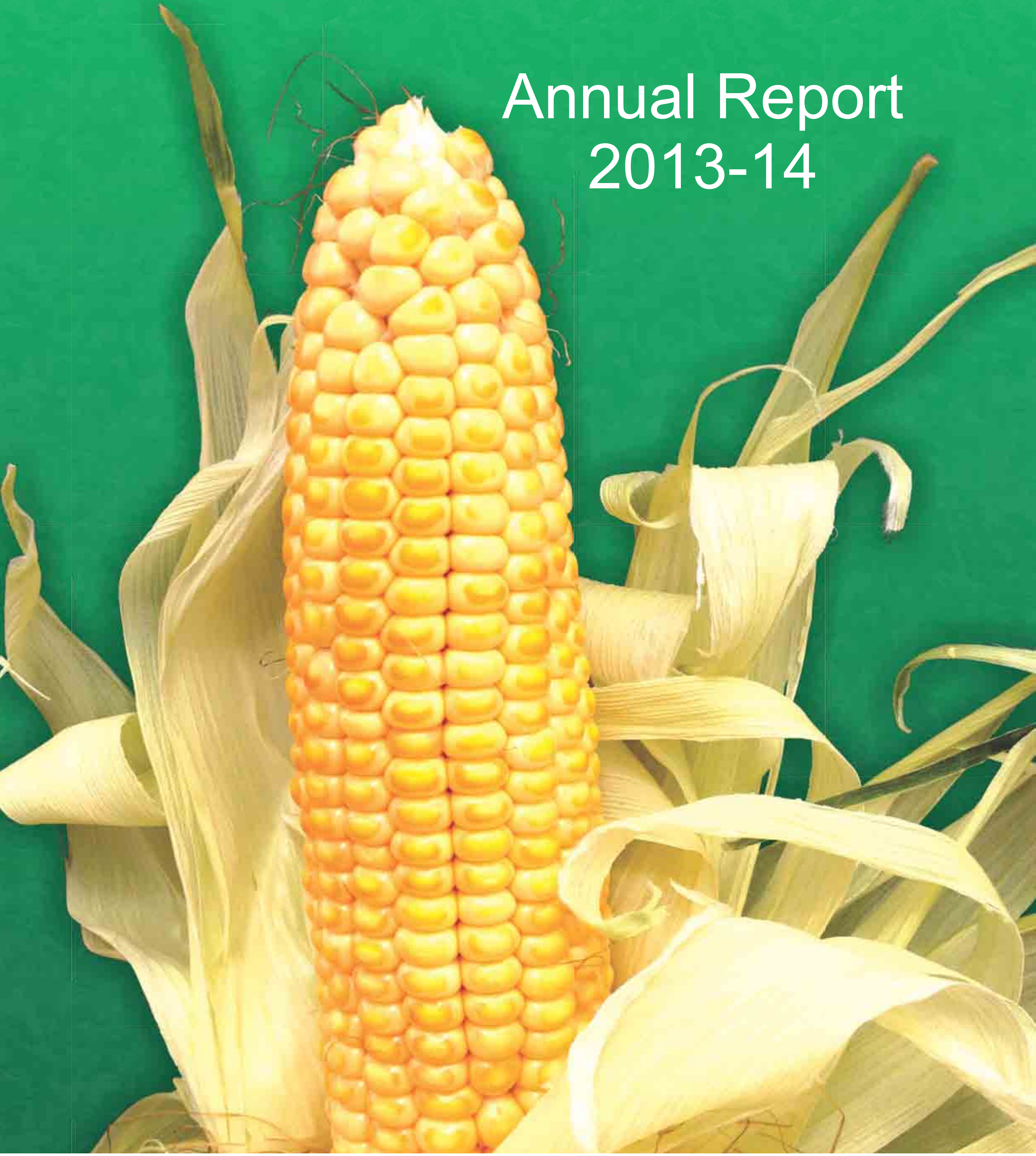
Annual Report 2013-14



DIRECTORATE OF MAIZE RESEARCH

(Indian Council of Agricultural Research)

Pusa Campus, New Delhi-110 012

Annual Report
2013-14

भाकृअनुप
ICAR

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(Indian Council of Agricultural Research)
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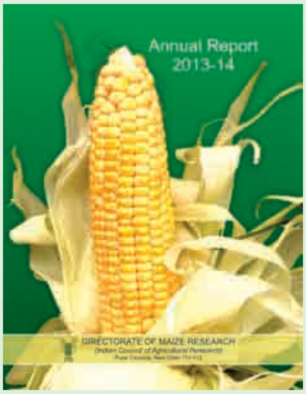

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Maize hybrid in demonstration at DMR

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Contents





Preface i

DMR at a glance iii

Executive Summary vii

1 Dimensions of Maize Improvement 1

2 Production Systems and Technology 15

3 Defending Diseases and Pests 23

4 Upscaling and Extension 34

5 All India Coordinated Research Project 41

6 Significant Events 55

7 Awards and Recognitions 63

8 Annexures 67-98

- 8(a) Annexure I: Hybrids Notified 67
- 8(b) Annexure II: Hybrids Identified 70
- 8(c) Annexure III: Germplasm Registration 71
- 8(d) Annexure IV: Seed Production 72
- 8(e) Annexure V: Varietal Registration 74
- 8(f) Annexure VI: Human Resource Development 76
- 8(g) Annexure VII: Trainings Conducted 78
- 8(h) Annexure VIII: Lectures 79
- 8(i) Annexure IX: Publications 82
- 8(j) Annexure X: On- going Research Projects 89
- 8(k) Annexure XI : Financial Statement 93
- 8(l) Annexure XII: Appointments/Promotions/Transfers/Retirements 94
- 8(m) Annexure XIII: Important committees 95
- 8(n) Annexure XIV: Personnel 97

Preface

The year 2013-14 was a remarkable year for the maize sector in several ways. As per third advanced estimates, India is poised to achieve its highest ever maize production at 24.19 million tonnes, surpassing even the set target of 23 million tonnes for the forthcoming year. This is despite widespread drought in major maize growing states of Karnataka, Bihar and Maharashtra. This indicates increasing resilience of the maize-based cropping systems to the vagaries of the climate. The year 2013-14, also saw for the first time, parity in minimum support prices of maize with that of common paddy. The Indian maize continued to be in good demand in the export markets destined for Far East and West Asia. This year, till December, India exported 2.7 million tonnes maize grain, worth ₹4,267 crores, even while the shipments were expected to pick-up greatly in the last quarter on the back of a strengthened dollar. The year was also marked by inclusion of maize in three key government supported initiatives- National Food Security Act, Nuti-Farm Scheme and National Food Security Mission. Thus, maize has truly emerged as a dominant commodity in India.

The rising importance of maize in the Indian economy necessitates further intensification of maize research aimed at its enhanced productivity and utilization. Being the only institute of its kind mandated exclusively for maize research, Directorate of Maize Research (DMR) has an important role to play in this endeavour. This year, DMR marked 20 years of its service to the nation, while the All India Coordinated Research Project on Maize (AICRP-Maize) is even older. The Directorate and its 27 AICRP centres spread across different agricultural universities have consistently delivered improved maize germplasm and production technologies over the years. While the various centres focus on developing region specific cultivars and production technologies, the Directorate conducts basic-strategic research, coordinates germplasm exchange between centres, provides them with international linkages and manages a national platform of maize field trials. In the year 2013-14, the Directorate distributed 4050 samples of maize seeds, consisting of 651 unique germplasm lines to various centres, thereby broadening the genetic base of the Indian maize programme. The distributed germplasm included lines for specific traits like yellow corn (200), white corn (53), Quality Protein Maize (341), sweet corn (45), popcorn (6), oil corn (4) and waxy corn (2). The national varietal testing service operated by DMR continued to be sought after not only by developers of public institutions but also by multi-national corporations and small and medium enterprises in the Indian seed industry. A total of 410 new cultivars were field-tested at multiple locations and 25 improved maize hybrids were identified for release. This year, in one of the unique initiative, the Directorate organized a National Live Demonstration of Maize Hybrids, in which 106 promising hybrids were demonstrated in a compact block showcasing the potential of the hybrid technology. The Directorate also organized brain-storming sessions on 'Public-Private Partnership', 'Trait prioritization in breeding' and 'Improving drought tolerance', in which important points for further strengthening the maize programme emerged.

While, the Directorate and its centres are doing seminal service in the area of maize research, the challenges ahead demand even greater efforts. The Indian maize sector is now deeply linked to global trade and technologies and the Indian maize farmer has to be globally competitive. Two clear challenges are just before us and the Directorate has to adequately respond to them. The first is asymmetries in the availability of cutting-edge farm technologies across time and geographies. For example, the growth engine of maize productivity- the single cross hybrid technology- was available to maize farmers in other countries much earlier than the Indian farmers. Similarly, farmers of other maize growing countries are benefitting from transgenic technology for last several years, while this is still a couple years away from the Indian maize farmer. There is a need to strengthen the time-tested AICRP system through appropriate legislative, executive and operational framework, to enable it to play a greater role in the field trials of new maize hybrids consisting of traits developed by genetic engineering. Also, as called by honourable President of India, the Directorate, as a part of the Indian Council of Agricultural Research (ICAR) "must contribute to the public discourse" in this area and also intensify its research efforts in this direction. Another challenge is to support and cater to the needs of the secondary agriculture aimed at enhancing domestic utilization of maize. Today, maize is clearly a non-food crop with only 20% being used as direct human food, while the remaining production going into feed, industrial and export purpose. With the current tempo, maize production is likely to double to 40-45 million tonnes in next five years through a combination of higher yield (4-5 tonnes/hectare) and preferably, without significantly enlarging the acreage. This may lead to an exportable surplus of 7-8 million tonnes every year. In order to sustain the production, the price of Indian maize has to be competitive to major exporters- USA, Brazil and Argentina- all of whom have been also the early adopters of the latest genetic technologies. Thus, demand diversification through alternative domestic utilization would safeguard the interests of the Indian maize farmers.

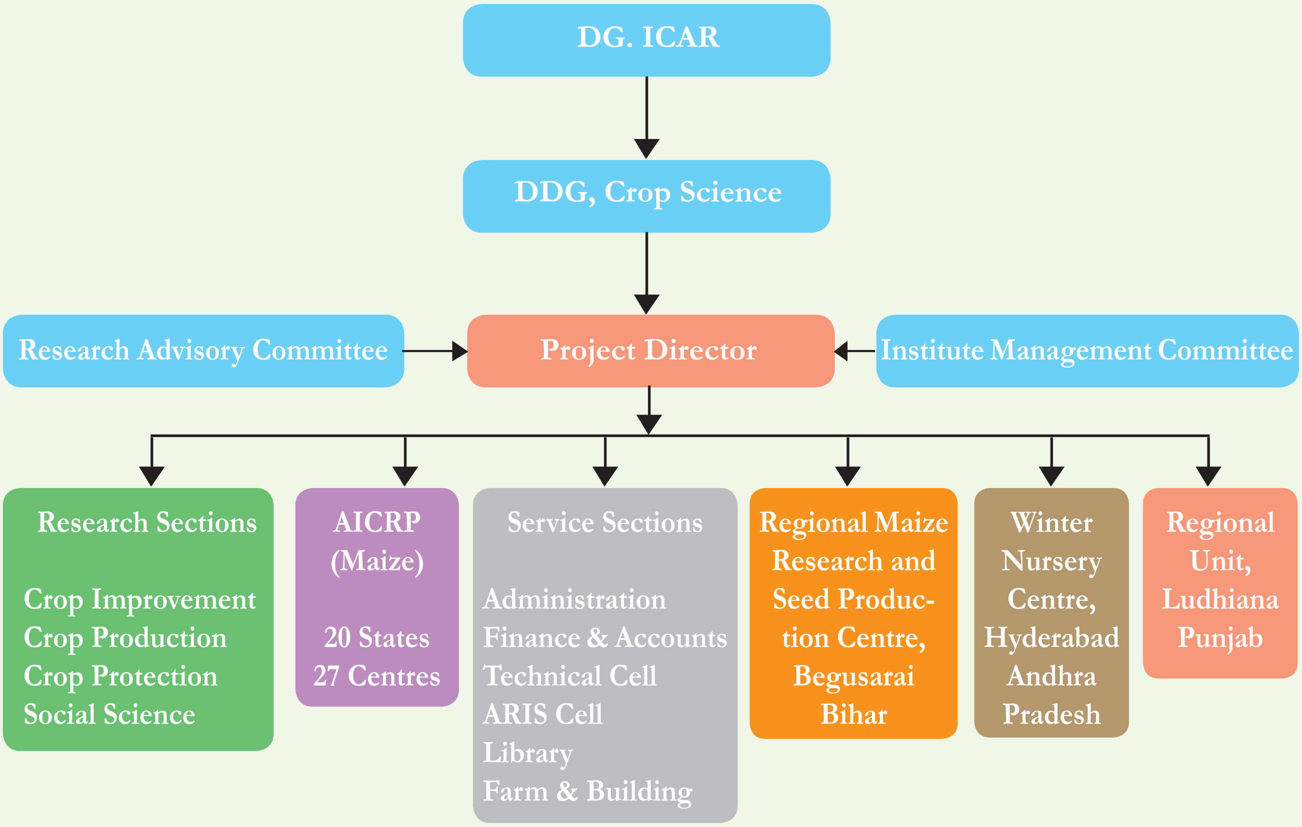
The Directorate is preparing itself to sufficiently address the challenges ahead. We have formulated an innovation action plan and strengthened our reporting systems, besides introducing a string of reforms directed at increasing efficiencies. This year, the Directorate was conferred ISO 9001:2008 certification and was ranked at number three position with 'very good' rating among 26 crop science institutes of ICAR. I am thankful to Dr S. Ayyappan, Secretary, DARE and DG ICAR, Prof. S.K. Datta, DDG (CS) and Dr R.P. Dua, ADG (FFC) for their able guidance and generous support for maize research. I also deeply acknowledge the efforts of our scientists, staff and all the stakeholders for making the maize sector one of the most vibrant facet of the Indian agriculture.

(O.P. Yadav)

Project Director

DMR 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 ❖ DMR is primarily crop based institute working under the umbrella of the Indian Council of Agricultural Research ❖ Mandate of DMR is to organize, conduct, coordinate and generate improved maize technology for continuous enhancement of maize productivity ❖ Directorate 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 ❖ Directorate'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 27 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 DMR.



DG. ICAR
DDG, Crop Science
Research Advisory Committee
Project Director
Institute Management Committee
Research Sections
Crop Improvement
Crop Production
Crop Protection
Social Science
AICRP (Maize)
20 States
27 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
Regional Unit, Ludhiana Punjab

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

Executive Summary

During 2013-14, Directorate of Maize Research made significant research achievements in different areas of maize research. Genetic enhancement of maize germplasm continued to be the major focus of the Directorate. The germplasm development programme revolved around four major themes: Genetic enhancement for different crop duration; enhancement and development of specialty maize; breeding for abiotic and biotic stress tolerance; and molecular approaches in maize research.

Crop duration is an important aspect of a cultivar, which determines its suitability for a particular ecology and cropping system. Research activities targeted at development of suitable germplasm for late, medium and early maturity duration yielded a number of inbred lines and experimental hybrids for these groups. During *kharif* 2013, out of 536 germplasm lines evaluated for various morpho-agro traits, 286 germplasm lines were found in late maturity group. Eight new experimental hybrids for late maturity have been developed and forwarded into initial varietal trials. Further, 151 new experimental hybrids were evaluated, of which 13 hybrids (3 in late, 7 in medium and 3 in early) were found superior over the best check of their respective maturity group.

Improving the nutritional and product quality in cereal crops is one of the major objectives of the plant breeders worldwide. The Directorate has robust programmes for genetic enhancement of important quality traits in maize, like protein quality, oil, starch, vitamin-A, iron and zinc and baby corn traits. Development of Quality Protein Maize (QPM) with high lysine and tryptophan content, which is otherwise deficient in normal maize, is the major goal of this programme. Towards this goal, 56 elite lines, 234 segregating lines, 168 identified lines, 419 exotic introductions, 12 accessions from International Maize and Wheat Improvement Center, Mexico and 50 Exotic Collections from National Bureau of Plant Genetic Resources were evaluated. During 2013–14, a total of 418 samples were analyzed for protein quality. The protein content in analyzed germplasm ranged from 6.66 to 12.36%. The range of tryptophan was 0.45 to 0.91%, whereas lysine content ranged from 1.67 to 4.43% of endosperm protein. Overall, as many as 17 hybrids were found to be promising in terms of protein quality. To identify high oil lines, 77 accessions were evaluated for oil content.

Sixty four new top crosses were attempted among experimental hybrids as female and identified high oil lines as pollinators. Similarly, suitable germplasm for high starch, high vitamin A, and high iron and zinc content have been identified and the breeding programmes for transferring these traits into elite commercial hybrids are under different phases.

Today, a number of maize hybrids are available that can easily yield up to 10 tonnes/ hectare, provided these are grown under ideal conditions. However, in real-life situation, even half of this yield potential is difficult to achieve at farmer's field due to incidence of various biotic and abiotic stresses. Therefore, the Directorate is focussing on developing germplasm that is genetically resilient to stresses, like drought, cold and charcoal rot disease. In a bid to identify genomic regions linked to drought tolerance, two mapping populations, viz. [HKI335 (highly tolerant) × MGUD22 (highly susceptible)] and [LM17 (highly tolerant)

× HKI 1015-wg8 (highly susceptible)] were developed and during *kharif* 2013, 216 and 266 recombinant inbred lines of these two populations were advanced from F_5 to F_6 generation. Through extensive screening, suitable lines for cold tolerance and charcoal rot resistance have also been identified and are being used in the breeding programme.

Molecular biology offers effective tools for accelerating breeding programmes and developing new germplasm through genetic engineering. In an effort to identify genomic regions associated with Maydis leaf blight resistance**,** the two different F_2 mapping populations of size 361 (CML269 × HKI4C4B) and 352 (Brasill117 × ESM 113) have been developed. Similarly, to identify and clone novel genes for abiotic stress tolerance, perturbations in the genes of antioxidant pathway in response to oxidative stress was studied. The Directorate is focussing on development of stem borer resistant transgenic maize by transforming maize with *Cry1Ab* gene. The integration of *Cry1Ab* gene in the transformants was confirmed through Southern hybridization and the selected events have been advanced to T_2 generation. Towards developing an efficient transformation protocol in tropical maize, the *in vitro* regeneration capacity of various lines was studied under different culture media.

The crop protection research in the Directorate focussed on unravelling dynamic interaction between host and various diseases and insects. Germplasm screening for discovering sources of resistance was also vigorously pursued. To understand the mode of infection of post flowering stalk rot pathogens- *Fusarium verticilloides* and *Macrophomina phaseolina*, their morphological and cultural characteristics were comprehensively delineated. The structure of the compound responsible for insecticidal activity of *Ixora coccinea* plant was established by extensive spectroscopic studies. On the other hand, new strategies for protection of stored grain against mycotoxin causing fungus-*Aspergillus* and storage insects- rice weevil (*Sitophilus oryzae)* and angoumois grain moth (*Sitotroga cerealella)* were worked out. Germplasm screening against various diseases and insect-pests resulted in identification of valuable sources of resistance, which would help in developing new cultivars with in-built resistance.

Apart from crop protection research, the Directorate also continued its efforts in assessment of various production technologies for working out efficient, sustainable and profitable maize based cropping systems. The research activities were focussed on strategies to diversify maize based cropping systems for higher productivity and sustained soil health; conservation agriculture for improving resource use efficiency and mitigating greenhouse gas emission; site specific nutrient management; and nitrogen management under conservation agriculture in maize based cropping systems. The improved packages of practices for maize cultivation were disseminated to farmers through organizing nationwide Frontline Demonstrations, trainings and exhibitions. A total of 6725 Frontline Demonstrations were conducted in different parts of the country in all the three maize growing seasons. Extension programmes especially targeted to tribal farmers were also conducted.

Apart from its core research activities, the Directorate also supports and coordinates maize research programmes of various agricultural universities through All India Coordinated Research Project on Maize (AICRP-Maize). Based on the data generated by AICRP-Maize, 15 new maize cultivars were notified by the Central government, thereby expanding the choice of hybrids for different ecologies. During the year, 298 maize lines from different developers were evaluated by AICRP-Maize. A total of 65.5 quintals of breeder seed comprising of 34 parental lines of 17 hybrids and 15 varieties was produced by the Directorate and its AICRP centres. The various AICRP centres also carried out diverse research activities in plant breeding, agronomy, pathology, nematology, and entomology.

The year was also marked with various activities and events organized by the Directorate. The significant events were: 56th Annual Maize Workshop at Hyderabad, National Live Demonstration of Maize Hybrids, and Brain storming sessions on 'public private partnership', 'trait prioritization in breeding' and 'improving drought tolerance'. The Directorate also launched its new website and acquired ISO9001:2008 certificate for quality service in the area of maize research and development.

RESEARCH ACHIEVEMENTS

1 Dimensions of Maize Improvement

Maize holds a prominent position in Indian agriculture. It has the highest genetic yield potential and wide adaptability making it as the miracle crop. India produces about 24 million tonnes (mt) of maize annually with average yield of 2.5 tonnes/hectare, consumes 19 mt and exports 4 mt. Our production, consumption and export pattern can scale up India's export intensity competitively over the next few years. Increasing use of maize as animal feed, interest of the consumers in nutritionally enriched products and rising demand for maize seed are the driving forces behind emerging importance of maize crop in India. Maize is also playing an important role in the crop diversification policy of various states. Therefore, efforts are integrated towards generating high yielding and value-added hybrids/cultivars fitting into different cropping systems in various agro-climatic regions of the country.

Enhancement and development of maize cultivars of different duration

Focus on variety/hybrid based on suitable maturity in a given agro-climatic area is of primary importance for production. During *kharif* 2013, 536 germplasm lines were evaluated for various morpho-agro traits. Out of these 286 germplasm lines were found in late maturity. Eight experimental hybrids (EHs) have been entered into initial varietal trials (IVT) of AICRP testing for *rabi* 2013-14 (Table 1). Further, 151 new EHs were evaluated, of which 13 hybrids (3 in late, 7 in medium and 3 in early) were found superior over the best check in their maturity group.

Table 1. List of DMR hybrids contributed in IVT trials of *rabi* 2013-14

Hybrid	IVT Trials
DMRH1	Medium maturity
DMRH2	Medium maturity
DMRH3	Medium maturity
DMRH4	Early maturity
DMRH5	Medium maturity
DMRH6	Medium maturity
DMRH7	Medium maturity
DMRH8	Late maturity

In medium duration maize, 325 EHs generated by line×tester mating design were evaluated in an augmented design at three locations *viz.,* Hyderabad, Begusarai and New Delhi under four yield trials (trial 1, trial 2, trial 3 and trial 4). The numbers of EHs evaluated under different trials *viz.,* trial 1, trial 2, trial 3 and trial 4 were 101, 122, 73 and 29, respectively against elite commercial check hybrids *viz.,* PMH1, PMH3, Pinnacle, 900MGold, 30V92, NK6240 (late maturity); PMH4 (medium maturity) and Prakash (early maturity). The observations were recorded on different yield and contributing traits *viz.,* days to 50% flowering (anthesis and silking), no. of rows/ear, no. grains/row, ear length, ear girth, 1000 kernel weight. The data was analyzed in SAS 9.3 ver. and the analysis of variance has shown significant differences between EHs and check hybrids for grain yield. The mean yield of top ten EHs under Trial-1 were 10.7, 11.2, and 4.7t/ha at New Delhi, Hyderabad and Begusarai, respectively. Similarly for Trial 2 and 3 the mean yield for each location was calculated for all the EHs evaluated. Based on the highest mean yield and yield consistency over three locations, 14 out of 325 EHs (approximately 4.31% of the total hybrids evaluated) were shortlisted from different trials for further evaluation under AICRP trials.

Early maturing and high yielding cultivars are a profitable choice for farmers in marginal maize growing areas. Hence, breeding for early-maturing maize is an important aspect. For germplasm enrichment, fifteen inbred lines were procured from Almora and were evaluated during *kharif* 2013. Out of twenty-four uniform

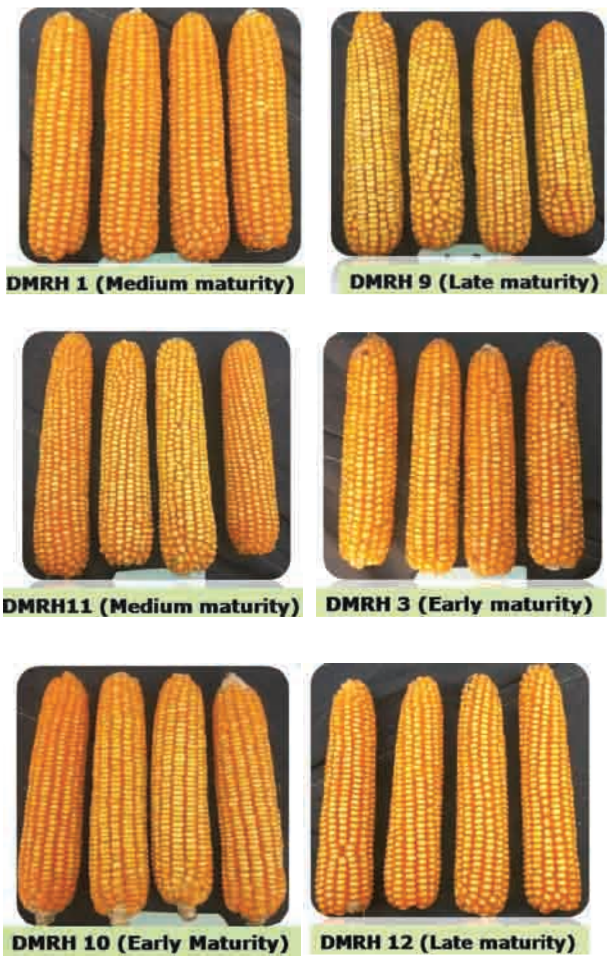


Figure 1. Experimental hybrids developed at DMR

inbred lines developed, sixteen inbred lines were selected. Seven pools *viz.*, 10309-K pool, C2 pool, C11 pool, yellow Pote, Pote brown, Hey Pool were maintained through chain crossing and new inbred lines derivation was initiated. A total of 117 lines were derived from Hill Early Yellow Pool, from these a subset of 76 lines was screened for Maydis leaf blight disease. Two lines were found resistant to Maydis leaf blight with disease score of 2 *viz.*, HEY Pool-2011-5-4-(1)1 and HEY Pool-2011-23-1-1. Two testers (V-373 and CML-474) were crossed with 118 inbred lines and 236 new cross combinations attempted, while 166 combinations achieved which will be evaluated during next cropping season. In one experiment, forty-eight early maturing single-cross hybrids while in another experiment twenty-three early maturing single-cross hybrids (SCHs) along with two early maturing checks (Vivek QPM 9 and Vivek Maize Hybrid 43) developed from twenty-eight uniform early maturing inbred lines, were evaluated over three locations *viz.* Srinagar (Jammu and Kashmir), Bajoura (Himachal Pradesh) and Directorate of Maize Research, New Delhi. The objective was to identify the early maturing single cross hybrids with at least 10% superiority over the best check and understand the correlation among different characters in two diverse zones for enhancing the usefulness of selection for different characters in these zones. Among the 58 SCHs),18 SCHs (Table 2) were superior over the best check 'Vivek QPM 9' by at least 10% over all the three locations.

White maize is grown for the human consumption in northern part of India, especially in Rajasthan, Gujarat, Himachal Pradesh and North Eastern parts of India. Local adapted varieties or land races are generally grown in these traditional areas. Productivity of these genotypes is low by virtue of their genetic makeup. To enrich the genetic potentiality and increase the yielding ability of white maize germplasm, task was initiated to collect and acquire the germplasm from different sources. A total 463 white maize inbred lines received from International Maize and Wheat Improvement Centre (CIMMYT), Mexico were maintained. Those inbred lines with good seed set were planted in replicated trial in *rabi* 2013-14 at Begusarai, Bihar and Delhi for evaluating morpho-agro traits.

Table 2. Performance of early maturing single cross hybrids along with heterosis (>10%) over best check over all three locations, Zone I (Srinagar, Bajoura) and Zone II (Delhi)

Over Zones			Zone I			Zone II		
Hybrid	Grain Yield (kg/ha)	Heterosis (%)	Hybrid	Grain Yield (kg/ha)	Heterosis (%)	Hybrid	Grain Yield (kg/ha)	Heterosis (%)
V335 x V325	9575	3774	CM119 x Indimyt	11793	2555	CML415 x V373	7722	7118
V341 x V373	9372	3480	V335 x V325	11563	2310	V335 x V325	7589	6823
CML415 x V373	9233	3281	V341 x V373	11510	2253	V341 x V373	7233	6034
V335 x V341	8724	2549	V341 x CML470	11249	1976	PFSR10227 x V373	7067	5666
CML415 x CM362	8621	2400	V335 x V341	11204	1928	HKI326-3 x CML325	6833	5147
PFSR10227 x V373	8462	2172	CML415 x CM362	11164	1885	V335 x V341	6244	3841
CML362 x V411	8291	1926	V341 x 760	10970	1679	CML338 x CML325	6100	3522
V341 x CML470	8252	1870	CML362 x V411	10882	1585	CML415 x CM362	6078	3473
CM119 x Indimyt	8213	1814	V351 x V341	10845	1546	HKI326-3 x CM119	5822	2906
V341 x 760	8213	1814	CM212 x V341	10759	1454	CML362 x V411	5700	2635
CML481 x Indimyt	7964	1455	CML415 x V373	10745	1439	CML325 x V341	5544	2289
CM212 x V341	7952	1438	PFSR10227 x CM212	10693	1384	CM145 x CM119	5511	2216
CML338 x CML325	7880	1334	CML481 x Indimyt	10672	1361	V341 x 760	5456	2094
HKI326-3 x CML325	7829	1262	V351 x CML325	10543	1225	V341 x CML470	5256	1651
CML470 x CM119	7686	1055	DMRN6 x CML371	10297	962	CML481 x Indimyt	5256	1651
CM145 x CM119	7660	1018	-	-	-	CML470 x CM119	5244	1624
PFSR10227 x CM212	7652	1007	-	-	-	CML470 x V373	5189	1502
DMRN6 x CML371	7649	1002	-	-	-	CM212 x V341	5144	1403
-	-	-	-	-	-	CML224 x CML415	5144	1403
-	-	-	-	-	-	CML338 x CM119	5067	1232
-	-	-	-	-	-	DMRN6 x CML371	5000	1084
Vivek QPM 9 (check)	6952	-	Vivek QPM 9 (check)	9393	-	Vivek QPM 9 (check)	4511	-
Vivek Hybrid 43 (check)	6415	-	Vivek Hybrid 43 (check)	9152	-	Vivek Hybrid 43 (check)	3678	-

Enhancement and development of specialty corn

Germplasm development and enhancement of Quality Protein Maize

Improving the nutritional quality in cereal crops is one of the major objectives of plant breeders worldwide as the benefits can easily spread to millions of people in a rapid and effective way without changing the traditional food habits. Maize is one among the leading crops of the world but nutritionally poor due to the limiting quantities of two essential amino acids *viz.,* lysine and tryptophan. The discovery of *opaque-2* gene paved the way for genetic manipulation leading to quality protein maize (QPM).

In QPM breeding programme, 56 elite lines, 234 segregating lines, 168 identified lines, 419 exotic introductions, 12 CIMMYT accessions and 50 exotic collections (ECs) from National Bureau Plant Genetic Resources (NBPGR) were evaluated for phenology, agro-morphology and uniformity and maintained by selfing at Delhi and Begusarai (Figure 9). Newly developed 40 QPM lines were screened against maydis leaf blight (MLB) and charcoal rot. Nine lines were found resistant and 14 moderately resistant against MLB whereas, 16 lines were found resistant and 16 moderately resistant against charcoal rot. Of these, four lines namely DQL503, DQL570, DQL597 and DQL770 showed resistant to moderate resistant reaction to both the diseases. In single cross hybrid development programme, 110 experimental hybrids along with two checks (VivekQPM9 and HQPM1) were evaluated in augmented design for phenology, agro-morphology, yield and quality attributes during *kharif* 2013. The results indicated 25 late maturing hybrids (days of maturity being >96) out-yielding check HQPM-1 by >5.0% while seven medium maturing (days to maturity being >85<95) hybrids out-performed Vivek QPM9 by >10% in yield.

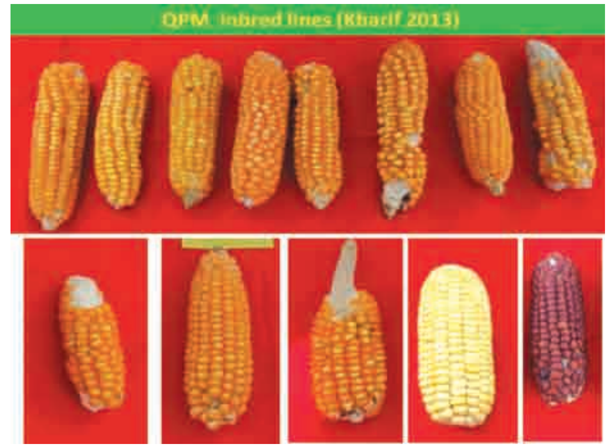


Figure 2. Promising QPM inbreds

During 2013–14, a total of 418 samples were analyzed for protein quality in biochemistry section. A set of 91 F_1 hybrids were analyzed for protein quality in the endosperm of kernels selected on the basis of opaqueness. Protein content ranged from 6.66 (CLQRCYQ 30 × CLQRCYQ-36) to 12.36% (HKI164-4(1-3)-1 × HKI-5072-2-BT). The range of tryptophan was 0.45 (CML163 × CML 154-2) to 0.91% (CLQ RCYQ36- × CML 167), whereas lysine content ranged from 1.67 (CML 195 × CML170) to 4.43% (CLQ RCYQ360 × CML 167) of endosperm protein. As many as 17 hybrids were found to be promising in terms of protein quality (Table 3).

In another set, 297 inbred lines were analyzed for protein quality. The range of protein was 6.41 to 13.60% with lowest and highest values being exhibited by the genotypes CLQRCYQ47-2 and BGS155, respectively. The range of tryptophan was 0.37 {HKI 34 (1+2) -1-2} to 0.94% (CML451Q), and lysine content ranges from 1.47 {HKI 34 (1+2)-1-2) to 4.35% (DQL 2062) of endosperm protein. The most promising lines are listed in Table 4.

Enhancement of oil in maize kernel

Maize oil extracted from kernel is an emerging commercial product. Realizing the market value of corn oil, research is being carried out in this area. To identify high oil lines, 77

Table 3. Performance of promising experimental QPM hybrids during *kharif* 2013

Experimental hybrid	Days to maturity	Yield (kg/ha)	% superiority over check	% tryptophan of endosperm protein	Total endosperm protein
HKI162-2-2-3 × CML167	96.7	7612	9.1	0.64	8.00
HKI162 × CML161	97.2	7626	9.2	0.78	8.15
HKI26-2-4(1-2) × VQL1	88.1	7559	8.3	0.77	8.00
HKI193-2-ER-IT × DMRQPM58	98.0	7709	10.4	-	-
HKI193-1 × DMRQPM58	88.7	6715	9.5	-	-
HKI164-7-4-ER-3-3 × CML161	98.0	7810	10.9	-	-
HKI164-7-6 × DMRQPM58	97.0	7815	11.5	0.67	11.00
HKI5072-2-BT × CML172	96.0	7907	13.2	0.68	8.25
HKI193-2 × DMRQPM58	96.2	7850	12.1	0.67	8.15
HKI5072-2-BT × HKI164-4	97.2	7689	10.1	0.80	8.00
HKI163 × CML161	96.5	7522	7.8	0.69	9.64
HKI162 × CML167	88.5	6772	10.3	0.66	8.02
HKI162 × CML163	87.1	6798	10.7	0.67	10.90
CML175 × HKI163	89.0	6789	10.5	0.67	8.12
DMRQPM58 HKI161	88.0	6800	10.7	0.66	7.35
DMRQPM58 × HKI193-2-2-4	88.0	6809	10.8	-	-
DMRQPM103 × CML167	97.5	7441	6.6	0.72	9.50
HKI162-2-3 × DMRQPM102	97.5	7338	5.2	0.75	11.20
DMRQPM58 × HKI164-1-4	98.2	7448	6.7	0.76	10.70
HKI162-2-3 × CML179	96.1	7800	11.7	0.60	9.90
HKI163 × CML161	96.5	7883	12.1	0.68	9.80
HKI26-2-4(1-2)× HKI163	96.5	7889	13.2	0.6	9.00
HKI34(1+2)-1 × HKI162-2-3	98.2	7900	13.0	0.6	9.50
HKI5072-2-BT × HKI193-2-2-4	98.2	7355	5.5	-	-
HKI163 × HKI164-1-4	98.2	7568	8.4	0.66	9.90
HKI193-2 × HKI134 (1+2)-1	98.2	7598	8.7	0.71	8.70
CML165-2 × CML154-2	99.5	7890	13.0	0.69	8.60
HKI164-4(1-3) × HKI163	99.5	7900	13.2	0.72	8.70
HKI162 -2-4(1-2) × HKI163	98.2	7800	11.7	0.71	11.60
HKI193-2 × HKI31-2	97.5	7667	9.8	0.69	11.97
CML172 × CML175	99.1	7600	8.9	0.70	10.90
CML154 -2 × CML176	99.8	7742	10.9	0.73	10.50
HQPM1 (check)	96.0	6980	-	0.74	10.80

Table 4. Most promising lines for protein quality

Genotype	Total endosperm protein	% tryptophan of endosperm protein	% lysine of endosperm protein	Specific gravity	100 grain weight
CML 451Q	9.07	0.94	4.21	—	—
DQL 659-1	9.13	0.86	4.15	1.12	24.65
DQL 667-6	9.61	0.82	4.21	1.04	25.95
DQL 2089	9.21	0.81	4.03	1.34	21.48
DQL 2084	9.24	0.80	4.12	1.02	24.47

accessions were evaluated for oil content. Four lines *viz*., (DTPWC9-F5-4-1-1-2-2-1-1-B/(FT/LN/EM-46-3-1×CML311-2-1-3)-B-F-243-2), (CLQ-RCY016×(CML165XCLQ6203)-B54-1-1-BB)-B-28-1-BBB-B, (G18SEQC5F76-2-2-1-1-1-B/BIO9681-WLS-6-3-2-1-2-B-B-B-B)-2 and (DTPWC9-F16-1-1-3-2-2-2-1-B/WLS-F36-4-2-2-B)-B-B-6-B recorded oil content above 5%. Increase in oil reduces yield in single cross hybrids. Hence, top crossing is done to produce hybrids without compromising yield levels. Sixty four new top crosses were attempted among experimental hybrids as female and identified high oil lines as pollinators. In *rabi* 2012-13, generation advancement of 48 S_4 families was carried out for deriving inbreds with high oil content.

Evaluation for babycorn traits

Baby corn is profitable speciality maize allowing crop diversification, value- addition and increased income. Practically, any hybrid can be used for babycorn cultivation but commercially early maturing, prolific and medium height hybrids are most suitable. Therefore, 51 experimental extra early/early maturing single cross hybrids were evaluated in high planting density (60x10cm). HM4 and Vivek Hybrid 25 were used as checks. Detasseling was done by removing the tassel as soon as it emerged from the flag leaf. Picking was done daily until 2-3cm silk comes out from top of the ear during morning hours. HM4 hybrid was prolific and showed the high total solid sugar content. Harvesting period was 10-12 days in this season. Three to four pickings were done during the harvest period. The best entry found for important baby corn traits were V364 × V373 for total weight of husked cobs, CML338 × CM119 for total weight of unhusked cobs, HM4 for brix value, DMRN6 × CML371 for total fodder weight, CML481 × Indimyt 345 for total number of cobs and V364 × CM120 for ratio of unhusked to husked cob weight. Retesting of these entries for baby corn traits is to be done for validating the results.

Germplasm enhancement of maize for high starch

Diverse uses of starch make it a very versatile product. Maize or Corn Starch is a typical cereal starch with distinctly low protein and ash contents while its high purity carbohydrate content makes it of use in several industries. Seeing its importance, 30 different inbred lines were analyzed for starch profile (starch, amylose and amylopectin). The range of starch varied from 67.77 to 74.82% with lowest and highest values being observed in the genotype CMH-08-433 and A-7501, respectively. The range of amylose in starch varied from 25.69 to 45.79% with lowest and highest values being observed in the genotypes CMH-08-350 and CMH-08-292, respectively. Amylopectin content in starch ranged from 54.21 (CMH 08-292) to 74.32% (CMH-08-350). A total of 29 pre-release hybrids were also evaluated, where starch content ranged from 67.77 to 74.81%, amylose from 25.68 to 45.79% and amylopectin content from 54.21 to 74.32%.

Provitamin-A enhancement

Vitamin A deficiency is a serious health issue, particularly among children in developing nations. To overcome vitamin A deficiency, biofortification is a promising strategy in maize based areas where the supply and availability of animal products, fruits and vegetables are limited. With the objective to identify inbred line having high provitamin-A, 40 genotypes had been screened through column chromatography for total carotenoid and beta carotene. Among them, four genotypes recorded total carotenoid more than 50 µg/g *viz.*, IC639247, IC639563, IC632050 and IC639253. More than 3 µg/g beta carotene content was found in MRCHY4856-3-1-3-1-1, MRCHY5782-2-2-1-2-1, HEYPool-55-2-5 and HEYPool-60-2-3. Maize genotypes were also classified into different groups based on their kernel colour and correlation studies of kernel colour with total carotenoid and beta carotene was carried out. Correlation studies revealed significant positive correlation between kernel colour and total carotenoid (0.393*).

In biochemistry section, a separate set of 27 inbred lines were characterized for total carotenoid, beta carotene and beta-cryptoxanthin using ultra-high pressure liquid chromatography (UPLC) (Figure 3). Beta carotene and beta cryptoxanthin are the two major components of provitamin-A in maize. DML26-B (42.36 µg/g) recorded highest total carotenoid content whereas DML8 (2.08 µg/g) showed highest beta carotene content followed by DML17 (2.07 µg/g). But, beta-cryptoxanthin content of genotype DML17 (7.18 µg/g) was much higher than DML-8 (1.86 µg/g).

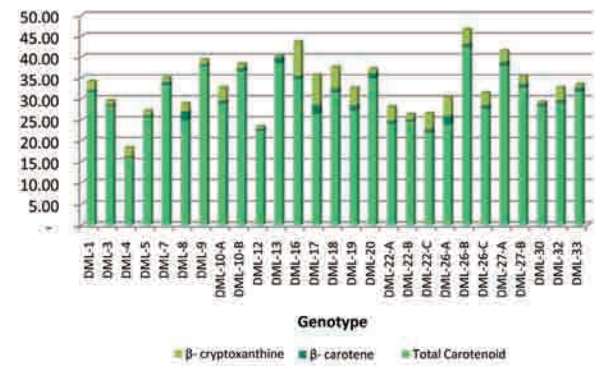


Figure 3. Carotenoid components of inbred lines using UPLC

Iron and Zinc content enhancement

Micronutrient malnutrition affects a significant percentage of world population. Micronutrients, such as vitamin A, zinc (Zn), and iron (Fe), are required only in very small amounts, but are essential for good health. Maize, being a staple crop in many developing countries enhancing Fe and Zn content in grain will help in alleviating the problem of malnutrition. A set of forty-five inbred lines selected from 150 were screened for Fe and Zn content during *rabi* 2012-13 and *kharif* 2013. Wide variation was observed for iron (18 to 104 ppm) and zinc (16.8 to 55.7ppm) content. DML221 and DML136 were superior for both Fe and Zn content. Promising lines are listed in Table 5 and 6.

Table 5. Inbred lines with high Iron (Fe) content screened for two seasons

Genotypes	Fe content (ppm)		Genotypes	Fe content (ppm)	
	Kharif 2013	*Rabi* 2012-13		*Kharif* 2013	*Rabi* 2012-13
DML300	73.5	68.3	DML60	53.9	57.1
DML221	69.2	72.1	DML106	53.8	50.2
DML78	64.8	61.2	DML16	51.7	47.7
DML136	61.4	64.4	DML154	51.7	55.2
DQL1019	59.6	52.7	DQL1005	50.2	48.6
DQL1022	59.3	56.2	DML104	46.4	48.2
DML59	58.4	62.7	BML6 (C)	45.3	47.2
DML62	58.4	53.3	HKI 163 (C)	42.1	44.3
DML216	58.1	55.2	CML269 (C)	30.2	33.4

Table 6. Inbred lines with high Zn content screened for two seasons

Genotypes	Zn content (ppm)	
	Kharif 2013	*Rabi 2012-13*
DML226	50.7	48.7
DML134B	48.9	51.4
DML35	47.2	49.2
DML136	47.1	42.5
DML227	38.3	36.7
DML165	37.8	41.2
DML269A	37.0	33.2
DML37A	36.3	38.2
DML281	35.9	40.3
DQL1001	35.1	29.4
DML221	35.0	32.1
HKI 163 (C)	24.3	26.2
BML6 (C)	22.1	20.3
CML269 (C)	18.5	22.2

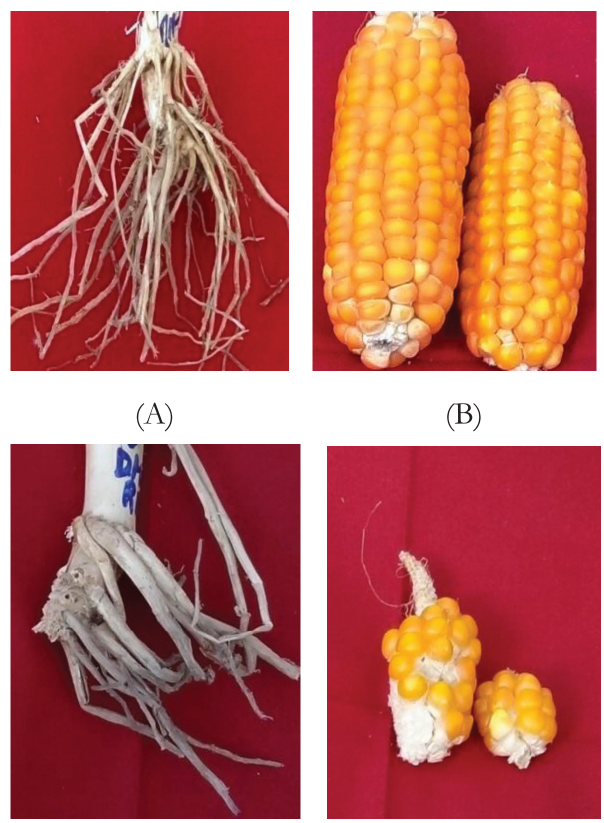
Breeding for abiotic/biotic stress tolerance

Germplasm development and enhancement for cold tolerance

Now-a-days, growing maize in non-traditional areas during winter season has increased the likelihood that a maize plant will spend most part of early development under suboptimal temperature conditions. A mild chilling stress between 10 and 15°C is much more common during winter season in northern plains. An improved tolerance of early seedling performance to such conditions would be the obvious and easiest way to increase chilling tolerance. Narrow source of genetic variability for early seedling vigor could be potentially broadened by utilizing exotic germplasm. Hence, to widen the germplasm base 130 entries comprising Exotic Collection and Indigenous Collection at S_6 stage and CIMMYT material were screened for traits related to seedling tolerance in cold conditions. Fifteen entries were found to be cold tolerant at seedling stage. Also, 153 experimental hybrids were evaluated at two locations viz., Delhi and Begusarai for yield traits.

Mitigating drought and heat stress

Most maize growing areas are rain-fed and the crop is subject to periodic water deficits that diminish yields and decrease economic returns. Under water limiting conditions a successful drought resistant genotypes yield by up to 15% higher than susceptible genotypes. During *kharif* 2013, 216 and 266 recombinant inbred lines (RILs) developed through single seed descent (SSD) method of two drought mapping populations, [HKI335 (highly tolerant) × MGUD22 (highly susceptible)] and [LM17 (highly tolerant) × HKI 1015-wg8 (highly susceptible)] respectively were advanced from F_5 to F_6. Selected RILs were phenotyped for major morph1o-physiological traits (plant height, stem girth, leaf area index (LAI), leaf chlorophyll, canopy temperature, an-



(A) (B) (C) (D)

Figure 4. Root development and grain yield in two contrasting maize hybrids [HKI 1532 X LM 17 (A, B), DTPYC9F46 (C, D)] under drought stress

Table 7. Influence of drought stress on plant survival, leaf area index (LAI), relative water content (RWC), leaf chlorophyll, root length, anthesis-silking-interval (ASI) and grain yield in maize hybrids

Hybrid	Plant survival%		LAI		RWC (%)		Leaf chlorophyll (SPAD value)		Root length (cm)		ASI		Grain yield per plant (g)	
	C	D	C	D	C	D	C	D	C	D	C	D	C	D
HKI 1532 × DTPYC9F73	93.4	82.3	3.53	2.42	90.1	74.1	50.3	38.3	27.4	23.4	1	7	71.9	10.5
DTPYC9F73 × HKI 1532	90.6	80.9	3.76	2.81	89.3	70.3	49.1	35.7	26.4	23.9	4	7	66.8	13.9
LM 13 × HKI 1532	92.4	71.4	4.75	2.91	91.3	74.2	47.9	35.2	35.3	30.6	0	3	69.3	23.6
HKI 1532 × LM 13	94.5	77.3	3.81	2.17	90.4	66.7	47.6	37.0	31.2	35.2	1	9	69.8	11.5
HKI 1532 × LM17	92.8	91.3	4.12	3.97	89.3	78.3	54.3	43.2	33.4	41.6	1	3	80.3	42.7
LM 17 × HKI 1532	98.6	79.4	4.39	3.39	91.9	84.2	50.7	44.7	37.4	43.8	2	3	85.7	47.8
HKI 577 × DTPYC9F46	94.3	82.8	3.62	2.12	88.2	65.3	48.2	37.8	38.5	29.6	0	9	88.4	15.9
DTPYC9F46 × HKI 577	93.2	80.3	3.91	2.31	91.3	69.8	49.5	35.3	31.9	26.9	0	8	68.4	12.2
HKI 1532 × DTPYC9F46	100	90.4	4.78	3.62	92.4	83.9	53.4	46.9	34.6	41.7	2	2	82.8	48.5
DTPYC9F46 × HKI 1532	98.3	91.6	4.97	4.04	90.4	84.3	54.3	47.9	37.3	43.8	0	3	87.4	53.8
Mean	95.6	84.8	4.2	3.1	90.5	76.1	51.0	41.2	33.3	35.1	1.1	5.4	77.1	30.0

thesis-silking-interval (ASI), cob position, grain yield and its attributes to study the phenotypic behavior of the segregating populations. Source germplasm of 66 inbred lines especially developed for abiotic stress tolerance (26 uniform and established, 42 at different developmental stages (F_3 to F_5), was maintained and advanced to next stage. Ten experimental F_1 hybrids were evaluated for their response to flowering stage drought stress. Two sets of hybrids, *viz.,* unstressed control and drought (under rain-out shelter) were sown in the micro plots maintained specially for drought studies. The drought stress was imposed under managed stress (rain-out shelter) conditions by withdrawing irrigation and closing the top of rain-out shelter two weeks before 50% male flowering till two weeks after completion of 50% female flowering. Out of 10 hybrids tested, 4 hybrids showed tolerance for flowering stage drought showing with comparatively less reduction in LAI, leaf chlorophyll, relative water content (RWC), grain yield and increase in root length under drought stress (Table 7). These hybrids possibly adapted to drought stress by having deeper root system and increased root length. (Figure 4)

Breeding for charcoal rot resistance

A set of 135 inbred lines with one check, each of resistant and susceptible was screened for charcoal rot disease in replicated trials at three environments [*rabi* 2012-13 (Hyderabad), *kharif* 2013 (Delhi) & *kharif* 2013 (Hyderabad)]. All the genotypes were subjected to artificial inoculation and disease scoring was done using 1-9 scale (1-highly resistant, and 9-highly susceptible). The details of inbred lines found resistant and moderately resistant to charcoal rot in all the three environments are given in Table 8. There was significant genotypic x environment interaction ($P<0.01$), observed for charcoal disease reaction. High interaction of genotypic x environment may show the complex nature of disease resistance and therefore there is need to study the details of gene action and interaction for effective resistance breeding programme.

Table 8. Inbred lines found resistant and moderately resistant to charcoal rot disease on disease score (1-9) in three environments

Genotype	*Kharif* 2013 (Delhi)	*Kharif* 2013 (Hyderabad)	*Rabi* 2012-13 (Hyderabad)	Disease Reaction
	Disease score (1-9)			
DML1	2.8	2.6	2.3	R
DML33	2.8	3.0	2.3	R
DML51	2.2	3.1	2.4	R
DML66	1.5	2.6	2.6	R
DML130	2.5	3.0	2.9	R
DML289	2.3	2.8	3.0	R
DML306	2.2	2.5	2.6	R
DML326	2.2	3.0	2.6	R
DML339	2.4	3.1	2.8	R
DQL1005	2.0	3.0	2.5	R
DQL1020	2.3	2.5	2.3	R
DQL1019	2.2	2.5	2.3	R
DML2	2.0	4.0	3.5	MR
DML50	2.4	4.8	5.0	MR
DML68	3.4	4.1	4.9	MR
DML77	4.3	4.1	4.1	MR
DML89	2.0	5.0	3.8	MR
DML95	3.4	5.0	3.1	MR
DML105	4.7	5.0	4.3	MR
DML111	1.7	4.6	2.9	MR
DML128	2.4	4.6	4.0	MR
DML139	2.3	4.0	2.6	MR
DML152	2.1	4.6	4.6	MR
DML167	4.3	3.4	4.2	MR
DML179	2.6	4.9	4.5	MR
DML315	3.1	4.0	4.1	MR
DQL1022	1.8	4.5	4.3	MR
DQL1030	4.3	4.5	4.2	MR
CM117-3-4-1 (Resistant-Check)	2.7	3.0	3.1	R
Win Orange sweet corn (Susceptible-Check)	7.0	7.6	7.0	HS

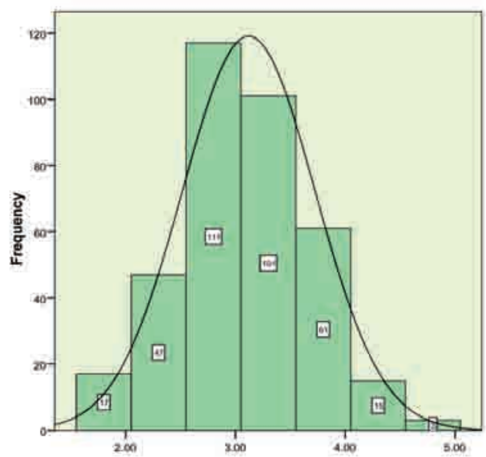
R-Resistant, MR- Moderately resistant

Molecular approaches in maize research

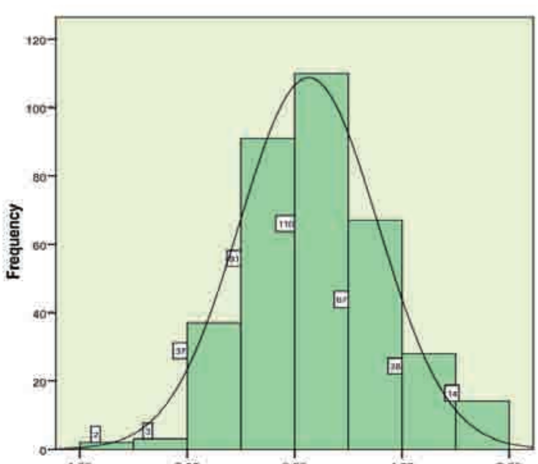
Molecular breeding for Maydis Leaf Blight *(Drechslera maydis)* resistance

The currently predominant form of *D. maydis* is *race O*, which can cause yield loss of up to 40%. However, at its severity, ≥45% yield loss in maize has been reported in India. Keeping in mind the importance of MLB disease, highly resistant and susceptible parents were selected for study of inheritance and development of mapping populations. These parents (CML 269, HKI4C4B, Brasill117 and ESM 113) have been selected from diverse germplasm continuously screened for multi- years under artificial inoculation conditions at hot-spot locations. The two different F_2 mapping population of size 361 (CML269 X HKI4C4B) and 352 (Brasill117 x ESM 113) along with their parents, F_1 and backcross were screened using 1(resistant) to 5 (susceptible) scale under artificial inoculated conditions during *kharif* 2013 at Delhi for *race O* of the pathogen.

Data was reported and analyzed. It is reported that resistance is partial dominant over the susceptibility in both the F_1 crosses. It may show the polygenic control of MLB resistance. Further, F_2 plants of both the population were screened for MLB under artificial inoculated conditions. It did not show the discrete classes of distribution but was showing the normal type of distribution (Figure 5 A and B), which also confirmed polygenic nature of its resistance. Due to contrasting of both the populations' parents for days to flowering, there was continuous variation observed in the F_2 population for days to anthesis and silking. Data for days to anthesis and silking was recorded in the parents, F_1 and their F_2. Highly significant (<0.01) negative correlation was observed between days to anthesis and severity of disease in both populations. Similar studies are also reported in temperate germplasm for most of foliar diseases in maize. Different genomic regions have been reported under the various mapping studies for MLB resistance in temperate genetic background germplasm. Markers reported to various genomic regions, which are contributing for MLB resistance has been synthesized. DNA of both the mapping populations has been isolated. The information generated in temperate germplasm will be validated in our tropical mapping populations. If needed, new regions will be identified, which shows major effect on MLB resistance.



A.



B.

Figure 5. Distribution of F_2 populations plants (A-F_2 derived from CML269 X HKI4C4B and B- derived from Brasill117 X ESM 113) for disease score reaction

Bt maize programme advances to T_2 generation

Globally, maize is the crop with maximum number of transgenic events commercialized. More than 35% of global acreage of maize is now occupied with cultivars with genetically engineered traits, like insect resistance, herbicide tolerance, drought tolerance, enhanced product quality etc. Transgenic maize is expected to be released in near future for the benefit of the Indian farmers as well. With this foresight, Directorate of Maize Research launched a strategic research programme on maize transformation in the 11th Plan with support from ICAR Network Project on Transgenics in Crops.

Figure 6. Putative *Cry1Ab* transformants generated by particle bombardment mediated maize transformation

CM300 maize genotype was transformed with a synthetic Cry1Ab gene by particle bombardment method using biolistic gene gun. A total of 15000 embryogenic calli derived from immature embryos were bombarded with DNA coated gold particles, out of which 250 putative transformants were transferred to the greenhouse (Figure 6, 7). 15 events were found PCR positive and 8 were advanced to T_1 generation.The transgenic events were characterized by PCR, ELISA and Southern hybridization. Cry1Ab integration in the genome of Event DTL 105 and Event DTL 110 were confirmed through Southern hybridization using radio-labelled Cry1Ab as probe (Figure 8). The *Bt* protein expression in some lines derived from these events was found to be up to 40 ng mg^{-1}.

Figure 7. T_2 generation *Bt* maize events under evaluation in the Transgenic Greenhouse Facility of the Directorate of Maize Research

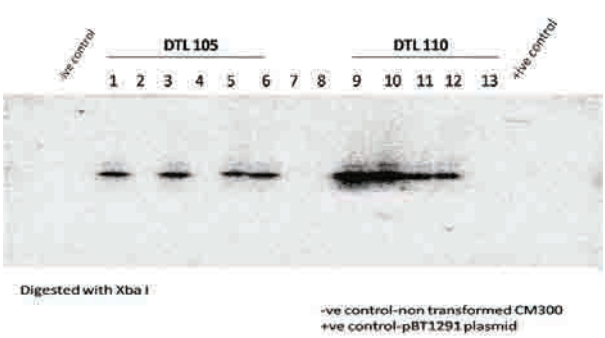


Figure 8. Southern blot for T1 stage Event DTL 105 and Event DTL 110 using radio labelled cry1Ab probe

The selected lines have now been advanced to T_2 generation. The Cry1Ab transgenics are expected to provide effective and durable resistance against maize stem borer (*Chilo partellus*)- a notorious insect pest causing significant yield losses.

Unravelling the role of salicylic acid in oxidative stress adaptation

Salicylic acid (SA) has long been known for its role in the responses to biotic stresses in plants, especially, its ability to induce systemic acquired resistance against viral diseases. It participates in diverse signalling pathways and has cross-talk with various plant growth regulators and hormones. Recent studies have suggested that it can also modulate pathways leading to adaptation to abiotic stresses, like drought, heat, salinity, chilling etc in plants. One of the common consequence of pathogen attack as well as that of incidence of abiotic stress is the rapid burst of Reactive Oxygen Species (ROS), which poses severe oxidative stress on plants.

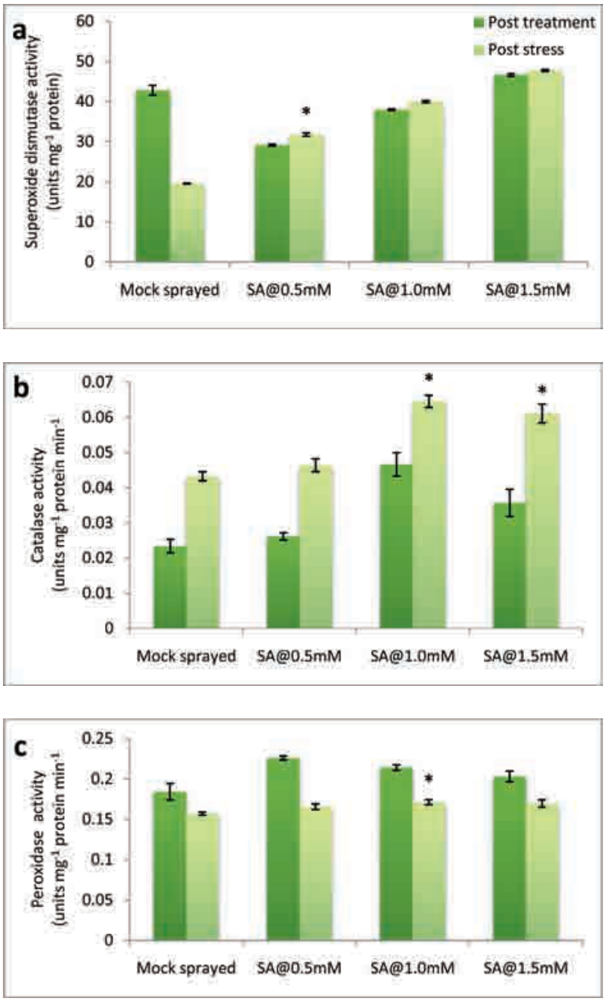


Figure 9. Specific activities of Superoxide dismustase (a), Catalase (b) and non-specific Peroxidases (c) in response to different concentrations of SA under normal and stressed conditions in maize. Each value represents mean of three independent replications ± S.E, asterisk indicate significant difference compared to the mock control post stress at $P<0.05$

We studied the physiological and biochemical changes in maize plants treated with SA during methyl viologen induced oxidative stress, and investigated the role of this plant regulator in altering the transcriptional dynamics of the antioxidant genes. SA was found to be capable of enhancing the chlorophyll content in both stressed and unstressed conditions as measured in terms of SPAD values. During stress, about 10.9, 5.6 and 2.0% increase in chlorophyll content was recorded in response to 0.5, 1.0 and 1.5 mM SA respectively, over the chlorophyll content recorded in mock sprayed plants. SA treatment also led to significant reduction in electrolyte leakage under stress, implicating its role in alleviating stress. Under stressed condition, each of the SA treatment, i.e. 0.5, 1.0 and 1.5 mM reduced the electrolyte leakage by 2.7, 4.4 and 3.3% respectively over the mock treated control. Similarly, SA also modulated specific activity of key anti-oxidant enzymes, viz superoxide dismutase, catalase and peroxidises (Figure 9). In order to understand more about the molecular mechanisms that may contribute to the changing activities of the above enzyme, quantitative Real Time–Polymerase Chain Reaction (qRT-PCR) of corresponding genes was employed. Though biochemically indistinguishable, some of these scavenging enzymes have a number of isozymes. Accordingly, bioinformatic analysis of the maize genome revealed that there are multiple gene homologs coding for one group of scavenging enzymes. Specific primers were designed and transcript abundance of these genes was quantified. Significant changes in SA mediated transcriptional dynamics were observed.

In vitro characterization on regeneration capacity of maize genotypes

Five well-adapted Indian maize inbred lines, *viz.,* BML 6, BML 7, LM 13, LM 15 and LM 16 were selected to standardize the callus induction and regeneration frequency at different levels of auxin and cytokinin. Immature embryos were inoculated on N_6 medium containing different levels of 2, 4-D (1, 2, 3, 4 and 5 mg L^{-1}) to study the callus induction response. Three replications per treatment were used and arranged in a completely randomized block design. Differences in frequency of embryogenic callus formation were observed among different levels of 2,4-D. Of different levels of 2,4-D tested, N_6 medium with 2.0 mg L^{-1} 2,4-D was found to be more effective in embryogenic callus induction with a frequency of 62.22% in BML 7 followed by 61.11% in LM 15 (Table 9, Figure 10). The percentage of embryogenic callus frequency at different levels of 2,4-D was significantly different among the inbreds and media used.

Table 9. Mean embryogenic callus induction response in various maize inbred lines

Genotypes	Mean Embryogenic Callus Induction percentage				
	N_6 with 2,4-D				
	1	2	3	4	5
BML 7	53.33± 3.85 (32.22)	62.22± 1.12 (38.46)	46.67± 1.92 (27.81)	51.11± 2.23 (30.72)	41.11± 2.94 (24.26)
LM 15	54.44± 1.12 (32.97)	61.11± 2.23 (37.65)	55.56± 1.12 (33.74)	45.56± 2.94 (27.09)	37.78± 2.23 (22.19)
LM 16	50± 3.34 (29.99)	55.56± 4.84 (33.74)	48.89± 2.94 (29.26)	42.22± 2.23 (24.96)	42.22± 1.12 (24.96)
LM 13	47.78± 2.94 (28.53)	58.89± 2.23 (36.06)	47.78± 4.01 (28.53)	41.11± 2.94 (24.26)	34.44± 1.12 (20.14)
BML 6	41.11± 1.12 (24.26)	52.22± 4.01 (31.47)	36.67± 3.34 (21.5)	32.22± 2.94 (18.79)	31.11± 2.94 (18.12)

The values presented are mean%±S.E. Values in parenthesis are transformed values; LSD is 3.78 at 5% level of significance

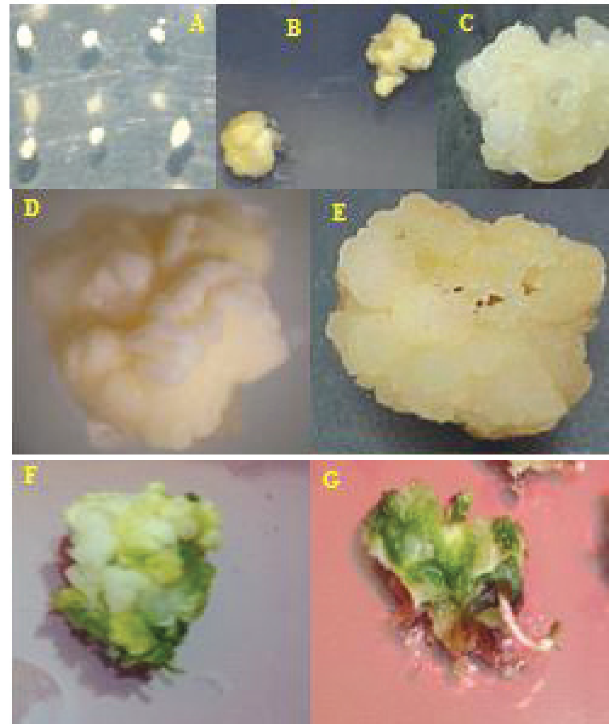


Figure 10. Callus induction from immature embryos of BML7. A) immature embryos on N6 medium (10-12 DAP); B) Pro-embryo; C) Primary callus induction; D) Regenerable embryogenic callus; E) Non-embryogenic callus; F) Callus on shooting medium; G) Shoot induction

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

Conservation agriculture (CA) based tillage and crop establishment practices plays vital role in achieving the sustainability in soil fertility, crop productivity and environmental quality. These practices have the potential to improve crop plants adaptation to climate change mainly due to altered moisture/water balance in the field CA practices also help in mitigation of climate change through increasing Carbon sequestration in soil which in-turn lessen CO_2 emission in to atmosphere. Keeping all these facts in mind, a long term experiment on conservation tillage in four maize based cropping systems was initiated during monsoon season of 2008. The treatments consisted of three tillage and crop establishment methods *viz.*, (i) Permanent bed (PB), (ii) No till/zero tillage (NT/ZT) and (iii) Conventional tillage (CT) in four maize based cropping systems (a) Maize-Wheat-Mungbean (MWM), (b) Maize-Mustard-Mungbean (MMM), (c) Maize-Chickpea-*Sesbania* (MCS) and (d) Maize-Maize-*Sesbania* (MMS).

System productivity

The experiment is being carried out at fixed site on CA from last five years (July 2008 to June 2013) in maize based cropping systems. The results based on the combined analysis of observations recorded during five year period showed significant improvement in system productivity over conventional till i.e. by 1.0, 4.2, 16.9, 20.0 & 18.4% under zero and 3.6, 6.4, 9.7, 14.6 & 11.4% under permanent beds planting in 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13 respectively (Figure 11).

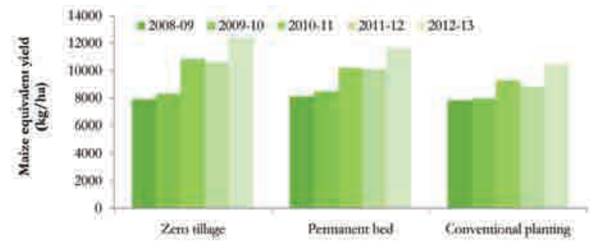


Figure 11. Effect of conservation tillage practices on maize based systems productivity during 2008-09 to 2012-13, [$LSD_{0.05}$=NS (2008-09), 455 (2009-10), 708 (2010-11), 708 (2011-12) 687 (2012-13)]

However, the experimental findings revealed that the system productivity of different maize based cropping systems under conservation tillage practices (mean of zero tillage and permanent bed together) varies from year to year. It was maximum with Maize-Mustard-Mungbean sequence during first year (2008-09) and fifth year (2012-13) of experimentation while the Maize-Wheat-Mungbean cropping sequence during second, third and fourth year of study (Figure 12).

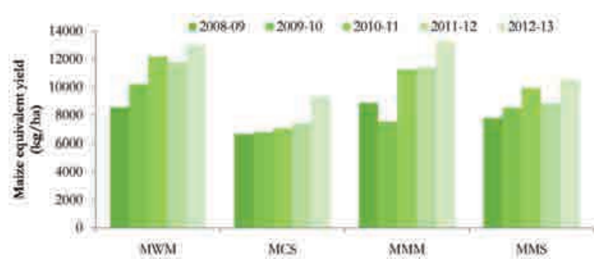


Figure 12. System productivity under conservation tillage practices during 2008-09 to 2012-13 [$LSD_{0.05}$=543 (2008-09), 253 (2009-10), 468 (2010-11), 607 (2011-12) 550 (2012-13)]

Net returns

The economics in terms of net return (₹/ha) of the maize based cropping systems under conservation tillage practices was influenced significantly over the years. In the first two years of experimentation, the highest net return was fetched under permanent bed planting, while third year onward it was under zero till planting (Figure 13).

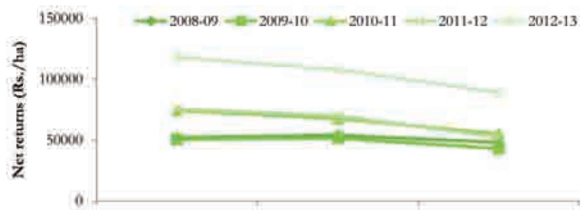


Figure 13. The net economic returns under conservation tillage practices vis-à-vis conventional planting across years (2008-09 to 2012-13) [$LSD_{0.05}$=4391 (2008-09), 2196 (2009-10), 4819(2010-11), 6933 (2011-12) 8628 (2012-13)]

The maximum net return was also recorded in different maize based cropping systems; the maximum net return was recorded in Maize-Wheat-Mungbean during all five years (Figure 14).

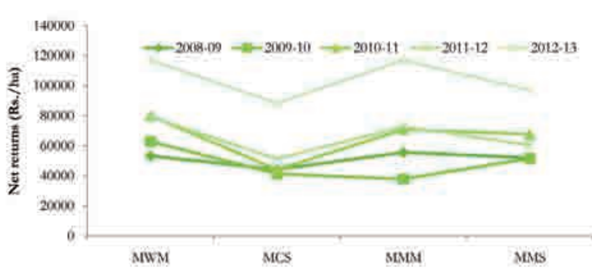


Figure 14. The maximum net returns in different maize based cropping systems under conservation tillage practices during 2008-09 to 2012-13 [$LSD_{0.05}$=4643 (2008-09), 2168 (2009-10), 4076 (2010-11), 5859 (2011-12) 6541 (2012-13)]

Kharif maize

Conservation agriculture based tillage and crop establishment techniques brought about a significant influence on *kharif* maize yield during sixth year of experimentation (2013). Zero till resulted 19.5 and 14.3% higher yield over conventional and permanent bed planting, respectively. This may be because in long run these conservation agriculture based tillage practices like zero till and permanent beds have significant positive effect on soil health and quality. However, among all the maize based cropping systems which are under investigation the maximum kharif maize yield during sixth year of study was recorded in Maize-Chickpea-*Sesbania* cropping system (Figure 15).

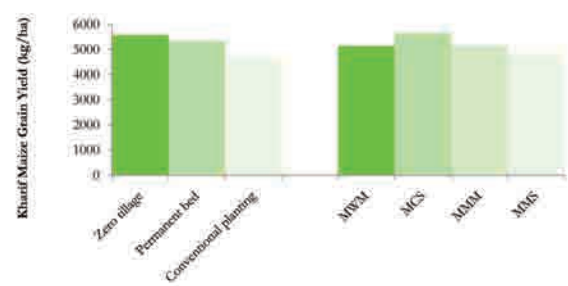


Figure 15. Maize grain yield (*kharif*) in sixth year (2013) under various conservation agriculture and cropping system practices [$LSD_{0.05}$=352 (Tillage systems), 554 (Cropping systems)]

Site specific nutrient management in maize based cropping systems

Site specific nutrient management (SSNM) provides specific principles for optimally supplying nutrients. SSNM has led to decision tools and guidelines for farmers and extension workers. Many countries in Asia have started replacing existing blanket fertilizer recommendations with site-specific guidelines suited to local needs. SSNM combined with good crop management practices helps farmers to attain high yield and profitability both for short and medium-term. Hence, experiments on nutrient management were initiated during *kharif* 2012. Among all cereals, maize in general and hybrids in particular are responsive to nutrients applied either through organic or inorganic sources. The rate of nutrient application depends mainly on soil nutrient status/balance and cropping system. Thus, for obtaining desirable yields, the doses of applied nutrients should be matched with plant demand by keeping in view of the soil supplying capacity and (SSNM) preceding crop (cropping system).

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 tillage and nutrient management practice under maize-wheat-green gram cropping system. The 2012-13 results indicated that the application of fertilizer as per nutrient expert system resulted in significantly higher yield over absolute control (no fertilizer application) and 50% recommended dose of fertilizers (RDF). However, in second year of experimentation (2013-14), SSNM resulted in significantly higher yield by 18.8% over RDF (Figure 16). During 2013-14, very high rainfall during maize growing season resulted in 3-4 times flooding in maize plots under conventional and zero-tillage plots. Thus, a significantly higher maize yield by 30.6% and 19.9% was recorded under permanent beds (PB) over conventional tillage (CT) and zero tillage (ZT) respectively.

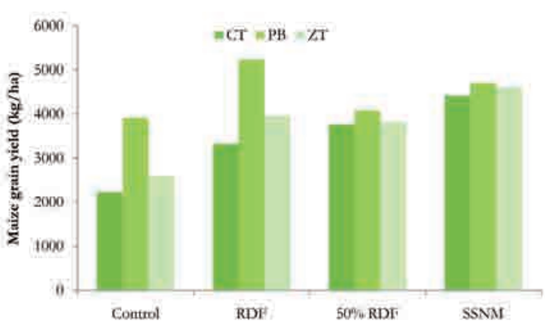


Figure 16. Effect of site specific nutrient management on *kharif* maize yield during 2013 under different tillage practices ($MSD_{0.05}$=365)

The succeeding crop wheat yielded 12.1% higher yield under permanent beds over conventional tillage (2012-13). However, it remained at par with zero tillage system. Amongst fertilizer treatments, SSNM gave significantly higher yield over control by 22.5%, however, it remained at par with RDF and 50% RDF treatment (Figure 17).

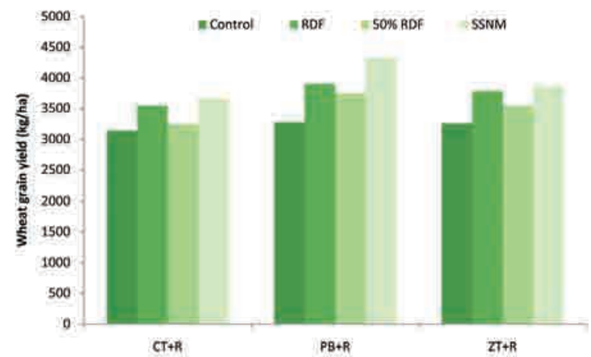


Figure 17. Effect of site specific nutrient management practices on the wheat productivity under different tillage practices ($MSD_{0.05}$=624)

SSNM in 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 second year (2013-14), SSNM gave significantly higher yield over 100% RDF, 50% RDF and absolute control by 14.7%, 26.4% and 42.9%, respectively. In *Kharif* 2013, significantly higher yield was recorded by PMH3 over other genotypes CMH08-292, PMH1 and HQPM1 by 7.5, 11.2, and 42.0% respectively but it remained statistically at par with S 6217 (Figure 18).

The succeeding crop wheat recorded significantly higher yield in STCR (Soil Test and Crop Response) based fertilizer management by 33.8, 13.9 and 5.0% over control, SPAD and RDF, respectively. However, it remained at par with green seeker based nutrient management practices (Figure 19).

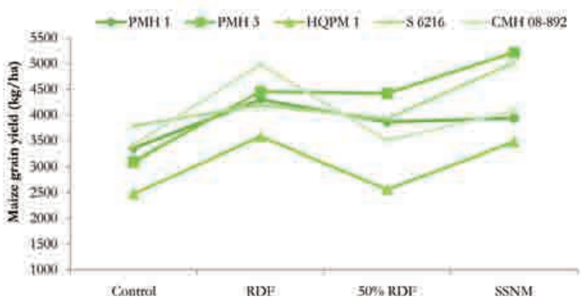


Figure 18. Effect of site specific nutrient management practices on the grain yield of different maize hybrids ($MSD_{0.05}$=642)

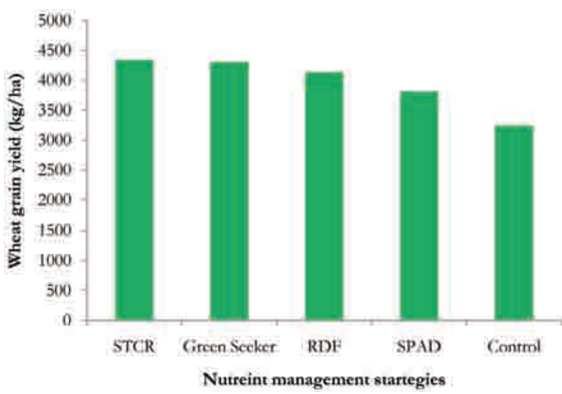


Figure 19. Effect of the precision nutrient management practices on the productivity of the wheat ($MSD_{0.05}$=321)

Nitrogen management under conservation agriculture in maize-based cropping systems

Intensified cereal based cropping system are suffering with declining factor productivity and yield stagnation along with economic sustainability due to rising prices of labour and fertilizer input. The conservation agriculture is gaining importance in this scenario and the increasing productivity and input-use efficiency will further increase the sustainability of the production. Tilled land provides the best opportunity to incorporate nutrients in the field which is not possible in no-tillage practices especially when residue is retained over the surface of the field. An experiment started during July 2012 to know the feasibility of one time coated fertilizer basal application under conservation agriculture in intensified maize-based systems.

Wheat

The succeeding wheat yield was higher with the one-time application of coated urea fertilizers *viz.*, neem coated urea (NCU) and sulphur coated urea (SCU) compared to conventional practice of split prilled urea (PU) application. The one-third maize crop residue retention (WR) also made significant effect on the *rabi* crops productivity compared to without residue (WoR). Tillage practices, tillage x residue combination and N management have impacted the grain yield of wheat. The wheat yield was higher by 7.8% under permanent bed (PB) over conventional bed (CB) planting. The N application through NCU gave maximum yield, which was 7.31 and 7.03% higher over to SCU and PU application, respectively (Figure 20).

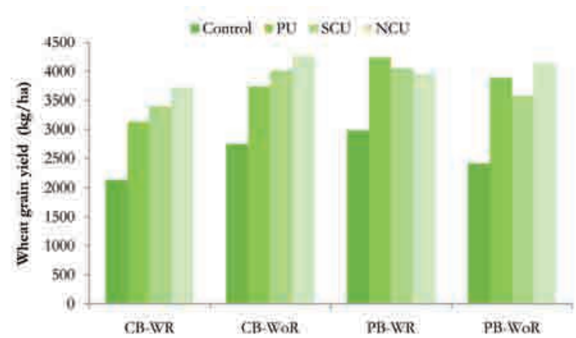


Figure 20. Effect of nitrogen management practices on the wheat productivity under different tillage and residue management practices [$MSD_{0.05}$=142 (Tillage), 343 (Tillage x residue), 641 (N application)]

Mustard

The succeeding mustard crop yield has

shown significant differences under different methods *viz.,* tillage, residue, tillage x residue combination and N management. The mustard yield under CB was much higher i.e. by 41.6% than the PB.However, the highest yield was under CB+WoR combination which was 26% higher than CB+R practices (Figure 21) which indicates yield penalty and thus residue incorporation in CB should not be practiced. On the contrary, residue retention in PB plots gave higher yield over without residue. Among N management options, SCU gave the highest yield which was 11.9 and 7.8 per cent higher over PU and NCU application in mustard.

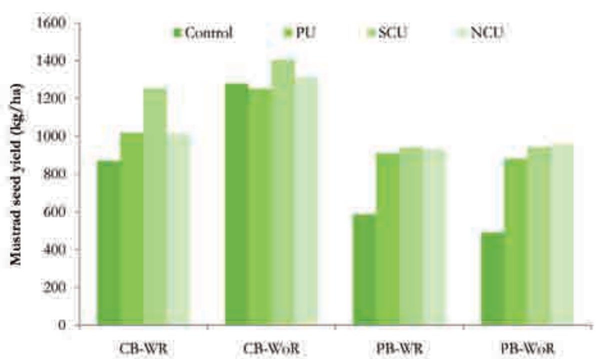


Figure 21. Effect of nitrogen management practices on the mustard productivity under different tillage and residue management scenario [$MSD_{0.05}$=339 (Tillage), 146 (Tillage x residue), 241 (N application)]

Summer Mungbean

The summer mungbean crop was sowed on residual fertility with 50 kg/ha basal application of di-ammonium phosphate after harvesting wheat and mustard under maize-wheat and maize-mustard cropping system, respectively. The sowing was undertaken with anchored one-third residue retention of *rabi* wheat and mustard. The residue retention had significant effect on the summer mungbean yield. The mungbean yield under maize-wheat system and residue retention were 14 and 24% higher over maize-mustard system and no residue application, respectively (Figure 22). However, there was no significant effect on the summer mungbean productivity with different kinds of nitrogen fertilizer application to the previous crops.

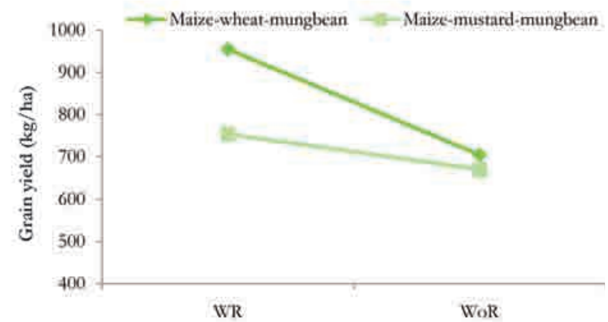


Figure 22. Effect of cropping systems and residue management practices on summer mungbean yield [$MSD_{0.05}$=53 (Cropping system), 48 (Residue)]

System productivity

The significantly higher system productivity (r^2=0.92) by 6.2% was obtained with residue retention compared to no residue. The system productivity under MWM was 22.8% higher as compared to MMM cropping system. Even though there were no significant differences amongst different N management practices with respect to system productivity but the highest was with NCU followed by SCU and PU, which indicates that the one-time application of N fertilizer can be done through coated fertilizer materials like SCU and NCU in intensive maize-based cropping systems. This in turn will help in making agriculture more convenient and less labour intensive as compared to conventional split fertilization practices. Finally, there were significant interaction effects were found *viz.,* tillage x residue, system x N application, tillage x system, residue x system and residue x N application. (Figure 23)

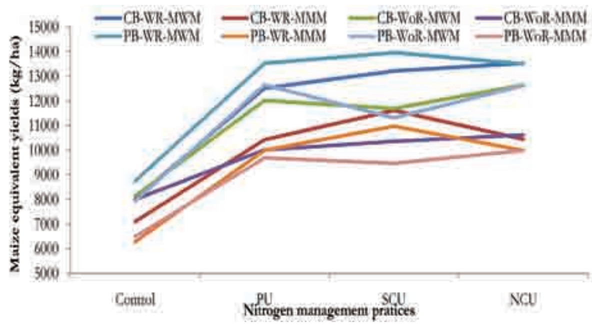


Figure 23. Effect of nitrogen management practices on the system productivity of maize systems under conservation agriculture [MSD$_{0.05}$=243 (Residue), 468 (Tillage x system), 467 (N application), 331 (System)]

Diversified maize based cropping systems for higher productivity and sustained soil health

To meet the increasing demand of various food items for ever rising population with shrinking land availability, there is need to evolve the intensive cropping systems especially with maize because, its demand is increasing day by day in different sectors. In view of this, three maize based cropping systems were evaluated with different planting methods and nutrient management practices for *peri* urban area. Among the different cropping systems, maize-potato-mungbean resulted highest maize grain equivalents (20.7t/ha) followed by maize-baby corn- mungbean (19.0t/ha) and maize-wheat-mungbean (15.1t/ha) cropping systems (Figure 24). The yield of maize, wheat, baby corn without husk, potato and mungbean under bed planting was found superior by 3.9, 1.5, 6.7, 6.1 and 10.1% over flat planting respectively (Table 10). The marked improvement (6.7%) in system productivity was also recorded under bed planting over flat planting. The application of recommended dose of nutrients to different crops coupled with 5t/ha farmyard manure resulted in the highest system productivity (24 t/ha) for maize grain equivalents. Similar response was also noticed with respect of yield and water productivity of different crops (Figure 25).

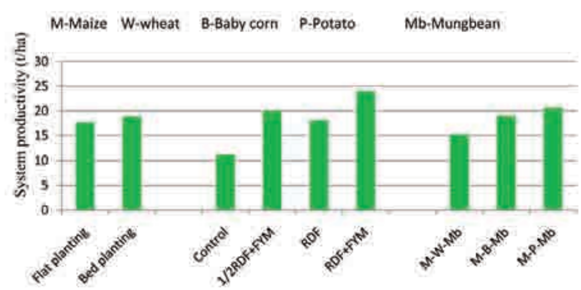


Figure 24. System productivity (t/ha) under different planting methods and nutrient management practices [LSD$_{0.05}$=2.6 (Planting system), 3.2 (Cropping system), 3.7 (Nutrient management)]

Table 10. Productivity of different crops under different treatments

Treatments	Productivity (kg/ha)				
	Kharif Maize	*Rabi* season crops			Summer Mung bean
		Wheat	Baby corn without husk	Potato tuber	
Planting Methods					
Flat planting	4147	4890	2222	33638	1153
Bed planting	4308	4962	2373	35701	1270
CD (P=0.05)	89.4	NS	NS	1274	62.4
Nutrient management					
Control	2671	3303	1145	22623	727
Half RDF + FYM 5 t/ha	4786	5418	2694	37920	1237

Productivity (kg/ha)					
Treatments	*Kharif* Maize	*Rabi* season crops			Summer Mung bean
		Wheat	Baby corn without husk	Potato tuber	
RDF	4337	5231	2441	35858	1034
RDF + FYM 5 t/ha	5275	5753	2912	42277	1847
C.D. (5%)	126.4	242.7	219.4	1801	88.3
Cropping system					
M-W-M	4053	—-	—-	—-	1096
M-B-M	4276	—-	—-	—-	1259
M-P-M	4473	—-	—-	—-	1279
CD (P=0.05)	1095	—-	—-	—-	76.4

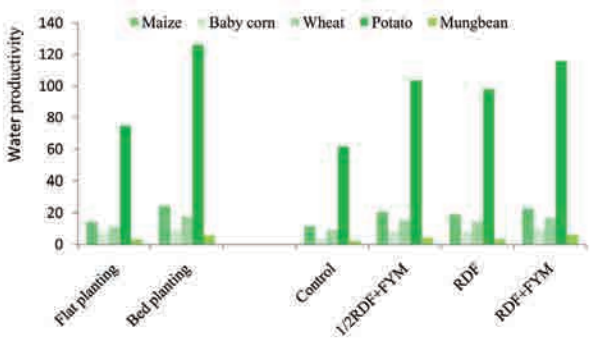


Figure 25. Water productivity (kg/ha-mm water applied) of different crops

Effect of nitrification inhibitors on productivity and nitrogen use efficiency of maize

Different nitrification inhibitors *viz.,* Neem oil coated urea (NOCU), Meliacin coated urea (MCU) and Dicyandiamide (DCD) each in two concentrations with two nitrogen levels (75 and 100 % of recommended dose of 180 kg N/ha) were compared in maize during *kharif* 2013 season. Results revealed that among the different nitrogen inhibitors, NOCU at 700 ppm concentration with recommended dose of N gave the highest yield of maize, which is at par with MCUat 350 ppm and DCD at 5% at similar N level (Figure 26). In case of NOCU there was an increase in yield with enhancement of concentration from 350 to 700 ppm. However, in respect of MCU and DCD reverse trend was noticed with increasing their concentration. However, the maximum agronomic N use efficiency was recorded with MCU at 700 ppm when applied at 75% N level.

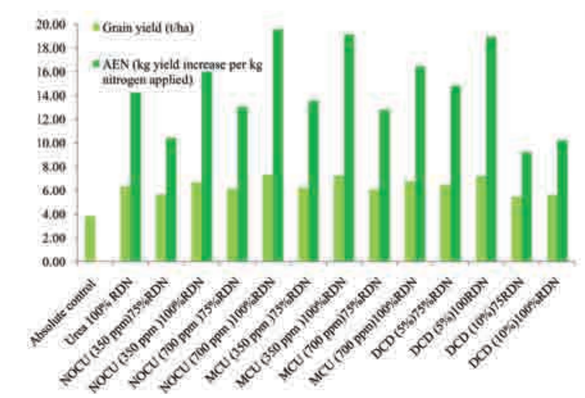


Figure 26. Grain yield (t/ha) and agronomic nitrogen use efficiency (kg grain yield/kg of N applied [$LSD_{0.05}$=0.60 (Grain yield)]

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

Potassium is one of the three major essential nutrient elements required by the plants, which is fast declining because of improper matching of fertilizer recommendations vis-a-vis removal through uptake by crops under different cropping systems. Considering this fact an experiment was initiated on management of potassium through different sources of nutrients in maize-wheat-mungbean cropping system. Fifteen treatment combinations between residue management (three practices *viz.,* no residue, crop residue incorporation and crop residue management

+fungal consortium) and potassium management [five practices *viz.,* control, potassium solublizing bacteria (KSB), recommended dose of potassium (RDK; 80 kg K_2O/ha), ½ RDK + KSB and ¾ RDK+ KSB] were tested in maize. During the first year of experimentation, maize grain yield enhanced by 6.2 and 14.1 % due to crop residue incorporation and crop residue management+fungal consortium treatments over control, respectively (Figure 27). Among the potassium management treatments, significantly maximum grain yield of maize was found with the application of recommended dose of K than remaining treatments. In general, percent increase in grain yield with the use of KSB, recommended dose of K, ½ RDK+KSB and ¾ RDK+KSB was 7.4, 35.8, 14.18 and 18.66 over control, respectively.

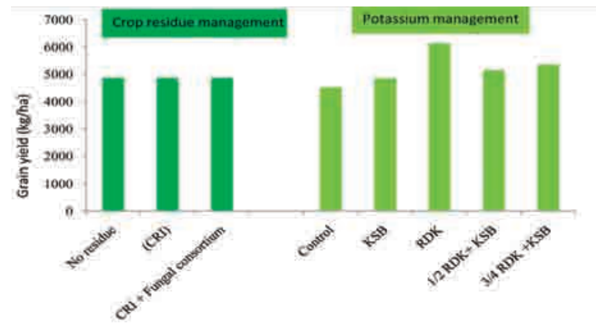


Figure 27. Maize grain yield under different residue and potassium management practices [$LSD_{0.05}$=221 (Crop residue), 232 (K management)]

3 Defending Diseases and Pests

Maize diseases and pests have been a major constraint in increasing the productivity of maize. Besides reduced 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 (PFSR) of maize is a destructive disease, prevalent in comparatively drier maize growing areas. It is apparent as the plant approaches maturity. The affected plants dry prematurely. It is caused by fungi *Fusarium verticilloides* and *Macrophomina phaseolina*. To understand the mode of infection, morphological and cultural characteristics of *M. phaseolina* (Figure 28) and *F. verticilloides* (Figure 29) were studies. Isolation was made from infected plant, obtained from DMR experimental field. In seed inoculation experiment, high mycelia growth on seed surface led to rotting in 36.6% of seeds inoculated by *F. verticillioides* and 10.0 % seeds when inoculated by *M. phaseolina* observed in seven days duration.

Culture characteristics of *M. phaseolina*

The full grown culture in Potato Dextrose Agar (PDA) was dark black in colour and microsclerotia were abundant, diameter varied from 95.6 µm to 55.0 µm with septate mycelium with width varied from 2.6 to 4.6 µm (Figure 28)

Culture characteristics *F. verticilloides*

The culture of *F. verticilloides* in PDA, observed pinkish in colour, single-celled, micro conidia (7–10 µm x 2.5–3.2 µm) were the most abundant while larger and septate macro-conidia (31–58 µm x 2.7–3.6 µm) were less abundant (Figure 29) when observed under microscope.

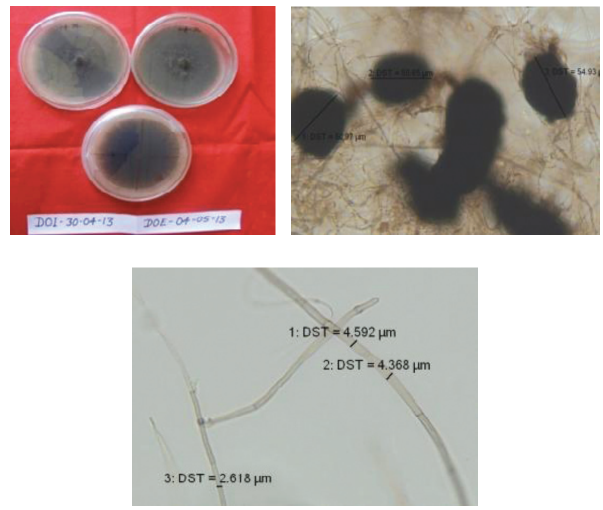


Figure 28. Culture of *M. phaseolina* Microscopic view of microsclerotia and mycelium of the fungus under 10X resolution

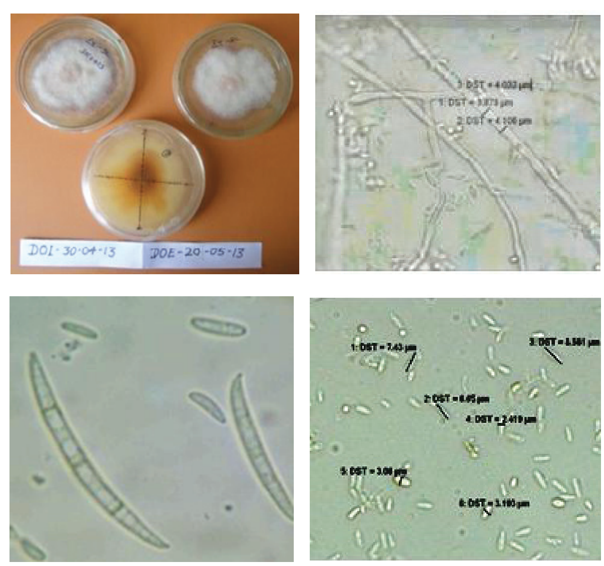


Figure 29. Culture of *F. verticilloides*, microscopic view of mycelium, macroconidia and microconidia under 10X resolution

Histopathological study- Transverse section (T S) of infected and healthy root of seedlings of maize

To carry out the experiments two contrast genotypes viz CM 123 (Resistant) and BML 6 (Susceptible) were selected on the basis of disease reaction (1-9 scale) reported in annual report 2011-12 and 2012-13.

Microscopic study of root of 10 days old seedling under 10X resolution

Histopathological studies were accomplished by transverse section (T.S.) (Figure 30 & 31) and longitudinal section (L.S.) (Figure 32) of root of seedlings of resistant (CM 123) and susceptible (BML 6) genotypes of maize.

Root inoculated with *F. verticilloides*

The fungal mycelia structure was noticed only in inoculated root both in susceptible and resistant (Figure 30). Disintegration of parenchymatus tissue was observed in susceptible genotypes.

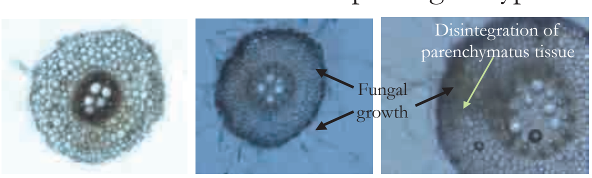


Figure 30 T. S. of root of 10 days old seedling control, resistant and susceptible genotypes showing mycelia mat of fungus *F. verticilloides* and tissue disintegration under 10X resolution

Longitudinal section (L.S.) of root of susceptible seedling infected with *F. verticilloides* observed under microscope 10X and 20 X resolutions. Mycelia mat of fungus were scattered all over the tissue (Figure 31).

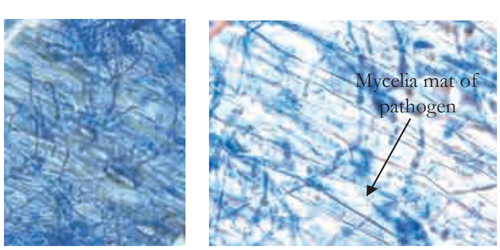


Figure 31 Microscopic view of L. S. of root showing mycelia mat under 10X and 20X

Root inoculated with *M. phaseolina*

Pathogen behaved similarly as in case *F. verticilloides* with mycelial growth both in susceptible and disintegration of parenchymatus tissue (Figure 32).

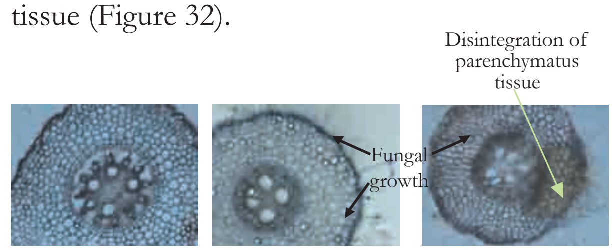
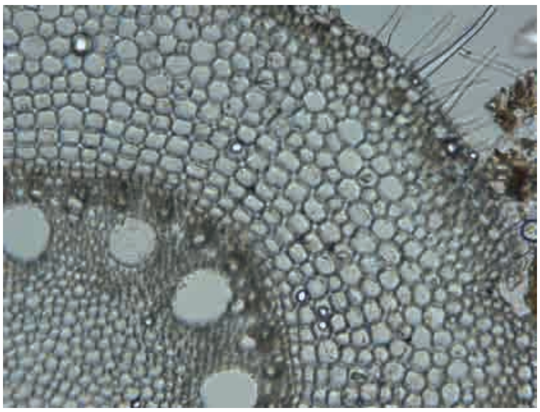


Figure 32. T. S. of root of 10 days old seedling control, resistant and susceptible genotypes showing mycelia mat of fungus *M. phaseolin* and tissue disintegration under 10X resolution

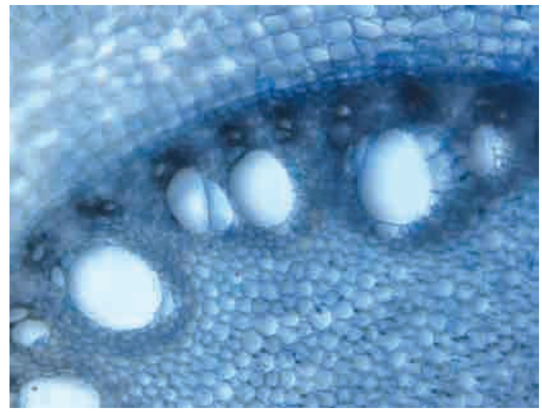
Histopathological study of root and stem of 25 days old plant raised in infected soil under controlled condition

Figure 33. Asymptomatic 30 days old plants in glass house

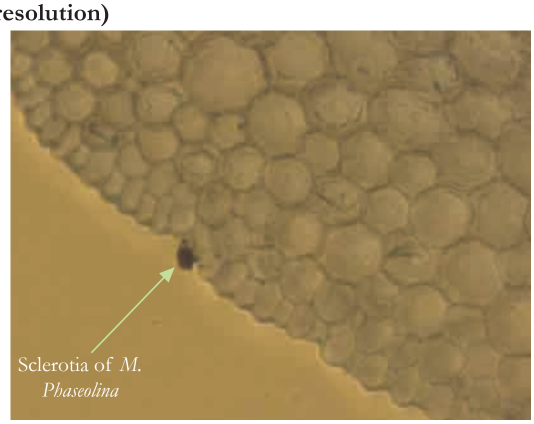
Maize genotypes CM 123 (R) and BML 6 (S) were raised in sterilized and artificially inoculated soil with stalk rot pathogens separately and in combination with three replications. The experiment was carried out in glasshouse under controlled condition. None of the plants exhibited any symptoms even after 30 days of germination/ inoculation (Figure 33). Histopathological studies were carried out in root (Figure 34) and stem (Figure 35) of susceptible and resistant plant.



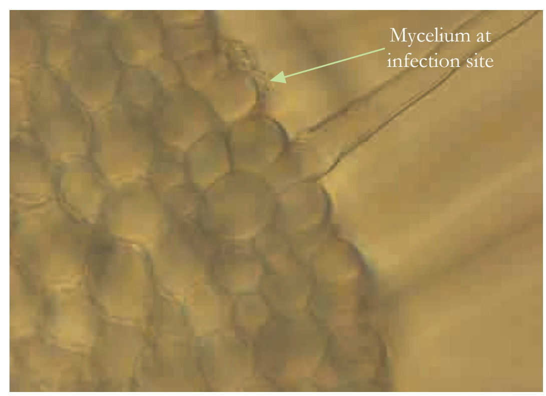
T.S. of healthy root of resistant maize genotype (10X resolution)



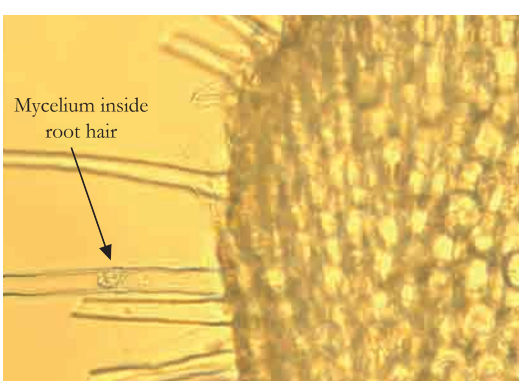
Xylem without any infection in resistant plant (20X resolution)



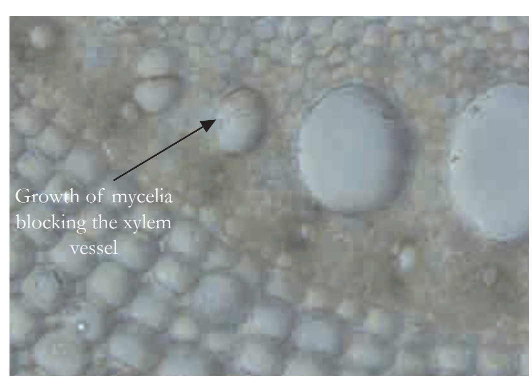
Sclerotia of *M. phaseolina* attached on epidermal layer of root



Mycelial growth of *F. verticilloids* on epidermal layer of root (20X resolution)



Fungal mycelium of *M. phaseolina* inside the root hair under (20 X resolution)

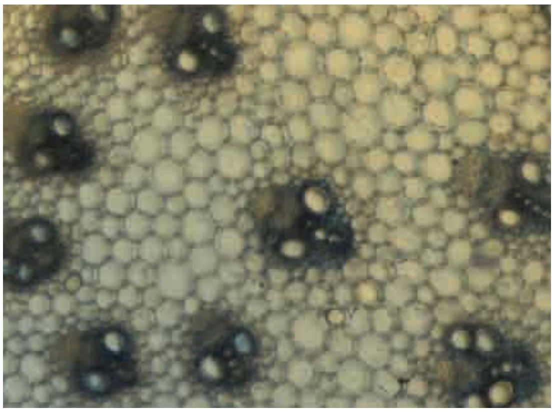


Fungal mycelium of *F. verticilloids* inside the xylem vessel of xylem of maize root (20 X resolution)

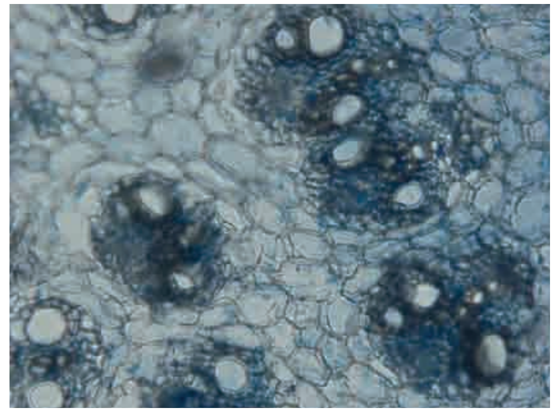
Figure 34. Histopathology of root of asymptomatic plant, 30 days after inoculation showing mode of infection

Histopathological study of stem of 28 days old asymptomatic plant raised in infected soil under controlled condition

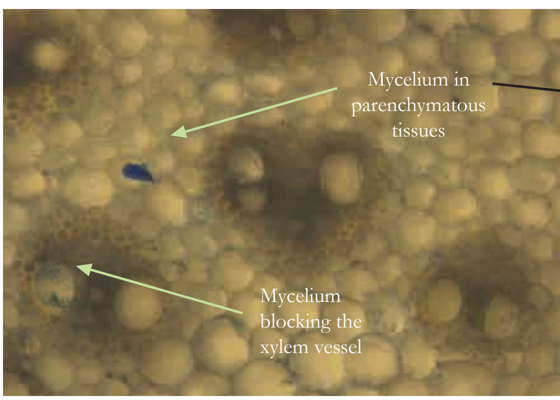
Subsequently histopathological study of stem of the same plant was done under microscope.



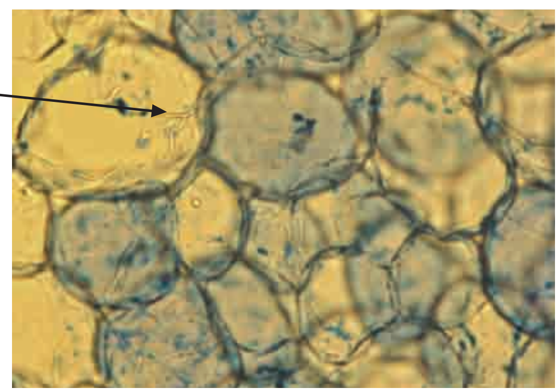
T.S. of stem of un inoculated resistant genotype without any fungal infection under 10X



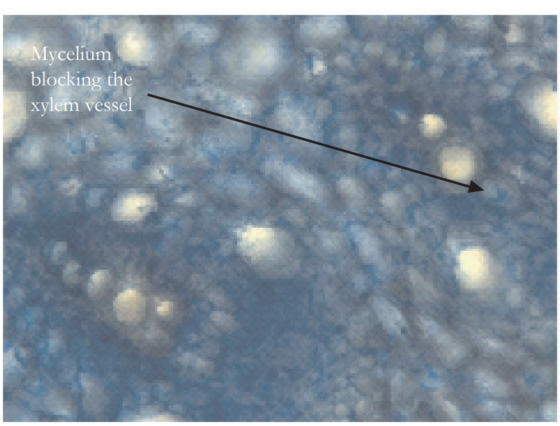
T.S. of stem of inoculated susceptible genotype with fungal infection (mycelia) under 10X resolution



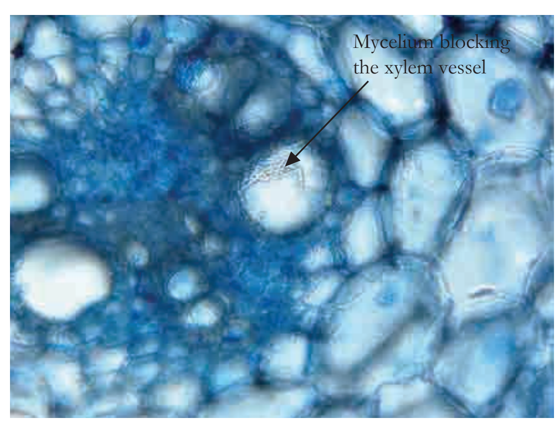
T.S. of inoculated resistant stem showing fungal growth blocking the xylem vessel under (10X resolution)



Parenchymatous tissue of infected stem showing intra and intercellular mycelium (zoom – in)



T.S. of stem of inoculated susceptible genotype showing fungal mycelia inside the xylem vessel under 10X



T.S. of stem of inoculated susceptible genotype showing fungal mycelia inside the xylem vessel (zoom – in)

Figure 35. Histopathology of stem of asymptomatic plant, 30 days after inoculation showing fungal mass in xylem vessels and in parenchymatous tissue of resistant and susceptible genotypes

Significant result of the study was that the soil inoculated plants were asymptomatic even often 30 days post inoculation/germination. However the causal organism of PFSR i.e *M. phaseolina* and *F. verticillioides* were already present inside the plants in the form of avirulent pathogen both in resistant and susceptible, confirmed by the histopathological study (Figure 34-35). This also confirmed that primary infection goes through soil via root.

Evaluation of maize germplasm to identify sources of resistance against Post flowering stalk rot of maize in field (*kharif* 2013) under artificial inoculation conditions

A total of 74 maize genotypes were evaluated under artificial toothpick inoculation condition in DMR experimental field during 2013 *Kharif*. The experiment was planted with 3 m row length x 75 cm plant to plant space and two replications. Susceptible check (Vivek QPM 9) was planted after every 10th entry. A total of 68 genotypes were selected from the first year data and selected material has been planted at Hyderabad winter nursery for evaluation and seed multiplication.

Evaluation of genotypes against PFSR at hot spot locations

A total of 50 genotypes (inbred lines) were screened for PFSR at four hot spot locations i.e. Hyderabad, Ludhiana, Delhi and Udaipur under artificial inoculation conditions. Of these, fourteen lines were found promising (Table 11) by showing resistant reaction for PFSR on a scale of 1-9.

Table 11. Genotypes resistant to PFSR on a score of 1-9 disease rating scale at four hot spot locations

S. No	Genotypes	Hyderabad	Ludhiana	Delhi	Udaipur
1	TL02A-11 84A-32-4-1-1-1-1	3.0	4.4	3.9	3.7
2	AF - 04-B-5779-22-3–3-2-1-1	3.0	4.2	4.1	2.4
3	AF-04-B-5796-A -7-1-2-2-1-1	2.7	4.0	3.7	4.2
4	CML 249-1-2-1-1	3.9	3.6	2.1	4.2
5	PFSR (Y)-C0-1-⊗-4-1⊗-1-1-1-3⊗-1-1-2	3.3	4.0	3.8	3.4
6	PFSR (Y)-C0-3⊗-1-1-1	4.0	3.0	1.3	2.4
7	Indimyt-300-B (B. G.)-2⊗-1-1-1	2.9	4.2	-	2.5
8	North east 3-1 (N) - ⊗ -1	2.9	3.3	1.8	1.7
9	North east 4-2 (N) - ⊗-1	4.3	4.0	1.5	3.5
10	North east 4-3 (N) - ⊗-1	2.7	4.0	1.8	2.2
11	NEH (W) -2 (N) - ⊗-2	3.6	3.8	1.6	2.4
12	NEH (W) -3 (N) - ⊗-2	3.6	3.5	2.6	3.1
13	CML 433-2-1	3.6	3.7	2.0	2.7
14	North east 4-1 (N) - ⊗ -1	3.6	4.0	1.2	3.8
SC	30V 92	6.8	-	1.5	-
SC	WINPOP-1	-	8.6	-	-
SC	LTP-1-B-B	-	8.5	-	-
SC	Local Sus Check	6.2	8.5	-	8.5

Identification of stable sources of resistance to major diseases of maize

A total of 173 maize lines were tested against major diseases at different hot spot locations under artificially inoculated diseased condition in *kharif* 2013. Out of them, 110 lines were resistant and 138 moderately resistant lines against different diseases (Table 12). Out of 110 resistant lines, 63 lines were having multiple disease resistance against major diseases. The entry wise disease reactions are given in Table 13.

Table 12. Promising lines identified against important diseases

Disease	Number of lines identified	Resistant	Moderately resistant
TLB	104	31	73
MLB	115	30	85
BLSB	76	03	73
C.ROT	86	80	78
FSR	112	75	37
SDM	03	01	02
RDM	17	11	06
CLS	78	52	26

Table 13. Inbred lines exhibiting resistance against one or more diseases

Genotype	Resistant to diseases	Moderately resistant to diseases
HKISCST	CLS	FSR
HKI 1040-11-7	FSR, CLS	C.ROT
SKV18	FSR	TLB, C.ROT, CLS, BLSB
WINPOP43	-	MLB, FSR
DMSC16-2	FSR, MLB	TLB, C.ROT, BLSB
CM130	-	MLB, TLB, C.ROT, FSR
DMRQPM 03-113	TLB, FSR	MLB, RDM, BLSB
Tempx Trop (H0) QPM-B-B-B-57-B-B	TLB, FSR	MLB, C.ROT, CLS
HKI PC8	-	FSR, BLSB
S99TLWQ-HG-B-B-B-20	CLS, FSR	TLB
HKI164-4(1-3)	TLB	FSR, C.ROT
SHD-1 ER6	-	C.ROT,BLSB
V 335	-	MLB, C.ROT, FSR, BLSB
HKI 164-D-3-3-2	FSR	MLB, TLB,C. ROT, BLSB
HKI 31-2	MLB	CLS
DMSC 20	CLS, FSR	BLSB, C.ROT
CM111	-	FSR, C.ROT
V390	MLB, CLS	FSR
BML13	MLB, TLB, CLS	FSR, C.ROT
CML 44	-	MLB, FSR, CLS, BLSB
CM 115	FSR	MLB, TLB, CLS, BLSB
HKI 2-6-2-4	TLB, FSR, CLS	C.ROT
CLQ-RCYQ40	TLB, C.ROT, FSR	MLB, BLSB
CM117-3-2-1-1-1-2-1	FSR	MLB, TLB, C.ROT, BLSB
HKI-2-6-2-4(1-2)-4	TLB, FSR	MLB, BLSB
G18seqcef74-2-1	TLB, C.ROT, RDM	FSR, MLB, BLSB
V336	-	MLB, TLB, C.ROT, FSR, RDM
CML161	TLB, FSR	MLB, C.ROT
HKI1352-5-8-9	FSR, CLS	MLB, TLB, BLSB
Pop.31DMR-88-3#-B*13-B-B-1	-	MLB, TLB, C.ROT, FSR
HKI191-1-2-5	MLB, CLS	TLB, C.ROT, FSR, BLSB
HKI 164-7-6 x 161	FSR, CLS	MLB, TLB, C.ROT, BLSB
P72c1xBrasil 1177-2-2-1-B-B	FSR, RDM, CLS, BLSB	MLB, TLB, C.ROT
CUBA 377	MLB, TLB, CLS, BLSB	C.ROT, FSR, RDM, SDM
HKI-484-5	CLS	MLB, TLB, C.ROT, FSR, BLSB
CM 132	TLB, FSR	C.ROT, CLS, BLSB
DMSC 36	FSR	CLS, BLSB
DMSC8	-	MLB, FSR
POBLAC61C4	TLB,	MLB, FSR, CLS, BSLB
CML 451(P2)	TLB, FSR	MLB, RDM, CLS, BLSB
CM123	TLB, FSR	MLB, C.ROT, CLS
CM 129	CLS, FSR	TLB, BLSB
La Posta Seq C7-F10-3-1-2-3-B-B-B-B-B-B	-	MLB, TLB, C.ROT,BLSB, FSR

Genotype	Resistant to diseases	Moderately resistant to diseases
DMSC6	-	TLB, FSR, CLS
HKI 586-1 WG'33	FSR	TLB, CLS
Tempx Trop (H0) QPM-B-B-B-57	RDM, CLS	MLB, TLB, C.ROT, BLSB
DMSC1	CLS	TLB, FSR
CML 33	MLB, TLB, , FSR, CLS	C.ROT, RDM, BLSB
CM149	MLB, TLB, FSR	C.ROT, CLS
BML15	FSR, RDM, CLS	MLB, TLB, C.ROT, BLSB
HKI 1128	-	TLB, FSR, CLS, BLSB
KML 3-3	FSR	MLB, TLB, C.ROT, CLS, BLSB
EC 646012	MLB, CLS	TLB, C.ROT, RDM, BLSB
SC24- (C12)-3-2-1-1	CLS	MLB, FSR
V 351	MLB, CLS, FSR	-
CM202	FSR, CLS	MLB, TLB, BLSB, C.ROT
KML 225	CLS	MLB, TLB, FSR, C.ROT, BLSB
SC7-2-1-2-6-1	MLB, FSR, SDM	TLB, C.ROT, BLSB, CLS
V334	FSR, CLS	MLB, TLB C.ROT, BLSB
La Posta Seq C7-F10-3-1	FSR, CLS	MLB, TLB, C.ROT, BLSB
CM119	FSR	TLB,
ITNA04	-	MLB, C.ROT, FSR, CLS
P390AM/CML-C4F230-B-2-1	-	MLB, TLB , FSR, BLSB
CM145	TLB, CLS	MLB, SDM
CM128	TLB, CLS, FSR	MLB
CML287	CLS, FSR	TLB
SC7-2-1-2-6	FSR, CLS	MLB
Temp.HOC15	-	C.ROT, FSR, BLSB
WS KHOTHAI-1-WAXY-1-1	CLS	TLB, FSR, BLSB
CM105	TLB, FSR, CLS	MLB, C.ROT, BLSB

Genotype	Resistant to diseases	Moderately resistant to diseases
V345	FSR, CLS	MLB, TLB, C.ROT, BLSB
HKI C 322	FSR	MLB, TLB, CLS, BLSB
S01sIyq-B-B-B-13-B	FSR	TLB, BLSB
BML 6	TLB, FSR, CLS	BLSB
EW-DMR-G-C7-HS-(SIB)-9-B-1-B-B-B	TLB, C.ROT, FSR, RDM, CLS	MLB, BLSB
42050-1	MLB, C.ROT, FSR	TLB, BLSB
Hyd05R/204-1	CLS	MLB, TLB, C.ROT, BLSB
TS2TR1107	MLB, C.ROT, FSR, CLS	TLB, BLSB
WINPOP2	FSR	MLB, TLB, BLSB
SC24-(C12)-3-2-1-1	FSR	TLB, BLSB
DMR QPM-03-124	FSR	MLB, TLB, C.ROT, BLSB
BML5	FSR, CLS	MLB, TLB, C.ROT, BLSB
BML8	CLS	FSR, C.ROT
P72c1Xbrasil1177-2	TLB, FSR, RDM, CLS	MLB, C.ROT, BLSB
BML 7	TLB, FSR, CLS	MLB, C.ROT, BLSB
LM 5	FSR	MLB, TLB, C.ROT, BLSB
HKI163	TLB, FSR	MLB
SC PINK	RDM, FSR	TLB, BLSB
HKI 226	MLB, TLB, FSR, CLS	C.ROT, BLSB
P3C45SB-33-##-11	FSR, CLS	MLB, TLB, C.ROT, BLSB
LTP 1	CLS, FSR	MLB, TLB, BLSB
WOSC	FSR, CLS	TLB, C.ROT, BLSB
SCF	CLS, FSR	MLB, C.ROT, BLSB
EI-586-2	MLB, FSR	TLB, CLS, BLSB
HKI 164-3 (2-1)-1	FSR, C.ROT	MLB, CLS, BLSB

Genotype	Resistant to diseases	Moderately resistant to diseases
CM 500	FSR, CLS	MLB, TLB, C.ROT, BLSB
CML171	-	TLB, C.ROT, FSR, CLS, BLSB
CM 501	MLB, TLB, FSR, CLS	BLSB, C.ROT
Temp.´Trop High oil QPM	FSR, RDM, CLS	MLB, TLB, C.ROT, BLSB
CML321	FSR, CLS	MLB, TLB C.ROT, BLSB
HKI193-1	FSR, CLS	TLB, C.ROT, BLSB
CML3	MLB, FSR, CLS	C.ROT, BLSB
DMRQPM 58	FSR	C.ROT, BLSB
HKI193-2-2-1	FSR,CLS	TLB, C.ROT, BLSB
Gen 6033	MLB, FSR, RDM	C.ROT, CLS
CML 154	-	MLB, TLB, C.ROT, FSR, CLS, BLSB
CM 502	-	MLB, TLB, C.ROT, CLS, FSR
DMHOC4	-	MLB, TLB, C.ROT, FSR
HKI-164-7-4-2	FSR, RDM	MLB, TLB, C.ROT, CLS, BLSB
WSCShrunken X MUS MADHU	C.ROT	MLB, TLB, FSR,
CML175	FSR,	MLB, TLB, C.ROT, BLSB
EI-670-2	MLB, TLB, C.ROT, RDM, BLSB	FSR
DQL 502	-	MLB
DQL 503	-	MLB
DQL 504	-	MLB
DQL 506	MLB	-
DQL 564 a	MLB	-
DQL 565	-	MLB
DQL 570	MLB	-
DQL 573	-	MLB

Genotype	Resistant to diseases	Moderately resistant to diseases
DQL 576	-	MLB
DQL 578	-	MLB
DQL 597	MLB	-
DQL 598	-	MLB
DQL 769	MLB	-
DQL 770	MLB	-
DQL 772	MLB	-
DQL 778	-	MLB
DQL 780	-	MLB
DQL 784	-	MLB
DQL 785	-	MLB
DQL 787	MLB	-
DQL 788	MLB	-
DQL-2008-1	FSR	TLB
DQL-2009	-	MLB, TLB, C.ROT
DQL-2010	MLB	TLB, C.ROT
DQL-2015	TLB	MLB, C.ROT
DQL-2019	-	MLB, TLB
DQL-2024	TLB	MLB
DQL-2025	MLB, TLB	-
DQL-2028	FSR	MLB, TLB, C.ROT
DQL-2031	-	MLB, TLB, C.ROT, FSR
DQL-2034	-	MLB, TLB, C.ROT
DQL-2038	FSR	MLB, TLB, C.ROT
DQL-2039	-	MLB, TLB, C.ROT, FSR
DQL-2048	TLB	MLB, C.ROT
DQL-2054	-	TLB, C.ROT
DQL-2055	-	TLB, C.ROT
DQL-2071	FSR	MLB, TLB, C.ROT

TLB – Turcicum 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.

Post harvest management of losses due to microbial colonization in stored maize grains

Aflatoxins are secondary metabolites produced predominantly by the ubiquitous fungal species *Aspergillus flavus* and *A. parasiticus* in maize in pre-and post-harvest storage. These are potent carcinogenic, hepatotoxic, teratogenic and immunosuppressive, which adversely affect health of humans and animals and have a negative economic impact on agriculture through reduced marketing options. Because of the importance of aflatoxin, the work on management of post harvest losses in maize was carried out. This project was winded up in the month of October 2013, RPF III was submitted. Based on the work, overall significant achievement of the project is given below;

- Specific gravity, starch%, oil, and sugar exhibited a decreasing trend while total protein increased in 100 kernel wt during nine months storage.
- Genotypes *viz.* JH31292, MCH42, NMH920, KMH3670, NMH803 and PMH1 (0.0639) were promising with minimum AFB_1 (<2.00ppb) in ambient storage in six months duration.
- Genotypes *viz.,* PFSR3, PFSR R9, LM 13-1 -3, AF04B-5427 -93-3 – 3-1, CML 321-1-2-2, AF04B-5405-15-3-1-2 CML 321-1-2, CML 249-1-2, AF-04-B-5779-22-3–2, PFSR (White), were found promising by producing AFB_1 <20 ppb under artificial inoculation condition
- Thickness of grain wall (pericarp + aleurone) is negatively correlated as PMH3 (203.94 µm), HQPM5 (198.01 µm), HM 7 (179.86 µm) and BPCH6 (162.76 µm) exhibited less concentration of AFB_1 as the thickness of wall was more than 170 µm.
- Wax and cutin layers of maize kernel pericarps may play a role in resistance to aflatoxin accumulation.
- Ammonium carbonate @ 4 g/kg seed and Sodium tripolyphosphate 4 ml/kg seed were the best in minimizing the aflatoxin build up (0.49 ppb) in hybrid HQPM1 in six months storage.
- The biocontrol agents *viz., Trichoderma asperellum* and *A. niger* were isolated from maize grains and further used in postharvest maize to minimize the aflatoxin concentration by suppressing the growth of aflatoxin producing mould *A. flavus.*

Predisposing factors identified

- The disease is favoured by high temperature and dry weather. Insect's damage and other stresses tend to increase the *Aspergillus* infection.
- Maize crop planted and harvested late and grown under nitrogen stress more commonly contains aflatoxins prior to harvest than corn grown under good management practices and supplied with adequate nitrogen.
- *Fusarium* ear rot occurs when harvest is delayed.
- Disease development and spread is favoured by dry warm weather after pollination.

Pre-harvest strategies

- Use recommended plant population and crop production practices.
- Timely irrigation to reduce drought stress
- Adopt practices to minimize the insect and

mechanical damage

- Dry and store the grains properly at 13% or less moisture
- Segregate, blend or destroy contaminated grains & keep storage facilities clean
- Avoidance of environmental conditions that favour infection in the field.
- Breeding for maize cultivars resistant to fungal infection
- If invasion in the field is probable and environmental conditions are favourable for mycotoxin production in the field, care should be taken to reduce sources of inoculum and to minimize plant stress and insect damage.
- Once it is determined that field contamination is likely, care should be taken to minimize the growth of the fungus after harvest and while in storage. Planning should begin for decontamination and include the diversion of contaminated maize away from human
- Use of antifungal agents such as non toxic chemicals such as ammonium carbonate @ 4 g/kg seed prior to storage.

Identification of multiple borer resistant genotypes in maize

Screening for borer resistance

A total of 212 genotypes were screened under natural infestation during *spring* 2013. The most promising genotypes with 0% dead hearts against shoot fly are; CML162, BCK/BC8, S0S1YQBBB-13, WINPOP8, SWEETCORN SYNTHETIC, CM115, AEBYC555-1-1, CM117-3-4-1, BML14, JCS796CH8, S87P66Q-BBB-30, BASILOCAL SELECTION, CUBA378, CLQRCYQ42, AEBYC534-1-1, CML485BBB, CM117, EC672591 and CML491-B6. Genotypes having dead hearts between 6-9% are; HKI170 (1+2), CM501, DMRSC1, EC614829, HKI164-3-(2-1)1, AEBYC538-1-1, HKI209, CML420 and P390AM/CMLC4F230-B-2.

Screening against *Chilo partellus*

A total of the 112 lines were screened during *kharif* 2013, resistant lines identified are; AEBY C5-34-1-1, P3C4S5-33-11-BBBB-2, PFSRS2, 390/AMCMLC4F230-B-2, AEBYC5-34-3-1 and CML384X176F3-100-9

Screening against *Sesamia inferens*

During *rabi* 2012-13, a total of 212 inbred lines were evaluated by releasing 10-12 neonate larvae on 12 day old plants. Leaf injury rating (LIR) was recorded 30 days after infestation. Of these 212 lines, two genotypes *viz.* WNZPBTL5 (2.17) and WNZPBTL9 (2.11) recorded LIR less than resistant check CM 500 (2.60).

Management of Sitophilus oryzae and Sitotroga cerealella infesting stored maize through host plant resistance and plant origin pesticides

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

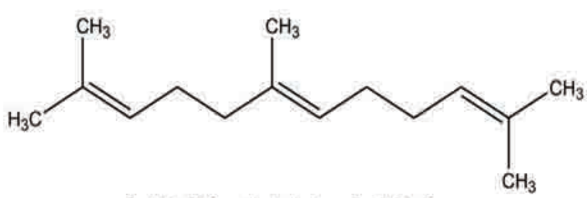
A total of 26 inbred lines were screened for their relative susceptibility to *S. oryzae*. Three lines *viz.* WNCDMR11R 0913, WNCSKNY 4854 (2) and WNCDMR19RYDWS 1518 were moderately susceptible based on Dobie's index (4-7). Out of the remaining lines, 11 were susceptible (8-10) and nine lines were highly susceptible (≥ 11).

Efficacy of plant extracts Ixora coccinea for insecticidal activities against *S. oryzae*

Efficacy of various polar extracts *viz* dichloromethane, methanol and acetone extracted from leaves of *Ixora coccinea* L. and one pure isolated compound i.e tanacetene (2, 6, 11-trimethyl-dodeca-2,6,10-triene) and synthetic insecticide deltamethrin (2.5 WP) as standard check were tested against weevil *Sitophilus oryzae* in stored maize. Three hrs exposure of *S. oryzae* to the extracts of *I. coccinea* and tanacetene at a concentration of 0.018 mg/cm^2 showed more than 95% repellence. Overall tanacetene, dichloromethane and methanol were found most effective as compared to check.

Identification of plant secondary metabolites

The compound tanacetene extracted from *I. coccinea* is responsible for insecticidal activity was identified, the structure of this sesquiterpene hydrocarbon was established as (2E, 6E, 10E) -2, 6, 11-trimethyl-dodeca-2, 6, 10-triene and was designated as tanacetene.



2,6,11-Trimethyl-dodeca-2,6,10-triene
#3: Please note: Alphabetic order of prefixes ignored while selecting parent chain

Tanacetene (2, 6, 11-Trimethyl-dodeca-2, 6, 10-triene)

The structure of the compound was established by extensive spectroscopic studies (IR[1] , H NMR[13], CNMR, MS).

Evaluation of different storage regimes for the management of *Sitophilus oryzae* and *Sitotroga cerealella*

Laboratory experiment was conducted on hermetic storage by evaluating different storage regimes *viz* double layered polythene bag (400 guaze) and High Density Polyethylene (HDPE) bags to manage stored maize against rice weevil *S. oryzae* and angoumois grain moth *S. cerealella* over 5 months storage period. The adult emergence of *S. oryzae* and *S. cerealella* was significantly low in maize when treated with *Ageratum conyzoides* stored in HDPE bag (7.75, 8.70), followed by double layered polythene bag (10.5, 14.75) compared to maize stored in cloth bag (91.0, 321.0) respectively. The per cent damage by *S. oryzae* and *S. cerealella* was significantly low in maize stored in HDPE bag (4.0, 5.0) followed by double layered polythene bag (5.75, 7.0) respectively as compared to control (22.75, 23.25).

Biological control of maize pests

Mass production and periodic release of egg parasitoid *Trichogramma chilonis* against stem borers

Field experiment was carried out to evaluate the effectiveness of *T. chilonis* in the suppression of *C. partellus* by releasing different doses of egg parasitoid. The per cent dead hearts was minimum in maize plot with four releases of *T. chilonis* @1,25,000/ha at 7 DAG, 10 DAG, 13 DAG and one release during second generation (3.16%) followed by three releases at 7 DAG and 10DAG and one release during second generation (5.21%) as compared to control (13.75%).

4 *Up scaling and Extension*

Extension plays key role in developing and improving the livelihoods of farmers. Improvement of agricultural production, profitability, and sustainability depends on the farmers to adopt innovative technologies, organizational approaches, management systems, institutions, and availability of resources. Agricultural extension strengthens the people's capacity to innovate by providing access to knowledge and information. The services provided by DMR include advisory and dissemination of improved production and management practices, communication and networking services, farm inputs and capacity building activities / trainings. Farmers get better services/technology and quality inputs to enhance the maize productivity through dissemination of technology by conducting various training programmes and exhibitions. DMR is looking after planning, implementation, monitoring, evaluation and reporting extension activities such as front line demonstrations.

The Directorate of Maize Research has provided extension service to the nation through organizing Frontline Demonstrations (FLDs) under Integrated Scheme on Oilseed, Pulses, Oilpalm and Maize (ISOPOM). It has also implemented Tribal Sub Plan (TSP) under Ministry of Agriculture, Government of India. This Directorate has also organised farm Innovators Day and Agricultural Education Day and participated in Kisan Melas and Exhibitions.

Frontline Demonstrations

DMR allocated 7355 FLDs for *rabi*/spring 2012-13 and 5125 FLDs for *kharif* 2013. Out of these, various DMR centres, agencies and NGOs conducted 2188 during *rabi* 2012-13, 754 in spring 2013 and 3783.3 FLDs during *kharif* 2013. Thus, a total of 6725 FLDs were conducted in three seasons. These demonstrations were laid out in twenty-six states by fourty-eight centres/ agencies/NGOs and an average grain yield of 5100 kg/ha was recorded which showed an increase of 98.77 per cent over all India average yield of maize. All promising technologies were demonstrated at farmers' field. Eleven FLDs in rabi 2012-13 and four FLDs in *kharif* 2013 were conducted on seed production of single cross hybrid. One hundred FLDs in *rabi* 2012-13

Input (Urea) distribution under FLD programme in Uttar Pradesh

Seed distribution under FLD Programme

and fourty one FLDs in *kharif* 2013 were conducted on baby corn cultivation in Haryana, U.P., Jammu & Kashmir and Sikkim using HM 4, Syngenta 5414 and EBCH-P/S varieties. An average yield of 1000 kg/ha dehusked baby corn in rabi 2012-13 and 1200 kg/ha in *kharif* 2013 along with green fodder was obtained. Four hundred seventy four FLDs in *rabi* 2012-13, two hundred thirty four in spring 2013 and seven hundred FLDs in *kharif* 2013 were conducted on Quality Protein Maize production technology in Bihar, Jharkhand, Uttar Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Gujarat, H.P., M.P., Haryana, Tripura, Manipur, Mizoram, Jammu & Kashmir, Uttarakhand, etc. using HQPM 1, HQPM 5, Shaktiman 2, Shaktiman 3, Shaktiman 4 and Vivek QPM 9 hybrids. Thirty seven FLDs were conducted on sweet corn cultivation in Haryana during *kharif* 2013 using Syngenta N 75 varieties. Pop corn cultivation was demonstrated in two acres in Sikkim during *kharif* 2013.

Tribal Sub Plan

Tribal Sub Plan (TSP) is a programme funded by Government of India to uplift the economic condition of tribal farmers. The Directorate of Maize Research is implementing TSP across the country in various tribal belts. Eight hundred forty demonstrations were conducted in Andhra Pradesh, Rajasthan, Madhya Pradesh, Maharashtra, Karnataka, Chhattisgarh, Jharkhand, Himachal Pradesh, Jammu & Kashmir, Odisha and Uttar Pradesh by DMR and All India Coordinated Research Improvement Project (AICRIP) centres on maize. Each demonstration was conducted in one acre of land using varieties DHM 117, HQPM 1, Rajarshi, Hi-shell, DKC 7074, Prabal, NMH 4139, Hema, Double Dekalb, C8, C 15, 30V 92 etc. The average yield of maize in demonstrations was 7097 kg/ha during *rabi* 2012-13 and 3783.19 kg/ha during *kharif* 2013. The national average yield of maize is 4158 kg/ha and 2245 kg/ha during *rabi* 2012-13 and *kharif* 2013 respectively.

TSP Training at Madhya Pradesh (Chhindwara)

The Directorate of Maize Research organized six national level training programmes for tribal farmers under Tribal Sub Plan (TSP) during March 2014. Two hundred nineteen participants attended these training programmes from different tribal populated states of the country viz. Rajasthan, Madhya Pradesh, Chhattisgarh, Odisha, Jharkhand, Gujarat, Nagaland, Jammu & Kashmir, Andhra Pradesh, Uttar Pradesh, etc. Knowledge and skill about improved maize technologies were imparted to the participants through lectures, field visit, practical and question answer sessions. Each training programme was of three days duration in which the first day was devoted for imparting knowledge on different aspects of maize e.g. suitable cultivars for different areas, seed production, production and protection technology, silage from maize, uses of maize, marketing of produce, etc. On the second day, maize technologies like hybrids, seed production, baby corn, sweet corn, intercropping in maize, processing plant, post harvest operations, success storey, exhibition, museum, etc were shown to the participants in the field. On the third day, the participants prepared different recipes from maize, quality protein maize (QPM), baby corn, sweet corn, etc. Maize shellers, seed of normal maize hybrid, QPM and baby corn were also distributed among all trainees.

Tribal Sub Plan Training at Jharkhand

TSP Training at Chhattisgarh (Ambikapur)

Pre and post training of the knowledge of trainees were also assessed. There was significant gain in knowledge level of the trainees. Trainees were satisfied and ranked the training programme as very good. All the trainees were determined for adoption and spread of suitable maize technologies in their region. Important activities of the training programme were also telecasted in Krishi Darshan programme of Doordarshan on 18th March, 1st April and 7th April 2014. Important dignitaries like World Food Prize winner Dr S.K. Vasal, Former Project Director (Maize) Dr Sain Das, Project Director (Maize) Dr O.P. Yadav and maize scientists graced these training programmes.

DMR also organized seven regional level training programmes wherein 863 tribal farmers from Madhya Pradesh, Chattisgarh, Jharkhand, Bihar, etc participated. AICRIP centres on maize conducted seven regional training programmes in Jharkhand, Tamil Nadu, Karnataka and Uttar Pradesh wherein 443 tribal farmers participated. DMR organized six exhibitions to create awareness among tribal farmers through displaying technologies of maize. Five field days were organized by DMR in Andhra Pradesh, Chhattisgarh, Jharkhand and Odisha.

AICRIP centres organized four field days in Andhra Pradesh, Jammu and Kashmir and Uttar Pradesh. Apart from the above mentioned activities, the inputs were distributed to the farmers for maize cultivation. Hybrid seed, maize shellers, weeders, bullock drawn intercultivators, sprayers, line markers, sickles, furrow openers, seed storage bins and booklets on maize were distributed among tribal farmers by DMR and AICRIP centres on maize in different parts of country.

Farm Innovators Day on October 10, 2013

Agriculture Education Day on October 17, 2013

Farm Innovators Day and Agriculture Education Day

Directorate of Maize Research organized Farm Innovators Day on October 10, 2013. Around 20 progressive farmers participated in this programme. Initially, the farmers were taken to experimental plots of maize. They had a view of 106 varieties of maize demonstrated at one place, maize cultivation using zero tillage and bed planting, etc. Farmers also had an interaction with scientists of DMR wherein they discussed various aspects of maize like procurement of quality seed, cultivation and marketing of baby corn, maize silage, setting of maize based industries, etc. Few progressive farmers shared their experiences and innovations in maize. Directorate of Maize Research organized Agriculture Education Day on October 17, 2013. Forty girl students from Sarvodaya Kanya Vidyalaya, Pusa Campus, New Delhi participated in this programme. They visited maize experiments. An exhibition of maize technologies was also organized for them. They listened to the lecture on importance and uses of maize. Later, the essay writing and quiz competitions were conducted for the students. They were asked to write an essay on "Maize Crop". Students and accompanying teachers were impressed by maize technologies and expressed satisfaction to their visit to DMR.

Kisan Mela and Exhibitions

In order to create awareness among farmers, youths and businessmen to take up maize cultivation, seed production, value addition etc., the Directorate of Maize Research actively participated in nine Kisan Melas and Exhibitions by putting up stalls. Technical Bulletins both in Hindi and English were also distributed among farmers.

Dr Gurbachan Singh Chairman ASRB visited DMR stall at Kisan Mela

All India Coordinated Research Project (AICRP)

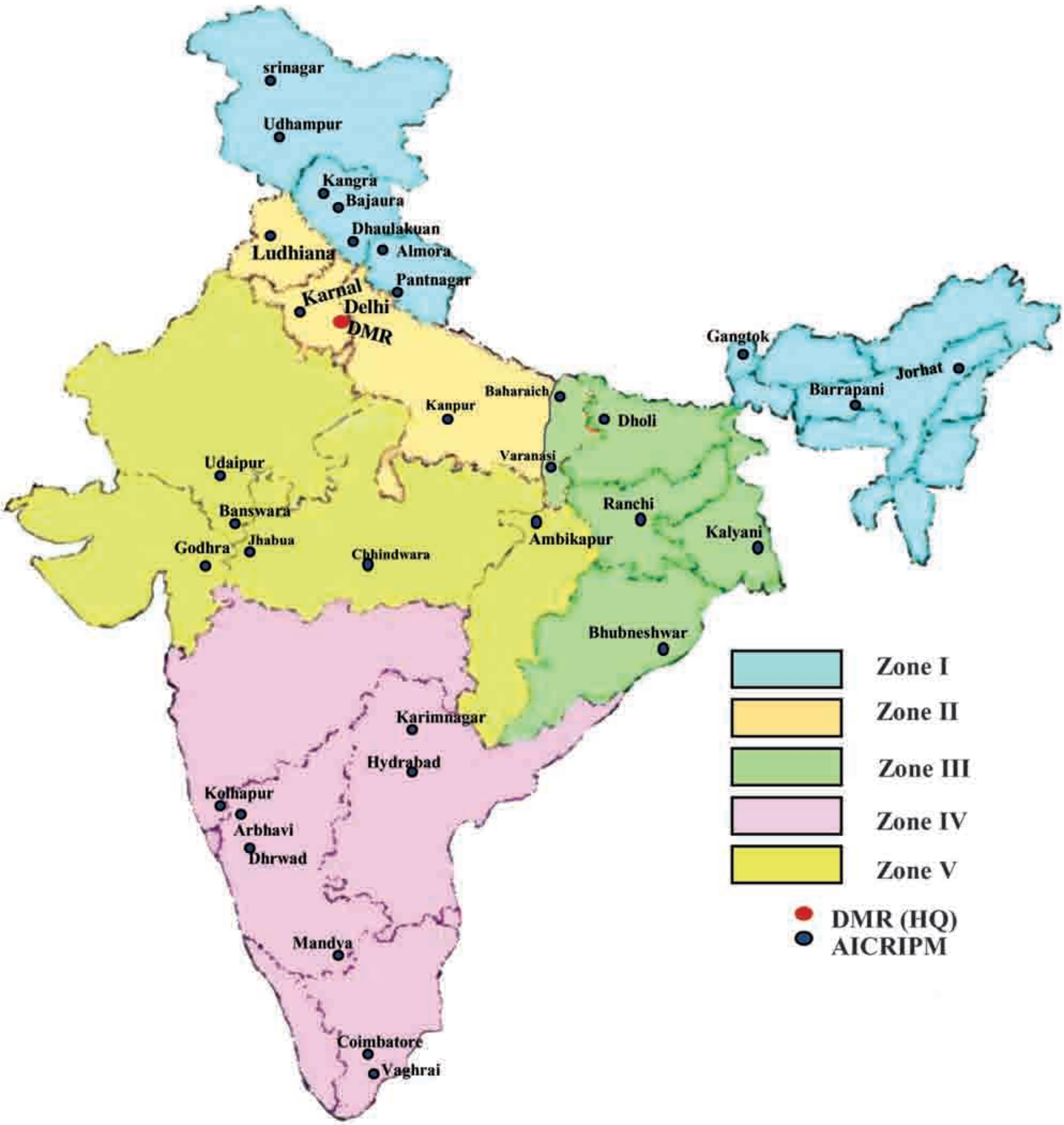
5 All India Coordinated Research Project (AICRP)

All India Coordinated Research Project (AICRP) on maize was initiated in 1957 with the objective to develop and disseminate superior cultivars and production/protection technologies. It si on oldest co-ordinated research system in India for varietal testing across different agro-climatic zones. Based on agro-climatic conditions, country has been demarcated into five zones (Figure 35) constituting 30 centres (Table 14) 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 14. Locations and soil characteristics of the various AICRP Maize Research Centres of Directorate of Maize Research

Zone	States	Centres	Latitude	Longitude	Altitude (masl)	Soil Type
Zone I	Himachal Pradesh	CSK, Himachal Pradesh Krishi Vishvidhyala, Bajaura	33°22' N	77°0' E	1090	Grey wooded Podzolic soil
		Himachal Pradesh Krishi Vishvidhyala, Dhaulakuan	30°30' N	77°20' E	468.0	Brown alluvial and grey brown podzolic soil
		CSK, Himachal Pradesh Krishi Vishvidhyala, Kangra	32°6' N	76°16' E	2404	
	Jammu and Kashmir	Sher-e-Kashmir University of Agricultural Science and Technology of Jammu, Udhampur, Jammu	32°56' N	75°8' E	2480	Sandy loam
	Uttarakhand	Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora	29°37' N	79°40' E	1650	Clay loam
	North Eastern States	ICAR Research Complex for NEH region, Barapani	25°70' N	91°97' E	1500	Sandy loam
		Assam Agricultural University (AAU), Jorhat, Assam	26°45' N	94°13' E	91.0	Sandy loam
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	Directorate of Maize Research, IARI, Delhi	28°39' N	77°13' E	228	Loam to sandy loam
	Uttar Pradesh	Chandra Shekhar Azad University of Agricultural and Technology, Kanpur	26°28' N	80°21' E	125	Sandy loam
	Uttarakhand	Govind Ballabh Pant University of Agriculture and Technology.	29°6' N	79°30' E	243	Clay loam

Zone	States	Centres	Latitude	Longitude	Altitude (masl)	Soil Type
Zone III	Bihar	Rajendra Agricultural University, Dholi	25°54' N	85°36' E	51.8	Sandy loam
	Jharkhand	Birsa Agricultural University, Ranchi	23°21' N	85°20' E	652	Sandy loam
	Orissa	Orissa University of Agriculture and Technology, Bhubaneswar	20°14' N	85°50' E	45	Clay loam
	Eastern Uttar Pradesh	Banaras Hindu University, Varanasi	25°20' N	83°0' E	128.93	Sandy loam
		Narendra Dev University of Agriculture and Technology , Bahraich	27°35' N	81°36' E	130	Sandy loam
Zone IV	Karnataka	University of Agricultural Sciences, Bangalore, Mandya	12°33'N	76°54' E	695	Light red sandy loam
		University of Agricultural Science, Dharwad, Arbhavi	16°13' N	74°48' E	640	Black soil; Medium black
	Andhra Pradesh	Acharaya N G Ranga Agricultural University, Hyderabad	17°23'N	78°29' E	530	Black Clay loam
		ANGRAU, Karimnagar	18°26'N	79°9' E	869	Red sandy- loamy
	Tamil Nadu	Tamil Nadu Agricultural University, Coimbatore	11°0'N	76°58' E	411.5	Black
		TNAU, Vagarai	10°35' N	77°34' E	926	Black
	Maharashtra	Kolhapur	21°0' N	77°52' E	574	Light to medium black
Zone V	Rajasthan	Maharana Pratap University of Agriculture and Technology, Banswara	23°33' N	74°27' E	218	Red loam
		MPUA&T, Udaipur	24°35' N	73°41' E	572	Loam to sandy loam
	Gujarat	Anand Agriculture University, Godhra	22°45' N	73°38' E	119.4	Sandy loam
	Madhya Pradesh	Jawaharlal Nehru Krishi Viswa Vidyalaya, Chhindwara	22°4' N	78°56' E	682	Medium clay
		Rajmata Vijayaraje Scindia Krishi Viswa Vidyalaya, Jhabua	22°46' N	74°36' E	318	Clayey to Sandy
	Chattisgarh	Ambikapur	23°7' N	83°12' E	1978	Sandy loam



Zones and Centres of All India Coordinated Research Project (AICRP) on maize

AICRP trials conducted during 2013-14

Breeding

Promotion of tested entries in breeding trials of *rabi* 2012-13

During *rabi* 2012, a total of 122 maize entries were tested in 10 different breeding trials at 18 locations across country. From 122 entries evaluated, 27 test entries were promoted from IVT late to AVT-I late (Trial 1 to Trial 4), 7 from IVT medium to AVT-I medium (Trial 2 to Trial 5) and 2 from IVT early to AVT-I early (Trial 3 to Trial 6). In advance varietal trial I, 9 entries were promoted from AVT-I late to AVT-II late (Trial 4 to Trial 7), 3 were from AVT-I medium to AVT-II medium (Trial 5 to Trial 8), 2 entries were promoted from AVT-I early to AVT-II early (Trial 6 to Trial 9) and one entry were promoted from QPM 2 to QPM 3. All the entries were promoted based on the 5% superiority over the best check (in late maturity), 10% (in medium, early, extra early) and 5% in QPM trial. All the promoted entries from first and second year of their testing have been recommended for further testing during *rabi* 2013-14.

Evaluation of *kharif* 2013 breeding trials

During *kharif* 2013, a total of 288 entries were received for evaluation in coordinated trials, of which, 156 entries were from public and 132 were from private sector. All the entries were used for constitution of 16 different breeding trials (4 each of IVT, AVT-I, AVT-II and specialty corns). A total of 36 locations (29 regulars and 7 volunteer) were selected across the country for evaluation of different trials. Details of the entries (in number) belonging to different maturity groups and trials are given in table 15.

Table 15. Number of public/private maize hybrids received for testing under AICRP Trial *kharif* 2013

Initial Varietal Trial (IVT)				
	Late Maturity	Medium Maturity	Early Maturity	Extra Early Maturity
Public	23	50	23	8
Private	41	34	5	1
Total	64	84	28	9
Advance Varietal Trial-I (AVT-I)				
	Late Maturity	Medium Maturity	Early Maturity	Extra Early Maturity
Public	4	2	11	4
Private	12	11	2	0
Total	16	13	13	4
Advance Varietal Trial-II (AVT-II)				
	Late Maturity	Medium Maturity	Early Maturity	Extra Early Maturity
Public	3	3	4	4
Private	14	3	3	1
Total	17	6	7	5
Specialty Corns Trials				
	QPM1-2-3	SC1-2-3	PC-1	BC-1
Public	6	3	5	3
Private	0	5	0	0
Total	6	8	5	3

Constitution of AICRP trials for multi-locations evaluation during rabi 2013-14

In *rabi* 2013-14, a total of 97 entries were received for evaluation in coordinated trials. Of which, 30 entries were from public and 67 were from private sector. All the entries are put for evaluation in 9 different breeding trials (3 each of IVT and AVT-I, and 2 of AVT-II and 1 of QPM) at 19 locations across the country. During *Rabi* season, no any trials are being conducted for sweet corns, baby corn, popcorn and normal extra early maturity group. Beside it, there are no trials in Zone-I which included Northern and Northern eastern hill part of the country. Details of the entries (in number) belonging to different maturity groups and trials are given in table 16.

Table 16: Number of public/private maize hybrids put for testing under AICRP trials of *rabi*-2013-14

Initial Varietal Trial (IVT)			
	Late Maturity	Medium Maturity	Early Maturity
Public	8*	15	5
Private	18	9	8#
Total	26*	24	13#
Advance Varietal Trial-I (AVT-I)			
	Late Maturity	Medium Maturity	Early Maturity
Public	0	0	0
Private	20	7	1
Total	20	7	1
Advance Varietal Trial-II (AET-II)			
	Late Maturity	Medium Maturity	Early Maturity
Public	0	1	0
Private	7	0	0
Total	7	1	0
	QPM1-2	SC 1-2-3/PC 1-2-3/BC 1-2-3/Extra early maturity	
Public	2	No trials are conducted for Extra early, sweet corn, popcorn and baby corn during Rabi season	
Private	0		
Total	2		

***Two hybrids in IVT late maturity trials were common with IVT medium maturity**
 # Two hybrids in IVT early maturity trials were common with IVT medium maturity

Agronomy

Evaluation of pre release hybrids under varying nutrient levels

A total of 35 genotypes of various maturity groups were tested at three fertility levels along with 10 national checks at 17 locations during *kharif* 2013. Among the late maturing hybrids, in Zone I out of thirteen only six (PFMH97157, P3580,HTMH5106,MCH45,PRO384,GK3103), in Zone III out of nine only four (CMH08-381,CMH09-464, P3580 & Orbit), in Zone IV out of twelve only four (P3580, CMH08-381, MCH46 & HTMH5106), in Zone V out of nine only one (CP333) were found significantly superior over to the best check. While, among medium maturity group the performance of hybrids in zone I out of three only one (EHL161708), in Zone III out of three only one (X35A-189) and in Zone IV out of six only two (PRO383, JH31470) were found significantly superior over to the best check. Among early maturity hybrids, in zone I out of seven only five (K21, DAS-MH-501, Bisco2238, EHL-162508, KNMH-4010141), in Zone III out of four only two (DAS-MH-501, EHL-162508), in Zone IV out of seven only five (K-21, DAS-MH-501, Bisco-2238, EHL-162508, KNMH4010141), in Zone V out seven only two (DAS-MH-501 and Bisco-2238) were found significantly superior over to the best checks. Among extra early maturity hybrids, in Zone I out of five only three (K75, FH3554, FH3556), in Zone III out of five, only two (K75, FH3558), in Zone IV out of three only one (FH3556), in Zone V out five only two (FH3555, FH3554) were found significantly superior over to the best checks.

Among various fertility levels (N:P_2O_5: K_2O kg/ha), late maturity hybrids responded up to 250:80:100 in Zone III and IV while up to 200:65:80 in Zone I. The significant response of medium maturity hybrids up to fertility levels of 200:65:80 in Zone III while at in Zone I and IV it was up to 250:80:100. The response of early maturating hybrids was up to 150:50:60 fertility levels at Zone III, whereas, the response was up to 200:60:80 at Zone I and IV. In extra early maturity hybrids, the response to different N: P_2O_5: K_2O level was recorded up to 150:50:60 at Zone III and IV and up to 200:60:80 at Zone I and V.

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

Planting of maize in paired row (84:50cm) resulted higher yield over to uniform row planting (67cm) at Bajaura, Srinagar, Ambikapur, Banswara and Udaipur. Retention of residue@ 5t/ha as mulch gave significant positive effect on maize yield attributes and yield at Bajaura, Srinagar, Ranchi, Ambikapur, Banswara and Udaipur. Under intercropping situation of maize with legume crops differential response was observed at different locations *viz.,* improvement in maize yield was found with intercropping of soybean compared to black gram at Bajaura, Ambikapur, Udaipur and black gram compared to soybean at Ranchi and Banswara.

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

Planting of maize under permanent bed gave significantly higher yield at Karnal, Delhi and Dholi locations by 13.2, 30.7 and 10.3 percent, respectively over conventional till planting. However, the method of conventional till planting gave highest yield at Pantnagar by 14.3 and 17.6 per cent over permanent bed and zero till planting, respectively. These results suggest that there is no universal planting method which is found suitable for various agro-ecologies. Hence, the site specific conservation agriculture based tillage interventions are essentially required for sustaining the higher yield of maize-wheat-green gram cropping system.

Among the nutrient management practices, nutrient expert based site-specific nutrient management (SSNM) gave significantly higher yield at Banswara, Delhi and Dholi which was at par to the RDF. However, the application of RDF at Karnal and Pantnagar locations gave highest yield which was at par to SSNM. These studies suggest that the nutrient expert based SSNM practice is giving at par or superior yield at various locations of the country and also found suitable for balanced nutrient prescriptions of the soil.

At Dholi zero till with 100% recommended dose of fertilizer (RDF) resulted significantly higher yield of succeeding wheat in maize system. In contrast to this, at Pantnagar conventional tillage resulted maximum wheat yield and system productivity with SSNM based nutrient management in maize system. But in this experiment (maize-wheat-mungbean cropping system) maximum B:C ratio was recorded with zero tillage and SSNM based crop management practices

Nutrient management in maize-chickpea/ mustard cropping system under different tillage practices under limited moisture conditions

The zero till planting of maize out yielded at Delhi by 7.6 and 28.3 per cent over conventional tillage and permanent bed, respectively. However, tillage practices could not made any significant effect on the maize productivity/yield at Chhindwara. Among the nutrient management practices, nutrient expert based SSNM gave significantly higher yield at Delhi location which was at par to the RDF. However, the SSNM gave 21.2 percent higher yields over to conventional fertilization practices (RDF) at Chhindwara.

Nutrient management in rice-maize cropping system under different tillage practices

In rice-maize system at Dholi, the maximum yield was obtained with the permanent beds planted maize with RDF application. At Hyderabad, maximum maize yield and system productivity was obtained in conventional till rice-zero till maize system with 100% RDF application.

Nutrient requirement of maize hybrids under different cropping systems

This trial was conducted at seven locations under maize-wheat system. Among the nutrient management practices, SSNM based on the nutrient expert gave 5.8, 2.2, 7.1, 13.3 and 14.5 per cent higher yield of maize over recommended fertilizer practices (RDF) at Jhabua, Banswara, Udaipur, Bajaura and Kanpur locations, respectively. However, the nutrient expert based SSNM practice of fertilizer management remained statistically at par to RDF at four locations *i.e.* Delhi, Karnal, Ludhiana and Banswara. Among the various maize hybrids tested, CMH-08-350 out-yielded at Jhabua while it remained at par to CMH-08-292 at Banswara and Ranchi over to others hybrids. The PMH-1 maize hybrid gave significantly higher yield over to others hybrids and which remained at par to PMH3 at Ludhiana and Bajaura locations. At Karnal location the HQPM1 maize hybrid gave significantly higher yield which remained on par with PMH3 and PMH4 maize hybrids. However, at Udaipur and Delhi centres PMH3 maize hybrid out-yielded to all other tested maize hybrids.

In maize-chickpea system, 15.0 and 16.2 per cent higher grain yield of maize was obtained with SSNM at Kanpur and Bahraich locations, respectively over RDF. Among the various maize hybrids tested, CHM08-292 out yielded over to all tested maize hybrids at both the locations which remained at par to PMH4 maize hybrid at Kanpur and CMH08-287 and PMH1 maize hybrids at Bahraich. The adoption of SSNM gave 9.6 and 18.0 per cent higher maize grain yield over RDF at Ambikapur and Chhindwara locations in maize-mustard cropping sequence. At both the locations, PMH-3 maize hybrid out-yielded to all other maize hybrids which remained at par to PMH1 hybrid at Ambikapur

The application of RDF in rice-maize system at Hyderabad gave significantly higher yield, which remained at par with SSNM based nutrient management. However, among the tested maize hybrids the PMH-1 gave significantly higher yield over to other hybrids except CMH08-292 which remained at par with this. Among the maize hybrids tested as single crop under rainfed conations at two locations, CMH08-287 gave significantly higher yield at Arbhavi while PMH1 out-yielded at Karimnagar but remained at par with CMH08-292. The SSNM based nutrient management practices resulted significantly higher yield at Arbhavi while it remained statistically same with RDF.

Water management in spring maize

The grain yield and irrigation water use of spring maize was affected remarkably with residue mulch and irrigation treatments. Residue mulch had significantly higher grain yield under most water management options except farmers practice. Precision irrigation practices saved up to 66 % irrigation water compared to farmers practice. In terms of maize yield, drip irrigation at 45 KPa with residue mulch was as good as flood irrigation with water saving of 4232 m3/ha wherein the irrigation water productivity increased from 1.59 to 4.37 m3/ha.

Weed management strategies for diverse weed flora in maize based cropping systems

Pre-emergence application of Atrazine @ 1.0 kg/ha was found the most effective weed management treatment at Chhindwara (3.4 t/ha) and Jhabua (4.7 t/ha). While, at Arbhavi, pre-emergence application of Pendimethalin @1.0 kg/ha as followed by one hand weeding at 25 DAS was found the best treatment in controlling the complex weed flora and getting highest yield of maize (6.4t/ha).

Tillage, residue management and mulching in maize systems

The highest maize yield (5.02 t/ha) was observed under zero tillage management with crop residue retention in maize-wheat cropping system at Udaipur, which was 18.8 and 38.4 % significantly higher over bed planting and conventional tillage.

Pathology

Survey and surveillance

Maize disease surveys were conducted in maize growing areas of Himachal Pradesh, Uttarakhand (Zone I), Karnataka (Zone IV) and Rajasthan (Zone V) during *kharif*. In Himanchal Pradesh foliar diseases i.e. Brown spot and Curvularia leaf spot (CLS) were observed in low incidence from Kullu, Bilaspur and Mandi whereas incidence of Banded leaf and sheath blight (BLSB), Maydis leaf blight (MLB) and Turcicum leaf blight (TLB) was observed from moderate to severe. In Uttarakhand a total of 130 fields were covered and BLSB was recorded in moderate incidence from Haldwani (3.0), Sitarganj (3.0) and Kashipur (3.5). CLS was observed from low to moderate incidence in these areas. Incidence of Brown stripe downy mildew (BSDM) was noticed in traces from few places. In Karnataka, foliar disease were important with severe intensity and stalk rot was moderate in all 34 ha area surveyed of 5 districts. The most predominant diseases of Rajasthan were MLB, CLS and Brown spot with disease incidence from moderate to severe. Incidence of Downy mildew was not more than 30%. Post flowering stalk rot (PFSR) was observed from traces to severe whereas TLB and BLSB were observed from traces to moderate. BSDM was noticed in traces. Based on the survey surveillance, the disease map was updated (Figure36).

During *kharif* 2013, a total of 10 trials of pathology were conducted under artificially created epiphytotic condition at identified hot spot locations viz, Bajaura, Dhaulakuan Almora in Zone I; Ludhiana, Delhi, Karnal, Pantnagar, in Zone II; Dholi, Bhubaneswar, Midanapur in Zone III; Arbhavi, Coimbaotre, Mandya, Hyderabad in Zone IV and Udaipur in Zone V. A total of 321 entries were evaluated against Maydis leaf blight (MLB), Turcicum leaf blight (TLB), Banded leaf and sheath blight (BLSB), Sorghum downy mildew (SDM), Brown stripe downy mildew (BSDM), Rajasthan downy mildew (RDM), Curvularia leaf spot (CLS), Post-flowering stalk rots (PFSR), Common rust and Erwinia stalk rot (ESR). The summarized results of various AICRP Pathology trials conducted at respective centres are presented below (Table 17).

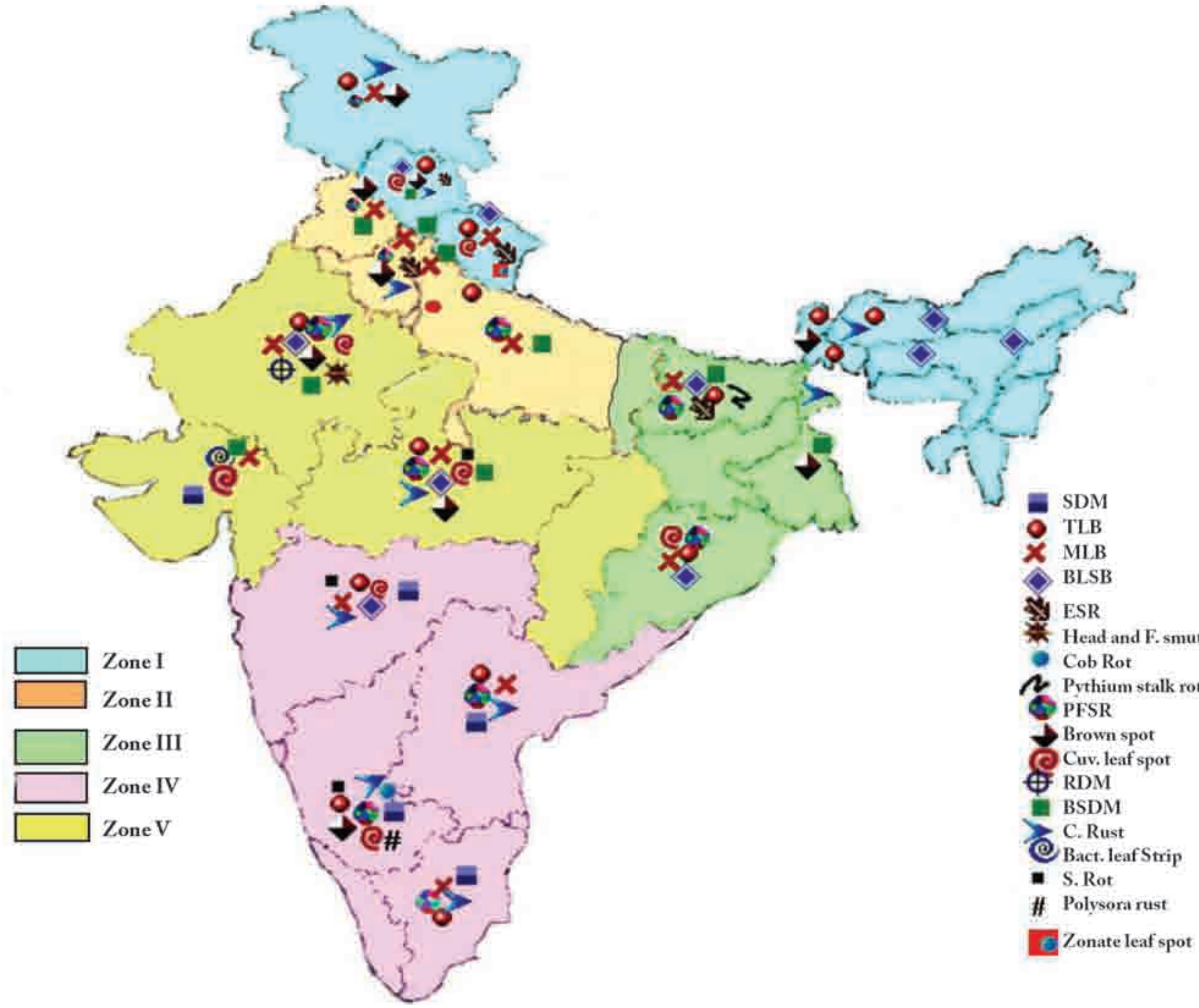


Figure 36. Disease distribution map based on survey 2013 *Kharif*

Table 17. Promising genotypes with combined diseases resistance

Major Diseases	Number of entries tested	Maturity group	Number of entries identified	Promising entries with multiple diseases resistance
Diseases	68	IVT(late maturity)	44	Genotypes
MLB, CLS				IM8556; Siri 4546; B-54; CP-999; GK-3158; DKC9133; X35D613; BB 032; PMH 1
MLB, TLB				Siri 4527; TMMH-807
TLB, CLS				Janahit
MLB, TLB, CLS				ASMH-777
Diseases	87	IVT (medium maturity)	47	Genotypes
MLB, TLB				RMH-932; SAFAL X-2; CMH 11-582

Major Diseases	Number of entries tested	Maturity groups	Number of entries identified	Promising entries with multiple diseases resistance
MLB, PFSR (FSR)				Kuber Shakthi; CMH 11-603; X35D602; JH 31244; KNMH-4010131
MLB, PFSR (FSR), RDM				KDMH-2705
MLB, CLS				EH-2205; JH 31554
MLB, PFSR (FSR), CLS				IM8479; IM8581; JH 31600 (JH 31627)
ESR, CLS				VEH 12-1
PFSR (FSR), CLS				X35D620
MLB, RDM, CLS				JH 31604
MLB, TLB, PFSR (FSR), CLS				KNMH-4305
Diseases	30	IVT (early maturity)	19	Genotypes
MLB, PFSR (FSR), CLS				FH-3669; CMH 11-595; CMH 11-629
MLB, CLS				B-52; CMH 11-626
PFSR (FSR), CLS				EH-2214; BH 411305
MLB, ESR				CMH 11-579
PFSR (FSR), ESR				JH 31610
Diseases	13	IVT (extra early maturity)	4	Genotypes
PFSR (FSR)				DH-266; Vivek Hybrid 9
MLB				FH-3641
PFSR (FSR), RDM, CLS				Vivek Hybrid 43
Diseases	37	AVT I & AVT II (late maturity)	35	Genotypes
PFSR (FSR), CLS				FMH-11195
PFSR (FSR) RDM,SDM				JH 31601
PFSR (FSR), MLB				JH 31555; HTMH 5106
TLB, RDM, PFSR (FSR)				CMH 10-477
RDM, CLS				P3491(X35B391)
CLS, MLB				P3596(X35B396); CMH 09-464
ESR, CLS				LTH-22
RDM, CLS				CP-802
PFSR (FSR), ESR				CMH 10-540
MLB, PFSR (FSR), CLS				X35B390; S 6668
MLB, PFSR (FSR), ESR				MCH-46
Diseases	22	AVT I & AVT II (medium maturity)	22	Genotypes
MLB, ESR				KMH-25K-45
MLB, PFSR (FSR), CLS				NMH-1276; X35B403
TLB, PFSR (FSR), RDM, CLS				S-6790
MLB, TLB, PFSR (FSR), RDM, CLS				EHL-2211
MLB, PFSR (FSR				Bio 719; EH-1974
PFSR (FSR), SDM				HM8

Major Diseases	Number of entries tested	Maturity groups	Number of entries identified	Promising entries with multiple diseases resistance
Diseases	22	AVT I & AVT II (early maturity	15	Genotypes
PFSR (FSR), RDM				FH-3609
MLB, RDM				FH-3626
MLB, PFSR (FSR), RDM				FH-3605; FH-3548
TLB, RDM				CMH 10-484
PFSR (FSR), CLS				KMH-7021
MLB, RDM, CLS				CMH 10-531

Assessment of avoidable yield losses due to major diseases of maize

Assessment of yield losses due to major diseases of maize was assessed at following locations using paired plot technique with nine replications under artificially created epiphytotic conditions. The extent of yield losses due to location specific diseases is given below (Table 18).

Table 18. Assessment of avoidable yield losses

Genotypes	Location	Disease	Disease score (AV)		Yield Kg/ha		Yield losses (%)
			P	NP	P	NP	
Vivek hybrid 5	Almora	TLB	2.6	4.6	5592.3	4606.8	17.62
Vivek QPM 9	Delhi	BLSB	2.1	2.8	71.05	61.66	13.21
Pant Sankul Makka-3	Pantnagar	BLSB	2.1	4.8	43.58	28.70	32.68
30V92	Hyderabad	PFSR(*M. Phaseolina*)	2.7	3.8	7.70	6.08	21.04
PMH 2	Ludhiana	PFSR(*M. Phaseolina*)	4.9	6.3	7.5	6.6	12.00

AV-Average; P- Protected, NP- Non Protected

Rabi 2013

Table 19: Promising lines identified for important diseases

Diseases	Resistant lines
Charcoal rot	DML66, DML35, DML68, DML85, DML51, DML80, DML38, DML276, DML261, DML264, DML200, DML241
Turcicum leaf blight	DMRPE 6, DML66, DML35, DML84, DML36, DML88, CML-285, DML38, DML90, DML126, DML71, DML101, DML91 , DML27, DML92, DML41, DML64, DML45, DML48, DML75, DML5, DML52, CML 117, JM-8 , DML56, DML58, DML61 ,DML78, DML113, DML116, DML119, DML121, DML77, DML127, DML129, DML133, DML80, DML82, DML147, DML72, DML150, CML-292-1-1, DML151, DML152, LM 18, BML- 7, DML242, DML2, DML209, DML273, DML250, DML276, DML23, DML38, DML103, DML257, DML259, DML33, DML264, DML263, DML174, DML271, DML162, CML 97, DML164, DML288, DML166, DMRPE 6-4, DML167, DML77, CML-10, DML11, DML196, DML91, DML238, DML6, DML297, DML370, DML 341, DML344, DML371, DML290

A total of 358 maize genotypes were evaluated comprising 122 experimental hybrids and 236 inbred lines for major disease of maize under artificial epiphytotic condition at various hotspot locations i.e. TLB (Turcicum Leaf Blight) at Mandya and Dholi SDM. (Sorghum Downy Mildew) at Mandya and PFSR (Post Flowering Stalk Rot) at Ludhiana, Arbhavi and Hyderabad. Out of 122 experimental hybrids 10 genotypes were found resistant against TLB some of them are; CMH08-282; CMH08-287; BP-007: BP-008: IL 8534: REH2012-1: JH 8825: HKH 326 etc. 3 for SDM at Mandya which are A 7501: X35B349: Rasi-3022: 7 for PFSR at Ludhiana, Arbhavi and Hyderabad some of them are BP-008: DK C9120: PMH-2277: IVORY: GK-3149: K-25 Gold: JH 8825: The genotypes with multiple resistance to PFSR & TLB are BP-008: IVORY and JH 8825.

A total of 236 lines were evaluated against major diseases of maize under artificial epiphytotic condition at various hotspot locations i.e. TLB & SDM at Mandya, PFSR at Ludhiana, Arbhavi and Hyderabad. The resistance lines are given in (Table: 19)

Nematology

Three hundred twenty one (321) maize entries belonging to different maturity groups of initial and advance trials were screened against cyst nematode (*Heterodera zeae). Out of them fifteen entries *viz.*; IM8539, BH 41036, JH 12003, SAFAL X-2, CMH 10-488, BH 41150, JH 31600(JH 31627), KNMH-4010131, FH-3669, CMH 11-629, S 6668, CP 333, EH-1974, CMH 10-531 and K-75 exhibited moderately resistant reaction to *Heterodera zeae*. Thirty two genotypes from specialty corn were screened and EHQ-64, HQPM 5 & CMH 11-659 were found moderately resistant to this nematode. Survey results showed that maximum nematode population (13.00 cyst/plant, 15.42 cyst/100 cc soil and 483.33 larvae/100 cc soil) was observed (Table 30) in samples collected from Rajsamand district with occurrence of 75.00 % while minimum nematode population (4.60 cyst/plant, 6.40 cyst/100 cc soil and 160.00 larvae/100 cc soil) was obtained from Banswara district of Rajasthan with 55.56 % occurrence. On the whole, occurrence of maize cyst nematode, *H. zeae* was observed 68.00 per cent in maize growing areas.

Entomology

Evaluation of germplasm from various maturity groups to identify resistance against *Chilo partellus*

A total of 97 germplasms comprising different maturity groups were evaluated under artificial infestation condition during *kharif*. Of them the promising germplasm were KMH 3110 in medium maturity group and DAS-MH-501 in early maturity group with less susceptibility. None of the germplasm was found least susceptible in full season and extra-early maturity group. To identify sources of resistance, a total of 141 inbred lines were evaluated of them 106 lines were moderately susceptible and only one was highly susceptible and rest 34 lines were highly promising with least susceptible. Out of 34 lines some of the most promising line on the basis of 1-9 rating scale, are HKI 577 (2.17), CM 202 (2.39), CM 500 (2.28), CM 131 (1.53), P3C4S5-33-11-BBBB-2 (2.12) and WNZPBTL5 (1.71)

Multilocation testing of insecticides against *Chilo partellus*

To find out the efficacy of seven insecticides with different mode of action against *C. partellus,* was done. Evaluation was done at eight locations under artificial infestation condition. Out of seven insecticides, Flubendiamide 480 SC was the most effective based on leaf injury rating and yield (figure 37). The plant damage in terms of LIR was observed to be relatively more when insecticides were sprayed before the infestation suggesting that there was little residual effect of these insecticides.

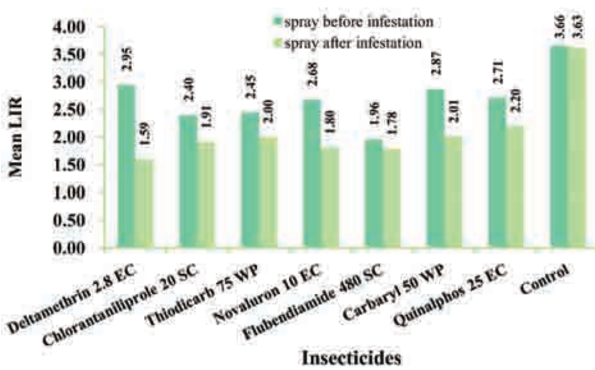


Figure 37. Efficacy of seven insecticides with different mode of action against *C. partellus*

Evaluation of biocontrol agents against *Chilo partellus*

Egg and larval parasitoids of *Chilo partellus* were evaluated in maize field at eight locations. Freshly laid eggs of *C. partellus* were exposed for two days in the field at different age intervals of maize crop. Egg parasitization by *Trichogramma* was evaluated by exposing *Corcyra* eggs. Parasitization of eggs was recorded as 15.32, 13.05 and 51.66 percent at Ludhiana Hyderabad and Udaipur respectively. Similarly, larvae collected from infested maize plants when reared in laboratory, resulted in 64.29, 12.93 8.7 and 31.25 percent parasitization by *Cotesia flavipes* at Delhi, Hyderabad Kolhapur and Udaipur centres respectively.

Assessment of crop loss caused by *Chilo partellus* and other factors

The crop loss assessment caused by *Chilo partellus* was estimated using an interactive formula at 21 plots in Gurgaon, Ludhiana and Hyderabad. Given below is the potential, expected and realized yield (Table 20). The yield potential is the yield of cultivar claimed in its variety release document. The expected yield is based on the yield loss caused by *C. partellus* only whereas the realized yield has losses caused by other insect pests and diseases also. The abiotic factors and variance in agricultural practises also contributed to the variation in realized yield.

Incidence of *C. partellus* at different sowing time after 35 DAS during kharif at Ludhiana

The observation was taken on hybrids viz, PMH1 and PMH2 on three dates viz. 20.06.2013, 01.07.2013 and 15.07.2013. The incidence of *C. partellus* was higher in early sown maize (second fortnight of June). The incidence decreased subsequently and recorded below 5 per cent in the plots sown in mid July in both the test hybrids.

Screening of maize germplasm against shoot fly, *Atherigona naqvii* under natural condition using fish meal technique at, Ludhiana during spring 2013

There was no significant difference in the number of eggs laid on different genotypes. However the dead hearts incidence of JH 31555, PMH7, PMH1, PMH8, DKC9108 and 31-7-45 were at par and significantly more resistant than PMH 2, JH 31554, JH 31544.

Table 20. Crop loss assessment caused by *Chilo partellus*

Plot No.	Yield potential (kg/ha)	Yield after loss by Chilo (Kg/ha)	Realized yield (Kg/ha)	Loss by Chilo (Kg/ha)	Loss caused by Chilo (%)	Variation due to other factors (%)
Institute of Pesticide Formulation Technology, Gurgaon						
1	6200	3987	3127	2213	35.69	-21.57
2	6200	4344	3824	1856	29.92	-11.97
3	6200	5475	5099	725	11.68	-6.87
4	6200	5002	4618	1198	19.31	-7.68
5	6200	5116	3475	1084	17.48	-32.08
6	6200	5591	4113	609	14.63	-26.44
7	6200	5525	3872	675	16.22	-29.92
8	6200	5131	4461	1069	25.69	-13.06
9	6200	5101	4221	1099	17.72	-17.25
10	6200	5595	4858	605	14.53	-13.17
11	6200	5765	4016	435	7.00	-30.34
12	6200	5296	4514	904	14.57	-14.77
13	6200	4160	4282	2040	7.54	2.93
14	6200	3665	3856	2535	18.55	5.21
15	6200	3898	4167	2302	13.36	6.90
PAU, Ludhiana						
16	3125	2735	2125	390	12.48	-22.3035
17	5250	4453	1907	797	15.18	-57.1749
18	5250	3944	1875	1306	24.88	-52.4594
19	5250	4748	2125	502	9.56	-55.2443
20	5250	4552	2750	698	13.30	-39.587
ANGRAU, Hyderabad						
21	7500	4837	2000	2663	35.51	-58.6521

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

Grain yield data of the best entry and the best check of full season maturity group were used for monsoon (*kharif*) season of AICMIP trials from the Annual Progress Report 1991 to 2012. The moving averages on three year basis for the best entry and the best check were computed from 1993 to 2012 in four agro-climatic zones of the country. The values of best test entry was *at par* or higher than the best check with significant and strong correlation with each other coupled with increasing trend for maize yields since 1991. The new maize hybrids from AICMIP are superior even under the changing climatic conditions in different agro-climatic zones, however there was a stabilization of the zonal yields (pooled over states within agro-climatic zones) of maize around year 2002 for seven to twelve years in different the zones of the country. The climatic factors as well as improved genotypes developed at AICMIP suitable under changing climatic conditions were important especially in past two decades. Thus, AICMIP had an important contribution in overall increase in zonal yields of the country even though the differential impact in different zones. The impact of new hybrids quick in Zone II and Zone III and this impact lasted for more years in Zone II than Zone III. Keeping in view the monthly fluctuations in different zones, the total rainfall in last 22 years during maize crop season decreased in all the zones except in Zone V, while the rainfall had decreased in month of October in all the Zones.

6 Significant Events

56^{th} Annual Maize Workshop

Directorate of Maize Research and Acharya NG Ranga Agricultural University, Hyderabad jointly organized the 56^{th} Annual Maize Workshop at Hyderabad from April 6-8, 2013.The address of Dr SK Datta, Deputy Director General (Crop Science) was focused on increasing trend in demand of maize in international market for food, feed and ethanol production. Dr A Padma Raju, Vice-Chancellor, ANGRAU extolled the scientists efforts in touching new heights of maize productivity from 3000 kg/ha to 8000 kg/ha in some areas of Andhra Pradesh in the *rabi* season. Dr RP Dua, Assistant Director General (FFC) was the Chief Guest of the inaugural function and Dr R Sudhakar Rao, Director (Research), ANGRAU presided over. Dr RP Dua emphasized the greater role of maize in future for providing nutritional and food security and in meeting challenges due to climate change. He also awarded certificate of appreciation to the best performing centre viz., VPKAS, Almora and best private sector, Kaveri Seed Company Limited. Dr OP Yadav, Project Director reviewed the maize improvement work carried out during 2012-13 in DMR and AICRP centres encompassing breeding, agronomy, pathology and entomology. In addition he also briefed the minutes of discipline-wise discussion covering new recommendations along with formulation of new experiments. 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. The new website of the Directorate of Maize Research (www.dmr.res.in) was launched in the workshop. More than 200 scientists from different national and international research Institutes/ Universities/Government Departments/Private sector organizations participated in this workshop.

Dr SK Datta, Deputy Director General (Crop Science), ICAR addressed the 56th Annual Maize Workshop at Hyderabad. He focused on increasing maize production to meet the rising demand in international market

Chief guest Dr RP Dua, Assistant Director General (FFC), ICAR inaugurating the 56th Annual Maize Workshop at Hyderabad. He emphasized on the role of maize in future food security

Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora awarded best performing centre at 56th Annual Maize Workshop (Hyderabad)

Dr OP Yadav, Project Director reviewed the maize improvement work carried out at Directorate of Maize Research and their Centres during the year 2012-13

National Demonstration of Maize Hybrids

Directorate of Maize Research DMR organized a 'National Demonstration of Maize Commercial Hybrids' and three brain storming sessions on 'Public-Private Partnership', 'Trait Prioritization in Breeding' and 'Improving Drought Tolerance' on September, 21-22, 2013. Dr S Ayyappan, Secretary, DARE and Director General, ICAR appreciated the efforts of DMR in maize national programme. Shri Ashish Bahuguna, Secretary, DAC, Government of India termed this initiative as unique showcasing of hybrid technology with great potential to enhance the income of farmers.

On this occasion, Dr HS Gupta, Director, IARI said that tremendous opportunities exist to take hybrids in non-traditional areas to replace low-yielding traditional varieties while Dr BS Dhillon, Vice Chancellor, PAU highlighted the importance of effective seed production programme to fully harness the benefits of hybrids. Dr JS Sandhu, Commissioner (Agriculture); Dr RP Dua, ADG (FFC); Dr JS Chauhan, ADG (Seeds) and Dr S. Mauria, ADG (IP & TM) also gave their valuable remarks on the occasion. Dr OP Yadav, Project Director welcomed the dignitaries and briefed the participants about the objective of National Demonstration.

Dr SA Ayyappan, Director General and Secretary DARE having a look of maize crop at DMR field

Shri Ashish Bahuguna having a critical look of maize hybrid and maize cob

Dr SA Ayyappan, Director General, ICAR and Secretary DARE, Dr OP Yadav, Project Director DMR and scientists visited experimental field

Brain storming session held on September 21-22, 2013

New Website of Directorate of Maize Research

The new website of the Directorate of Maize Research (http://dmr.res.in) was launched during the 56th Annual Maize Workshop held at Hyderabad from April 6-8, 2013. It is regularly updated with new research finding, news, jobs, reports and tender documentation etc.

Directorate of Maize Research gets ISO 9001:2008

Directorate of Maize Research- the apex institute responsible for coordination of maize research in India- is now an ISO 9001:2008 certified institution. The United Registrar of Systems (URS)- an independent third party certification organisation based at Bournemouth, UK has granted the Quality Management Systems Certification ISO 9001: 2008 to DMR on August 8, 2013. The scope of activities covered by this certificate include-'Research and Development of Maize'. Acquiring ISO 9001:2008 certification is one of the performance monitoring indicators for the ICAR institutes. It testifies the commitment towards assuring quality services to its clients with continual improvement of its delivery system.

Certificate of Registration

This certificate has been awarded to

Directorate of Maize Research

Pusa Campus, New Delhi, 110012, India

in recognition of the organization's Quality Management System which complies with

ISO 9001:2008

The scope of activities covered by this certificate is defined below

Research and Development of Maize

Certificate Number:	Date of Issue: (Original)	Date of Issue:
59812/A/0001/NB/En	08 August 2013	08 August 2013
Issue No:	Expiry Date:	
1	07 August 2016	

Issued by: *On behalf of the Schemes Manager*

NABCB QM018

Research Advisory Committee Meeting

Research Advisory Committee (RAC) meetings of the Directorate of Maize Research were held on June 2 and July 20, 2013 under the chairmanship of Dr BS Dhillon, Vice Chancellor, PAU. The other members were Dr VP Ahuja, Prof. HS Shetty, Prof. DN Yadav, Prof Amar Kumar, Dr Sain Dass, Dr OP Yadav and Dr KS Hooda (Member Secretary). Dr Dhillon underlined the importance of maize in crop diversification and sustainable agriculture in Indo-Gangetic Plains of country with many industrial uses. The Project Director presented an overview of maize research and significant achievements of the Directorate for the year 2012 and sought the guidance of RAC on how to make germplasm development programme at DMR more efficient for developing high yielding hybrids and to cater the needs of different agro-climatic zones. The RAC members expressed satisfaction over the efforts that are being made on the breeding of high yielding single cross hybrids of different maturity with resistance/tolerance to various biotic and abiotic stresses and adaptation to different agro-ecologies in the country. The committee emphasized the strengthening and enhancement of source germplasm for breeding. It also stressed on the utility of defining heterotic pools in hybrid breeding, increasing introgression of temperate germplasm and development of genetically diverse, vigorous and productive inbred lines and recycling of inbred lines through hybridization within the heterotic group.

Germplasm day

Directorate of Maize Research organized a germplasm day at its Winter Nursery Centre, Hyderabad on 16th March, 2014. Dr SK Dutta, DDG (CS), ICAR graced the occasion as Chief Guest. Dr Padma Raju, VC, ANGRAU, Hyderabad and Dr K. Raja Reddy, Director of Research, ANGRAU were also present on the occasion. Dr O.P. Yadav, Project Director, DMR welcomed the dignitaries and participants and briefed about the genetic background of more than 3000 lines including 1652 germplasm lines from NBPGR and 1600 nearly homozygous lines developed at DMR. More than 40 breeders from NBPGR, AICRP centres on maize from 24 SAUs, IARI, New Delhi and VPKAS, Almora participated in the event.

Germplasm Day (16th March, 2014)

Institute Research Council (IRC)

The Institute Research Council Meetings of Directorate of Maize Research was held on June 26-27, 2013 in the Dr NL Dhawan Committee room under the chairmanship of Dr OP Yadav, Project Director. Dr KV Prabhu, Head Division of Genetics, IARI, New Delhi was invited as an expert from outside. Scientists of Directorate presented the significant achievements of their research projects and future work plan. The achievements of each project were reviewed and expert put forth the valuable suggestions to enhance the quality of research project. New projects were also presented and discussed by the members.

Institute Technology Management Unit Committee

ITMU meetings were held four times on April 12, June 20, August 7 during 2013 and March 25, 2014, to discuss several issues *viz.,* undertaking a project on screening of maize germplasm of MIL for BLSB resistance/tolerance, to provide contractual services to Bioseed Research India for testing the nutritive value of grains of five maize hybrids, to undertake contractual research project of Monsanto India Ltd., to conduct training program for an Entomologist of Syngenta Bioscience Pvt. Ltd., and to undertake contractual service between Margo Biocontrols Pvt. Ltd. and Directorate of Maize Research for the product "Ecohume" on maize crop. The decisions were taken that each projects/contractual services will be undertaken as per the ICAR guidelines.

Institutional Bio Safety Committee (IBSC)

IBSC meetings were held on August 19, 2013 and March 13, 2014 for discussion on the biosafety aspects of the ongoing projects of DMR. The agenda of the meeting was to review the biosafety aspects taken in research activities at the Directorate. Dr Pradyumn Kumar explained the biosafety measures being adopted in different laboratories/projects and Dr Pranjal Yadava apprised IBSC members for the disposal of Ethidium Bromide. The committee decided that the transgenic material should be disposed of after autoclaving it. In view of the fire incidence occurred last year in the Directorate, it was decided that Fire Station in the vicinity may be requested to impart training to DMR staff to prevent the recurrence of fire incidence and also an annual mock exercise may be arranged to increase alertness. The IBSC committee members discussed on other biosafety issues and they were satisfied as the Directorate functioning was following IBSC guidelines.

Other Activities

Vigilance Week

The Directorate observed Vigilance Awareness Week during October 28, 2013 to November 2, 2013. Dr OP Yadav, Project Director, DMR administered the pledge to the staff members.

Sports Activities

ICAR Central Zone Sports Meet 2013 was held at CIAE, Bhopal from September 24-28, 2013. Total 13 staff members from DMR participated. Mr Yatish K R won 1st Prize in 200 meter race and Badminton team reached upto semi-final stage. Dr Yatish participated in ICAR Inter Zonal Sports Meet held at Hyderabad during December 17-20, 2013.

हिंदी चेतना मास 2013

मक्का अनुसंधान निदेशालय में दिनाँक 1 सितम्बर 2013 से 30 सितम्बर 2013 तक हिंदी चेतना मास मनाया गया। इसका समस्त कार्यभार डॉ प्रद्युम्न कुमार एवं श्रीमती सपना को दिया गया। इस दौरान हिंदी की विभिन्न प्रतियोगिताओं का आयोजन किया गया जैसे निबंध लेखन, कविता पाठ, आशुभाषण, श्रुतलेख इत्यादि। दिनाँक 11 अक्टूबर 2013 को समापन समारोह की अध्यक्षता करते हुए डॉ ओम प्रकाश यादव, निदेशक, ने प्रतियोगिता के सभी विजेताओं को पुरस्कार प्रदान किया एवं वहाँ उपास्थित सभी लोगों को हिन्दी के प्रचार और प्रसार का बढ़ावा देने के लिए उत्साहित किया।

हिंदी कार्यशाला

निदेशालय में दिनाँक 30 जनवरी 2014 को ''युवा पीढ़ी, हिंदी एवम ज्ञान विज्ञान'' विषय पर एक कार्यशाला का आयोजन किया गया । कार्यशाला की अध्यक्षता डॉ ओम प्रकाश यादव, द्वारा की गयी। डॉ विजय वेदालंकार, भुतपूर्व प्रवक्ता, हिंदी विभाग, हिंदी महाविद्यालय सोनीपत को मुख्य प्रवक्ता के रूप मे आमंत्रित किया गया । कार्यशाला मे निदेशालय के सभी वैज्ञानिको, तकनीकी एवम प्रशासनिक अधिकारियो एवम कर्मचारियो ने भाग लिया ।

7 Awards and Recognitions

Award

- Dr Ganapati Mukri, Scientist received Jawahar Lal Nehru outstanding doctoral research thesis award 2012, for his PhD.

Dr Ganpati Mukri receiving Jawahar Lal Nehru Award 2012

- Dr CM Parihar, SL Jat, AK Singh and Bahadur Singh received Shreeram Puruskar of the Fertiliser Association of India for best popular article on December 11, 2013.

Recognition

Dr Ashok Kumar

- Panelist in National Seminar on "Eco-friendly environment" sponsored by Higher education Commission, Panchkula held at GVMGC, Sonipat on March 12, 2013
- Member, Inspection committee of H N B Garhwal University, Srinagar, Garhwal for inspection of R M P (P G) College, Gurukul Narson (Haridwar)

Dr Ishwar Singh

- Joint Secretary of the Indian Society for Plant Physiology, New Delhi for a period of three years (2013-15).
- Managing Editor of the Indian Journal of Plant Physiology for a period of three years (2013-15)
- Treasurer of the Maize Technologists Association of India, New Delhi for a period of two years (2013-14)
- Expert/Advisor for selection of Assistant Agriculture Officers for Agriculture Department on 9th and 10th July 2013 by the Rajasthan Public Service Commission (RPSC).

Dr K S Hooda

- Secretary, Maize Technologists Association of India, DMR, Pusa Campus, New Delhi 12 for 2013-14

Dr Vinay Mahajan

- Expert on Central Compliance Committee for monitoring the Biosafty Research Level-1 (BRL-1) trial of insect tolerant transgenic corn hybrids containing new genes/events conducted during Rabi-2013, on 12th March 2014 at Sansoli, Ahmadabad, Gujarat (No. BT/03/09/2012-PID dt 21.2.2014).
- Expert for the selection of Professor on 17th & 18th June 2013 at SKRAU, Bikaner (DMR F.No.: 1-37/VM-L/Pr.Sci/2010/1589/2 dt 15th June 2013).
- Nominated member of Selection Committee for the recruitment of Technical Officer (T-3) (Interview) 17th -18th Dec 2013 at NRL, IARI, New Delhi (No, 20-1/2013-P-V dt 16th Dec 2013)

ANNEXURE

8 Annexures

8a Annexure I

Maize hybrids notified for cultivation

During 2013, 16 hybrids of maize were notified for different agro-climatic conditions for cultivation in different parts of the country. Of these, one each is QPM hybrid and sweet corn while three are state release.

Hybrid	Pedigree	Name of centre/ company	Year of release	Notification no.	Area of adaptation	Maturity	Yield (Kg/ ha)	Characteristics
CMH 08-282	UMI-1200 X UMI-1230	TNAU, Coimbatore	2013	2187 (E)	Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	Late	6000	Orange-yellow, semi-dent
Pratap QPM Hybrid-1 (EHQ-16) (QPM)	DM-RQPM106 (CLQ RCYQ-40) X HKI-193-1	MPUA &T, Udaipur	2013	2187 (E)	Rajasthan, Gujarat, Madhya Pradesh and Chhatisgarh	Medium	5900	Yellow, semi-dent, resistant to PFSR, RDM, TLB and moderately resistant to MLB and cyst nematode
Pant* Shankar Makka-1	YHP Alm ⊗ 85-4-3-2-3-3-1-1-1 X YHP Pant ⊗ 161-1-4-1-2-1-2-1	GBPUA &T, Pantnagar	2013	2187 (E)	Uttarakhand	Early	4800	Yellow, semi-flint
Shalimar* Maize Composite-3 (OPV)	-	SKUAS & T, Srinagar	2013	2187 (E)	Jammu & Kashmir	Early	-	White, flint
KDM438* (OPV)	-	SKUAS & T, Srinagar	2013	2187 (E)	Jammu & Kashmir	Early	-	White, flint
Bisco 97 Gold (Bisco New 704)	BS 240 X BSI 202)/BSI 264	Bisco Bio Sciences Pvt. Ltd.	2013	2187 (E)	Jammu & Kashmir, Himachal Pradesh, Uttarakhand and NE hills	Late	8000	Yellow, semi-dent and moderately resistant to MLB, TLB, BSDM, C. rust and tolerant to pests (stem borers)
KDMH017	KDMI 65 X KDMI 57	Krishidhan	2013	2187 (E)	Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, and Orissa,	Medium	8000	Orange-yellow, semi-flint
Bio 9544 (Bio 151)	By070-nm (BIOSEED KNPR-3/ BIO PCI001-nm (BIO PT963018)	Bioseed Research India Pvt. Ltd.	2013	2187 (E)	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, NE hills, Punjab, Haryana, Delhi, Uttar Pradesh, Bihar,	Medium	7300	Orange-yellow, semi- dent

Hybrid	Pedigree	Name of centre/ company	Year of release	Notification no.	Area of adaptation	Maturity	Yield (Kg/ ha)	Characteristics
					Jharkhand, Odisha, Andhra Pradesh, Tamil Nadu, Karnataka Maharashtra, Rajasthan, Gujarat, Madhya Pradesh and Chhatisgarh			
NMH 1242	NM-161 X NM-250	Nuziveedu Seeds Limited	2013	2187 (E)	Andhra Pradesh, Tamil Nadu, Karnataka Maharashtra, Rajasthan, Gujarat, Madhya Pradesh and Chhatisgarh	Medium	7300	Yellow, dent and moderately tolerant to MLB
S6217	TO254 X TO202	Syngenta India Pvt. Ltd.	2013	2187 (E)	Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Tamil Nadu, Karnataka Maharashtra, Rajasthan, Gujarat, Madhya Pradesh and Chhatisgarh	Medium	7600	Orange, semi flint and tolerant to MLB, TLB, PFSR and RDM
LG 32-81 (Yuvraj Gold)	AT 69 X AT 226	Bisco Bio Sciences Pvt. Ltd.	2013	2187 (E)	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, NE hills, Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Gujarat, Madhya Pradesh and Chhatisgarh	Medium	7400	Yellow, semi-dent and moderately resistant to MLB, TLB, BSDM, P. rust and C. rust and tolerant to pests (stem borers)
Bio 605	CZ170nm (Bioseed Pop B) X PC 1001nm (PT 963018)	Bioseed	2013	2187 (E)	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, NE hills, Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu	Early	5500	Orange- yellow, flint
Sun Vamman	SL 16 X SL 32	Suncrop Sciences Pvt. Ltd.	2013	2187 (E)	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, NE hills, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	Early	7600	Yellow with cap, semi flint and tolerant to MLB and TLB

Hybrid	Pedigree	Name of centre/ company	Year of release	Notification no.	Area of adaptation	Maturity	Yield (Kg/ ha)	Characteristics
NSCH-12 (Misthi)	NSCL-15 X NSCL-63	Nuziveedu Seeds Limited	2013	2187 (E)	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, NE hills, Punjab, Haryana, Delhi, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra	Medium	14944 (Green ear yield)	Yellow, shrunken and resistance to BSDM
Vivek Maize Hybrid 45 (FH 3483)	V373 X V390	VPKAS, Almora	2013	312 (E)	Uttarakhand, Himachal Pradesh and Jammu and Kashmir	Extra-early	5400	Yellow, semi-flint
MCH 42 (Hishell)	(D5681Z X H0148Z) X B 4070Z	Monsanto	2013	312(E)	Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	Medium	6000	Yellow, semi-flint

8b Annexure II

Maize Hybrids Identified

At the 56th Annual Maize Workshop held at DRR, Hyderabad, 5-7 April, 2013, a total of 25 hybrids were identified for release.

Hybrid	Maturity group	Area of Adaptation
Bisco New704	Late	Zone 1 (Jammu and Kashmir, Himachal Pradesh, Uttarakhand and North East Hills)
CMH08-287	Late	Zone 3 and 4 (Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra)
BH41009	Medium	Zone 3 and 5 (Uttar Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh)
Bio151	Medium	All Zones (1, 2, 3, 4 and 5)
Bisco2668	Medium	Zone 3 (Uttar Pradesh, Bihar, Jharkhand, Odisha)
CMH08-350	Medium	Zone 3 and 5 (Uttar Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh)
CMH08-292	Medium	Zones 2, 3, 4 and 5 (Punjab Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh)
CMH08-433	Medium	Zones 4 and 5 (Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra)
KDMH176	Medium	Zone 1 (Jammu and Kashmir, Himachal Pradesh, Uttarakhand and North East Hills)
NMH1242	Medium	Zone 4 and 5 (Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh)
S6217	Medium	Zones 2, 3, 4 and 5 (Punjab, Haryana, Delhi Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh)
Yuvaraj Gold	Medium	All Zones (1, 2, 3, 4 and 5)
VMH4106	Medium	Zone 3 (Uttar Pradesh, Bihar, Jharkhand and Odisha)
FH3515	Early	Zone 1, 4 and 5 (Jammu and Kashmir, Himachal Pradesh, Uttarakhand, North East Hills, Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh)
HKH317	Early	Zone 1 (Jammu and Kashmir, Himachal Pradesh, Uttarakhand and North East hills)
Sun Vamman	Early	Zone 1 and4 (Jammu and Kashmir, Himachal Pradesh, Uttarakhand, North East hills, Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka)
31Y45	Early	Zone 2, 3 and 5 (Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh)
X8 F984	Early	Zone 2 (Punjab, Haryana, Delhi and Uttar Pradesh)
KDMH755	Early	Zone 2 (Punjab, Haryana, Delhi and Uttar Pradesh)
REH2009-12	Early	Zone 3 (Uttar Pradesh Bihar, Jharkhand and Odisha)
X35A019	Rabi	Zone 2, 3, 4 and 5 (Punjab , Haryana , Delhi, Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh)
Pro379	Rabi	Zone 3, 4 and 5 (Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh)
MH QPM09-08	Late	Zone 3 (Uttar Pradesh, Bihar, Jharkhand and Odisha)
EHQ16	Medium	Zone 5 (Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh)
NSCH12	Medium	Zones 1, 2 and 4 (Jammu and Kashmir, Himachal Pradesh, Uttarakhand and North East hills, Punjab, Haryana, Delhi, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka)

8c Annexure III

Germplasm Registration

Four inbred lines registered at NBPGR as unique/useful germplasm

Inbred line	Centre	IC number	INGR number	Characteristics
MCM-11/01	NBPGR, Delhi	0524594	13054	Early maturing and 3-4 cobs per plant
DMRQPM102	DMR, Delhi		13074	Medium maturity, low ASI, high tryptophan, high protein and resistance to Madys leaf blight
DMRQPM103	DMR, Delhi	0594370	13023	Early maturity, low Anthesis- Silking interval, median ear placement, high tryptophan
E-63	WNC, Hyderabad	0594373	14014	Pink borer resistance

8d Annexure IV

Seed Production

Seeds of maize and regionally important crops like wheat, soybean and lentil were produced at Regional Maize Research & Seed Production Centre, Begusarai

Crop	Variety/Inbred line	Class of Seed	Quantity (kg)		
			Rabi	*Kharif*	Total
Maize	HKI193-1	Breeder	4304*	1508	5812
	HKI163	Breeder	3810*	1983	5793
	BML7	Breeder	478*	—	478
Soybean	PS1029	Foundation		4415*	4415
	PS1241	Foundation		12233.27*	12233.27
Wheat	HD2733	Foundation	16010*	—	16010
	PBW343	Foundation	16400*	—	16400
	PBW373	Foundation	9720*	—	9720
Lentil	Vaibhav	TFL	2946*		2946

* produced in *rabi* 2012-13 but sold in 2013

Breeder Seed Production

An indent of 6033 kg of maize breeder seed was indented for *kharif* 2013 production year. The indent included 3465 kg breeder seed of parental lines of 19 hybrid and 2568 kg of 15 composites. A total of 4587 kg of seed is produced during kharif 2013 and the rest produced during *rabi* 2013-14.

Centre	Inbred/Variety	DAC indent (kg)	Allocated (kg)	Actual Produced (kg)
VPKAS, Almora	Vivek Maize Hybrid 39 (V-373) (F)	3.0	3.0	3.0
	Vivek Maize Hybrid 39 (CM-212) (M)	1.0	1.0	4.0
	Vivek Maize Hybrid 33 (FH 3352) (V-372)(F)	4.0	4.0	10.0
	Vivek Maize Hybrid 33 (CM212)(M)	2.0	2.0	4.0
	Vivek QPM-9 (FQH 4567) (VQL1) (F)	3.0	3.0	190.0
	Vivek QPM-9 (VQL2) (M)	1.0	1.0	1.0
	Vivek Maize Hybrid-17 (FH-3186) (CM-153)(F)	150.0	150.0	175.0
	Vivek Maize Hybrid-17 (FH-3186) (CM-212)(M)	50.0	50.0	50.0
PAU, Ludhiana	PMH 4 (LM-5) (F)	42.0	42.0	100.0
	PMH 4 (LM-16) (M)	13.0	13.0	15.0
	PMH 5 (JH 3110) (LM16) (F)	42.0	42.0	45.0
	PHM 5 (LM18) (M)	13.0	13.0	15.0
	PMH 3 (JH 10704) (LM-17) (F)	42.0	42.0	80.0
	PMH 3 (JH 10704) (LM-14) (M)	13.0	13.0	2000.0
	Vijay Composite	10.0	10.0	20.0
CCSHAU, Karnal	HQPM 4 (HKI-193-2) (F)	450.0	450.0	0.0
	HQPM 4 (HKI-161) (M)	150.0	150.0	0.0

Centre	Inbred/Variety	DAC indent (kg)	Allocated (kg)	Actual Produced (kg)
	HM 10 (HKH-1200) (HKI 1128) (M)	120.0	120.0	0.0
	HM 10 (HKH-1200)(HKI 193-2)(F)	230.0	230.0	0.0
	HQPM 7 (HKI 161) (M)	120.0	120.0	0.0
	HQPM 7 (HKI 193-1) (F)	50.0	50.0	0.0
	HQPM 5 (HKI-163) (F)	430.0	430.0	0.0
	HQPM 5 (HKI-161) (M)	140.0	140.0	0.0
	HM 4 (HKI-1105) (F)	37.0	37.0	0.0
	HM 4 (HKI-323) (M)	13.0	13.0	0.0
	HM 8 (HKI-1105) (F)	15.0	15.0	0.0
	HM 8 (HKI-161) (M)	5.0	5.0	0.0
	HQPM 1 (HKI-193) (F)	415.0	415.0	0.0
	HQPM 1 (HKI-163) (M)	205.0	205.0	0.0
IARI, Delhi	Pusa Extra Early Hybrid Makka 5 (CM-150) F	104.0	104.0	0.0
	Pusa Extra Early Hybrid Makka 5 (CM-151)M	52.0	52.0	0.0
	Pusa Composite 3 (Composite-85134)	127.0	127.0	85.0
	Pusa Composite 4(Composite-8551)	30.0	30.0	145.0
MPUAT, Udaipur	Pratap Hybrid Maize 1 (EI-116) (F)	300.0	300.0	0.0
	Pratap Hybrid Maize 1 (EI-364) (M)	150.0	150.0	0.0
	PRATAP MAKKA 4 (EC-1108)	200.0	200.0	0.0
	PRATAP MAKKA 5 (EC-3116)	200.0	200.0	0.0
RAU, Dholi	Shaktiman 2 (CML-176) (M)	65.0	65.0	0.0
	Shaktiman 2 (CML-186) (F)	35.0	35.0	0.0
CSAUAT, Kanpur	Azad Kamal (R 9803)	20.0	20.0	0.0
GBPUAT, Pantnagar	AMAR (D-941)	20.0	20.0	200.0
	KANCHAN	17.0	17.0	200.0
	SONARI (SHWETA)	4.0	4.0	5.0
BAU, Ranchi	BIRSA MAKKAI-1	230.0	230.0	0.0
	BIRSA MAKKAI-2	200.0	200.0	0.0
Mandya, UAS Bangaluru	NAC 6004	110.0	110.0	0.0
Chindwara	JAWAHAR MAKAI-216 (JM-216)	1200.0	1200.0	1240.0
	JAWAHAR COMPOSITE MAKKA-12 (JM-12)	100.0	100.0	0.0
MPUAT,Banswara	Pratap Kanchan 2 WC-236(Y)	100.0	100.0	0.0

8e Annexure V

Varietal registration

DUS testing

During *kharif* 2013, 107 entries including 16 references were tested at two locations, namely DMR, New Delhi and SRTC, Hyderabad, respectively. In the hybrid trial, 54 entries *viz.*, 45 new hybrids, four OPVs and five farmers varieties (FV) were evaluated. In the inbred trial, 21 new inbred lines were evaluated. Nine hybrids and seven inbred lines were tested under Variety of Common Knowledge (VCK). 16 references including six hybrids, two OPVs and eight inbreds were used in DUS testing at two locations. The details of the 1st and 2nd year DUS testing are given below:

Hybrid DUS Trial 2013	Inbred DUS Trial 2013	Variety of Common Knowledge (VCK)
2nd year DUS Testing (completed) **Public-bred hybrids** namely DHM 117, HQPM4, PMH4, Vivek Maize Hybrid39 and Vivek Maize Hybrid 43 **Proprietary hybrids** namely MIM002, IG8011, IG 7806, BISCO 555 (BISCO UJALA), BISCO 4564, BISCO 731, BISCO 777, KMH3712, KMH2446, KMH7148, P3502, P3470, P3441, P 3785, P 3501, NSCH12, NMH1242, NIRMAL27, BIO 50265 H and IH8006 **OPVs** namely Vivek Sankul Makka 31, Jawahar Pop Corn 11 and Vivek Sankul Makka37 **1st year DUS Testing (completed)** **Public-bred hybrids** namely DHM 111, DHM 113, DHM 119, PMH 5 and Rajendra Hybrid Makka 3 **Proprietary hybrids** namely P3396, P1864, P3580, P3436, P3303, P3522, P3570, P3377, P3373, KMH25K45, KMH2589, NM734, INDRA17, BISCOX5141 and BISCO506 **OPV** namely Pant Sankul Makka 3 **Farmers Varieties** (FVs) namely Hacci Kukari, Ratti (Red Maize), Malan, Chitkanu and Sathi completed one year of grow out test at Delhi and Hyderabad, respectively.	**2nd year DUS Testing (completed)** **Proprietary inbreds** KML 5263, KML 5264, KML 112, KML 2276, KML 5015, KML 5080, KML 5004, KML 133, KML 5013, NM 161, NSCL 15, PHRRC, PHDMK, PH698 and PHM6T **1st year DUS Testing (completed)** **Proprietary inbreds** KML2286, KML2293, BIO101271, BYO70NM, M3434 and PC1001NM	**Hybrids** (proprietary) BIO 9544, BISCO NEW 704, BISCO SUPER PRINCE, 30R77, BCN402, P3540, BISCO2668, BISCO SURAJ 11 and BISCO 74 **Inbreds (proprietary**) namely KML5163, KML 2168, KML5165, KML2254, KML5277, M32 and NM 45 completed one year of DUS testing at two locations i.e. Delhi and Hyderabad.

Hybrids/varieties registered

Eight cultivars including seven hybrids and one OPV have been registered for protection under PPV&FR Act, 2001.The details are given below:

S.No.	Name	Centre	Period of protection (Years)
Normal Hybrids			
1.	HHM 1	CCSHAU, Karnal	January 31, 2013 to April 2, 2015
2.	Vivek Maize Hybrid 33	VPKAS Almora	February 06, 2013 to February 05, 2028
3.	PAU 352	PAU, Ludhiana	February 12, 2013 to February 11, 2028
4.	HM 10	CCSHAU Karnal	April 30, 2013 to April 29, 2028
5.	HM 8	CCSHAU Karnal	May 16, 2013 to May 15, 2028
Quality Protein Maize(QPM) Hybrid			
6.	Vivek QPM 9	VPKAS, Almora	January 17, 2013 to January 16, 2028
7.	HQPM 7	CCSHAU, Karnal	February 5, 2013 to February 4, 2028
Composites			
8.	Vivek Sankul Makka 11 (VCK)	VPKAS, Almora	January 17, 2013 to January 16, 2028

New applications filed

Six applications of hybrids/varieties of maize were filed at PPV&FR, Authority, New Delhi. The details are given below:

New Hybrids				
S.NO	Hybrids	Name of centre	Date of filing	Acknowledgement no.
1	Vivek Maize Hybrid 45	VPKAS, Almora	17.12.2013	REG/2013/1286
2	Pratap QPM Hybrid 1	MPUA&T Udaipur	18.11.2013	REG/2013/774
3	TNAU Maize Hybrid Co 6	TNAU Coimbatore	17.05.2013	REG/2013/302
Extant Hybrids				
4	EH 434042	UAS Dharwad	31.12.2013	REG/2013/1672
5	KMH 22168	MSASC, Kolhapur	23.05.2013	REG/2013/310
Extant Composites				
6	Pratap Makka Chari 6	MPUA&T Udaipur	23.05.2013	REG/2013/309

8f Annexure V

Human Resource Development

Trainings attended

Name	Programme	Venue	Date
International			
Dr KS Hooda	Marker Assisted Selection	Cornell University Ithaca, NY, USA	July 15 -October 12, 2013
National			
Dr Chikkappa G Karjagi	Managing IP under PVP and PGR	Directorate of Sorghum Research (DSR), ICAR, Hyderabad	May 15-24, 2013
Dr Ganapati Mukri	Advances in Statistical Genetics	IASRI, New Delhi	July 2-7, 2013
Dr Dharam Paul	Refresher Course on Agricultural Research Management	NAARM, Hyderabad	July 15-27, 2013
Dr Sunil Neelam	Management of Plant Genetic Resources	NBPGR, New Delhi	September 16-25, 2013
Dr KP Singh	Training for NAIP Consortium Strengthening Statistical Computing for NARS	IASRI, New Delhi	September 17-18, 2013
Dr Ashok Kumar Dr Ishwar Singh	Management Development Programme on Leadership Development (Pre-RMP Cadre)	NAARM, Hyderabad	November 26 - December 7, 2013.
Dr KS Hooda Dr KP Singh Dr Dharam Paul Dr Chikkappa G Karjagi	Implementation of Management Information System including Financial Management System in ICAR	ASRB online Centre, LBS Building, IARI, New Delhi	November, 27 – 28, 2013
Dr Nirupma Singh Dr Ambika Rajendran Ms Sapna Dr Avinash Singode	Implementation of Management Information System including Financial Management System in ICAR	ASRB online Centre, LBS Building, IARI, New Delhi	December 2-3, 2013
Dr Sunil Neelam	Plant Quarantine National Regulations & Procedures	NIPHM, Hyderabad	December 4-9, 2013
Dr Meena Shekhar Mr Yatish Mr Vishal Singh	Implementation of Management Information System including Financial Management System in ICAR	ASRB online Centre, LBS Building, IARI, New Delhi	December 6-7, 2013
Dr Avinash Singode	ERS solution and FMS and MIS training	IASRI, New Delhi	December 21-22, 2013
Dr Ramesh Kumar	Drought tolerance in Maize	CIMMYT-Asia, Hyderabad	January 21-Feburary 21, 2014
Dr Ishwar Singh	Performance Monitoring and evaluation System (PMES)/Result Framework Document (RFD), Institute of Secretariat Training and Management (Department of Personnel and Training, Govt. of India)	New Delhi	February 3-4, 2014

Participation in Conference/Seminar/Meeting/ Workshop

Name	Programme	Venue	Date
Dr Pranjal Yadava	Taking forward berbicide tolerant GM crops: opportunities and challenges	NASC Complex, New Delhi	May 2, 2013
Dr SL Jat	ADB Annual Meeting of the Board of Governors	Expo Centre and Mart (IECM), Greater Noida	May 2-5, 2013.
Dr Ramesh Kumar	Annual Review meeting of BMZ project	Udaipur	June 5-6,2013
Dr AK Singh Dr CM Parihar Dr SL Jat	Nutrient expert™ decision support tools for maize and wheat	NASC Complex, New Delhi	June 20, 2013
Dr Meena Shekhar	Review meeting on Status of Aflatoxin research and its implications on human and animal health and food and feed processing	NASC, New Delhi	August 12, 2013
Dr P Kumar DrVinay Mahajan Dr Meena Shekhar Dr A K Singh Dr Ishwar Singh Dr Ashok Kumar Dr K P Singh Dr Nirupma Singh Dr CM Parihar Dr Chikkappa GK Dr S L Jat Dr Pranjal Yadava	International Conference 'Commemorating 50 Years since Borlaug's Visit to South Asia: A Retrospective and Perspective of the Green Revolution' organized by CIMMYT-BISA-ICAR	NASC Complex, New Delhi	August 16-17, 2013
Dr SL Jat	Conservation Agriculture for the key scientist involved in the ICAR-CRP on CA planned	IARI, DMR, CSSRI, DWR, PAU, DWSR, ICAR RC for ER, IARI Regional station, Pusa and BISA locations	September 16-25, 2013
Dr P Kumar	South Asia Biosafety Conference	Vivanta by Taj Ambassasor, New Delhi	September 18-20, 2013
Dr P Kumar Dr V Mahajan Dr KS Hooda Dr AK Singh	Maintaining cereal productivity under climate change through international collaboration	NASC Complex, New Delhi	November 18-20, 2013
Dr P Lakshmi Soujanya	4th International conference on Biopesticides (BIOCICON), 2013	St. Xaviers College, Palayam Kottai, Tirunelveli, Tamil Nadu	November 28 -30, 2013
Dr CM Parihar	FAI Annual Seminar 2013 on Fertiliser Sector at Crossroads	The Ashok, New Delhi	December 11-13, 2013
Dr VK Yadav	Krishi ki Aadhunik Praudyogiki ki Uplabdhiyan awan chunautiyan	CIFE, Mumbai	December 14-16, 2013
Dr P Kumar	Problem Formulation for Indentifying Protection Goals Relevant to ERA of GE Plants in India	NASC Complex, New Delhi	December 19-20, 2013
Dr SL Jat	India Innovation Growth Programme 2014	FICCI Federation House, New Delhi	January 21, 2014
Dr Ishwar Singh	Performance Monitoring and evaluation System (PMES)/Result Framework Document (RFD), Institute of Secretariat Training and Management (Department of Personnel and Training, Govt. of India)	New Delhi	February 3-4, 2014
Dr Ramesh Kumar	Annual Review meeting of BMZ project	Udaipur	February 11-12, 2014
Dr Vinay Mahajan	Diversification led Agricultural Transformation toward Greener Economy"	NBPGR, New Delhi.	February 14- 15, 2014
Dr VK Yadav	Abiotic stress tolerant maize for food and income security among the poor in South and South-East Asia	ICRISAT, Hyderabad	February 17-18, 2014
Dr Meena Shekhar	Meeting on "Mapping Aflatoxin Contaminated Maize in Food and Feed Chain: Implications for Food Safety"	NASC, New Delhi	March 15, 2014

8g Annexure VII

Training conducted to disseminate technology

Training	Date	Venue
Maize production systems for improving resource use efficiency and livelihood security	September 2-9, 2013	Directorate of Maize Research, Pusa Campus, New Delhi
Single Cross Maize Hybrid Seed Production	February 22, 2014	Village Pasraha
	March 25, 2014	Distt-Khagariya, Bihar
	February 27, 2014	RMR&SPC Farm Kushmahut, Begusarai, Bihar Village Gara Distt Vaishali, Bihar
DUS testing in Maize	September 22, 2013	NRCPB, Auditorium, Pusa Campus, New Delhi
Farmers National Level Training Programme		
Seed Production, Cultivation and Value Addition in Maize	February 26-28, 2014	DMR, Pusa Campus, New Delhi
Seed Production, Cultivation and Value Addition in Maize	March 5-7, 2014	DMR, Pusa Campus, New Delhi
Seed Production, Cultivation and Value Addition in Maize	March 10-12, 2014	DMR, Pusa Campus, New Delhi
Seed Production, Cultivation and Value Addition in Maize	March 21-23, 2014	DMR, Pusa Campus, New Delhi
Seed Production, Cultivation and Value Addition in Maize	March 25-27, 2014	DMR, Pusa Campus, New Delhi
Seed Production, Cultivation and Value Addition in Maize	March 29 -31, 2014	DMR, Pusa Campus, New Delhi
Makka ki Vaigyanik Kheti, Sankar Beej Utpadan evam Moolya Samvardhan	March 24-26, 2014	RMR & SPC Begusarai, Bihar
Regional Level Training Programmes		
Makka ki Vaigyanik Kheti Va Sankar Beej Utpadan	March 22, 2014	Village Pandet Theeka, Distt Jamui, Bihar
	March 28, 2014	Village Maira , Distt-Katihar, Bihar
Kharif Maize Production	September 13, 2013	RMD CARS Ambikapur
Kharif Maize Production	June 27, 2013	KVK Garwah, Jharkhand
Kharif Maize Production	June 29, 2013	KVK, Hazaribag, Jharkhand
Rabi Maize Production	November 13, 2013	Ranideh, Jamtara, Jharkhand
Seed Production, Cultivation and Value Addition in Maize	February 7, 2014	Amarwada, Chhindwara, MP
Farmers Training cum- Field Day	September 17, 2013	RMR & SPC, Begusarai, Bihar
Hybrid maize seed production	April 30, 2013	RMR & SPC, Begusarai, Bihar
Training programme for women farmers on scientific cultivation of QPM maize	November 21, 2013	Village Rajapakar, Distt. Vaishali
Scientific cultivation of single cross maize hybrids	November 25, 2013	Village Qvota Patti, Distt-Saupol
Promotion of maize production technology	September 20, 2013	Nedunuru village, Kandukuru mandal, District Ranga Reddy, Andhra Pradesh
Field day	September 30, 2013	Village Sagwara, district Dungarpur, Rajasthan

8h Annexure VIII

Lecture Delivered

Scientist	Topic	Purpose	Venue	Date
Dr Bhupender Kumar	Development of hybrids for different ecosystem of maize	Directorate of Extension, Ministry of Agriculture Sponsored model training course on "Maize production systems for improving resource use efficiency and livelihood security	DMR, New Delhi	September, 2, 2013
Dr DP Chaudhary	Production and Preservation of fodder for dairying	Maize production systems for improving resource use efficiency and livelihood security	DMR, Delhi	September 2 - 9, 2013
Dr Ishwar Singh	Abiotic Stresses and their Management in Maize	DAC, Ministry of Agriculture, sponsored Model Training Course on 'Maize Production systems for improving use efficiency and livelihood security'	DMR, New Delhi	September 2-9, 2013
Dr Meena Shekhar	Integrated Disease Management	Maize production systems for improving resource use efficiency and livelihood security	DMR, Delhi	September 2 - 9, 2013
Dr Pranjal Yadava	Prospects of genetic engineering in maize improvement and the role of state department of agriculture	Maize production systems for improving use efficiency and livelihood security	Directorate of Maize Research, New Delhi	September 2-9, 2013
Ms Sapna	Maize Qualitative Dynamics for Enhanced Livelihood Security	Maize Production systems for improving resource-use efficiency and livelihood security	Directorate of Maize Research, New Delhi	September 2 - 9, 2013
Dr Vinay Mahajan	Seed Production of Single Cross Hybrids of Maize	Model Training Course on Maize production system for improving resource use efficiency and livelihood security	DMR, New Delhi	September, 2-9, 2013
Dr AK Singh	Nutrient and water management in maize based cropping systems	Directorate of Extension, Ministry of Agriculture sponsored model training course on "Maize production systems for improving resource use efficiency and livelihood security"	DMR, New Delhi	September 3, 2013
Dr Sunil Neelam	PGR Management under	Climate Change Regime- Implications and ResponseAgroforestry as a strategy for adaptation and mitigation of climate change in rainfed areas	CRIDA, Hyderabad	September 4-24, 2013
Dr AK Singh	Site specific nutrient management in maize based cropping systems	Directorate of Extension, Ministry of Agriculture sponsored model training course on "Maize production systems for improving resource use efficiency and livelihood security"	DMR, New Delhi	September 4, 2013
Dr CM Parihar	Resource conservation techniques for higher resource use efficiency	Directorate of Extension, MoA sponsored model training course on "Maize production systems for improving resource use efficiency and livelihood security"	DMR, New Delhi	September 5, 2013
Dr SL Jat	Management on non-monetary inputs in maize for improving resource-use efficiency	Directorate of Extension, Ministry of Agriculture sponsored model training course on "Maize production systems for improving resource use efficiency and livelihood security"	DMR, New Delhi	September 6, 2013

Scientist	Topic	Purpose	Venue	Date
Dr CM Parihar	Mechanization in maize production systems- practical	Directorate of Extension, MoA sponsored model training course on "Maize production systems for improving resource use efficiency and livelihood security"	DMR, New Delhi	September 7, 2013
Dr Ashok Kumar	Boron : Boon or Bane for sustainable agriculture	International faculty Training to Afghan Nationals on 'Teaching of Post Graduates Courses in Agronomy"	Division of Agronomy, IARI, New Delhi	September 13, 2013
Dr CM Parihar	Conservation agriculture in maize systems for higher productivity, sustainable soil and environmental health	Directorate of Extension, MoA sponsored model training course on "Environmental Resources Management for Sustainable Agriculture	CESCRA, IARI, New Delhi	October 26, 2013
Dr CM Parihar	Root Image Analysis Exercise	CIMMYT sponsored advance Course-Asia on "Conservation Agriculture: Gateway for Productive and Sustainable Cropping Systems"	CA platform, Karnal, Haryana	October 29, 2013
Dr KP Singh	कार्वन नैनोट्यूब एवं कृषि में इसके जैव संवेदन अनुप्रयोग	National Conference on Biomedical Science and Technology	National Physical laboratory, New Delhi	November 21-22, 2013
Dr Pranjal Yadava	RNAi technology as biocontrol	3rd National Conference on Agri-biotechnology.	The Taj West End, Bengaluru	December 10-11, 2013
Dr SL Jat	Production technologies for baby corn	International Faculty Training to Afghanistan on "Teaching of Post-Graduate Courses in Agronomy"	Division of Agronomy, IARI, New Delhi	December 11, 2013
Dr CM Parihar	Management of water stress in rainfed farming for higher productivity	International Faculty Training to Afghanistan on "Teaching of Post-Graduate Courses in Agronomy"	Division of Agronomy, IARI, New Delhi	January 15, 2014
Dr SL Jat	Agronomic practices for cultivation of groundnut	International Faculty Training to Afghanistan on "Teaching of Post-Graduate Courses in Agronomy"	Division of Agronomy, IARI, New Delhi	January 15, 2014
Dr CM Parihar	Taxonomy and classification of maize crop	International Faculty Training to Afghanistan on "Teaching of Post-Graduate Courses in Agronomy"	Division of Agronomy, IARI, New Delhi	January 16, 2014
Dr SL Jat	Agronomic practices for cultivation of maize crop	International Faculty Training to Afghanistan on "Teaching of Post-Graduate Courses in Agronomy"	Division of Agronomy, IARI, New Delhi	January 16, 2014
Dr Vinay Mahajan	Suitable varieties for different tribal areas (M.P.), Rajasthan, Jharkhand, J&K)		DMR, New Delhi	February 26, 2014

Scientist	Topic	Purpose	Venue	Date
Dr Ashok Kumar	Maize production technology including specialty corn	National level training programme on "Seed production, cultivation and value addition of maize" for tribal farmers under Tribal Sub Plan of ICAR.	DMR, New Delhi	February 27, 2014
Dr AK Singh	Baby corn and Sweet corn for sustainability and way forward	Seminar-cum-awareness programme on "Processing of baby corn, sweet corn and mushroom"	NIFTEM Campus, Sonepat, Haryana	March 1, 2014
Dr SL Jat	Maize production technology including specialty corn	National level training programme on "Seed production, cultivation and value addition of maize" for tribal farmers under Tribal Sub Plan of ICAR.	DMR, New Delhi	March 05, 10, 21 and 29, 2014
Dr CM Parihar	Maize production technology including specialty corn	National level training programme on "Seed production, cultivation and value addition of maize" for tribal farmers under Tribal Sub Plan of ICAR.	DMR, New Delhi	March 25, 2014

8i Annexure IX

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8j Annexure X

On-going projects

Projects	Principal Investigator	Co- Principal Investigator	Duration
Plant Breeding and Genetics			
Development of normal and quality protein maize hybrids for winter season.	SB Singh	Jyoti Kaul GK Chikkappa Nirupma Singh Bhupender Kumar Pradyumn Kumar KS Hooda Dharam Paul	May 2011 to April 2016
Germplasm development and enhancement for cold tolerance in maize	Nirupma Singh	Ambika Rajandren Avinash Singode Ramesh Kumar JC Sekhar Ishwar Singh Meena Shekhar	July 2011to June 2016
Breeding for Drought Tolerance in Maize	Ramesh Kumar	GK Chikkappa Vinay Mahajan Ishwar Singh SL Jat Ganpati Mukri Yathish K.R.	April 2011 to March 2016
Genetic enhancement of medium duration normal maize germ plasm	Chikkappa G Karjagi	JC Sekhar KS Hooda Bhupender Kumar Ganapati Mukri CM Parihar G Ramesh Abhijeet Dass	June 2011 to May 2016
Genetic enhancement of early maturing maize	Vinay Mahajan	Avinash Singode R Amibika Rajendran Meena Shekhar JC Sekher Ashok Kumar	April 2012 to March 2017
Development and enhancement of Quality Protein Maize Germ plasm	Jyoti Kaul	Ramesh Kumar Dharam Paul KS Hooda	May 2012 to April 2017
Genetic Enhancement of Late duration Normal Maize Germ plasm	Bhupender Kumar	JCSekhar KS Hooda GK Chikkappa Vishal Singh CM Parihar Ramesh Kumar Abhijeet Dass	June 2012 to May 2017

Projects	Principal Investigator	Co- Principal Investigator	Duration
Genetic Enhancement of White Maize Germ plasm	Ganapati Mukri	Ambika Rajandren Bhupender Kumar KS Hooda CG Karjagi Vishal Singh SL Jat Abhijit Kumar Das	June 2012 to May 2017
Genetic enhancement for provitamin – A in maize	Abhijit Kr. Das	Bhupender Kumar CG Karjagi Ganapati Mukri Yatish K Avinash Singode Sapna Vishal Singh Pranjal Yadava	Oct. 2012 to Oct. 2017
Genetic enhancement and development of high oil and baby corn traits in maize	Ambika Rajendran	Nirupma Singh Vinay Mahajan Dharam Paul Ganapati Mukri Meena Shekhar Lakshmi Saujanya	Nov. 2012 to Dec. 2016
Germplasm Enhancement of Maize for High Starch and Methionine Content	Vishal Singh	Sapna Bhupender Kumar Yatish KR Abhijit Kr. Das Ganpati Mukari Chikkappa G Karjagi	June 2012 to May 2017
Plant Pathology			
Identification of stable sources of resistance to major diseases of maize.	KS Hooda	R Sai Kumar# Sangit Kumar## Meena Shekhar JC Sekhar Jyoti Kaul Avinash Singode GK Chikkappa	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 against Post Flowering Stalk Rots of maize	Meena Shekhar	KS Hooda Nirupma Singh Dharam Paul	Jan. 2013 to Dec.2018
Entomology			
Study on biochemical basis of resistance against major pests of maize	Suby SB*/P.Kumar from 5.8.11	P Kumar Dharam Paul JC Sekhar Aditi Kundu	April 2010 to March 2015
Biological control of maize pests	P Lakshmi Soujanya	P Kumar JC Sekhar	June 2011 to April 2016

Projects	Principal Investigator	Co- Principal Investigator	Duration
Identification of Multiple Borer Resistant Genotypes in Maize	JC Sekhar	P Kumar P Lakshmi Soujanya CG Karjagi	June 2012 to May 2017
Management of Sitophilus oryzae (L) and Sitotroga cerealella (Oliv) infesting stored maize through Host Plant resistance and Plant origin pesticides"	P Lakshmi Soujanya	P Kumar JC Sekhar Dharam Paul CG Karjagi Suby SB	June 2012 to April 2017
Agronomy			
Evaluating conservation tillage practices for Improving resources use efficiency in maize based cropping system	CM Parihar	P Kumar Sangit Kumar SL Jat AK Singh Chikkappa GK	July 2008 to June 2013
Diversified maize based cropping system for higher productivity and sustained soil health	Ashok Kumar	AK Singh Ishwar Singh Dharam Paul CM Prihar SL Jat GK Chikkappa	July 2011 to June 2016
Site specific nutrient management in maize based cropping system	Aditya Kumar Singh	SL Jat CM Parihar Ashok Kumar	June 2012 to June 2017
Nitrogen Management under Conservation Agriculture in Maize Based Cropping System	SL Jat	AK Singh CM Parihar Ashok Kumar	June 2012 to June 2017
Biochemistry			
Biochemical Characterization of Normal and Speciality Corn Germplasm	Dharam Paul	Jyoti Kaul Ramesh Kumar Bhupinder Kumar Ms Sapna	April 2012 to March 2017
Social Science			
Strengthening and Refinement of Maize AGRIdaksh	Virendra Kumar Yadava	KP Singh KS Hooda Jyoti Kaul Avinash Singode Chikkappa G Karjagi SLJat R Ambika Rajendran	April 2011to March 2016
Data mining and management of data generated through AICRP on maize	K P Singh	Vinay Mahajan Bhupender Kumar Chikkappa G.Karjagi Meena Shekhar CM Parihar P Kumar Dharam Paul	April 2012 to March 2017

Projects	Principal Investigator	Co- Principal Investigator	Duration
Biotechnology			
Cloning and characterization of abiotic stress regulated genetic elements from maize	Pranjal Yadava	Ishwar Singh P Kumar Avinash Singode	Sept. 2012 to Sept. 2017
Completed Project			
Pathology			
Post harvest management of losses due to microbial colonization in stored maize grains.	Sangit Kumar	Meena Shekhar KS Hooda	June 2008 to May 2013
Entomology			
Management of maize insect pests	Pradyumn Kumar	R Sai Kumar # JC Sekhar	Jan. 2008 to Dec. 2013
Physiology			
Identification, characterization and utilization of source of tolerance to drought and high temperature stress in maize	Ishwar Singh	ML Jat	April 2008 to March 2013

\# Upto 2012
\#\# Upto 2013

Externally Funded Projects

Projects	In collaboration with	Principal Investigator	Duration
Strengthening of DUS centres for implementation of PVP legislation	PPV&FRA	Dr Jyoti Kaul	2004 to continue
Mega seed project	DSR/ICAR	Dr S B Singh	2007 to continue
Abiotic stress tolerant maize for increasing income and food security in South East Asia	ICAR-CIMMYT/BMZ	Dr O P Yadav	May 2011 to April 2014
Development of Maize Transgenic for Stem Borer Resistance	ICAR- Network Project	Dr P Kumar	April 2012 to March 2017
Functional genomics of drought tolerance in maize	ICAR- Network Project	Dr Ishwar Singh	April 2012 to March 2017
Baseline – susceptibility of multiple populations of *Chilo partellus, Sesamia inferens* and *Helicoverpa aringera* for two Bt insecticidal proteins	Syngenta Bio-sciences India. Pvt. Ltd.	Dr P Kumar	January 2013 to December 2014
Special Test in Maize	PPV&FRA	Dr Jyoti Kaul	2013 to continue

8k Annexure XI

Financial Statement

Sanctioned Budget (Rupees in Lakhs)					2013-2014 Expenditure (Rupees in Lakhs)				
Head of Account	Plan	Non- Plan	AICRP on Maize	Total	Head of Account	Plan	Non- Plan	AICRP on Maize	Total
Establishment	-	438.0	1102.44	1540.44	Establishment	-	438.00	1102.44	1540.44
OTA	-	0.50	-	0.5	OTA	-	0.42	-	0.42
TA	11.30	4.00	24.00	39.3	TA	11.3	3.97	24.0	39.27
Rec. Conti.	278.70	252.0	158.56	689.26	Rec. Conti.	278.70	251.56	158.56	688.82
Minor Works	-	-	-	-	Minor Works	-	-	-	-
Equipment	-	17.00	-	17	Equipment	-	15.02	-	15.02
TSP/ HRD	35.0	-	25.00	65.0	TSP/ HRD	20.42	-	25.00	51.08
	5.0					5.66			
Total	330.0	711.50	1310.0	2351.5	Total	316.08	708.97	1310.00	2335.05

Resource Generation	
Particulars	(in Lakh)
Sale of farm produce	42.68
Sale of publications and tender form	-
Standard license fee	0.88
Analytical and testing fee	18.60
Receipts from services rendered	0.04
Interest earned on short tem deposits	3.70
Income generated from IRG	0.35
Training miscellaneous receipts	11.32
Total	77.57

Funds received for externally funded Projects	
Particulars	(in Lakh)
FLD	95.00
DUS Testing	19.40
Transgenic Project	17.34
IPR	5.60
Total	137.34

81 Annexure XII

Appointments/Promotions/Transfers/Retirements

Appointments

Name	Post	Date & Place of Joining
Dr N Sunil	Sr. Scientist	June 17, 2013 Winter Nursery Centre, Hyderabad

Promotions

Name	Promoted Post
Mr Samir Kumar Rai	T-3
Mr Rahul	T-3
Mr Kamal Vats	T-3
Mr Ajay Kumar Singh	T-2
Mr Raj Kishor Singh	T-2

Transfers

Name	Transferred from	Date of joining	Transferred to
Dr Chikkappa G Karjagi	Winter Nursery Centre, Hyderabad	August 8, 2013	DMR New Delhi
Dr Diwakar Bahukhandi	IGFRI, Jhansi	November 25, 2013	DMR New Delhi
Dr Avinash Singode	DMR, Pusa Campus, New Delhi	February 5, 2014	DMR Unit, PAU Campus Ludhiana (Punjab)
Dr Dharam Paul	DMR, Pusa Campus, New Delhi	February 12, 2014	DMR Unit, PAU Campus Ludhiana (Punjab)
Dr Ramesh Kumar	DMR, Pusa Campus, New Delhi	March 3, 2014	DMR Unit, PAU Campus Ludhiana (Punjab)

Superannuation

Dr Sangit Kumar superannuated on October 31, 2013 after serving as Principal Investigator of Plant Pathology for a period of eleven years. He began his career as a Scientist S-1 in the Division of Plant Pathology, ICAR Complex for NEH Region Shillong in 1977. He made several contributions and accomplished outstanding research work on various crops. In DMR, he took responsibilities of coordination of pathological trials in various centres of AICRP maize in the country. He also contributed to post harvest management in maize, pyramiding of gene for improving resistance for disease Turcicum Leaf Blight and Polysora rust. His coordinated approach and positive working environment enriched DMR.

8m Annexure XIII

Important committees

Research Advisory Committee (RAC)

1.	Dr BS Dhillon	Vice Chancellor, Punjab Agricultural University	Chairman
2.	Dr VP Ahuja	Principal Scientist (Retd.) & Eminent Plant Breeder, IARI	Member
3.	Dr V Satanarayana	Retd. Professor (Agronomy)	Member
4.	Prof HS Shetty	Professor Emeritus	Member
5.	Dr DN Yadav	Ex-Professor & Head (Entomology)	Member
6.	Prof Amar Kumar	Department of Botany	Member
7.	Dr Sain Dass	Ex-Project Director, DMR	Member
8.	Dr OP Yadav	Project Director, DMR	Member
9.	Dr RP Dua	ADG (FFC), ICAR	Member
10.	Dr KS Hooda	Principal Scientist	Member Secretary

Institute Research Council (IRC)

Director of the Institute	Chairman	Dr OP Yadav
Joint Director / Incharge	Member	Dr KS Hooda, Principal Scientist
Head of Division / Section	Member	All PI/ Section I/c are Members
All PI of the Project	Member	All PI/ Section I/c are Members
All Scientist working in the Directorate	Member	All Scientists
ADG(FFC)	Member	ADG (FFC)
Scientists In-charge of RM Unit of the Institute	Member Secretary	Dr P Kumar

Institute Management Committee (IMC)

The Joint Director (Agri.), Govt. of NCT of Delhi
The Director (Agri.), Govt. of Haryana
The Joint Director (Ext.), IARI
Dr P Kumar, Pr. Scientist, DMR
Dr Pratibha Sharma, Pr. Scientist (Pl. Patho.), IARI
Dr S Vennila, Pr. Scientist, NCIPM
Dr TR Sharma, Pr. Scientist, NRCPB
The ADG (FFC), ICAR
Shri Mohan Singh, F & AO, NRCPB

Prioritization Monitoring and Evaluation (PME) Cell

Dr P Kumar	Incharge, PME Cell
Dr KS Hooda	Member
Dr Ishwar Singh	Member, RFD Nodal Officer
Dr AK Singh	Member
Dr KP Singh	Member
Dr R Ambika Rajendran	Member
Dr Shankar Lal Jat	Member

Institute Technology Management Committee (ITMC)

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

Institutional Biosafety Committee (IBSC)

Dr OP Yadav	Director	Chairman
Dr Pradyumn Kumar	Principal Scientist	Member Secretary
Dr Jyoti Kaul	Principal Scientist	Member
Dr Pranjal Yadava	Scientist	Member
Dr CM Parihar	Scientist	Member
Dr S Vennila	Principal Scientist	Member
Dr Anita Srivastava	Medical Officer In-charge	Member
Prof. Amar Kumar	Professor	Member

Institute Germplasm Identification Committee (IGIC)

Dr OP Yadav	Project Director	Chairman
Dr P Kumar	Principal Scientist	Nodal Officer
Dr KS Hooda	Principal Scientist	Member
Dr Dharam Paul	Senior Scientist	Member
Dr Jyoti Kaul	Principal Scientist	Member Secretary

Institute's Result Framework Document (RFD) Committee

Dr Ishwar Singh	Nodal Officer
Dr Shankar Lal Jat	Co-Nodal Officer
Dr AK Singh	Accounts Officer (Act.)
Dr Dharam Paul	Member
Mr Abhijit Kumar Das	Member
Mr AK Mathur, A.O.	Member

Purchase Advisory Committee

Dr Ishwar Singh	Chairman
Dr Ashok Kumar	Member
Dr AK Singh	I/c Audit
Dr Meena Shekhar	Member
Dr Dharam Paul	Member
Mr AK Mathur	Member Secretary

Annual Report Editorial Committee

Dr Meena Shekhar	Principal Scientist
Dr Nirupma Singh	Scientist
Dr R Ambika Rajendran	Scientist
Dr Chikkappa G Karjagi	Scientist
Dr Pranjal Yadava	Scientist

Contractual Services Advisory Committee

Dr KS Hooda	Chairman
Dr Ashok Kumar	Member
Dr CM Parihar	Member
Dr Bhupender Kumar	Member
Ms Sapna	Member
Mr AK Mathur, A.O.	Member Secretary

Committee of Data Digitization for implementation of MIS/FMS Solution at the Institute

Dr P Kumar	Chairman /Nodal Officer	PME
Dr AK Singh	Member	Finance
Dr Ashok Kumar	Member	Supply Chain Management (Procurement & Store)
Dr KP Singh	Member	Human Resources
Mr AK Mathur, A.O.	Member Secretary	Administration

8n Annexure XIV

Personnel

Name	Designation	Discipline
Dr OP Yadav	Project Director	Plant Breeding
Dr Sangit Kumar	Principal Scientist	Plant Pathology (up to October 31, 2013)
Dr P Kumar	Principal Scientist	Entomology
Dr Vinay Mahajan	Principal Scientist	Plant Breeding
Dr Jyoti Kaul	Principal Scientist	Plant Breeding
Dr KS 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 ML Jat *	Senior Scientist	Agronomy
Dr VK Yadav	Senior Scientist	Agricultural Extension
Dr Diwakar Bahukhandi	Senior Scientist	Plant Pathology
Dr KP Singh	Scientist (SG)	Computer Application
Dr Nirupma Singh	Scientist	Plant Breeding
Dr CM 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
Mr Vishal Singh	Scientist	Plant Breeding
Mr Yathish K.R.	Scientist	Genetics
Dr Ganapati Mukri	Scientist	Plant Breeding
Mr Abhijit Kumar Das	Scientist	Genetics
Dr Pranjal Yadav	Scientist	Agricultural Biotechnology

Administrative staff

Name	Designation	Discipline
Mr Atul Kumar Mathur	AO	
Mrs Seema Khatter	PA	
Mrs Kamlesh Malik	Assistant	
Ms Chinkey Aggarwal	Assistant	
Mr Dharambir Singh	Sr. Clerk	
Mr Ajay Kumar Singh	T-2	
Mr Raj Kishor Singh	T-2	
Mr Amar Nath	SSS	
Mr Anwar Ali	SSS	
Mr Ram Kishan	SSS	

Winter Nursery Centre, Hyderabad

Name	Designation	Discipline
Dr JC Sekhar	Principal Scientist	Entomology
Dr N Sunil	Senior Scientist	Genetics & Plant Breeding
Dr PL Soujanya	Scientist	Entomology

Regional Maize Research and Seed Production Centre, Kushmahout Farm, Begusarai (Bihar)

Name	Designation	Discipline
Dr SB Singh	Principal Scientist	Plant Breeding
Mr Samir Kumar Rai	T-3	
Mr Rahul	T-3	
Mr Kamal Vats	T-3	

Directorate of Maize Research Unit, PAU Campus, Ludhiana (Punjab)

Name	Designation	Discipline
Dr Dharam Paul	Senior Scientist	Biochemistry
Dr Ramesh Kumar	Senior Scientist	Plant Breeding
Dr Avinash Singode	Scientist	Plant Breeding
* On Deputaion;	** Study Leave	

भाकृअनुप
ICAR

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