiana and NEH region, Umiam. Total 111 candidate entries tested including 48 new hybrids, 2 Open Pollinated Varieties (OPVs), 16 Variety of Common Knowledge (VCKs), 22 Farmer Varieties (FVs) and 23 new inbred lines. Of these 48 new hybrids, 2 OPVs, and 23 new inbred lines were tested at IIMR, New Delhi and SRTC, Hyderabad, whereas 16 VCKs were evaluated at two locations namely SRTC, Hyderabad and PAU, Ludhiana. Under grow out test, 7 FVs were tested at SRTC, Hyderabad and PAU, Ludhiana while, 15 at VPKAS, Almora and NEH region, Umiam. The details of the entries are given below:

Hybrid DUS trial 2014	Inbred DUS trial 2014	Variety of Common Knowledge	Farmer Varieties (grow out test)
2nd Year Testing *Public -bred hybrids (5)* DHM119, DHM 113, DHM111, PMH5 , Rajendra Hybrid Makka3 *Proprietary hybrids (15)* P3396, P1864, P3580, P3436, P3303, P3522, P3570, P3377, P 3373,KMH25, K45,KMH 2589,NM734, Indra17, BiscoX5141, Bisco 506 *OPVs (1)* Pant Sankul Makka 3 **1st Year Testing** *Public –bred hybrids(2)* PMH 3 , TNAU Maize Hybrid Co 6 *Proprietary hybrids(26)* NMH 920 , NMH1247, TMMH 809, TMMH 801, TMMH 802, HTMH5101 SONA KMH 1411, KMH3110, KMH6681, GK3090 , KING II, PAC753 , PAC751 , RMH3033, TMMH 805, BIO 9211, BIO 032, BIO 719 , BIO 605, BIO 237, P3546, P3533, P 3542, D4141, NMH803, MM 2100 *OPVs (1)* Pratap Kanchan 2	**2nd Year Testing** *Proprietary Inbreds (6)* KML2286, KML2293, BIO101271, BYO70NM, M3434, PC1001NM **1st Year Testing** *Proprietary Inbreds (17)* H 7PH , PH1BFR, PHBFE, PH 15K0 , PH 1WA2, BIO82015HI, BY 778-nm, PHBET,PH17H, KML 2078, KML 2006, KML 5253 , NM 183, NM 250, NM 199, CZ 170 nm, PH 9 JM	**One Year Testing** *Proprietary hybrids (6)* PAC745, Bisco1102, Bisco2225 , RMH3022, NMH459, NMH2277 *Proprietary Inbreds(10)* NM 206, NM130, NM119, NM58, NM85, SYN-CO-NP 5063, SYN-CO-NP 5038, SYN-CO-NP 5088 , NM115, NM 61	Makka, Makka Bansi, Jindhara Makai, Budha Makai, Safed Lalk, Vinod, Jayanti, Magudam Mami, Magudam Borok, Mimban Charhang, Mimpui, Mimban Sen, Mimpui Var,Pukazo Var, Mimban Dum, Mimpui Sen, Mimban Var, Pukazo Eng, Pukazo Sen, Imkonda Choigi, Imkonda Maimi, Mokonda Toima

Hybrids/Varieties Registered

In 2014-15, four cultivars including one hybrid and three OPVs registered under PPV&FR Act, 2001. The detailed information is given below:

Hybrids/OPVs	Name of centre	Period of protection
HM-11 (HKH-1237)	CCSHAU, Karnal	December 4, 2014 to December 3, 2029
Vivek Sankul Makka 35 (VL 113)	VPKAS, Almora	December 4, 2014 to December 3, 2029
Bajaura Makka-1	CSK HPKV, Bajaura	January 22, 2015 to January 21, 2030
Vivek Sankul Makka 31	VPKAS, Almora	March 30, 2015 to March 29, 2030

Annexure 4

Breeder Seed Production

A total of 4.466 tonnes of breeder seed of 17 OPVs and parental lines of 16 hybrids were indented by Department of Agriculture and Cooperation, Ministry of Agriculture, GOI and allocated to thirteen AICRP centres. The production was taken up during *kharif* 2014 and *rabi* 2014-15. During *kharif* 2014, 2.768 tonnes of breeder seed has been produced as per reports received by March 23, 2015.

Centre-wise breeder seed production (tonnes) of parental lines of maize hybrids and OPVs

Production year 2014							
Name of producing state/ centre	Variety Name	Year of notification	DAC Indent (tonnes)	Total Allotment as per BSP-1 (tonnes)	Production (tonnes)	Deficit	Remarks
Tirhut College of Agriculture Dholi, Bihar	Shaktiman-4 ; (F) CML 161	2006	0.04	0.04			*Rabi* 2014-15
	Shaktiman-4 ; (M) CML 169		0.01	0.01			*Rabi* 2014-15
	Shaktiman-2 ; (F) CML 176	2004	0.16	0.16			*Rabi* 2014-15
	Shaktiman-2 ; (M) CML 169		0.04	0.04			*Rabi* 2014-15
IARI, Delhi	Pusa Extra Early Hybrid Makka -5 (AH-421) ; (F) CM 150	2004	0.164	0.164			*Rabi* 2014-15
	Pusa Extra Early Hybrid Makka -5 (AH-421) ; (M) CM 151		0.051	0.051			*Rabi* 2014-15
	PEHM-2 ; (F) CM 137		0.004	0.004			*Rabi* 2014-15
	PEHM-2 ; (M) CM 138		0.001	0.001			*Rabi* 2014-15
	Pusa Composite-3 (Composite - 85134)	2005	0.208	0.208			*Rabi* 2014-15
	Pusa Composite -4 (Composite -8551)	2005	0.033	0.033			*Rabi* 2014-15
AAU Godhara, Gujarat	Narmada Moti (IC-9001)	2002	0.05	0.05			*Rabi* 2014-15
CCHAU, Karnal, Haryana	HQPM-4 ; (F) HKI 193-2	2010	0.40	0.40			*Rabi* 2014-15
	HQPM-4 ; (M) HKI 161		0.10	0.10	0.01	(-) 0.09	
	HM-10 (HKH-1200)(HKI 1128 (M))	2008	0.02	0.02			*Rabi* 2014-15
	HM-10 (HKH-1200)(HKI 193-2 (F))	2008	0.04	0.04			*Rabi* 2014-15
	HQPM-7 ; (HKI 161 (M))	2008	0.02	0.02	0.02		*Rabi* 2014-15
	HQPM-7 ; (HKI 193-1 (F))	2008	0.08	0.08			*Rabi* 2014-15
	HQPM-5 ; (F) HKI 163	2007	0.12	0.12	0.12		
	HQPM-5 ; (M) HKI 161		0.03	0.03			*Rabi* 2014-15
	HM-8 ; (F) (HKI 1105)	2007	0.015	0.015	0.015		
	HM-8 Male	2007	0.005	0.005			*Rabi* 2014-15
	HQPM-1 ; (F) HKI 193-1	2007	0.52	0.52			*Rabi* 2014-15
	HQPM-1 ; (M) HKI 163	2007	0.24	0.24	0.28		
	HQPM-5 ; (F) HKI 163	2007	0.12	0.12			*Rabi* 2014-15
	HQPM-5 ; (M) HKI 161	2007	0.04	0.04			*Rabi* 2014-15
	HM-4 ; (F) HKI 1105	2005	0.04	0.04	0.04		
	HM-4 ; (M) HKI 323		0.01	0.01	0.01		
Zonal Agricultural Research station Mandya, Karnataka	NAC 6004	2001	0.20	0.20			*Rabi* 2014-15
JNKVV, Chindwara, Madhya Pradesh	Jawahar Makai -216 (JM-216)	2002	0.26	0.26			*Rabi* 2014-15

Production year 2014								
Name of producing state/ centre	Variety Name	Year of notification	DAC Indent (tonnes)	Total Allotment as per BSP-1 (tonnes)	Production (tonnes)	Deficit	Remarks
MPUA & T, Banswara, Rajasthan	Pratap Kanchan-2 WC-236(Y)	2009	0.105	0.105	0.09	(-) 0.015	
MPUA & T, Udaipur	Pratap Hybrid Maize-1 ; Female EI-116	2004	0.20	0.20			*Rabi* 2014-15
	Pratap Hybrid Maize-1 ; Male EI-364	2004	0.10	0.10			*Rabi* 2014-15
	Pratap Makka-5 (EC-3116)	2006	0.26	0.26	1.0		
	Pratap Makka-5 (EC-3116)	2004	0.06	0.06	0.20		
	Pratap Makka-3 (EC-3108)	2005	0.40	0.40	0.45		
PAU, Ludhiana, Punjab	Parkash (JH-3189) ; Female CM 139	1997	0.004	0.004	0.04		
	Parkash (JH-3189) ; Male CM 140		0.001	0.001	0.05		
ANGRAU, Hyderabad, Telangana	Priya Sweetcorn	2002	0.001	0.001			*Rabi* 2014-15
C.S. Azad University of AG. & Tech., Kanpur, Uttar Pradesh	Azad Kamal (R 9803)	2005	0.02	0.02			Not Reported
	Azad Uttam (Composite R-2)		0.016	0.016			Not Reported
	Sharadmani	2008	0.006	0.006			Not Reported
VPKAS Almora, Uttarakhand	Vivek Maize Hybrid-9 (FH-3077) ; (F) CM 214	2001	0.004	0.004	0.004		
	Vivek Maize Hybrid-9 (FH-3077) ; (M) CM 145		0.001	0.001	0.001		
	Vivek Sankul Makka-31(VL-103)	2008	0.019	0.019	0.325		
G.B.Pant Agriculture University Pant nagar, Uttarakhand	Ganga Safed-2 CM-400	1969	0.12	0.12	0.037	(-) 0.083	
	Ganga Safed-2 CM-300		0.06	0.06			Spring 2015
	Ganga Safed-2 CM-600		0.04	0.04	0.07		
	Pant Sankul Makka-3 (D131)	2008	0.006	0.006			Spring 2015
	Amar (D-941)	2001	0.006	0.006			Spring 2015
	Gaurav (D-931)	1999	0.016	0.016	0.006	(-) 0.01	
	Total			**4.466**	**2.768**		

Note: *Rabi* crop to be harvested at the end of April, 2015

Breeder seed allocated and produced by AICRP (Maize) centres during 2013-14

A total of 6.033 tonnes of breeder seed of maize hybrids and OPVs indented by Department of Agriculture and Cooperation, Ministry of Agriculture, GOI and allocated to the twelve AICRP centres. Fifteen OPVs and parental lines of 17 hybrids were included in the breeder seed programme. During *kharif* 2013, 6.365 tonnes of breeder seed was produced; while 2.582 tonnes seed of eight OPVs and parental lines of nine hybrids was produced in the rabi season (2013-14).Thus a total of 8.947 tonnes breeder seed in respect of maize has been produced.

Five centers *viz.*, IARI, Delhi, CSAU (Kanpur), JNKVV (Chhindwara) , BAU (Ranchi) and UAS (Mandya) did not report the production while three centres, namely MPUAT(Banswara and Udaipur) and CCSHAU (Karnal) reported deficit production in respect of five parental lines and one OPV, respectively.

Breeder seed production report (2013-14)

S. No	Name of the producing state /centre	Parental line/varieties	DAC indent (tonnes)	Actual allotment as per BSP-I target (tonnes)	Actual production (tonnes)	Production surplus/deficit over BSP-I target	Remarks
			Uttarakhand				
1	VPKAS, Almora	Vivek Maize Hybrid 39 ; (V-373) (F)	0.003	0.003	0.003		
2	VPKAS, Almora	Vivek Maize Hybrid 39 ; (CM-212) (M)	0.001	0.001	0.004	(+) 0.003	
3	VPKAS, Almora	Vivek Maize Hybrid 33 (FH 3352) ; (V-372)(F)	0.004	0.004	0.010	(+) 0.006	
4	VPKAS, Almora	Vivek Maize Hybrid 33 ; (CM212)(M)	0.002	0.002	0.004	(+) 0.002	
5	VPKAS, Almora	Vivek QPM-9 (FQH 4567) ; (VQL1) (F)	0.003	0.003	0.190	(+) 0.187	
6	VPKAS, Almora	Vivek QPM-9 ; (VQL2) (M)	0.001	0.001	0.001		
7	VPKAS, Almora	Vivek Maize Hybrid-17 (FH-3186) ; (CM-153)(F)	0.150	0.150	0.175	(+) 0.025	
8	VPKAS, Almora	Vivek Maize Hybrid-17 (FH-3186) ; (CM-212)(M)	0.050	0.050	0.050		
9	GBPUAT, Pantnagar	Kanchan	0.017	0.017	0.200	(+) 0.183	
10	GBPUAT, Pantnagar	Sonari (Shweta)	0.004	0.004	0.005	(+) 0.001	
11	GBPUAT, Pantnagar	Amar (D-941)	0.020	0.020	0.200	(+) 0.180	
			Punjab				
12	PAU, Ludhiana	PMH 4 ; (LM-5) (F)	0.042	0.042	0.100	(+) 0.058	
13	PAU, Ludhiana	PMH 4 ; (LM-16) (M)	0.013	0.013	0.015	(+) 0.002	
14	PAU, Ludhiana	PMH 5 (JH 3110) ; (LM16) (F)	0.042	0.042	0.045	(+) 0.003	
15	PAU, Ludhiana	PHM-5 ; (LM18) (M)	0.013	0.013	0.015	(+) 0.002	
16	PAU, Ludhiana	PMH-3 (JH 10704) ; (LM-17) (F)	0.042	0.042	0.080	(+) 0.038	
17	PAU, Ludhiana	PMH-3 (JH 10704) ; (LM-14) (M)	0.013	0.013	2.00	(+) 1.987	
18	PAU, Ludhiana	Vijay Composite	0.010	0.010	0.020	(+) 0.010	
			Haryana				
19	CCSHAU, Karnal	HQPM-4 ; (HKI-193-2) (F)	0.450	0.450	0.040	(-) 0.410	
20	CCSHAU, Karnal	HQPM-4 ; (HKI-161) (M)	0.150	0.150	0.165	(+) 0.015	
21	CCSHAU, Karnal	HM-10 (HKH-1200) ; (HKI 1128) (M)	0.120	0.120	0.097	(-) 0.025	
22	CCSHAU, Karnal	HM-10 (HKH-1200) ; (HKI 193-2)(F)	0.230	0.230	0.00	(-) 0.230	
23	CCSHAU, Karnal	HQPM-7 ; (HKI 161) (M)	0.120	0.120	0.165	(+) 0.045	
24	CCSHAU, Karnal	HQPM-7 ; (HKI 193-1) (F)	0.050	0.050	0.110	(+) 0.060	

S. No	Name of the producing state /centre	Parental line/varieties	DAC indent (tonnes)	Actual allotment as per BSP-I target (tonnes)	Actual produc-tion (tonnes)	Production surplus/deficit over BSP-I target	Remarks
25	CCSHAU, Karnal	HQPM-5 ; (HKI-163) (F)	0.430	0.430	0. 430		
26	CCSHAU, Karnal	HQPM-5 ; (HKI-161) (M)	0.140	0.140	0.160	(+) 0.020	
27	CCSHAU, Karnal	HM-4 ; (HKI-1105) (F)	0.037	0.037	0.040	(+) 0.03	
28	CCSHAU, Karnal	HM-4 ; (HKI-323) (M)	0.013	0.013	0.022	(+) 0.09	
29	CCSHAU, Karnal	HM-8 ; (HKI-1105) (F)	0.015	0.015	0.015		
30	CCSHAU	HM-8 ; (HKI-161) (M)	0.005	0.005	0.160	(+) 0.11	
31	CCSHAU	HQPM-1 ; (HKI-193-1) (F)	0.415	0.415	0.415		
32	CCSHAU	HQPM-1 ; (HKI-163) (M)	0.205	0.205	0.091	(-) 0.114	
		Delhi					
33	IARI, Delhi	Pusa Extra Early Hybrid Makka -5 ; (CM-150) F	0.104	0.104			Not reported
34	IARI, Delhi	Pusa Extra Early Hybrid Makka -5 ; (CM-151)M	0.052	0.052			Not reported
35	IARI, Delhi	Pusa Composite-3 (Composite-85134)	0.127	0.127	0.085	(-) 0.042	
36	IARI, Delhi	Pusa Composite-4 (Composite-8551)	0.030	0.030	0.145	(+) 0.115	
		Rajasthan					
37	MPUAT, Udaipur	Pratap Hybrid Maize-1 ; (EI-116) (F)	0.300	0.300	0.150	(-) 0.150	
38	MPUAT, Udaipur	Pratap Hybrid Maize-1 ; (EI-364) (M)	0.150	0.150	0.160	(+) 0.010	
39	MPUAT, Udaipur	PRATAP MAKKA-4 (EC-1108)	0.200	0.200	0.200		
40	MPUAT, Udaipur	PRATAP MAKKA-5 (EC-3116)	0.200	0.200	0.460	(+) 0.26	
41	MPUAT, Banswara	Pratap Kanchan-2 WC-236(Y)	0.100	0.100	0.090	(-) 0.010	
		Bihar					
42	RAU, Dholi	Shaktiman-2 (CML-176) (M)	0.065	0.065	0.300	(+) 0.235	
43	RAU, Dholi	Shaktiman-2 (CML-186) (F)	0.035	0.035	0.150	(+) 0.115	
		Uttar Pradesh					
44	CSAUAT, Kanpur	Azad Kamal (R 9803)	0.020	0.020			Not reported
		Madhya Pradesh					
45	JNKVV, Chindwara	JAWAHAR MAKAI-216 (JM-216)	1.200	1.200	1.240	(+) 0.040	
46	JNKVV, Chindwara	JAWAHAR COMPOSITE MAKKA-12 (JM-12)	0.100	0.100			Not reported
		Jharkhand					
47	BAU, Ranchi	BIRSA MAKKAI-1	0.230	0.230			Not reported
48	BAU, Ranchi	BIRSA MAKKAI-2	0.200	0.200			Not reported
		Karnataka					
49	Mandya, UAS	NAC 6004	0.110	0.110			Not reported
	TOTAL :		**6.033**	**6.033**	**8.947**		

Annexure 5

Human Resource Development

A. Trainings attended

Name	Programme	Venue	Date
Dr. Chikkappa G.K. Mr. Vishal Singh	Short Course "Statistical and Genomic Analysis".	CIMMYT, Patancheru, Hyderabad	May 12-17, 2014
Dr. K.P. Singh	Regional Training & Awareness Program on "J-Gate @ cera".	NASC Complex, New Delhi	September 29, 2014
Dr. P. Lakshmi Soujanya	21-days Training Programme on "Stored Grain Pests-Detection and Identification and Phyto Sanitary treatments (MBr and ALP)".	National Institute of Plant Health Management, Hyderabad	November 10 - December 01, 2014
Dr. Pranjal Yadava	ICAR-sponsored Short Course on "Non-destructive phenotyping and phenomics for dissection of abiotic stress tolerance, gene discovery and crop improvement".	Indian Agricultural Research Institute, New Delhi	July 14-23, 2014
Dr. Sunil N.	One-week Training, Programme on "Analysis of Experimental Data.	NAARM, Hyderabad	November 10-15, 2014
Dr. Vimla Singh	Model Training Course on "Practices for Conservation Agriculture and Climate Resilient Maize Systems".	ICAR-Indian Institute of Maize Research, New Delhi	August 30 - September 06, 2014

B. Training conducted

Name	Programme	Venue	Date
Course Director (Dr.A.K. Singh) and course co-cordinators (Drs C.M.Parihar and S.L.Jat)	Eight days model training course on "Practices for conservation agriculture and climate resilient Maize system" sponsored by Directorate of Extension, Ministry of Agriculture , Government of India	ICAR-Indian Institute of Maize Research, New Delhi	August 30-September 06, 2014
Dr. K. P. Singh	Training cum Workshop on "Implementation of Management Information System (MIS) including Financial Management (FMS)"	ICAR-Indian Institute of Maize Research, New Delhi	July 11- August 11, 2014
Dr. Pradyuman Kumar	Five days training on "Maize Entomological Research" to Dr. Panjab Ghuggi (Entomologist) Syngenta.	ICAR-Indian Institute of Maize Research, New Delhi	October 12-17, 2014
Dr. Pradyuman Kumar	Two days training on "Maize Entomological Research" to Dr. Maha Singh, Associate Professor (Entomology), CCS HAU, Hisar.	ICAR-Indian Institute of Maize Research, New Delhi	November 12-13, 2014
Dr. S.B. Singh	Three days farmers training prog. on seed production technology of single cross maize hybrids	RMR & SPC, Begusarai	Jannuary 19-21, 2015

C. Participation in Conferences/ Seminars/ Workshops/ Meetings

Name	Programme	Venue	Date
Dr. Aditya K. Singh	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
	International Conference on "Natural Resources Management for Food Security and Rural livelihoods"	New Delhi, India	February 10 - 13, 2015
Dr. Ashok Kumar	National Symposium on "Agriculture diversification for sustainable livelihood and environmental security"	Punjab Agricultural University, Ludhiana	November 18-20, 2014
Dr. A. Manivannan	Germplasm Field Day and Brain Storming Session on Maize Genetic Resources	National Bureau of Plant Genetic Resources, New Delhi	September 15, 2014
	Ek divasiya hindi sanghosti	NASC Complex, Delhi	September 26, 2014
	National Seminar on "Challenges and Innovative Approaches in Crop Improvement"	AC&RI, TNAU, Madurai	December 16 - 17, 2014

Name	Programme	Venue	Date
Dr. Bhupender Kumar	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security"	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
Dr. C.M. Parihar	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
	International Conference on "Natural Resources Management for Food Security and Rural livelihoods"	New Delhi, India	February 10 - 13, 2015
	Workshop on "Synthesizing Statistical and Agricultural Sciences for Harnessing and Enhancing Quality of Agricultural Research"	IASRI, New Delhi	March 25, 2015
Dr. D.P Chaudhary	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
	National Symposium on "Crop Improvement for Inclusive Sustainable Development"	Punjab Agricultural University, Ludhiana	November 7-9, 2014
	83rd Annual meeting of the Society for Biological Chemists	Bhubaneswar	December 17-21, 2014
Dr. Ganpati Mukari	National Symposium on "Crop Improvement for Inclusive Sustainable Development"	Punjab Agricultural University, Ludhiana	November 7-9, 2014
Dr. Ishwar Singh	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security"	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
	8th Annual Review Meeting of "ICAR-Network Project on Transgenics in Crops"	NRCPB, New Delhi	December 2 - 3, 2014.
	Workshop on "Training Needs Assessment" for HRD Nodal Officers of ICAR	NAARM, Hyderabad	February 26, 2015
Dr. J.C. Sekhar	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security"	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
Dr. Jyoti Kaul	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security"	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
Dr. K.S. Hooda	National Symposium on "Crop Improvement for inclusive sustainable development"	Punjab Agricultural University, Ludhiana	November 7-9, 2014
	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security"	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
Dr. Meena Shekhar	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security"	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
Dr. Nirupma Singh	Germplasm Field Day and Brain Storming Session on Maize Genetic Resources	National Bureau of Plant Genetic Resources, New Delhi	September15, 2014
	Ek divasiya hindi sanghosti	NASC Complex, Delhi	September 26, 2014
	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security"	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
Dr. N. Sunil	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security"	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
Dr. P. Kumar	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security"	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
	National Symposium on "Crop Improvement for inclusive sustainable development"	Punjab Agricultural University, Ludhiana	November 7-9, 2014
Dr. P. Lakshmi Saujanaya	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security"	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014

Name	Programme	Venue	Date
Dr. Pranjal Yadava	Workshop on Biosafety and Detection of GM Crops	National Bureau of Plant Genetic Resources, New Delhi,	11-16 August 2014
	Germplasm Field Day and Brain Storming Session on Maize Genetic Resources,	National Bureau of Plant Genetic Resources, New Delhi	September15, 2014
	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
	Communication Workshop on Agricultural Biotechnology,	Ministry of Environment and Forests, New Delhi	November 19, 2014
	8th Annual Review Meeting of ICAR-Network Project on Transgenics in Crops	National Research Centre on Plant Biotechnology, New Delhi	December 2-3, 2014
	Meeting on priority areas of collaboration with Borlaug Institute for South Asia	National Agricultural Science Centre Complex	January 12, 2015
	Biological Nitrogen Fixation group and sub-group meetings under XII Plan scheme 'Incentivizing Research in Agriculture'	National Research Centre on Plant Biotechnology, New Delhi	January 29 & February 11, 2015
Dr. Ramesh Kumar	National Symposium on "Crop Improvement for Inclusive Sustainable Development"	Punjab Agricultural University, Ludhiana	November 7-9, 2014
Dr. S.B. Singh	Meeting for Identification of Maize Hybrids for Kharif Season	Patna	June 05, 2014
	Workshop on " Maize Production, Processing, Storage, Marketing and Statistic data Development"	Patna	June 06, 2014
	Meeting Called by Hon'able Union Agriculture Minister, GOI	Patna	June 21, 2014
	Meeting of ATMA Project District Begusarai	Begusarai	July 14, 2014 September 26, 2014
	Meeting of ICAR Institutes of Eastern Region	ICAR, Patna	July 19, 2014
	Scientific Advisory Committee Meeting of KVK, Khagaria (Bihar)	KVK, Khagaria, Bihar	September 03, 2014
	IX Annual Review Meeting of ICAR Seed Project- "Seed Production in Agricultural Crops"	ANGRAU, Hyderabad	September 22-23, 2014
	Meeting for Identification of Maize Hybrids for Rabi Season	Patna	October 20, 2014
	National Conference on "Emerging Challenges and Opportunities in Biotic and Abiotic Stress Management"	Directorate of Rice Research, Hyderabad	December 13-14, 2014
	Meeting organized by IFFCO	Begusarai	December 23, 2014
Dr. S.L. Jat	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
	International Conference on "Natural Resources Management for Food Security and Rural livelihoods"	New Delhi, India	February 10 - 13, 2015
Dr. Vimla Singh	National Symposium on "Innovative Approaches for Plant Disease Management for Sustainable Development"	Plant Virology Unit, I.A.R.I	January 17, 2015
Dr.Vinay Mahajan	12th Asian Maize Conference and Expert Consultation on "Maize for Food, Feed, Nutrition and Environmental Security	Rama Garden Hotel, Bangkok, Thailand	October 30 - November 01, 2014
	National Symposium on "Crop Improvement for Inclusive Sustainable Development"	Punjab Agricultural University, Ludhiana	November 7-9, 2014

Annexure 6

Lectures / Radio/ Television talks Delivered

Scientist	Topic	Programme	Venue	Date
Dr. Aditya K. Singh	Maize and its scientific production technologies	Model training course on "Practices for conservation agriculture and climate resilient maize systems"	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"	Indian Institute of Maize Research, New Delhi	September 05, 2014
	Makka ki navintam shasya vidhiya	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	September 24, 2014
Dr. Ashok Kumar	Scientific cultivation of maize	Training programme on "Improved agricultural technologies for higher productivity and income for institute of rural development".	Guwahati	August 11, 2014
	Crop rotation and their importance in conservation agriculture	Model training course on "Practices for conservation agriculture and climate resilient maize systems"	Indian Institute of Maize Research, New Delhi	September 03, 2014
Dr. A. Manivannan	Biplot analysis in germplasm characterization of industrial legume – clusterbean (*Cyamopsis tetragonoloba* (L.) Taub.) "	National Seminar on "Challenges and innovative approaches in crop improvement"	AC&RI, TNAU, Madurai	December 16 - 17, 2014
	Makka ki unnat prajatiya	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	September 24, 2014
Dr. Bhupender Kumar	Important maize hybrids for different ecologies	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	September 10, 18 & 24, 2014; October 08, 2014
Dr. C. M. Parihar	Conservation agriculture: improving resource efficiency in maize-based systems of India	Model training course on "Practices for conservation agriculture and climate resilient maize systems"	Indian Institute of Maize Research, New Delhi	August 30, 2014
	Makka ki utpadan taknikiya	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	September, 10 & 17, 2014;
	Makka ki navintam sashay vidhiya	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	March 10 & 24, 2015
	Medium term effects of a long term conservation agriculture study in maize based cropping systems on productivity, profitability and climate resilience	International conference on "Natural Resources Management for Food Security and Rural livelihoods"	New Delhi, India	February 10 - 13, 2015
Dr. D. P. Chaudhary	Maize as Future Crop for Punjab	Training programme on "Perspectives of Diversification in Agriculture"	Punjab Agricultural Management and Extension Training Institute, Ludhiana	May 19, 2015
	Maize Prospectus in Punjab	Field day	Purkhowal village , Near Garshankar, Punjab	February 05, 2015
Dr. Jyoti Kaul	Quality protein *makka ki aadi vasi shetro mein mahatvta*	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	September 12 & 19, 2014; October 08, 2014
	Quality protein makka ka yogdan	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	September 26, 2014
Dr. K.P. Singh	Maize AgriDaksh- an Expert System.	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	September 19 & 26; October 08, 2014; March 19 & 26, 2015
Dr. K.S. Hooda	Disease dynamics under conservation agriculture in maize systems	Model training course on "Practices for conservation agriculture and climate resilient maize systems"	Indian Institute of Maize Research, New Delhi	September 03, 2014
	Makka ki mukhye bimariya avam unki roktham	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	September 10 & 17, 2014

Scientist	Topic	Programme	Venue	Date
Dr. Meena Shekhar	*Makka ki bimariya evam unki roktham*	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	September 24, 2014; October 08, 2014
Dr. Nirupma Singh	*Vishisht makka avam unki utpadan taknikiya*	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	October 08 & 10, 2014; September 17, 2014; March 17 & 24 & 29, 2015
	Vishisht makka ki kheti se adhik aaye	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	September 24, 2014
Dr. P. Kumar	Insect dynamics under conservation agriculture in maize systems	Model training course on "Practices for conservation agriculture and climate resilient maize systems"	Indian Institute of Maize Research, New Delhi	September 03, 2014
	IPM in Maize Ecosystem	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	September 10, 17 & 24; October 08, 2014; March 17 & 24, 2015
Dr. Shankar Lal Jat	*Rabi makkka main samsamyik kiriyaye*	Krishi Darshan Programme.	Door Darshan, Delhi	December 23, 2014
	Maize and its uses	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	March 10, 17 & 24, 2015
	Uses of maize	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	September 10 & 17, 2014
	Makka ek bhuupyogi fasal	National Training Programme under TSP for tribal farmers	Indian Institute of Maize Research, New Delhi	September 24 & October 8, 2014
	Kharif makkka main samsamyik kiriyaye	Krishi Darshan Programme.	Door Darshan, Delhi	September 23, 2014
	Root image analyzer	CIMMYT organized Advance Course-Asia on "Conservation Agriculture: Gateway for Productive and Sustainable Cropping Systems"	Karnal	October 17, 2014
	Speciality corn production technologies	Model training course on "Practices for conservation agriculture and climate resilient Maize systems"	Indian Institute of Maize Research, New Delhi	September 03, 2014
	Conservation tillage and soil physical environment	Model training course on "Practices for conservation agriculture and climate resilient maize systems"	Indian Institute of Maize Research, New Delhi	September 04, 2014
	Maize Agridaksh: an online expert systems	Model training course on "Practices for conservation agriculture and climate resilient maize systems"	Indian Institute of Maize Research, New Delhi	September 04, 2014
Dr. Vinay Mahajan	Climate change and maize productivity in north-western plains regions of India	National Symposium on "Crop Improvement for inclusive sustainable development	PAU, Ludhiana, Punjab	November 7 - 9, 2014
	Quality seed production technology of composites and hybrids of maize	Quality Seed Production in Cereals	National Seed Training and Research Center, Ministry of Agriculture , Varanasi	August 26, 2014
	Specialty corn, quality protein maize, climate change and maize production	Quality Seed Production in Cereals	National Seed Training and Research Center, Ministry of Agriculture , Varanasi	August 26, 2014
	Breeding strategies on climate ready traits in maize.	Quality Seed Production in Cereals	National Seed Training and Research Center, Ministry of Agriculture , Varanasi	August 26, 2014
	Recommended varieties, package & practices and roadmap of maize development in NE state	Workshop for North-East States on promotion of pulses and coarse cereals	Umiam, Meghalaya	June13, 2014

Annexure 7

A. Research Papers

1. Abhishek A., Rita K., Chikkappa G.K., Kumar P., Kumar B., Dass S., Kumar R.S. and Ramteke P.W. 2014. Tissue culture independent *Agrobacterium tumefaciens* mediated in planta transformation method for tropical maize (*Zea mays*.L). Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci. Published online: 12 December, 2014. DOI 10.1007/ s40011-014-0454-0.

2. Abhishek A., Chikkappa G.K., Ravindra N., Meenakshi B., Ramteke P.W., Kumar P., Dass S. and Kumar R.S. 2014. Differential effect of immature embryo's age and genotypes on embryogenic type II callus production and whole plant regeneration in tropical maize inbred lines (*Zea mays* L.). Indian Journal of Genetics & Plant Breeding 74(3):317-324. DOI: 10.5958/0975-6906.2014.00849.9.

3. Ahmad B., Kumar V., Singode A., Mahajan V. and Singh K.P. 2014. Evaluation of maize (*Zea mays*) inbred lines for tolerance to low temperature stress under field conditions. Indian Journal of Agricultural Sciences, 84 (7): 873–876.

4. Beslin J.J., Yathish K.R., John J.A., Kumar K.K., Kokiladevi E., Arul L., Gnanam R., Balasubramanian P. and Sudhakar D. 2014. A high-throughput regeneration protocol for recalcitrant tropical Indian maize (*Zea mays* L) inbreds. Maydica, 59: 211-216.

5. Brahmaiah M., Jhansi R.K., Sunil N. and Keshavulu K. 2014. Genetic divergence in cowpea [*Vigna unguiculata* (L.) Walp] for yield components and seed quality parameters. Electronic Journal of Plant Breeding, 5(1): 107-111.

6. Dahima V., Sharma S.S., Khokhar M.K. and Hooda K.S. 2014. Post-infectional changes in maize leaves affected by banded leaf and sheath blight disease. Indian Phytopathology, 67 (4): 370-373.

7. Elayaraja K., Gadag R.N., Kumari J., Singode A. and Paul D. 2014. Analysis of combining ability in experimental hybrids of sweet corn (*Zea mays* var. saccharata). Indian Journal of Genetics and Plant Breeding, 74(3): 387-391. DOI : 10.5958/0975-6906.2014.00859.1

8. Ganesan S.K., Singh R., Choudhury D.P., Bharadwaj J., Gupta V. and Singode A. 2014. Genetic diversity and population structure study of drumstick (*Moringa oleifera* Lam.) using morphological and SSR markers. Industrial Crops and Products, 60: 316-325.

9. Hedau N.K., Dhar S., Mahajan V., Agarwal P.K. and Bhatt J.C. 2014. VL Tamatar 4: New Tomato Cultivar for open-field and greenhouse cultivation. Horticultural Science, 49(1): 105-106.

10. Jakkeral S.A., Nadaf H.L., Gowda M.V.C., Bhat R.S., Patil R.K., Motagi B., Kenchanagowda P., Mukri G., Archana B., Ganagshetty P., Gangadhar K. and Jaggal L.2014. Marker detection and genetic analysis for rust resistance of recombinant and backcross inbred lines in groundnut (*Arachis hypogaea* L.), Indian Journal of Genetics & Plant Breeding, 74(2): 213-221.

11. Jalali S.K., Yadavalli L., Ojha R., Kumar P., Suby S.B., Sharma R., Nair R., Kadanur R.C., Kamath S. P. and Komarlingam M.S. 2014. Baseline sensitivity of maize borers in India to the *Bacillus thuringiensis* insecticidal proteins Cry1A105 and Cry2Ab2. Pest Management Science, 09/2014; DOI 10.1002/PS.3888.

12. Jat S.L., Shivay Y.S. and Parihar C.M. 2014.Effect of dual-purpose summer legumes and zinc fertilization on system productivity, economics and nutrient use-efficiencies of rice (*Oryza sativa*)– wheat (*Triticum aestivum*) cropping. Indian Journal of Agricultural Sciences, 84 (8): 942–50.

13. Kaur J., Kumar P., Singh J. and Suby S.B.2014. Plant age preference for oviposition by Sesamia inferens (Walker) on maize, *Zea mays* L. Indian Journal of Entomology, 76 (3): 245-249.

14. Kaur J., Kumar P., Singh J., Suby S.B. and Bajya D.R. 2015. Egg laying pattern of *Sesamia inferens* on maize, *Zea mays* L. Indian Journal of Agricultural Sciences, 85(1):109-113.

15. Khokar M.K., Hooda K.S., Sharma S.S. and Singh V.2014. Post-flowering stalk rot complex of maize - present status and future prospects. Maydica, 59:226-242.

16. Khokar M.K., Hooda K.S., Sharma S.S., Singh V. and Saini A. 2014. *Fusarium* stalk rot: a major threat to maize production in India. Maize Journal, 2(1&2): 1-6.

17. Kumar B., Talukdar A., Bala I., Verma K., Lal S.K., Sapra R.L., Namita, Chander S., Tiwari R. 2014b. Population structure and association mapping studies for important agronomic traits in soybean. Journal of Genetics**,** 93 (3):775-784.

18. Kumar B., Talukdar A., Verma K., Bala I., Harish G.D., Gowda Samrat D.S., Lal S.K., Sapra R.L. and Singh K.P.2014. Mapping of yellow mosaic virus (YMV) resistance in soybean (*Glycine max* L. Merr.) through association mapping approach. Genetica, 143:1-10.

19. Kumar R., Singode A., Chikkappa G.K., Mukri **G.**, Dubey R.B., Komboj M.C., Singh H.C., Olakh D.S., Ahmad B., Krishna M., Zaidi P.H., Debnath M.K., Seetharama K. and Yadav OP.2014. Assessment of genotype × environment interactions for grain yield in maize hybrids in rainfed environments. SABRAO Journal of Breeding and Genetics, 46 (2) 284-292.

20. Kumar V., Singh A.K., Jat S.L., Parihar C.M., Pooniya V., Sharma S. and Singh B. 2014. Influence of site-specific nutrient management on growth and yield of maize (*Zea mays*) under conservation tillage. Indian Journal of Agronomy, 59(4): 657-660.

21. Mahadeva Swamy H.K., Singh A., Somappa J., Yathish K.R., Nemappa L. and Bajpal G.C. 2014. Genetic analysis of milling quality in inter-specific progenies of pigeon pea (*Cajanus cajan* (L.) Millsp. Progressive Research, 9 (conf. spl.) 19-21.

22. Meena B.P., Kumar A., Dotaniya M.L., Jat N.K. and Lal B. 2014. Effect of organic sources of nutrients on tuber bulking rate, grades and specific gravity of potato tubers. Proceedings of the National Academy of Sciences, India, Section B: Biological Sciences, DOI 10.1007/s40011-014-0398-4 .

23. Meena M.R., Singh N., Jain N., Kumar R. and Singh S.S. 2015. Genetic analysis of the stem rust resistance genes in synthetic hexaploid wheat (Triticum aestivum) lines. Indian Journal of Agricultural Sciences, 85 (3):331–334.

24. Mishra P.K., Gogoi G., Singh P.K., Rai S.N., Singode A., Kumar A. and Manjunatha C. 2014. Morpho-cultural and pathogenic variability in *Rhizoctonia solani* isolates from rice, maize and green gram. Indian Phytopathology, 67 (2): 147-154.

25. Mukri G., Biradar B.D. and Sajjanar G.M. 2014. Influence of sowing dates on phenotypic traits in sorghum. Indian Journal of Ecology, 41(1): 129-134.

26. Mukri G., Nadaf H.L., Gowda M.V.C., Bhat R.S. and Upadhyaya H.D. 2014. Genetic analysis for yield, nutritional and oil quality traits in RIL population of groundnut (*Arachis hypogaea* L.). Indian Journal of Genetics and Plant Breeding, 74(4): 450-455.

27. Mukri G., Jakkeral S. and Nadaf H.L.2014. Nutrition and fatty acid composition in different botanical groups of groundnut (*Arachis hypogaea*. L) in ICRISAT mini core collection. Electronic Journal of Plant Breeding, 5(3): 489-494.

28. Mukri G., Nadaf H.L., Gowda M.V.C., Bhat R.S. and Upadhyaya H.D. 2014. Genetic diversity analysis based on nutritional, oil quality and yield component traits in mini core collection of groundnut (*Arachis hypogaea* L.) Karnataka Journal of Agricultural Sciences, 27 (2): 219-221.

29. Mukri G., Nadaf H.L., Gowda M.V.C., Bhat R.S., Koti R.V. and Chimmad B. 2014.Isolation of superior segregants for yield, nutritional and oil quality traits from RILs population of groundnut. Karnataka Journal of Agricultural Sciences, 27 (2): 111-115

30. Pandey M.K., Upadhyaya H.D., Rathore A., Vadez V., Sheshshayee M.S., Sriswathi M., Govil M., Kumar A., Gowda M.V.C., Sharma S., Hamidou F.,V. Kumar A, Khera P., Bhat R.S., Khan A.W., Singh S., Li H., Monyo E., Nadaf H.L., Mukri G., Jackson S.A., Guo B., Liang X. and Varshney R.K. 2014. Genome wide association studies for 50 agronomic traits in peanut using the 'reference set' comprising 300 genotypes from 48 countries of the semi-arid tropics of the world. PLOS ONE, 9 (8) 1-14.

31. Pandravada S.R., Sivaraj N., Jairam R., Sunil N., Begum H., Reddy M. T., Chakrabarty S.K., Bisht I.S. and Bansal K.C.2014. *Luffa hermaphrodita*: First Report of its Distribution and Cultivation in Adilabad, Andhra Pradesh, South India. Asian Agri-History, 18(2): 123–132.

32. Sanjeev P., Chaudhary D.P., Sreevastava P., Saha S., Rajenderan A., Sekhar J.C. and Chikkappa G.K. 2014. Comparison of fatty acid profile of specialty maize to normal maize. Journal of the American Oil Chemists' Society. DOI 10.1007/s11746-014-2429-y

33. Sharanappa S.D., Kumar J., Meena H.P., Bharadwaj C., Jagadeesh H.M., Raghvendra K.P. and Singode A. 2014. Studies on heritability and genetic advance in Chickpea (Cicer arietinum L.). Journal of Food Legumes, 27(1): 71-73.

34. Shekhar D., Singh A.K., Singh V., Nepalia and Choudhary J. 2014. Weed dynamics, productivity, economics and soil health under different tillage and weed control practices in wheat (*Triticum aestivum*)-maize(*Zea mays*) cropping sequence in southern Rajasthan. Indian Journal of Agronomy 59(4): 561-567

35. Singh A.K., Parihar C.M., Jat S.L., Singh B. and Sharma S. 2015. Weed management strategies in maize (*Zea mays*): Effect on weed dynamics, productivity and economics of the maize- wheat *(Triticum aestivum*) cropping system in Indo-gangetic plains. Indian Journal of Agricultural Sciences. 85 (1): 87–92.

36. Singh K.P., Mahajan V., Srivastava E. and Rai K. 2014. Climate change and maize productivity in north-western plains regions of India. Indian Journal of Genetics and Plant Breeding, 74(4) Suppl., 568-571.

37. Singh V., Kumar S., Lal M. and Hooda K.S. 2014. Cultural and morphological variability among isolates of *Rhizoctonia solani* from trans-gangetic plains of India. Research on Crops. 15 (3): 644-650.

38. Singode A., Singh K.P., Srivastava E., Guleria S.K., Devlash R., Dar Z.A., Lone Z.A., Ahmad B. and Mahajan V. 2014. Heterosis and correlation deviations in maize under different agroecologies. Indian Journal of Genetics and Plant breeding, 74(4): 438-443.

39. Singh I., Langyan S. and Yadava P. 2014. Sweet corn and corn-based sweeteners. Sugar Tech, 16(2):144–149. DOI 10.1007/s12355-014-0305-6.

40. Sivaraj N., Kamala V., Pandravada S.R., Sunil N., Elangovan M., Sarath Babu B., Chakrabarty S.K., Varaprasad K.S. and Krishnamurthy K.V. 2014. Floristic ecology and phenological observations on the medicinal flora of Southern Eastern Ghats, India. Open Access Journal of Medicinal and Aromatic Plants Vol. 5(2): 5-24.

41. Sunil N., Kumar V., Reddy M.T. and Kamala V. 2014. Phenotypic diversity and genetic variation within a collection of onion (*Allium cepa* l.) germplasm from Peninsular India. Electronic Journal of Plant Breeding, 5(4): 743-751.

42. Sunil N., Pandravada S.R., Sivaraj N., Reddy J., Chakrabarty S.K., Ashok J., Bisht I.S., 2014. Diversity in the Landraces of Green Gram [*Vigna radiata* (L) R. Wilczek. Collected from Tribal Communities of Peninsular India. The Journal of Biodiversity- Photon 114: 392-400.

43. Sunil N., Thirupathi Reddy M., Hameedunnisa B., Vinod, Someswara Rao P., Sivaraj N., Kamala V., Prasad R.B.N., Rao B.V.S.K., Chakrabarty S.K. 2014. Diversity in bottle gourd (*Lagenaria siceraria* - (Molina) Standl.) Germplasm from peninsular India. Electronic Journal of Plant Breeding, 5(2): 236-243.

44. Yadav O.P. 2014. Developing drought-resilient crops for improving productivity of drought-prone ecologies. Indian Journal of Genetics and Plant Breeding 74: 548-552.

B. Extended Summary / Abstract / Conference Paper

1. Biradar K., Mukri G. and Nadaf H.L.2014. Development/ identification of new genetic sources for high oleic acid in groundnut (*Arachis hypogaea* L.). In: Book of Abstracts, 7th International Conference of the Peanut Research Community; November 11 to 14, 2014; Savannah Marriott Riverfront, Savannah, Georgia 31401 USA.

2. Blummel M., Zaidi P.H., Vinayan M.T., Babu R. and Yadav O.P. 2014. The fodder value of maize stover vis-à-vis other cereals residues and opportunity for improvement through crop breeding and value addition. In: Book of Extended Summaries, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

3. Changan S., Chaudhary D.P., Kumar S., Kumar B., Kaul J., Guleria S., Jat S.L. and O.P. Yadav.2014. Exploitation of natural variability in maize for major micronutrients. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

4. Changan S., Chaudhary D.P., Kumar B., Kaul J., Guleria S. 2014. Biochemical Characterization of Maize Germplasm for Protein Quality. In: Book of Abstracts, National Symposium on Crop Improvement for Inclusive Sustainable Development; November 7-9, 2014; P.A.U., Ludhiana, Punjab.

5. Chikkappa G.K., Sekhar J.C.**,** Soujanya P.L. and Kumar P. 2014. Generation Mean analysis of preferential oviposition behavior of Pink stem borer (*Sesamia inferens* L.) in maize germplasm. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

6. Gangadhara K., Nadaf H.L. and Mukri G. 2014. Selection for high oleate phenotype with foliar disease resistance from backcross population in groundnut (*Arachis hypogaea* L.). In: Book of Abstracts, 7th International Conference of the Peanut Research Community; November 11 to 14, 2014; Savannah Marriott Riverfront, Savannah, Georgia 31401 USA.

7. Garg N.K., Dahuja A., Chaudhary D.P.**,** Singh A. and Jain P.K. 2014. Carbohydrate Profile and Starch Digestibility Characteristics of Indian Maize Genotypes. In: Proceedings of the 83rd Annual meeting of the Society for Biological Chemists; December 17-21, 2014; Bhubaneswar.

8. Hooda K.S., Shekar J.C., Chikkappa G.K., Kumar B., Kaul J., Singode A., Dass S., Kumar R.S., Yadav O.P., Singh V., Kumar S., Khokar M.K., Sharma S.S., Kaur H., Sreerama Setty T.A., Pandurnge Gowda K.T., Gogoi R., Devlash R.K., Basandarai A., Chandraskehara C. and Kumar P. 2014. Stable sources of multiple disease resistance in maize. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

9. Jakkeral S.A., Nadaf H.L., Gowda M.V.C., Bhat R.S., Motagi B., Mukri G., Ganagshetty P., Talawar A. and Archana B.2014. Genetic variability and marker detection for rust resistance in recombinant inbred lines and backcross inbred lines of groundnut (*Arachis hypogaea* L.) . In: Book of Abstracts, 7th International Conference of the Peanut Research Community; November 11 to 14, 2014; Savannah Marriott Riverfront, Savannah, Georgia 31401 USA.

10. Jakkeral S.A., Nadaf H.L., Gowda M.V.C., Bhat R.S., Motagi B., Mukri G., Ganagshetty P., Talawar A. and Kolakar S.2014. Backcross breeding in groundnut (*Arachis hypogaea* L.). In: Book of Abstracts, 7th International Conference of the Peanut Research Community; November 11 to 14, 2014; Savannah Marriott Riverfront, Savannah, Georgia 31401 USA.

11. Jat M.L., Jat R.K., Singh P., Parihar C.M., Gathala M.K., Sindhu H.S., Sapkota T.B., Ridaura S.L., and Singh Y. 2014. Conservation agriculture based management practices for sustainable maize systems: Learning from South Asia. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

12. Jat S.L., Parihar C.M., Singh A.K., Kumar A. and Sharma S. 2014. Nitrogen management under conservation agriculture for enhancing resources use efficiency in intensified maize system. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

13. Kumar A., Parihar C.M., Jat S.L. and Singh A.K. 2014. Potassium management in maize-wheat-mung bean cropping reference. In: Book of Abstracts , National symposium on agriculture diversification for sustainable livelihood and environmental security; November 18-20, 2014; P.A.U., Ludhiana, Punjab .

14. Kumar A., Singh A.K., Jat S.L. and Parihar C.M. 2014. Enhanced productivity and resource use efficiency through maize based cropping systems in peri- urban areas .In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

15. Kumar B. , Guleria S.K., Dubey R.B. , Khanorkar S.M., Patel J., Varghese E., Kumar V., Abhishek A., Das A.K., Mukri G., Kumar R., Singh V., Yathish K.R., Hooda K.S., Singh S.B., Sekhar J.C. and Yadav O.P. 2014. The additive main effects and multiplicative interaction (AMMI) analysis for yield stability of elite maize hybrids under rainfed and irrigated conditions. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

16. Kumar B., Chaudhary D.P., Parihar C.M., Jat S.L., Sapna, Pradeep T., Puttaramanaik, Kumar V., Varghese E., Abhishek A., Das A.K., Mukri G., Kumar R., Singh V., Yathish K.R., Singh S.B., Sekhar J.C., Kaul J. and Yadav O.P.

2014. Study of genotype by environmental interactions (GEI) for quality traits in maize. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

17. Kumar B., Hooda K.S., Gogoi R., Kumar V., Kumar S., Abhishek A., Sekhar J.C., Das A.K., Mukri G., Singh V., Yathish K.R. and Yadav O.P. 2014. Inheritance Studies and Development of Mapping Populations for MLB Resistance in Maize. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

18. Kumar B., Yadava P. and Singh I. 2014. Physiological and biochemical effects of 24-epibrassinolide on drought tolerance in maize. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

19. Kumar R., Hooda K.S., Kaul J., Chaudhary D.P., Malik V.K., Kaur H., Sharma S.S., Gogoi R., Devlash R. and Mallikarjuna N. 2014. Screening of QPM germplasm for multiple disease resistance. In: Book of Abstracts, National symposium on Crop improvement for inclusive sustainable development; November 7 to 9, 2014; P.A.U., Ludhiana.

20. Kumar P., Suby S.B., Kaur J., Sekhar J.C. and Bana J.K. 2014. Development of susceptible index for maize germplasm against shoot fly, *Atherigona soccata* (Rondani). In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

21. Kumar P., Suby S.B., Kaur J., Sekhar J.C. and Bana J.K. 2014. Relationship between plant age and *Atherigona soccata* (Rondani) infestation .In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

22. Kumar R., Singode A., Chikkapa G.K., Mukri G., Dubey R.B., Komboj M.C., Singh H.C., Olakh D.S., Ahmad B., Krishna M., Zaidi P.H., Manoj K.D., Seetharama K. and Yadav O.P.2014. Assessment of genotype × environment interaction for grain yield in maize hybrids under rainfed ecology. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

23. Mahajan V. 2014. Climate change and maize productivity in north-western plains regions of India [contributory paper] In: Proceedings of the National symposium on agriculture diversification for sustainable livelihood and environmental security; November 18-20, 2014; P.A.U., Ludhiana, Punjab.

24. Mahajan V., Sudan R.S., Singode A., Srivastava E. and Singh K.P. 2014. Can change in correlation coefficients at another location be used to differentiate between locations for the performance of maize - A case study. In: Book of Abstracts, National symposium on agriculture diversification for sustainable livelihood and environmental security; November 18-20, 2014; P.A.U., Ludhiana, Punjab.

25. Manivannan A., Anandakumar C. R., Ushakumari R., Yesu Raja I. and Balakrishnan K.2014. Biplot analysis in germplasm characterization of industrial legume – clusterbean (*Cyamopsis tetragonoloba* (L.) Taub.) In: Book of Abstracts, National Seminar on Challenges and Innovative Approaches in Crop Improvement; December 16-17, 2014; AC&RI, TNAU, Madurai.

26. Mariyammal I., Usha Kumari R., Lakshmi Narayanan S. and Manivannan A. 2014. Screening for drought tolerance in cowpea (*Vigna unguiculata* (L) Walp.) under field condition. In: Book of Abstracts, National Seminar on Challenges and Innovative Approaches in Crop Improvement; December 16-17, 2014; AC&RI, TNAU, Madurai.

27. Mukri G., Das A.K., Rajendran A., Kumar B., Singh V., Jat S.L., Hooda K.S., Sekhar J.C. and Singh S.B. 2014. Evaluation and selection of inbred lines for genetic enhancement of white maize. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

28. Mukri G., Nadaf H.L., Bhat R.S., Gowda M.V.C., Upadhyaya H.D. 2014. Screening of ICRISAT mini core collection of groundnut (*Arachis hypogaea* L.) for high oleate trait: A step towards genetic improvement of nutritional quality of oil. In: Book of Abstracts, National Symposium on Agriculture Diversification for Sustainable Livelihood and Environmental Security; November 18-20, 2014; P.A.U., Ludhiana, Punjab.

29. Pandey M. K., Upadhyaya H.D., Rathore A,. Vadez V., Sheshshayee M.S., Sriswathi M., Govil M., Kumar A., Gowda M.V.C., Sharma S., Hamidou F., Anil Kumar V., Khera P., Bhat R.S., Khan A.W., Singh S., Li H., Monyo E., Nadaf .HL., Mukri G., Jackson S.A., Guo B., Liang X. and Varshney R.K. 2014. Comprehensive association analysis for 50 agronomic traits in peanut using the 'reference set' comprising 300 genotypes from 48 countries of the semi-arid tropics of the world. In: Proceedings of the 7th International Conference of the Peanut Research Community; November 11 to 14, 2014; Savannah Marriott Riverfront, Savannah, Georgia 31401 USA.

30. Parihar C.M., Singh A.K, Kumar Ashok, Jat S.L., Choudhary Vandana and Jat M.L. 2014. Medium-term effects of conservation agriculture on systems, water and nutrient productivity of maize based cropping sequences. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

31. Parihar C.M., Jat S.L., Singh A.K., Chaudhary V. and Jat. M.L. 2015. Medium term effects of a long term conservation agriculture study in maize based cropping systems on productivity, profitability and climate resilience. In: Book of Abstracts, International Conference on Natural Resources Management for Food Security and Rural livelihoods ; February10 to 13, 2015; New Delhi, India.

32. Pooniya V., Parihar C.M., Jat S.L., Singh A.K. and Choudhary A.K. 2014. Influence of conservation agriculture and nutrient management on crop productivity and soil –The Physical and biological Properties in maize – mustard cropping system. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

33. Reddy M. T., Begum H., Sunil N., Rao P. S., Sivaraj N., Rao N. H., Babu J. D., Reddy R. V. S. K., Sireesha K., Latha P. M. and Vijaya M. 2014. Production potential and genetic variability of landraces of roselle (*Hibiscus sabdariffa* L.) for key agro-economic traits under high density planting and once over harvest system. In: Book of Abstracts, National Symposium on Precision Horticulture for Small and Marginal Farmers; June 24 to 27, 2014; Indira Gandhi Krishi Vishwavidyalaya, Raipur.

34. Sapkota T., Parihar M.D., Rai M., Singh L.K., Singh A.K., Parihar C.M., Nanwal R.K., and Jat M.L. 2014. Environmental footprint of Maize based cropping systems under different crop establishment methods in North-West India. In: Book of Extended Summary, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

35. Sekhar J.C., Soujanya P.L., Chikkappa G.K., Kaul J., Singh K.P. and P. Kumar. 2014. Response of different maize accessions to pink stem borer *Sesamia inferens* Walker (Lepidoptera: Noctuidae). In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

36. Sekhar J.C., Soujanya P.L., Chikkappa G.K., Kumar P. and Singh K.P. 2014. Differential response of maize inbred lines to stem borers. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

37. Singh A.K., Parihar C.M., Jat S.L. and Sharma S. 2014. Site specific nutrient management in maize-wheat-mungbean cropping system under different tillage based on the Nutrient Expert-Decision support system. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

38. Singh K. P., Mahajan V., Srivastava E., Rai K., Guleria S. K. 2014. Development of early and medium maturing maize to changing climatic condition in north-western Himalayan state. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

39. Singh N. and Rajendran A. 2014. Relationship between gamma - zein and kernel vitreousness in quality protein maize. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

40. Singh N., Rajendran A., Singh I., Singode A., Kumar R., Manivannan A. and Ram Babu. 2014. Genetic variation in morpho-physiological traits for cold tolerance in tropical maize genotypes. In: Book of Abstracts, National Seminar on Emerging Challenges and Opportunities in Biotic and Abiotic Stress Management; December 13-14, 2014; D.R.R., Hyderabad.

41. Singh S.B., Kumar R., Kumar B., Mukri G., Singode A., Mishra R.P. and Kumar S. 2014 . Stress adaptive changes in morphological and yield related traits under water-logging condition in maize. In: Book of Abstracts, National Seminar on Emerging Challenges and Opportunities in Biotic and Abiotic Stress Management; December 13-14, 2014; D.R.R., Hyderabad.

42. Singode A., Singh K.P., Srivastava E., Guleria S.K., Sudan R.S., Dar Z.A., Lone A.A., Ahmed B., Mahajan V. 2014. Change in correlation coefficients and heterosis at diverse locations in early maturing maize hybrids. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

43. Soujanya P.L., Sekhar J.C., Chikkappa G.K. and Kumar P. 2014. Sources of resistance to rice weevil *Sitophilus oryzae* (L.) and anguomois grain moth *Sitotroga cerealella* (Oliv.) in Indian maize. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

44. Sunil N., Sekhar J.C., Kaul J. and Yadav O.P.2014. Genetic diversity in the regenerated set of maize germplasm conserved in the gene bank of India. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

45. Yadav O.P., Karjagi C.G., Kumar B., Jat S.L., Chawla J.S., Kaul J., Hooda K.S., Kumar P., Yadava P. and Dhillon B.S. 2014. Maize improvement in India. In: Book of Extended Summaries, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; CIMMYT, Mexio D.F. and APAARI, Bangkok.

46. Yadav O.P. 2014. Hybrid development in maize and pearl millet: Current status and future prospects. In: Compendium of lead papers and abstracts, 7th Seed Science Congress; September 25-27, 2014; Bhopal.

47. Yadava P., Thirunavukkarasu N., and Singh I. 2014. Salicylic acid mediated transcriptional modulation of antioxidant genes alleviates oxidative stress in maize. In: Book of Abstracts, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security; October 30 to November 01, 2014; Bangkok, Thailand.

C. Books Edited

1. Dass A., Singh A.K., Kaur R., Choudhary A.K., Parihar C.M., Jat S.L., Rana D.S. and Rana K.S. 2014. Agronomy in the Service of Nation: A Directory of Indian Agronomists. New Delhi, India. Indian Society of Agronomy, Division of Agronomy, Indian Agricultural Research Institute.

2. Rana D.S., Singh A.K., Dass A., Choudhary A.K., Parihar C.M., Bana R.S., Kaur R., Raj R., Jat S.L., Meena S.L., Sepat S., Pooniya V., Majumdar M. and Rajpoot S. 2014. Book of Extended Summaries, National Symposium on Agricultural Diversification for Sustainable Livelihood and Environmental Security. PAU, Ludhiana, November 18-20, 2014. ISA, New Delhi and ICAR, New Delhi.

D. Book Chapters

1. Chaudhary D.P., Sapna and Kumar R. 2014. Fodder preservation for dairying. In: Maize production systems for improving resource-use efficiency and livelihood security (74-77). ISBN 978-81-928624-0-8.
2. Dass S., Jat S.L., Parihar C.M., Chikkappa G.K., Kamboj M.C., Singh A.K. and Chaudhary V. 2014. Scientific Cultivation of Babycorn. In: Choudhary *et al.* (Eds.), Advances in Vegetable Agronomy (206-270). Post Graduate School, IARI, New Delhi. ISBN 978-93-83168-17-0.
3. Jat S.L., Parihar C.M., Singh A.K., Sing B. and Kumar A. 2014. Production technologies for baby corn. In: Rana et al. (Eds.), Advances in Field Crop Production (55-61). Post Graduate School, Indian Agricultural Research Institute, New Delhi.
4. Kumar B., Jat S.L., Mukri G. and Yatish K.R. 2014. Botany of maize plant. In: Maize production systems for improving resource-use efficiency and livelihood security. ISBN 978-81-928624-0-8.
5. Kumar D. and Kumar A. 2014. Nutrient use efficiency (NUE): An overview. In: Compendium of Lectures of Summer School "Recent Innovations for Improving Nutrient Use Efficiency through Integrated Nutrient Management in Major Field Crops" (22-32). Division of Agronomy, Indian Agricultural Research Institute, New Delhi, India.
6. Kumar P. and Suby S.B. 2014. Bio-pesticides in maize pest management. In: Koul O., Dhaliwal G.S., Khokhar S. and Singh R. (Eds.), Bio pesticides in Sustainable Agriculture-Progress and Potential(48-71). Jallandhar: Scientific Publishers (India).
7. Sapna, Chaudhary D.P. and Srivastava P. 2014. Qualitative dynamics of maize for enhanced livelihood security. In: Maize production systems for improving resource-use efficiency and livelihood security (81-84). ISBN 978-81-928624-0-8.

E. Technical Bulletins /Extension Bulletins

1. Tandon J.P., Sharma S.P., Sandhu J.S., Yadava D.K., Prabhu K.V. and Yadav O.P. 2015. Guidelines for testing of crop varieties under the All-India Coordinated Crop Improvement Projects. Indian Council of Agricultural Research, Krishi Bhavan, New Delhi 110 001. 250 pp.
2. Datta S.K., Chauhan J.S., Bansal K.C., Yadav O.P. and Tyagi R.K. 2014. Guidelines for registration of plant germplasm (revised, 2014). National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi. 28 pp.

F. Popular articles

1. Chaudhary D.P. 2014. Round the year fodder avilability from maize. Indian Farming 64(4): 44-47.
2. Dass S., Chikkappa G.K., Kumar B., Jat S.L., Parihar C.M., Kumar R. and Kamboj M.C. 2014. Single cross hybrid: A potential technology for boosting maize production. Indian farming, 64 (4):68-71.
3. Jat S.L., Parihar C.M. and Singh A.K. 2014. Conservation agriculture for enhancing resource use efficiency in maize systems. Indian farming, 64 (4):20-21 & 28.
4. Jat S.L., Parihar C.M., Singh A.K., Kumar Ashok and Singh Bahadur. 2014. Makka beej *utpadan: kishano ke liye ekal sankar ek vardan. Prasar Doot*, 18 (3): 16-19.
5. Kumar A., Kumari J., Rana J.C., Chaudhary D.P., Kumar R., Singh H. and Singh T.P. 2014. Variation in agronomic performance and grain quality of Indian maize landraces of high altitude region of Jammu Kashmir and Himachal Pradesh. Maize Genetics Cooperation Newsletter. 88: 1-11.
6. Kumar P., Sekhar J.C., Soujanya P.L. and Kaur J. 2014. Management of insect pests of maize. Indian Farming, 64 (4): 30-36.
7. Mahajan V., Srivastava E., Singh K.P. and Singode A. 2014. *Badalti jalvayu me ati-shigre pakane wali makka (Hindi). Kheti* 66(4):10-13.
8. Parihar C.M., Singh A.K. and Jat S.L. 2014. Higher productivity and profitability in maize systems by nutrient management. Indian farming, 64 (4):12-15 & 19
9. Shekhar M., Kumar S., Kumar S. and Hooda K.S. 2014. Disease management in maize. Indian Farming 64(4): 22-28.
10. Shekhar M., Singh N. and Bahukhandi D. 2015. Post flowering stalk rot of maize and their management practices. Krishisewa: Agriculture Information Hub. March, 2015
11. Soujanya P.L., Sekhar J.C., Kumar S., Kumar P., Hooda K.S. and Shekhar M. 2014. Management of post-harvest losses in maize. Indian Farming 64(4): 37-43.
12. Yadav O.P., Karjagi C.G., Jat S.L. and Dhillon B.S. 2014. Overview of maize improvement in India. Indian Farming 64(4): 5-11.
13. Yadav V., Jat S.L and Singh K.P. 2014. *Adhik aaye ke liye sweet corn ki kheti* (Hindi). *Kisan Kheti* 1(4): 13-15.

G. Institute Publication

1. Annual Progress Report Rabi Maize 2013-14. All India Coordinated Research Project on Maize. Directorate of Maize Research, Pusa Campus, New Delhi-110 012, INDIA.
2. Annual Progress Report Kharif Maize 2014. All India Coordinated Research Project on Maize. Directorate of Maize Research, Pusa Campus, New Delhi-110 012, INDIA.

Annexure 8

A. On-going Projects

Projects	Principal Investigator	Co- Principal Investigator	Duration
Plant Breeding and Genetics			
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
Development and enhancement of Quality Protein Maize Germplasm	Dr. Jyoti Kaul	Dr. Ramesh Kumar, Dr. Dharam Paul, Dr. N. Sunil	May, 2012 - April, 2017
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 Mukari Mr. Vishal Singh, Dr. Yatish Kumar, Dr. S.B. Singh, Dr. N. Sunil	June, 2014 - May, 2019
Development of high yielding maize hybrids for different ecologies	Dr. Bhupender Kumar	Dr. Avinash Singode, Dr. Manivannan, Dr. Chikkakpa G.K. Mr. Vishal Singh, Dr. Yatish Kumar, Dr. Ganpati Mukari Dr. Nirupma Singh, Dr. Ramesh Kumar, Dr. S.B. Singh, Dr. K.S. Hooda	June, 2014 - May, 2019
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	August, 2014 - July, 2019
Genetic enhancement for industrial, specialty and quality traits	Mr. Vishal Singh	Dr. Yatish Kumar, Dr. Dharam Paul, Dr. Pranjal Yadava	August, 2014 - July, 2019
Development of maize hybrids for eastern India	Dr. S.B. Singh	Dr. Avinash Singode, Dr. Yatish Kumar, Dr. Ganpati Mukari, Dr. N. Sunil	October, 2014 - September, 2019
Biotechnology			
Cloning and characterization of abiotic stress regulated genetic elements from maize	Dr. Pranjal Yadava	Dr. Ishwar Singh, Ms. Avni	September, 2012 - September, 2017
Agronomy			
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	June, 2013 - June, 2018
Diversified maize based cropping system for higher productivity and sustained soil health	Dr. Ashok Kumar	Dr. C.M. Parihar	July, 2011 – June, 2016
Site specific nutrient management in maize based cropping system	Dr. Aditya Kumar Singh	Dr. S.L. Jat, Dr. Ashok Kumar	June, 2012 - June, 2017
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
Pathology			
Identification of stable sources of resistance to major diseases of maize.	Dr. K.S. Hooda	Dr. Jyoti Kaul	April, 2010- March 2015
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, Dr. Dharam Paul	January, 2013- December, 2018
Entomology			
Study on biochemical basis of resistance against major pests of maize	*Ms. Suby S.B./ Dr. P. Kumar from 5.8.11	Dr. J.C. Sekhar, Ms. Aditi Kundu	April, 2010 - March, 2015

Projects	Principal Investigator	Co- Principal Investigator	Duration
Development of management tools for maize pests	Dr. P. Kumar	Dr. P. Lakshmi Soujanya	January, 2014– December, 2019
Identification of multiple borer resistant genotypes in maize	Dr. J.C. Sekhar	Dr. P. Kumar, Dr. P. Lakshmi Soujanya, Dr. N. Sunil	June, 2012 – May, 2017
Management of *Sitophilus oryzae* (L.) and *Sitotroga cerealella* (Oliv.) infesting stored maize through host plant resistance and plant origin pesticides	Dr. P. Lakshmi Soujanya	Dr. J.C. Sekhar	June, 2012 – April, 2017
Biochemistry			
Biochemical characterization of normal and speciality corn germplasm	Dr. Dharam Paul	-	April, 2012 – March, 2017
Physiology			
Physiological and molecular basis of heat tolerance in maize	Dr. Ishwar Singh	Dr. Pranjal Yadava, Ms. Avni	October, 2014- September, 2017
Social Sciences			
Strengthening and refinement of Maize AGRIdaksh	Dr. Virendra Kumar Yadav/Dr. K.P.Singh as PI from June 2014	-	April, 2011 - March, 2016
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

B. Externally Funded Projects

Project	Funding agency	Duration	P.I./Mentor
Baseline – susceptibility of multiple populations of *Chilo partellus, Sesamia inferens* and *Helicoverpa arinigera* for two Bt insecticidal proteins	Syngenta Bio-sciences India. Pvt. Ltd.	January, 2013 onwards	Dr. Pradymun Kumar
Development of Maize Transgenic for Stem Borer Resistance	ICAR- Network Project	April, 2012 onwards	Dr. Pradymun Kumar
Institute Technology Management Unit	ITMU-IIMR	April, 2012 onwards	Dr. Pradymun Kumar
Strengthening DUS test centres for effective implementation of PVP legislation	PPV&FRA	2004, onwards	Dr. Jyoti Kaul
Mega Seed Project	DSR/ICAR	2007, onwards	Dr. S. B. Singh
Functional genomics of drought tolerance in maize	ICAR- Network Project	April, 2012 - March, 2017	Dr. Ishwar Singh
Study of host pathogen interactions as affected by extrachromosal factors dsRNA and DNA Plasmids in Rhizoctonia sp	DST	April, 2014 - March, 2017	Dr. Vimla Singh/ Dr. K.S. Hooda As Mentor
CRP on Maize Agro-biodiversity	ICAR (NBPGR)(CRP)	June, 2014 - March, 2017	Dr. Jyoti Kaul
National Initiative on Climate Resilient Agriculture (NICRA) at CRIDA	ICAR (CRP)	April, 2012 - March, 2017	Dr. Aditya Kumar Singh
Consortia for Research Platform (CRP) in Biofortiification in selected crops or nutritional security	ICAR (CRP)	April, 2012 - March, 2017	Dr. Bhupender Kumar

C. Closed/Merged Project during 2014 as per recommendation of Institute Research Council or their maturity

Project	Principal Investigator	Co- Principal Investigator
Molecular characterization of elite maize inbred lines	Dr. Avinash Singode	Dr. Jyoti Kaul
In-vitro characterization of regeneration capacity of maize genotypes	Dr. Yathish K.R.	Dr. Vishal Singh, Dr. Avinash Singode, Dr. Ganpati Mukri, Mr. Abhijith Kr. Das
Development of normal and quality protein maize hybrids for winter season.	Dr. Ramesh Kumar / Dr. S.B. Singh	Dr. Jyoti Kaul, Dr. G.K. Chikkappa, Dr. Nirupma Singh, Dr. Bhupender Kumar Dr. Pradyumn Kumar, Dr. K.S. Hooda, Dr. Dharam Paul
Germplasm development and enhancement for cold tolerance in Maize	Dr. Nirupma Singh	Dr. Ambika Rajandren, Dr. Avinash Singode, Dr. Ramesh Kumar Dr. J.C.Sekhar, Dr. Ishwar Singh, Dr. Meena Shekhar
Breeding for Drought Tolerance in Maize	Dr. Bhupender Kumar/Dr. Ramesh	Dr. G.K. Chikkappa, Dr. Vinay Mahajan, Dr. Ishwar Singh, Dr. S.L.Jat Dr. Ganpati Mukri, Mr. Yathish K.R.
Genetic enhancement of medium duration normal maize germ plasm	Dr. C.G. Karjagi	Dr. J.C.Sekhar, Dr. Bhupender Kumar, Dr. Ganapati Mukri, Dr. C.M. Parihar Dr. G. Ramesh, Mr. Abhijeet Dass, Dr. N. Sunil
Genetic Enhancement of Late duration Normal Maize Germ plasm	Dr. Bhupender Kumar	Dr. J.C. Sekhar, Dr. K.S. Hooda, Dr. G.K. Chikkappa, Mr. Vishal Singh Dr. C.M. Parihar, Dr. Ramesh Kumar, Mr. Abhijeet Dass
Genetic Enhancement of White Maize Germ plasm	Dr.Ganapati Mukri	Dr. Ambika Rajandren Dr. Bhupender Kumar, Dr. K.S. Hooda, Dr. C.G. Karjagi Mr. Vishal Singh, Mr. Abhijit Kumar Das, Dr. S.L. Jat
Genetic enhancement for provitamin – A in maize	Mr.Abhijit Kr.Das	Dr. Bhupender Kumar, Dr. C.G. Karjagi, Dr. Ganapati Mukri, Mr. Yatish K. Dr. Avinash Singode, Ms. Sapna, Mr. Vishal Singh, Dr. Pranjal Yadava
Genetic enhancement and development of high oil and baby corn traits in maize	Dr. Ambika Rajendran	Dr. Nirupma Singh, Dr. Dharam Paul, Dr. Ganapati Mukri, Dr. Meena Shekhar Dr. Lakshmi Saujanya
Germplasm Enhancement of Maize for High Starch and Methionine Content	Mr. Vishal Singh	Ms. Sapna, Dr. Bhupender Kumar, Mr. Yatish K.R., Mr. Abhijit Kr. Das Mr. Ganpati Mukari, Dr. Chikkappa G. Karjagi
Evaluating interactive effects of plant geometry and fertility levels on the productivity of full season maize genotypes under irrigation conditions	Dr. S.L. Jat	Dr. A. K. Singh, Dr. C.M. Parihar, Dr. Ashok Kumar, Dr. Chikkappa G.K.
Studies on inheritance of resistance of Sitophilus oryzae (L) and Sitotroga cerealella (Oliv) in maize”	Dr. P. Lakshmi Soujanya	Dr. J.C. Sekhar, Dr. G.K. Chikkappa
Management of Sitophilus oryzae (L) and Sitotroga cerealella (Oliv) infesting stored maize through plant origin pesticides”	Dr. P. Lakshmi Soujanya	Dr. P. Kumar, Dr. J.C. Sekhar, Dr. Dharam Paul, Mrs. Suby S.B.
Biological control of maize pests	Dr. P. Lakshmi Soujanya	Dr. P. Kumar, Dr. J.C. Sekhar
Biochemical studies on shelf-life of carotenoids in maize	Mrs. Sapna	Dr. Nirupma Singh

Annexure 9

Important Committees

Research Advisory Committee

Dr. B.S. Dhillon	Vice Chancellor, Punjab Agricultural University, Ludhiana	Chairman
Dr. V.P. Ahuja	Principal Scientist (Retd.)	Member
Dr. D.N. Yadav	Ex-Professor & Head (Entomology)	Member
Dr Sain Dass	Ex-Director, DMR & Advisor (Hybrid Crops)	Member
Prof. H.S. Shetty	Professor Emeritus	Member
Dr. O.P. Yadav	Director, ICAR-IIMR	Member
Dr. K.S. Hooda	Principal Scientist, ICAR-IIMR	Member Secretary

Prioritization Monitoring and Evaluation Cell

Dr. P. Kumar	Principal Scientist	In charge
Dr. K.S. Hooda	Principal Scientist	Member
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 Research Council

Dr. O.P. Yadav	Director, ICAR-IIMR	Chairman
All PI/ Section In charge	Head of Division/Section	Member
All Scientist	ICAR-IIMR	Member
ADG(FFC)	ICAR	Member
Dr. P. Kumar	Principal Scientist, ICAR-IIMR	Member Secretary

Annual Report Editorial Committee

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

Institute Germplasm Identification Committee

Dr. O.P. Yadav	Director	Chairman
Dr. P. Kumar	Principal Scientist	Nodal Officer
Dr. K.S. Hooda	Principal Scientist	Member
Dr. Dharam Paul	Senior Scientist	Member
Dr. Jyoti Kaul	Principal Scientist	Member Secretary

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	Scientist	Member
Mr. Abhijit Kumar Das	Scientist	Member
Administrative Officer	A.O.	Member

Institute Technical Cell Committee

Dr. A. K. Singh	Principal Scientist	Incharge
Dr. Jyoti Kaul	Principal Scientist	Member
Dr. K.S. Hooda	Principal Scientist	Member
Dr. K.P. Singh	Senior Scientist	Member
Dr. Nirupma Singh	Scientist	Member
Dr. C. M. Parihar	Scientist	Member
Dr. Bhupender Kumar	Scientist	Member

Institute Technology Management Committee

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

Women Complaint Committee

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

Purchase Advisory Committee

Dr. Ishwar Singh	Principal Scientist	Chairman
Dr. Ashok Kumar	Principal Scientist	Nodal Officer
Dr. A.K. Singh	Principal Scientist	Member
Dr. Meena Shekhar	Principal Scientist	Member
Administrative Officer	A.O.	Member Secretary

Staff Welfare Committee

Dr. P. Kumar	Principal 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. P. Kumar	Principal Scientist	Chairman
Dr. Ishwar SIngh	Principal Scientist	Member
Dr. Jyoti Kaul	Principal Scientist	Member
Administrative Officer	A.O.	Member Secretary

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
Ms. Sapna	Scientist	Member
Administrative Officer	A.O.	Member Secretary

Innovation Cell

Dr. Pranjal Yadava	Scientist	Chairman
Mr. Abhijit Kumar Das	Scientist	Member
Ms. Sapna	Scientist	Member

Management Information System including Financial Management System

Dr. K.P. Singh	Scientist (SS)	Nodal Officer & System Administrator

Annexure 10

Staff Position

Staff position of the Directorate as on March 31, 2015:

Type of Posts	Approved by D/o expenditure	In Position	Vacant
Scientific	40	32	08
Technical	06	05	01
Administrative	13	04	09
Supporting	03	03	0
Total	**62**	**44**	**18**

Transfers

Name	Transferred from	Transferred to	Date of joining
Dr. Virendra K. Yadav	ICAR-IIMR , Pusa Campus, New Delhi	Indian Institute of Agricultural Biotechnology, Ranchi (Jharkhand)	June 24, 2014
Dr. Diwakar Bahukhandi	ICAR-IIMR , Pusa Campus, New Delhi	IARI Pathology, New Delhi	July 31, 2014
Dr. Vinay Mahajan	ICAR-IIMR , Pusa Campus, New Delhi	IIMR Unit, PAU Campus, Ludhiana (Punjab)	July 30, 2014
Sh. Vishal Singh	ICAR-IIMR , Pusa Campus, New Delhi	IIMR Unit, PAU Campus, Ludhiana (Punjab)	July 15, 2014
Sh. Yatish K.R.	ICAR-IIMR , Pusa Campus, New Delhi	IIMR Unit, PAU Campus, Ludhiana (Punjab)	July 15, 2014
Dr. Ganapati Mukri	ICAR-IIMR , Pusa Campus, New Delhi	IIMR Unit, PAU Campus, Ludhiana (Punjab)	July 17, 2014
Mr. Abhijit Kumar Das	ICAR-IIMR , Pusa, New Delhi	IIMR Unit, PAU Campus, Ludhiana (Punjab)	July 15, 2014

Annexure 11

Personnel

Name	Designation	Discipline
Indian Institute of Maize Research, Pusa Campus, New Delhi		
Dr. O.P. Yadav	Director	Plant Breeding
Dr. P. Kumar	Principal Scientist	Entomology
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
Administrative staff		
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	

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

* On Deputaion   *** Study Leave

Annexure 12

Financial Statement 2014-2015

Head of Account	Sanctioned Budget (Lakhs)				2014-2015 Expenditure (Lakhs)			
	Plan	Non-Plan	AICRIP on Maize	Total	Plan	Non-Plan	AICRIP on Maize	Total
Establishment	-	490.00	1094.00	1584.00	-	489.16	1094.00	1583.16
OTA	-	0.50	-	0.50	-	0.15	-	0.15
TA	11.00	8.00	44.00	63.00	10.99	7.96	44.00	62.95
Recurring Contingency	335.00	240.00	60.00	635.00	334.99	237.90	60.00	632.89
Minor Works	-	16.50	-	16.50	-	16.30		16.30
Equipment	75.00	27.00	-	102.00	73.81	26.64		100.45
Other Items/HRD	31.00	4.00	26.00	61.00	30.78	4.01	26.00	60.79
Total	**452.00**	**786.00**	**1224.00**	**2462.00**	**450.57**	**782.12**	**1224.00**	**2456.69**

Resource Generation

Particulars	Rs. (in Lakh)
Sale of farm produce	33.52
Sale of publications and tender form	-
Standard License Fee	1.25
Analytical and Testing Fee	127.80
Receipts form Services Rendered	-
Interest earned on short term deposits	2.88
Income generated from IRG	-
Training Miscellaneous receipts	0.41
Total	**165.86**

Funds Received for Externally Funded Projects

Particulars	Funds (Lakh)
AP Cess fund scheme	-
FLD	5.00
DUS Testing	
Transgenic Project	10.52
IPR	4.13
CRP NICRA	24.15
CRP Agribiodiversity	8.00
CRP Biofartification	11.00
Total	**62.80**

Annexure 13

Results-Framework Document (RFD)

for

Directorate of Maize Research

(2013-2014)

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 multidisciplinary 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.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target/Criteria value				
							Excellent	Very Good	Good	Fair	Poor
							100%	90%	80%	70%	60%
1	Genetic enhancement and development of improved cultivars	49	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	15	1100	1000	900	800	700
				Entries tested in AICRP trials for multi-location testing	Number	8	240	230	220	210	200
				Lines identified for unique traits	Number	7	11	10	9	8	7
			Development of improved cultivars	Entries contributed for AICRP multi-location trial	Number	6	122	120	118	116	114
				Varieties identified for release	Number	7	5	3	2	1	0
			Seed production programme	Breeder seed produced	Weight (Quintals)	6	55	50	45	40	35
2	Development and identification of appropriate crop production and protection technologies	15	Development and testing of new technologies	New technologies tested	Number	8	5	4	3	2	1
				Technologies recommended	Number	7	3	2	1	0	0
3.	Technology dissemination and capacity building	25	Demonstrations conducted	Front line demonstrations conducted	Number	15	550	500	450	400	350
			Farmers/ Extension officials training programmes organized	Trainings organized	Number	10	7	6	5	4	3
* Efficient functioning of the RFD system		3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	15/05/ 2013	16/05/ 2013	17/05/ 2013	20/05/ 2013	21/05/ 2013
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	01/05/ 2013	02/05/ 2013	05/05/ 2013	06/05/ 2013	07/05/ 2013
* Administrative reforms		4	Implement ISO 9001 as per the approved action plan	% implementation	%	2	100	95	90	85	80
			Prepare action plan for innovation	On-time submission	Date	2	30/07/ 2013	10/08/ 2013	20/08/ 2013	30/08/ 2013	10/09/ 2013
* Improving internal efficiency/ responsiveness/ Service delivery of Ministry/ Department		4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80
				Independent Audit of Implementation of public grievance redressal system	%	2	100	95	90	85	80

*Mandatory Objective(s)

Section 3:

Trend Values of the Success indicators

S. No.	Objectives	Actions	Success Indicators	Unit	Actual Value for FY 11/12	Actual Value for FY 12/13	Target Value for FY 13/14	Projected Value for FY 14/15	Projected Value for FY 15/16
1	Genetic enhancement and development of improved cultivars	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	4435	2985	1000	1100	1200
			Entries tested in AICRP trials for multi-location testing	Number	313	349	230	240	250
			Lines identified for unique traits	Number	10	2	10	11	12
		Development of improved cultivars	Entries contributed for AICRP multi-location trial	Number	159	192	120	122	125
			Varieties identified for release	number	0	6	3	4	5
		Seed production programme	Breeder seed produced	Weight (Quintals)	172	108	50	55	60
2	Development and identification of appropriate crop production and protection technologies	Development and testing of new technologies	New technologies tested	Number	2	3	4	5	6
				Number	1	1	2	2	3
3	Technology dissemination and capacity building	Demonstrations conducted	Front line demonstrations conducted	Number	226	75	500	550	600
		Farmers/ Extension officials training programmes organized	Trainings organized	Number	14	7	6	7	8
	* Efficient functioning of the RFD system	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date			16/05/2013		
		Timely submission of Results for RFD (2012-13)	On-time submission	Date			02/05/2013		
	* Administrative reforms	Implement ISO 9001 as per the approved action plan	% implementation	%			95		
			On-time submission	Date			10/08/2013		
	* Improving internal efficiency/ Responsiveness/ Service delivery of Ministry/ Department	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%			95		
			Independent Audit of implementation of public grievance redressal system	%			95		

*Mandatory Objective(s)

Acronyms

Sl No.	Acronym	Description
1	AICRP	All India Coordinated Research Project
2	DAC	Department of Agriculture and Cooperation

Section 4:

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
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	
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

Location Type	State	Organization Type	Organization Name	Relevant Success Indicator	What is your requirement from his 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

Section 6:

Outcome/Impact of Department/Ministry

S. No.	Outcome/ impact of organization	Jointly responsible for influencing this outcome/impact with the following department(s)/ ministry(ies)	Success Indicator	Unit	2011-12	2012-13	2013-14	2014-15	2015-16
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)	%	-2.4*	1.7**	2	2.2	2.4

*Due to drought maize productivity decreased. **Based on 3rd advance estimate.

Performance Evaluation Report

SN	Objective(s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target / Criteria Value					Achieve-ments	Performance		Percent achieve-ments against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excel-lent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw Score	Weigh-ted Score		
1	Genetic enhance-ment and development of improved cultivars	49	Evaluation of genetic material	Breeding and germ-plasm lines evaluated	Number	15	1100	1000	900	800	700	1298	100	15	129.8	The ongoing research projects were able to generate more number of segregating lines
				Entries tested in AICRP trials for multi-location testing	Number	8	240	230	220	210	200	298	100	8	129.6	More experimental hybrids were contributed by the institutions
				Lines identified for unique traits	Number	7	11	10	9	8	7	10	90	6.3	100.0	NA
			Develop-ment of improved cultivars	Entries contributed for AICRP multi-loca-tion trial	Number	6	122	120	118	116	114	156	100	6	130.0	There was better response from AICRP partners
				Varieties identified for release	Number	7	5	3	2	1	0	10	100	7	333.3	Superior material was available over the existing hybrids
			Seed production programme	Breeder seed produced	Weight (Quin-tals)	6	55	50	45	40	35	65.5	100	6	131.0	20 quintal seed of LM 14 was produced against indent of 0.13 quintal by PAU, Lu-dhiana

SN	Objective(s)	Weight	Action(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		
2	Development and identification of appropriate crop production and protection technologies	15	Development and testing of new technologies	New technologies tested	Number	8	5	4	3	2	1	5	100	8	125.0	This is equivalent to achievements mentioned in 100% column
				Technologies recommended	Number	7	3	2	1	0	0	3	100	7	150.0	This is equivalent to achievements mentioned in 100% column
3	Technology dissemination and capacity building	25	Demonstrations conducted	Front line demonstrations conducted	Number	15	550	500	450	400	350	550	100	15	110.0	NA
			Farmers/ Extension officials training programmes organized	Trainings organized	Number	10	7	6	5	4	3	7	100	10	116.7	This is equivalent to achievements mentioned in 100% column
*	Efficient functioning of the RFD system	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	15/05/2013	16/05/2013	17/05/2013	20/05/2013	21/05/2013	09/ 05/2013	100	2	-	-
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	01/05/2013	02/05/2013	05/05/2013	06/05/2013	07/05/2013	01/ 05/2013	100	1	-	-
*	Administrative reforms	4	Implement ISO 9001 as per the approved action plan	% implementation	%	2	100	95	90	85	80	100	100	2	-	-
			Prepare action plan for innovation	On-time submission	Date	2	30/07/2013	10/08/2013	20/08/2013	30/08/2013	10/09/2013	27/ 07/2013	100	2	-	-
*	Improving internal efficiency/ responsiveness/ Service delivery of Ministry/Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80	100	100	2	-	-
				Independent Audit of Implementation of public grievance redressal system	%	2	100	95	90	85	80	100	100	2	-	-

Total Composite Score: 99.3

Rating: Excellent

NOTE

NOTE

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

Agrisearch with a human touch