Annual Report
2012-13

DIRECTORATE OF MAIZE RESEARCH
(*Indian Council of Agricultural Research*)
Pusa Campus, New Delhi-110 012

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Front Cover : Conventional method of drying of maize cobs at Ambikapur (Chhattisgarh)

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Preface

Maize is potentially highest yielder among cereals and has myriad of uses in food, feed and industrial segment. The demand for maize will rise in coming times. The projected growth rates suggest that maize demand is expected to increase from current level of 22 mt to 45 mt by 2030. The sudden demand for industrial use of maize for bio-fuel production has created an additional demand for maize in the coming decades. Maize is truly a forward looking crop especially in the context of climate change. Being C_4 plant, maize can assimilate more CO_2 than C_3 plants. It can also become a driving force for crop diversification. Quality Protein Maize (QPM) has a potential role to play in achieving nutritional security of the people. The cost of production of protein through QPM is much lesser than any other source.

Maize research is a highly competitive area. Many international organizations and multinational corporations are investing heavily in maize research, as it allows maximum 'value capture' due to prevalence of hybrids. Globally, there is enhanced application of genetic engineering in developing new traits. From among various food crops, maize is having the highest number of distinct transgenic 'events'. With the advent of genomics research, the pace of which has accelerated greatly since 2009 when complete maize genome was cracked, maize breeders in most advanced laboratories are now routinely using whole genome selections in the breeding schemes for rapid genetic gain. The Directorate needs to transform itself to become a centre of excellence in maize research to lay a greater emphasis on harnessing science through basic research. Unravelling biological mechanisms of plant development and adaptation, germplasm prospecting for discovering novel genes, marker-assisted selection in breeding schemes and trait engineering by transgenic technologies could be the major themes directed for genetic enhancement of maize.

In recent times, the rising incomes have led to an increased consumption of meat, particularly of poultry. This has increased the demand of maize for feed and industrial utilization in India and neighborhood. India has been exporting, on an average, 15% of its maize produce during last five years.

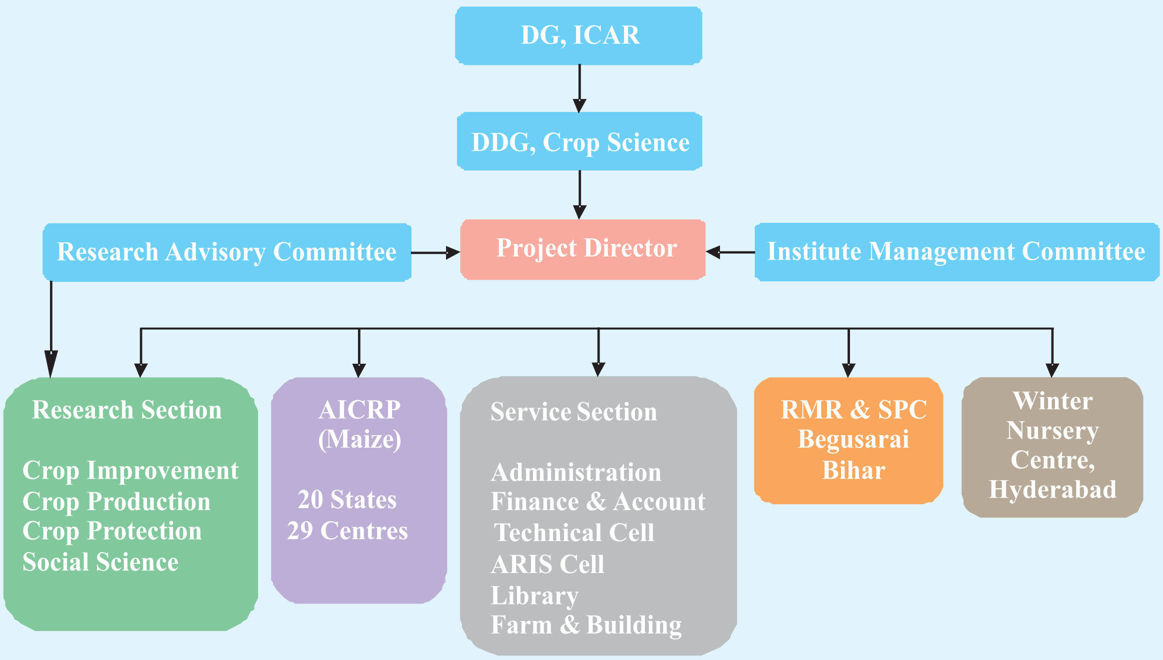
The Directorate of Maize Research (DMR) has continued to focus its attention on increasing productivity and production of maize in a sustainable manner. In order to meet the national challenge of achieving higher production and nutritional security for an ever increasing population, accelerating productivity and growth rate of maize is need of hour. The Directorate has shown success in multi-locational evaluation of agricultural technologies through effective inter-disciplinary approach. Our current priorities include mobilization of germplasm resources and free exchange of research data among research workers, review of experimental data, advancing of breeding materials in Winter Nursery at Hyderabad and breeder seed production at Regional Maize Research and Seed Production Centre at Begusarai. The effective monitoring of field trials and strong in-house research on applied, strategic and basic aspects on improved production technologies including management of abiotic and biotic stresses are major focus areas of the Directorate.

Cultivation of maize is expanding in new non-traditional areas and is being cultivated throughout the year. This has necessitated the greater need of germplasm development and diversification in order to cater to the need of diverse agro-ecologies of different regions by delivering superior high-yielding single-cross hybrids to farmers across the country as greater adoption of single cross hybrids has helped in increasing production and productivity of maize. During 2012-13, 19 hybrids of maize were notified for general cultivation in different parts of the country. A total of 9900 kg of breeder seed was indented through Department of Agriculture and Co-operation, Ministry of Agriculture and 11855 kg of seed was produced. Research on crop diversification, intercropping and resource conservation technologies was also taken to improve the farm profitability in maize-based cropping systems.

(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 located at New Delhi to increase the production and productivity of maize in the country ■ Directorate of Maize Research 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 critically evaluated by the Quinquiennial Review Team ■ Based on agro climatic conditions, country has been demarcated into five zones constituting 29 centres for varietal testing ■ Winter Nursery Centre, Hyderabad and Regional Research Maize Production Centre, Begusarai caters significantly the off-season and seed production requirements of DMR.



DG, ICAR
DDG, Crop Science
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Crop Production
Crop Protection
Social Science
AICRP
(Maize)
20 States
29 Centres
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Finance & Account
Technical Cell
ARIS Cell
Library
Farm & Building
RMR & SPC
Begusarai
Bihar
Winter
Nursery
Centre,
Hyderabad

Executive Summary

Maize is an emerging cereal crop with highest genetic yield potential and wide adaptability under varied agro-climatic conditions. With the increase in industrial requirements and value-added foods for a growing economy and population, maize would continue to hold its share as a significant crop. Globally, India ranks 4th in area and 7th in production of maize. The area, production and productivity of maize in India is 8.93 m ha, 21.57 mt and 2.50 t/ha, respectively during 2011-12. New production technologies offer great promise for increasing productivity to meet the growing demands of consumers. Focussed research on single cross hybrids across the country has helped in increasing production and productivity of maize.

Developing maize across different maturity groups is important to utilize the selection gain in a breeding programme. In this direction, 235 germplasm lines for early and extra early duration and 342 segregating lines in medium maturity were evaluated. Also, 30 new inbred lines of late maturity have been developed. Work has been initiated in grouping medium maturity inbred lines into different heterotic groups by developing a total of 300 cross combinations using four testers. In early maturity group, based on *per se* performance and general combining ability effects LM13, PFSR10104, HKI326-3 and CML451 were found superior for yield while, HKI326-3, CM501 and CML474 were found better combiners for early flowering. The major research area in maize breeding is single cross hybrid development. In step forward to it, 10 promising new experimental single cross hybrids in late maturity were found to be superior over the best checks *viz.*, SeedTech2324 and Bio9681. A total of 275 experimental crosses in medium maturity and 56 experimental hybrids in early maturity group were also made. Among the crosses in early group, LM13 X CML451 recorded 17.5% and 11.5% higher yield than Bio9681 and DHM117, respectively.

Quality protein maize (QPM) is a biofortified maize with increased lysine and tryptophan levels. In a quest to identify high quality protein maize, a total of 248 samples were analyzed. The highest tryptophan and lysine levels among inbreds were observed in QPM105 and QPM116 (0.74%). A total of 272 high yielding single cross hybrids of QPM were also generated using identified productive inbreds where protein content ranged from 6.84% to 11.81%, tryptophan from 0.36% to 0.78% and lysine content from 1.44% to 3.49% of endosperm protein. Developing maize germplasm high in β carotene, is an important area where Directorate has taken initiative. The highest amount of total carotenoids and β-carotene were exhibited by BAJIM11-3 (38.58 μg/g) and CL02-45 (2.09 μg/g). More rigorous attempts were made during 2012-13 in development of specialty maize. Eight promising sweet corn inbred lines (3131, WNHYSC(NA), WNC10R4856, EC619451, WNC10R4908, EC619337Ä, MH, WNC10R4894) were selected. Five sweet corn promising crosses (EC619451 Ä X WNC10R 4908, WNC10R 4856 X (Madhuri X HSC1), EC619337Ä X 3131, WNC10R 4894 X WN HYSC (NA) and 3131 X EC619451Ä) were identified. In popcorn, 29 popcorn segregating lines were advanced and two promising inbred lines (Winpop3 and 3172) and one promising cross (Winpop3 X 3172) was identified. Attempts to identify high oil genotypes led to identification of superior top crosses Vivek Hybrid 4 X [Temperate x Tropical (HO) QPM] BBB 60 BB (4.85% oil) and Vivek Hybrid 9 X [Temperate x Tropical (HO) QPM] BBB60BB (4.81% oil). In baby corn experiments, 45 public sector early maturing single cross hybrids were evaluated where, FH3513 was high in brix value and fodder yield whereas hybrid GYM9842 (Godhra) showed higher cob yield over check. Biochemical evaluation of 171 inbred lines for starch contents led to identification of 33 inbreds with more than 74% starch. Screening of 283 germplasm lines for cold tolerance resulted in identification of eight inbred *viz.*, Z172-276, EC655724, A2-49 Z172-97, A8-9, 121022, A8-28 and A2-9 as cold tolerant at seedling stage for two consecutive years. Similarly, out of 107 inbred lines that were subjected to managed moisture stress at two stages (flowering and grain filling) at three locations (Delhi, Hyderabad, Udaipur), four inbreds *viz.*, DML177, DML272, DML116 and DML135 were found tolerant to drought at flowering stage with low anthesis silking interval (ASI). In AICRP breeding trials, 275 entries were evaluated in 16 different trials at 29 locations across the country using 20 checks of different maturity groups. Of these, 136 entries were contributed by public sector and 139 from private sector. In *rabi*, a total of 122 entries were evaluated in coordinated trials 19 locations across the country against 10 checks of different maturity.

Maize is cultivated throughout the year in all states of the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn, pop corn in peri-urban areas. Conservation tillage like zero till and permanent beds resulted in significantly positive impact on crop yield, soil health and quality and provides the best opportunity to halt degradation and for restoring and improving soil productivity. Bed planting recorded an improvement of 5.8, 7.2, 27.88, 17.67 and 17.74% in the yield of maize, wheat, baby corn, potato and mungbean over flat planting. Site specific nutrient management (SSNM) gave significantly higher yield over 100% Recommended Dose of Fertiliser (RDF), 50% RDF and absolute control by 19.2%, 31.7% and 105.8%, respectively. Nitrogen is the most crucial nutrient for crop production and its management and application is more important in conservation agriculture (CA) due to presence of crop residue. Hence, under CA, the application of sulphur-coated urea resulted in 54% and 8% grain yield increase over control and prilled urea application, respectively. During the last few decades, cyclic patterns of drought, flood, rainfall intensity and spatial distributions have become more frequent resulted in severe impacts on crop production. Late (PMH3) and medium (DHM117) maturity hybrid perform significantly better until 15th July sowing. In delayed sowing until 10th August, early (PEHM5) and extra early (Vivek QPM9) hybrids performed well and hence found suitable for succeeding *rabi* crop. Drip irrigation and nitrogen fertigation @ 200 kg/ha with 100% Epan in sweet corn was found superior over conventional irrigation methods.

Among inbred line evaluated against stem borer one entry CML261 was found least susceptible and CML152 line was moderately susceptible. Study on oviposition behaviour of *Sesamia inferens* using artificial release method, suggested that 12 days old maize plants attracted maximum number of eggs. Laboratory study was conducted to determine the efficacy of medicinal plant powders against rice weevil *Sitophilus oryzae* in stored maize. Three medicinal plants *viz.*, *Ageratum conyzoides* L.,*Cissus quadrangularis* L., *Albezzia lebbeck* L. and one insecticide (Deltmethrin 2.5 WP) were tested. Of these *A. conyzoides* @ 2 % w/w was found most effective with higher per cent mortality (92.21) of *S.oryzae* followed by insecticide Deltamethrin. Efficacy of egg parasitoid *Trichogramma chilonis* against *Chilo partellus* and *Sesamia inferens* was evaluated. It was effective by less infestation (5.68 %) with *Chilo partellus* as compared to unreleased plots (14.15 %) in *kharif*, whereas during *rabi* this treatment was effective by less (14.52 %) infestation with *Sesamia inferens* as compared to unreleased plots (23.71 %). In Entomology trials of AICRP a total of 104 hybrids were evaluated for resistance against Stem borer (*Chilo partellus)* and 24 were found more promising under artificial infested condition at seven locations.

Genotypes NMH958, PMH3, MCH40, FH3487 had better storability in natural condition by showing aflatoxin B1 (AFB1) from 0.001 to 0.833 parts per billion (ppb) in six months storage period. Based on three years experiment the non toxic chemical, ammonium carbonate was the best in minimizing the aflatoxin build up in nine months storage period. Accession Number has been allotted by Indian Type

Culture Collection, Identification/Culture Supply Services, Division of Plant Pathology, Indian Agricultural Research Institute, New Delhi for two biocontrol agents *viz.*, *Trichoderma asperellum* and *Aspergillus niger*, to be used to reduce the aflatoxin build up in post harvest maize. Based upon evaluation across years against major diseases 43 lines were found to be either resistant or moderately resistant to Maydis leaf blight; 32 to Turcicum leaf blight; 58 to brown stripe downy mildew; 56 to post flowering stalk rot; six to Rajasthan downy mildew and two each to polysora rust, Curvularia leaf spot and Erwinia stalk rot. Under survey surveillance programme of AICRP, Curvularia leaf spot (CLS) has shown widespread occurrence in Rajasthan. Polysora rust and CLS are emerging as a potential threat in Karnataka and Rajasthan respectively. A total of 293 maize hybrids and 39 specialty corn in nine different trials were evaluated against various maize diseases under artificial inoculated condition at hot spot locations and 171 hybrid showed resistant reaction in AICRP trials.

For strengthening, refinement and dissemination of maize information to the users an online expert system MaizeAGRI*daksh* has been developed. A total of 8515 frontline demonstrations (FLDs) comprising 2664 in *rabi;* 788 in spring and 5063 *kharif* were carried out to demonstrate productive potential of newly released hybrids/technologies in farmer's conditions. Institute also conducted around 26 training programmes for various extension personnel and farmers of different geographical locations.

During 2012, 19 maize hybrids were identified for released by Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops. Of these, seven are late, 10 medium and two extra-early maturing hybrids.

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

Dimensions of Maize Improvement

Maize (*Zea mays* L.) is one of the important cereal food crops of India with annual production of around 21 million tonnes covering 8.5 million hectares area. It is utilized domestically for poultry and cattle feed, food, manufacturing of starch and other industrial purposes. In the last few years, good quantity of maize is also being exported from India to different countries. With the increasing demand for value-added foods and industrial requirements, from a growing economy and population, maize would hold its share as a significant crop. Therefore, breeding efforts are focussed towards generating high yielding and value- added single cross hybrids. Development of productive hybrids fitting into different cropping system is a continuous process targeting Indian farmers in different agro-climatic regions of the country.

HM4-1-3-2

SeedTech2324-7-4-5

MRCHY5126-4-6-1

EC4400238-3-4-1

Figure 1. Promising late maturing inbreds

Enhancing maize yield in different maturity groups

Exploiting maize across different maturity groups is important to utilise the selection gain in a breeding programme. In general, average productivity of late duration maize hybrids is higher among all maturity groups. Hence, 30 new inbred lines of late maturity have been developed from various exotic collections, promising single cross hybrids and segregating material (Figure 1) and 68 lines were identified as good pollen as well as seed parents. Ten new experimental single cross hybrids were found to be superior over the best checks *viz.*, SeedTech2324 and Bio9681 (Table 1).

In medium duration maize, grouping of inbred lines into different heterotic groups has been initiated by developing 300 cross combinations between uniform inbred lines and four testers during *rabi* 2012-13 by following Line X Tester (L X T) crossing. Seventy eight new germplasm lines were acquired from different sources *viz.*, PAU Ludhiana, ANGRAU Hyderabad and Winter Nursery Centre Hyderabad. Evaluation of 342 segregating lines and 275 experimental crosses was done for improving medium maturity maize.

Developing high yielding early maturity maize can benefit many producers. Despite the ability of early maize to provide food early in the season and its ability to escape drought, it is associated with low yield. Therefore, evaluation of 235 germplasm lines for early and extra early traits and development of 116 inbred lines from the Hill Early Yellow (HEY) Pool and hybrids was carried out. Fifty six experimental hybrids were developed (Table 2). Combining ability study of nine inbred lines with two testers (CML474 and CML451) revealed significant variability for yield, number of rows and number of kernels per row.

Table 1. Performance of late maturity superior experimental hybrids in two locations (Delhi and Bihar)

Hybrids	Parentage	Delhi			Bihar		
		Days to maturity	Average yield (kg/ha)	% superiority over Seed Tech 2324	Days to maturity	Average yield (kg/ha)	% superiority over Bio 9681
DMRH1	DML1 X DML38	180	7924	26.62	172	7150	18.43
DMRH2	DML12 X HKI1128	183	7184	14.80	174	6351	5.20
DMRH3	DML61 X HKI1128	178	8653	38.27	170	7312	21.11
DMRH4	DML24 X DML43	177	7240	15.70	169	6316	5.36
DMRH5	DML4 X DML165	176	8817	40.89	172	7125	18.01
DMRH6	DML65 X HKI1105	180	6716	7.31	168	6440	6.67
DMRH7	DML52 X HKI163	181	7987	27.62	168	7218	19.56
DMRH8	LM13 X HKI 1128	183	8423	34.59	173	6525	8.08
DMRH9	DML121 X HKI163	184	7269	16.15	171	6937	14.90
DMRH10	DML126 X HKI1128	180	9927	58.62	172	8226	36.25

Table 2. Best performing early maturity crosses evaluated during *kharif* 2012

Crosses	DTA	DTS	PH (cm)	EH (cm)	GY (kg/ha)	EL (cm)	ED (cm)	NKR	KPR	Sh %	TW (kg)	Type	Colour
IC-NTI x CML224	50.0	51.0	173.0	90.6	6850	14.5	4.3	15.3	33.0	83.3	0.29	F	Y
EC618176 x CML73	57.0	59.0	198.2	118.0	5620	17.5	4.0	12.7	40.7	65.9	0.28	F	O
CML338 x V373	49.0	51.0	169.4	82.0	7020	17.6	4.6	14.7	34.0	80.9	0.28	F	Y
CML122 x CM502	50.0	52.0	224.4	105.8	6510	18.5	4.6	14.7	29.7	81.1	0.33	F	Y
DMRN6 x CML470	48.0	49.0	174.0	102.4	6510	15.1	3.9	12.0	37.7	83.4	0.25	F	YO
CML422 x V373	48.0	50.0	170.4	78.6	7420	17.6	4.4	14.0	29.7	85.3	0.37	F	Y
V335 x 10227 PFSRK10	51.0	53.0	169.0	91.6	6740	14.9	3.9	14.0	37.3	83.5	0.24	F	O
CML182 x CM132	57.0	58.0	204.6	112.6	9010	17.9	4.5	14.0	37.3	80.3	0.27	SD	W
Prakash (check)	45.0	47.0	200.8	98.3	6300	-	-	-	-	82.5	-	F	Y
Vivek Hybrid 9 (check)	6.0	48.0	184.7	77.0	5710	-	-	-	-	81.8	-	F	Y

DTA (days to Anthesis); DTS (Days to Silking); PH (Plant Height); EH (Ear Height); GY (Grain Yield); EL (Ear Length); ED (Ear Diameter); NKR (Number of Kernel Rows); KPR (Kernel Per Row); Sh% (Shelling percentage); TW (Test weight)

Based on *per se* performance and general combining ability effects LM13, PFSR10104, HKI326-3 and CML451 were found superior for yield. HKI326-3, CM501 and CML474 were found better combiners for early flowering. Among the crosses LM13 X CML451 gave 17.5% and 11.5% higher yield than Bio9681 and DHM117, respectively.

For home food and feed, still farmers in some regions of Rajasthan, Gujarat, Madhya Pradesh, Bihar and Uttar Pradesh prefer to grow local/ traditional white maize varieties for their good eating quality and low input requirement. It is being used in food processing industries to manufacture prepared food and snacks and also to manufacture starch and whisky. Concerted efforts are initiated to widen the scope of white maize in India. 363 white maize germplasm received from CIMMYT, Mexico were grown at WNC, Hyderabad for acclimatisation of temperate materials.

Healthy maize for better tomorrow

Quality Protein Maize for nutrition

Quality Protein Maize (QPM) is a biofortified maize variety with increased lysine and tryptophan levels. This maize can be a good food supplement to reduce malnutrition. QPM contains higher amount of lysine and tryptophan in the endosperm ensuring higher biological value and availability of protein to human and animal. QPM development requires continuous monitoring of protein quality. The kernels were first screened on the basis of opaqueness to select the representative sample. The endosperm was separated, defatted and processed for protein quality. Germplasm having threshold concentrations of protein quantity (≥ 9% protein) along with quality (≥ 0.6% tryptophan and ≥ 2.50% lysine in the endosperm protein) was selected and identified as promising QPM material.

During 2012-13, a large number of samples received from different centres were analyzed by biochemistry section for total protein, tryptophan and lysine. A set of 131 F_1 hybrids were analyzed for protein quality in the endosperm of selected kernels. Protein content ranges from 6.84% (CML179 X CML163) to 11.81% (HKI26-2-4-(1-2) X CML163). The range of tryptophan was 0.36% (HKI31-2 X CML169) to 0.78% (HKI193-1 X CML161), whereas lysine content ranges from 1.44% (HKI31-2 X CML169) to 3.49% (HKI164-7-4-ER-3-3 X HKI193-1) of endosperm protein. As many as 20 hybrids were found to be promising in terms of protein quality, best 5 hybrid shown in Table 3.

The biochemical analysis of 30 inbreds resulted protein content ranges from 6.76% (QPM111) to 11.79% (DMRWNCQPMY52). The range of tryptophan and lysine was 0.41% (DMRWNCQPMY87) to 0.75% (QPM114) and 1.66% (DMRWNCQPMY84) to 3.10% (QPM114) of endosperm protein, respectively. Inbreds found to be promising in terms of protein quality shown in Table 4.

Table 3. Promising hybrids for protein quality

S. No.	Hybrids	Protein (%)	Tryptophan (%)	Lysine (%)
1.	CML163 X CML169	9.50	0.82	3.34
2.	HKI164-7-4-ER-3-3 X CML163	9.19	0.73	3.02
3.	HKI164-7-4-ER-3-3 X CML161	9.36	0.72	2.91
4.	DMRQPM-03-104-1 X CML161	9.07	0.70	2.87
5.	HKI31-2 X CML161	10.33	0.67	2.77

Table 4. Promising germplasm for protein quality

S. No.	Hybrids	Protein (%)	Tryptophan (%)	Lysine (%)
1.	QPM105	9.49	0.74	3.06
2.	QPM116	9.12	0.74	3.05
3.	QPM103	11.61	0.65	2.69
4.	DMRWNCQPMY82	10.69	0.65	2.66
5.	DMRWNCQPMY81	9.66	063	2.60

In QPM breeding programme, 45 elite inbreds; 419 exotic introductions; 274 segregating lines in high plant density, were evaluated and maintained. Simultaneously, inbred lines were evaluated against post flowering stalk rot, turcicum leaf blight and maydis leaf blight. Promising QPM inbreds to be utilized in breeding programme is shown in Figure 2. In single cross hybrid development programme, 182 F_1 crosses in *kharif* 2012 and 90 F_1 crosses in *rabi* 2012-13 were attempted. Continuous efforts were made for enhancing germplasm by procuring from CIMMYT (12) and Exotic Collections (50) from NBPGR and incorporation in current breeding programme.

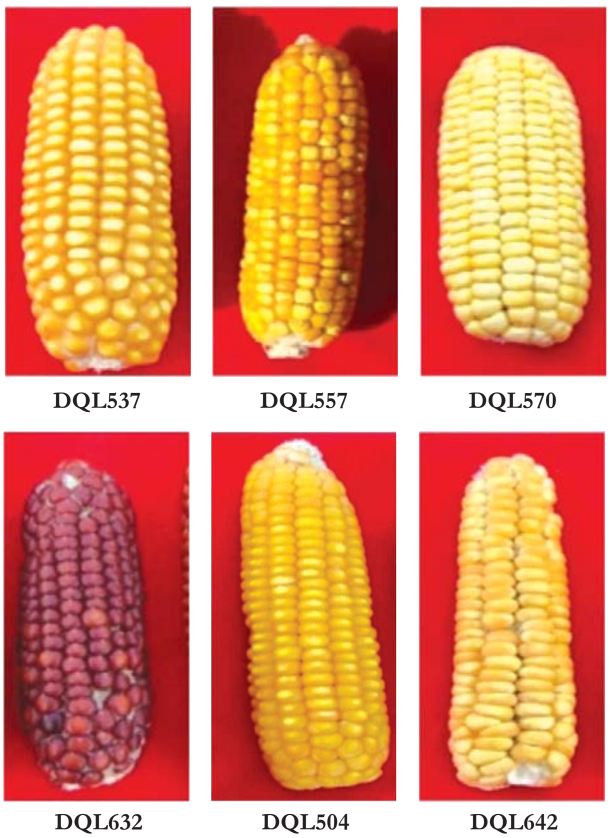


Figure 2. Promising QPM inbreds of *kharif* 2012

Provitamin-A enhancement

Vitamin A deficiency is a serious global health problem that can be alleviated by improved nutrition. Maize is an essential staple cereal that naturally accumulates carotenoid in the edible seed endosperm. Developing maize varieties high in β-carotene, a precursor to provitamin A, can play a significant role in improving the health and nutritional status of the poor through reduction in vitamin-A deficiency. Maize germplasm resources exhibit wide genetic diversity with corresponding variation in carotenoid profiles that are useful in investigating pathway regulation and new breeding lines. In this direction, initiative has been taken and donor parents for provitamin-A were received from CIMMYT, Mexico for further evaluation. Simultaneously, the Ultra Performance Liquid Chromatography (UPLC) has been standardized for amino acid and carotenoid composition. Maize germplasm received from various AICRP centres and regional centres were analysed and highest amount of total carotenoids and β-carotene were exhibited by BAJIM11-3 (38.58 mg/gm) and CL02 45 (2.09 mg/gm).

Iron-content enrichment

Breeding for enhanced micro-nutrients in maize is a cost effective and sustainable approach to alleviate iron deficiency in humans. Iron and zinc biofortified maize requires 60 and 55mg/kg of iron and zinc on dry weight basis to create an impact on nutrition. Primarily, 150 inbred lines were evaluated from which thirteen inbred lines have been identified with iron content of more than 30mg/kg on dry weight basis.

Focus on Specialty Corn

Development of sweet corn and popcorn

Sweet corn is gaining importance in urban and peri-urban areas. The green plants left over after harvest of sweet corn gives additional income to the farmers in the form of green fodder which stimulates the cattle industry. The economic dividend of both sweet corn and popcorn is much higher. During 2012-13, 306 sweet corn segregating lines were advanced. 310 single cross hybrids of sweet corn were evaluated at WNC, Hyderabad in augmented design. Eight promising sweet corn inbred lines (3131, WN HYSC (NA), WNC10R 4856, EC619451Ò, WNC10R 4908, EC619337 Ä, Madhuri X HSC1 or MH, WNC10R 4894) were selected. In a set of inbreds analysed for sugar, the content varied from 3.40% (DMR WNC SC 146) to 18.66% (DMR WNC SC 5). Three lines were found to be having more than 6% of sugar in the mature kernels (Table 5). Five sweet corn crosses (EC619451 Ä X WNC10R 4908, WNC10R 4856 X (Madhuri X HSC1), EC619337Ä X 3131, WNC10R 4894 X WNHYSC (NA), 3131 X EC619451 Ä) were identified for their performance.

Table 5. Promising high sugar lines

Pedigree	Sugar (%)
DMR WNC SC 5	18.66
DMR WNC SC 151	15.81
DMR WNC SC 22	6.99

Popcorn has become popular as snacks in urban localities. Though yield level of popcorn is low, they are being sold at 3-4 times higher price than normal maize. In 2012-13, 29 popcorn segregating lines were advanced. Seven hybrids of popcorn were evaluated at WNC, Hyderabad in augmented design. Promising two popcorn inbred lines (Winpop-3 and 3172) were selected. One best popcorn cross (Winpop-3 X 3172) was identified. Simultaneously at DMR, four promising hybrids have been identified for popcorn quality (Table 6).

Enhancement of oil in maize kernel

High oil corn is a special type of corn with more than 6% oil content. Corn oil is extracted from the germ of maize. High oil corn hybrids shows lower yields so there has been much interest in producing high oil corn from hybrids using the top cross system. Such hybrids produce more oil without compromising yield levels. The top cross high oil grain production system involves crossing an elite hybrid as female parent with elite high oil inbred as pollinator. The pollen shed from these pollinator plants contain genes

Table 6. Performance of promising popcorn experimental hybrids

Cross	Seed volume (ml)	Popping volume (ml)	Popping %	Flake Type
CM133 X CM120	27	200	79	Mushroom + Butterfly
CM130 X CM120	23	200	83	Butterfly
CM12 X CM119	25	250	92	Butterfly
CM119 X V373	20	225	96	Butterfly

that cause a kernel to produce a much larger than average germ or embryo utilizing xenia effect. In our experiments, the top crosses Vivek Hybrid4 X [Temperate x Tropical (HO) QPM] BBB 60 BB (4.85%) and Vivek Hybrid9 X [Temperate x Tropical (HO) QPM] BBB60BB (4.81%) showed highest oil. High mean oil percentage value was recorded in single cross hybrids [Temperate x Tropical (HO) QPM] BBB 100 BB X [Temperate x Tropical (HO) QPM] BBB14BB (6.04%). New set of germplasm procured from various sources was selfed and seed increased to estimate oil.

Evaluation of baby corn traits

Baby corn is an immature part of the female flower. Baby corn cobs are harvested when 50% cob showed 1-2 cm silk emergence. In the areas adjoining cities or other urban areas (peri-urban agriculture) multiple crop of baby corn is raised fetching greater income to the farmers. Baby corn can be effectively used as both a nutritious vegetable and as an export crop. After harvest the still young plants may be used as fodder for cattle. Removing the male flower (tassel) is essential to maintain the quality of baby corn. Early single cross hybrids are the best for baby corn purpose in high planting density. Forty five public sector early maturing single cross hybrids were evaluated for baby corn traits. HM4, a popular cultivar for baby corn utility was the check. Harvest was done three to four times, two to three days after ear silk emergence. The baby corn without husk was 8 to 12 cm long and 1.0 to 1.5 cm wide with golden yellow colour. FH-3513 (Almora) hybrid was high in brix value and fodder yield whereas hybrid GYM 9842 (Godhra) showed high cob yield over check.

Maize for high starch

Starch is an important component in many foods and is a functional ingredient in industries. Maize is the most important raw material for industrial starch. Seeing its importance biochemical evaluation of 171 inbred lines has been done. 33 inbreds were found to have more than 74% of starch. (Table 7) shows the promising lines with starch content above 75%. Starch content varied from 61.92 to 76.31%. Selfed seed samples of thirty pre-released hybrids were also evaluated for their starch content.

Table 7. Promising high starch lines

Pedigree	Starch (%)
DMR DE 6-4	75.71
845AF	75.76
EC645989	75.81
EC646048-3	75.86
MRCHY5106	75.88
EC618990	76.31

Approaches for abiotic stress tolerance

Germplasm development and enhancement for cold tolerance

Current trend of 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

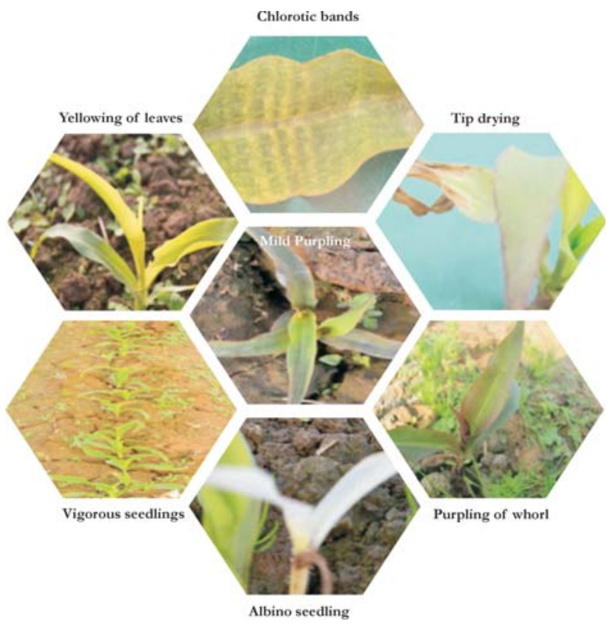


Figure 3. Symptoms exhibited in cold conditions

suboptimal temperature conditions. During winter season in Northern plains, the average temperature falls up to 15^{0}C and minimum touches 2^0-3^{0}C in December-January with frost incidence, which causes both freezing (chlorotic bands, chlorosis, drying of leaves) (Figure 3) and non-freezing (leaves turn oily followed by drying after frost incidence) injuries. Therefore, adaptation of maize to winter season and similar environment in tropics requires genetic improvement for low temperature tolerance, which implies vigorous seedling growth without suffering with cold injuries under low temperature conditions.

For traits related to early development in cold conditions 283 entries comprising exotic and indigenous (EC and IC) accessions, CIMMYT lines and elite inbreds were screened. Eight inbreds were found to be cold tolerant at seedling stage for two consecutive years (Table 8). Out of 180 experimental single cross hybrids evaluated for yield and yield contributing traits, four hybrids *viz.* LM16 X EC655724, LM16 X BML7, HKI161 X CML217 and CML186 X HKI295 were found superior to check.

Mitigating drought and heat stress

Water shortage is a major challenge in maize production. Drought tolerant genotypes can give 15-20% more yield over the susceptible one under moisture stress condition. However so far there is not much advance in the development of hybrids and source germplasm which can perform better under drought stress. Further it is very important to identify the secondary traits for direct selection, which can improve the selection gain for yield under drought stress.

Inbred lines (107) were subjected to managed moisture stress at two stages (flowering and grain filling) in three locations (Delhi, Hyderabad, Udaipur) in *rabi* 2012-13. Four inbreds (Figure 4) have been found tolerant to drought at flowering stage with low anthesis silking interval (ASI) (Table 9). Hybrids usually yield better than varieties under drought with heterosis acting as an important source of stress tolerance. Two sets of 25 hybrids were evaluated in control and drought (under rain-out shelter) in the micro plots maintained specially for drought studies. The flowering stage drought caused reduction in leaf

Table 8. Seedling performance of promising cold tolerant inbreds in *rabi* 2012-2013

Genotypes	Leaf Colour (1 dark green - 9 albino)		Early Vigour Rating (1= vigorous to 9= weak)	Survival %	ASI
	January 2013 (cold stress)	2nd fortnight of February (recovery)			
Z172-276	3	2	4	80	4
EC655724	4	3	6	58	2
A2-49	5	3	4	72	3
Z172-97	5	4	5	70	3
A8-9	5	3	5	60	4
121022	5	4	5	65	2
A8-28	5	3	5	60	3
A2-9	5	4	5	54	3
A2-36 (susceptible)	9	7	8	20	5
S.E. ±	0.54	0.47	0.4	4.71	0.18

Table 9. Performance of promising tolerant inbreds for key drought related traits

Genotype	ASI (under stress)			Leaf angle			Leaf firing			Tassel blast		
	Delhi	Hyder-abad	Udai-pur	Delhi	Hyder-abad	Udai-pur	Delhi	Hyder-abad	Udai-pur	Delhi	Hyder-abad	Udai-pur
DML177	3.5	4.5	4.0	Narrow			Absent			Absent		
DML272	5.0	4.0	3.5	Narrow			Absent			Absent		
DML116	5.5	3.5	3.0	Narrow			Absent			Absent		
DML135	4.5	4.0	4.0	Narrow			Absent			Absent		

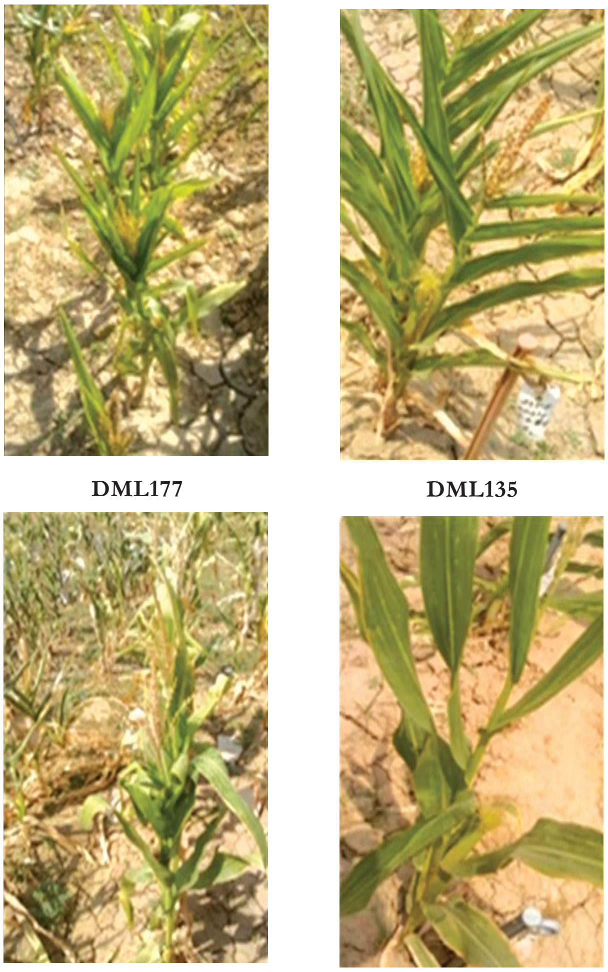


Figure 4. Identified drought tolerant inbreds

chlorophyll content (LCC), relative water content (RWC), net photosynthetic rate and transpiration rate, which finally resulted in reduction in grain yield. ASI was enhanced significantly by flowering stage drought. ASI in control plants ranged between -2 to +4 days (Figure 5) while under drought condition it ranged between +1 to +15 days (Figure 6). Flowering stage drought reduced the number of fertile cobs significantly. Out of 25 hybrids evaluated 11 hybrids showed tolerance to drought while 6 hybrids were highly sensitive. F_4 generation of 227 and 288 recombinant inbred lines (RILs) of two mapping populations respectively were phenotyped for major morpho-physiological traits. ASI in two mapping populations ranged between -3 to +6 days and -5 to +5 days, respectively.

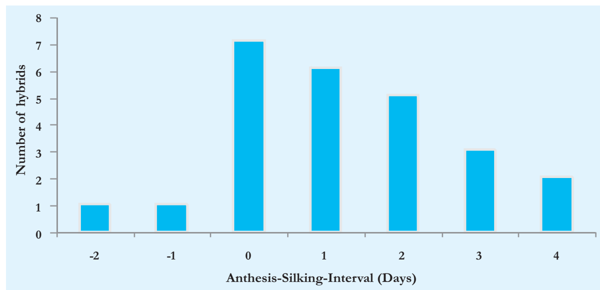


Figure 5. Frequency distribution of ASI under control conditions

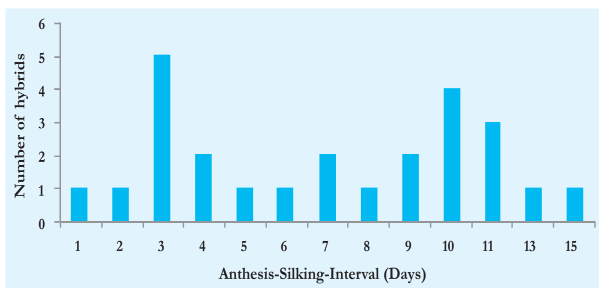


Figure 6. Frequency distribution of ASI under drought conditions

To investigate the performance in high temperature (heat stress) during summer, 34 single cross hybrids were grown and harvested during last week of June 2012. The crop season (March-June) was hot and dry with maximum and minimum temperatures ranging between 31.4-44.5°C and 15.2-29.8°C, respectively with total rainfall of 6.8 mm (April) and 12.4 mm (June) during the period. High temperature reduced plant height, induced leaf senescence and negatively influenced photosynthetic efficiency of maize plant during vegetative growth. Flowering stage coincided with high temperature resulted in tassel blasting, increased ASI and reduced pollen viability. ASI ranged between +1 to +11 days in the hybrids tested (Figure 7). Barrenness was observed in high temperature susceptible hybrids with only few fertile cobs. Overall 17 hybrids showed tolerance to high temperature in which grain yield ranged between 3.2-22.4 q/ha, while 6 hybrids were highly sensitive with no fertile cobs (Figure 8).

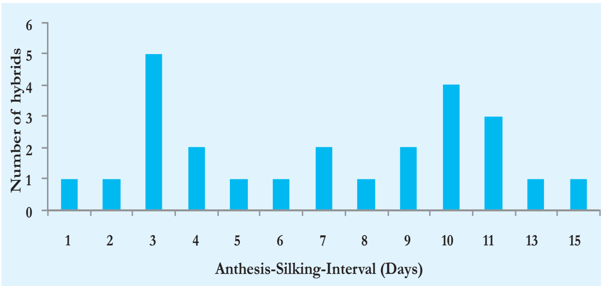


Figure 7. Frequency distribution of antheisis-silking interval in selected single cross maize hybrids under heat-stress conditions

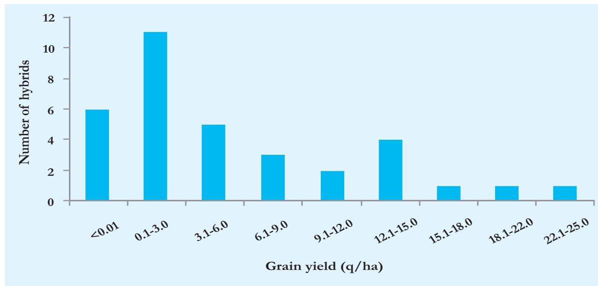


Figure 8. Frequency distribution of grain yield in selected single cross maize hybrids under heat-stress conditions

Biotechnological Interventions

Biotechnology enables scientific techniques to improve plants, animals and microorganisms. It holds considerable promise to meet challenges in agricultural production. New approaches can develop high yielding and more nutritious crop varieties, improve resistance to disease, reduce the need for fertilizer and other chemicals. DMR is working in all major aspects of biotechnology including genetic engineering for biotic and abiotic stress tolerance, molecular markers for genotype characterization and plant tissue culture.

Cloning and characterization of abiotic stress regulated genetic elements

Abiotic stresses are major constraints limiting maize productivity in the tropics and the subtropics. Presently, research is focussed on adaptive regulation of genetic elements by cellular Reactive Oxygen Species (ROS) pathway under oxidative stress. The role of ascorbate in modulating the biochemical and physiological response of maize plant under oxidative stress has been also been studied. A high degree of oxidative stress was induced in maize plants by application of methyl viologen at the flowering stage. A set of plants were treated with graded concentrations (0.5 mM, 1.0 mM and 1.5 mM) of ascorbate 48 hours prior to stress.

The physiological effects were monitored by measuring electrolyte leakage, total soluble protein levels, and specific activities of three key ROS scavenging enzymes *viz.*, superoxide dismutase (SOD), catalase (CAT), and peroxidases (POX) before and after stress (Figure 9). Ascorbate treatment led to increase in chlorophyll content and reduced electrolyte leakage under stress. Biochemical analysis revealed widespread rebalancing of ROS scavenging enzymes after stress and treatment. In control plants, SOD activity decreased upon induction of stress, while in treated plants, SOD activity increased significantly. Similarly, ascorbate caused remarkable increase in CAT activity, while it do not significantly affect POD activity under stress. This study suggests that the genes of ascorbate biosynthetic pathway and that of ROS scavenging pathway could be potential candidate genes that could be cloned and used to engineer climate resilient maize cultivars.

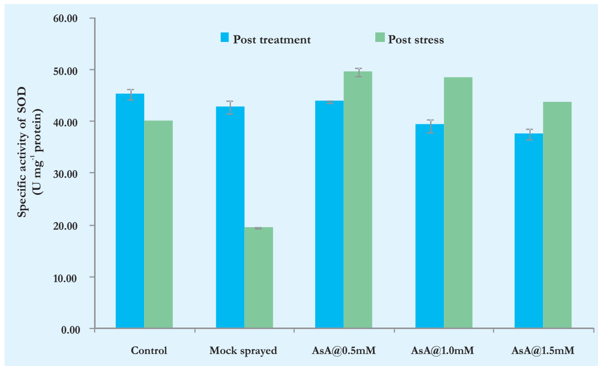


Figure 9. Specific activity of superoxide dismutase in response to different concentrations of ascorbate under normal and stressed conditions

Molecular characterization of elite maize inbred lines

Characterization of genetic diversity is of great value to assist breeders in parental line selection and breeding system design. Genetic diversity in 88 Indian maize inbred lines was assessed using 27 SSR markers. Based on pair wise Roger's distance, matrix was generated. Roger's distance was more than 0.7 in some of inbred pairs (Figure10). In general, pair wise genetic distance was found to be high (> 0.6) between CIMMYT Inbred Lines (CML) and VPKAS Almora lines. The distance was moderate to high between Indian maize lines (0.3 – 0.5). The pair wise distance matrix was used to

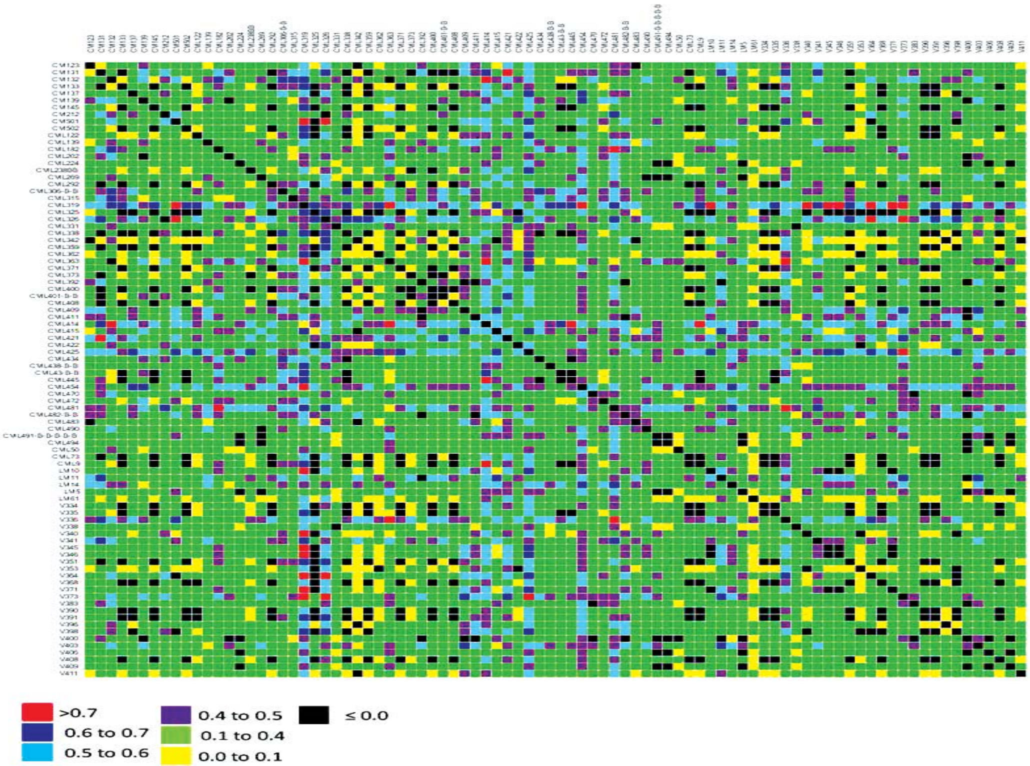


Figure 10. Graphical representation of pairwise Roger's distance between 88 inbred lines

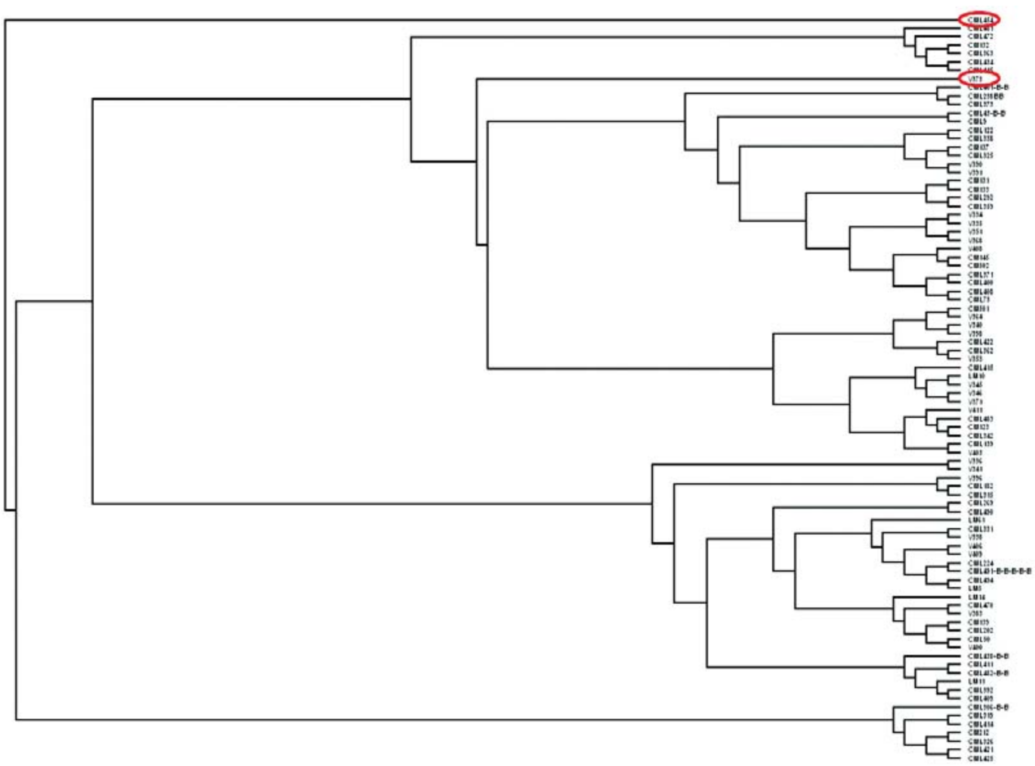


Figure 11. Genetic relationship between inbred lines

construct dendrogram using neighbour joining method (Figure 11). The dendrogram revealed two outliers, V373 and CML454. V373 is a productive line which is a parent of hybrids Vivek Hybrid39, Vivek Hybrid43.

In vitro characterization of regeneration capacity of maize genotypes

The modern plant biotechnology has provided novel means for crop improvement through integration and expression of defined foreign genes into plant cells. Plant tissue culture plays a pivotal role in rapidly increasing desirable plants while maintaining the genotype of the original plant, inducing desirable and heritable changes in regenerated plants and producing homozygous, pure-breeding lines of plants for hybrid production and genetic studies. It is a basic prerequisite for the production of genetically transformed plants. Well established callus regeneration system is essential for genetic transformation in a crop.

Five elite maize inbred lines *viz.,* BML6, BML7, LM13, LM15 and LM16 were selected to standardize the protocol for callus induction and regeneration. For analysing callus induction frequency, 10-12 days old selfed cobs were collected from the field and immature embryos were isolated aseptically and inoculated on N6 media containing different levels of 2,4-D concentration. Immature embryos of LM13 and LM15 were inoculated on 1, 2, 3 and 4 mg/L concentration of 2,4-D (two replications each) and BML6 and BML7 on 1 and 2 mg/L concentration of 2,4-D. After 15 days of inoculation, primary calli were sub-cultured on the same medium. Embryogenic calli were obtained after 30 days of inoculation (Figure 12).

These were transferred to MS medium (shooting medium) with 2 and 4 mg/L concentration of BAP to induce shooting. Well developed shoots were transferred to rooting medium (MS without hormones) for root induction.

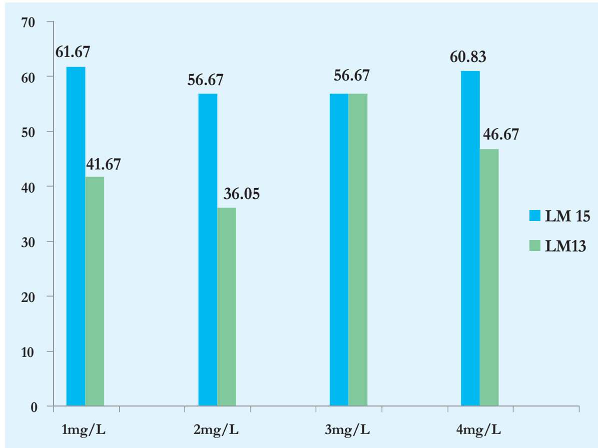


Figure 12. Mean percentage of embryogenic calli induction in different levels of 2, 4-D

Molecular Breeding for Quality Protein Maize (QPM) and Maydis Leaf Blight (MLB)

Conversion of white maize normal inbred lines *viz.* HKI1344, HKI1348 and HKI1378, parents of two productive white maize hybrids (HM12 and HM5) into QPM has been initiated using marker assisted selection (MAS). Four inbred lines (CML269, HKIPC4B, P72clxbrasil1117-2 and ESM11-3) identified as resistant and susceptible for MLB under artificial inoculation at hot-spot multiple locations across the country has been used for development of two mapping population (CML269 X HKIPC4B and P72clxbrasil1117-2 X ESM11-3). Crosses have been made and F_1 generation is grown along with parents in the field to further advance the population.

Production Systems and Technology

Maize is cultivated throughout the year in all states of the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn, pop corn in peri-urban areas. It can be grown successfully in variety of soils ranging from loamy sand to clay loam. Maize can be grown in all seasons *viz. kharif* (monsoon), post monsoon, *rabi* (winter) and spring. During *rabi* and spring seasons to achieve higher yield at farmer's field assured irrigation facilities are required. During *kharif* season it is desirable to complete the sowing operation 12-15 days before the onset of monsoon under irrigated conditions. However, in rainfed areas, the sowing time should be coincided with onset of monsoon. To achieve higher productivity and resource-use efficiencies optimum plant stand is the key factor.

Conservation tillage practices for improving resource use efficiency in maize-based cropping systems

Tillage and crop establishment is the key for achieving the optimum plant stand which is the main driver of the crop yield. Conservation tillage provides the best opportunity to halt degradation and for restoring and improving soil productivity. Interest in conservation tillage has increased in response to the need to limit erosion and promote water conservation. Long term experiment on conservation tillage in four maize based cropping systems was initiated from 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) and (iii) Conventional tillage (CT) in four maize based cropping systems (a) Maize-Wheat-Mungbean (M-W-M), (b) Maize-Mustard-Mungbean (M-M-M), (c) Maize-Chickpea-Sesbania (M-C-S) and (d) Maize-Maize-Sesbania (M-M-S). In zero tillage, grain yield of succeeding *rabi* season crops (Chickpea, Mustard and Maize) was higher over bed planting and conventional till, while the grain yield of wheat was 5.53 and 21.0% higher under permanent bed planting over zero-till and conventional tillage (Figure 13) respectively.

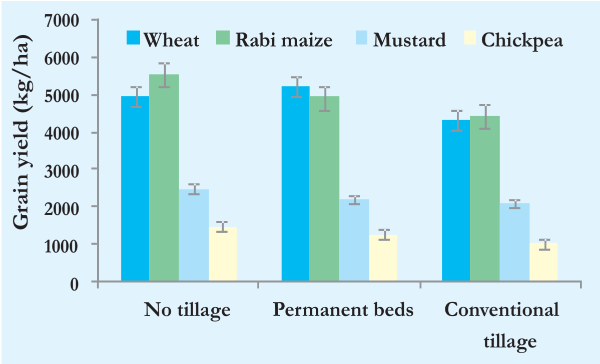


Figure 13. Grain yield of *rabi* season crops in different maize based cropping systems

However, the grain yield of preceding *kharif* season maize was highest under zero till which was 6.80 and 25.92% higher over bed planting and conventional till, respectively in all the four maize based cropping systems (Figure 14). In all the four maize based cropping systems, conservation agriculture based practices like zero till and permanent beds resulted in significantly positive impact on soil health and quality.

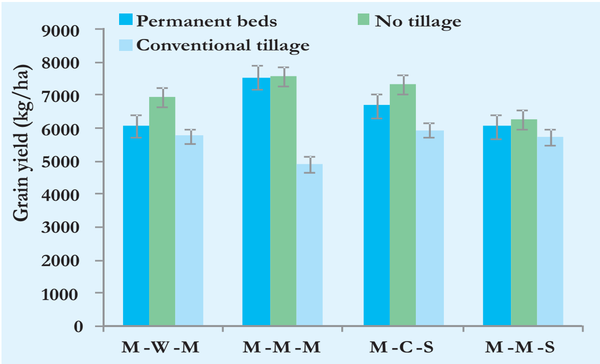


Figure 14. *Kharif* maize grain yield under different tillage practices and cropping systems

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 more site-specific guidelines adapted 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*. Among all the 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. For obtaining desirable yields, the doses of applied nutrients should be matched with the soil supplying capacity and plant demand (SSNM) by keeping in view of the preceding crop (cropping system).

Nutrient management in different tillage practices

The productivity of the system mainly depends on proper nutrient and moisture management practices. Tilled land provides the best opportunity to incorporate nutrients. Nutrient management is possible within most conventional and minimum-tillage cropping systems. This experiment studied the best tillage and nutrient management under maize- wheat-green gram cropping system.

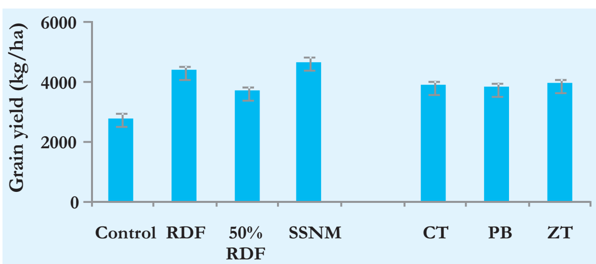


Figure 15. Effect of nutrient management and tillage practices on the grain yield of maize

In the first year of this experiment, fertilizer dose by nutrient expert resulted in significantly higher yield over absolute control and 50% recommended dose of fertilizers (RDF) (Figure 15).

Nutrient management using Nutrient Expert – Decision Support System

The Nutrient Decision Support System provides decision support on SSNM. It is a software programme (Nutrient expert) used to estimate the nutrient requirements for realistic target yields, to select the adequate and least costly combination of quality fertilizer sources matching the nutrient requirement, to decide on fertilizer split applications and to estimate the profit gained from improved nutrient and crop management programs. An experiment was planned to test the feasibility of SSNM in realising targeted potential yield of the maize hybrids. SSNM gave significantly higher yield over 100% RDF, 50% RDF and absolute control by 19.2%, 31.7% and 105.8%, respectively. Similarly amongst genotypes, PMH3 gave significantly higher yield over PMH1, DHM117, HQPM1 and Bio9637 by 15.0%, 19.3%, 36.7% and 39.6%, respectively. A significant interaction was found between genotypes and nutrient. Data showed that PMH3 with nutrient expert (180:60:90 Kg/ha N: P_2O_5: K_2O) resulted in significantly higher yield over all treatment combinations (Figure 16). In economic terms, also highest net returns (‘55, 334) and benefit: cost ratio (2.51) was observed with PMH3.

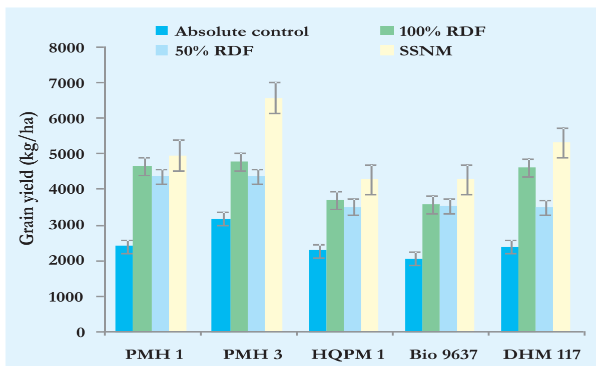


Figure 16. Interaction effects of nutrient management strategies and hybrids on grain yield of maize

Nitrogen management under conservation agriculture in maize-based cropping systems

Nitrogen became the most crucial nutrient for crop production and it is more important in conservation agriculture due to its higher losses on application in standing crop with residue conditions. Hence, one time application strategy with coated fertilizer investigated to increase its efficiency in maize systems. The application of the coated fertilizer *viz.*, neem coated urea (NCU) and sulphur coated urea (SCU) resulted in significant yield improvement of maize as compared to conventional practice of three split prilled urea (PU) application (Figure 17). The application of sulphur coated urea resulted in 54% and 8% grain yield increase over control and prilled urea application, respectively. A significant variation in the ammonical and nitrate N concentration in two soil layers (0-15 and 15-30 cm) was also observed after harvest of maize. The result showed that the grain yield of maize was 5% higher with the application of residue (WR) as compared to no application (WoR).

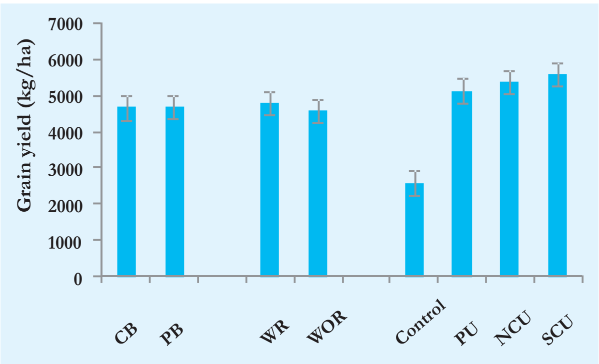


Figure 17. Effect of tillage, residue and nitrogen management practices on yield of maize

Likewise, an improvement of 18% in the agronomic nitrogen-use efficiency (NUE) was also found with application of sulphur coated urea over prilled urea application (Figure 18). Similarly, the agronomic NUE was 9% higher with the application of residue over no residue application. However, tillage systems comprising of conventional bed (CB) and permanent bed

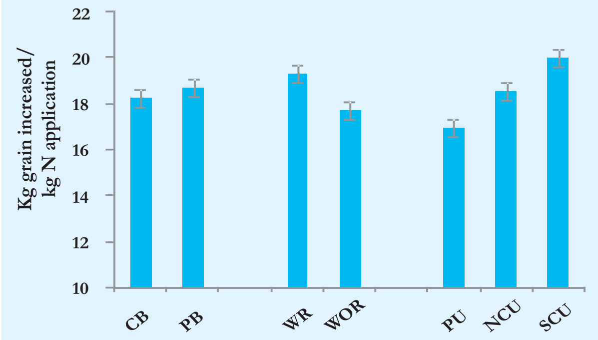


Figure 18. Effect of tillage, residue and nitrogen management practices on agronomic NUE of maize

(PB) had resulted in non-significant effect on the grain yield and NUE in the first year of the experimentation.

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

The increasing demand for maize is rapidly transforming cropping systems in India. A field trial was conducted to study the performance of different maize based cropping system in relation to different planting methods and nutrient management practices. Bed planting recorded an improvement of 5.8, 7.2, 27.88, 17.67 and 17.74% in the yield of maize, wheat, baby corn without husk, potato and mungbean over flat planting, respectively (Table 10).

Similarly, there were significant variation in the productivity of component crop and cropping system under different nutrient management practices. Maximum yield was found at RDF + 5 t/ha FYM application. The water productivity also showed similar trend (Figure 19). Among the different cropping systems, maize-potato-mungbean resulted in the highest maize grain equivalent yield followed by maize-babycorn-mungbean and maize-wheat-mungbean cropping sequence at all the planting methods and fertility levels (Figure 20).

Performance of maize hybrids to adopt rainfall change and climatic aberrations

Climate change is probably the most complex and challenging environmental problem. During

Table 10. Productivity of different crops under different treatments

Treatments	Productivity (t/ha)				
	Kharif	*Rabi* season crops			Summer
	Maize	Wheat	Baby corn	Potato	Mung- bean
Planting Methods					
Flat planting	3.94	4.47	2.08	31.96	0.62
Bed planting	4.17	4.79	2.66	37.61	0.73
C.D. (5%)	0.04	0.17	0.38	1.27	0.05
Nutrient management					
Control	2.64	3.40	1.26	26.90	0.42
Half RDF + FYM 5 t/ha	4.21	4.34	2.22	33.80	0.68
RDF	4.42	5.12	2.71	38.03	0.57
RDF + FYM 5 t/ha	4.94	5.65	3.10	40.40	1.03
C.D (5%)	0.04	0.06	0.17	0.80	0.07

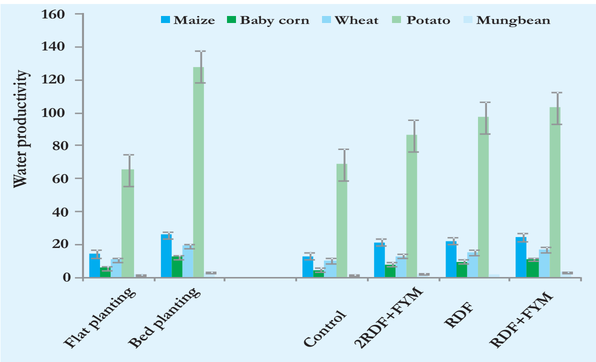


Figure 19. Water productivity (Kg/ha-mm water applied) of different crops

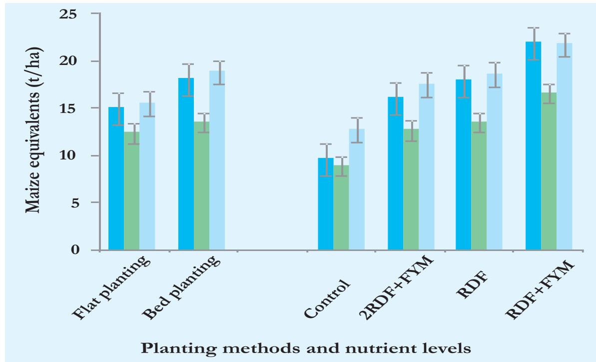


Figure 20. Maize equivalents of different cropping systems in different planting methods and nutrient levels

the last few decades, cyclic patterns of drought, flood and rainfall intensity and spatial distributions have become more frequent resulted in severe impacts on crop production. Hence, the performances of different maturity group maize hybrids were evaluated to assess the impact of rainfall with varying dates of sowing (Figure 21). The data of different hybrids and dates of sowing indicated that late (PMH3) and medium (DHM117) maturity hybrid perform significantly better up to 10th July. For delayed sowing up to 10th August, early (PEHM5) and extra early (Vivek QPM9) hybrids performed well and hence found suitable for succeeding *rabi* crop. However, PMH3 and DHM117 showed an improvement in grain yield by sowing on normal date and

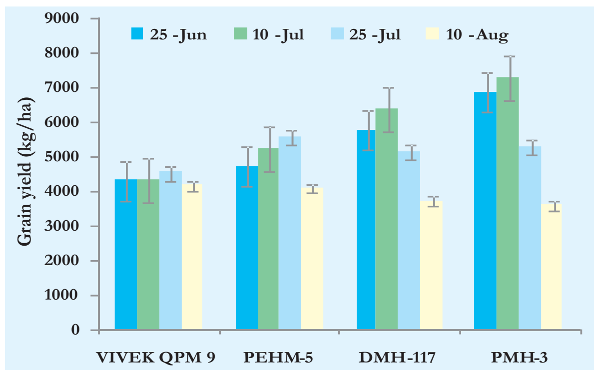


Figure 21. Productivity of different maturity hybrids under varying planting dates

further delay in sowing by 15 and 30 days reduced the grain yield to the tune of 22.23 and 43.55; and 29.10 and 53.21%, respectively.

Defending Diseases and Pests

Among the factors, adversely affecting productivity of maize, ubiquitous incidence of insect-pests and plant pathogens are the most important in pre-harvest and post-harvest maize.

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

Aflatoxins are potent toxic secondary metabolites produced mainly by *Aspergillus flavus* and *Aspergillus paraciticus,* is a serious problem in post-harvest maize. Aflatoxin contributes to significant nutritional and economic losses which prevent them from meeting international and national standard, for agricultural trade and food safety, posing a major obstacle to agriculture producer and stakeholder.

Genotypic Variability for Mycotoxin Contamination

A total of 35 genotypes were tested for storability under natural condition, all exhibited concentration of aflatoxin B_1 (AFB_1) less than 20 parts per billion (within permissible limit). Out of them NMH958, PMH3, MCH40, FH3487, were promising by showing AFB_1 from 0.001 to 0.833 ppb. Estimation of fumonisin was done using flurometer in these genotypes and exhibited concentration less than 2 ppm (permissible limit), whereas in Bio 9637 and HQPM5, it was above the permissible limit (2.5 & 2.7 ppm respectively) in six months storage.

Genotypes VEH092 (124.85 µm), BIO 9681 (127.42 µm), HM4 (138.36 µm), HM11 (134.32 µm) and JH31292 (160.39 µm) with grain wall thickness > 170 µm showed more AFB_1 as compared to genotype like PMH3 (213.95 µm) etc with more thickness (190 to 288 µm).

Popcorn (BPCH6) genotype with 162.76 µm thickness of seed coat exhibited less concentration of aflatoxin (0.848 ppb) may be due to tight packing of starch and hard seed coat.

Postharvest management of stored maize grains using biocontrol agents isolated from maize grains and nontoxic chemicals under six months storage

Experiment for management of post harvest losses in stored maize grain was conducted in HQPM1 and DHM117. Grain lot of 8.5 kg of each genotype was inoculated with *Aspergillus flavus* strain 22 (highly toxic) except one lot left uninoculated for check. The inoculated grains further treated with biocontrol agent *Aspergillus niger* @ 10 mg/kg, calcium carbonate @ 4 g/kg, sodium tripoly phosphate @ 4g/kg and ammonium carbonate @ 4g/kg. Ammonium carbonate was the best in minimizing the aflatoxin build up (0.493 ppb) followed by sodium tripoly phosphate (2.13 ppb), *A. niger* (2.16 ppb) and calcium carbonate (6.30) over the control (inoculated) (9.11ppb) in hybrid HQPM1 at 11-12% grain moisture in six months storage.

In hybrid DHM117 sodium tripolyphosphate was the best by exhibiting minimum aflatoxin build up (1.10 ppb) followed by ammonium carbonate (1.98 ppb), *A. niger* (2.41) and calcium carbonate (6.93 ppb) as compared to untreated control 33.09 ppb at 11-12 % grain moisture range in six month 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*. Application for registration has

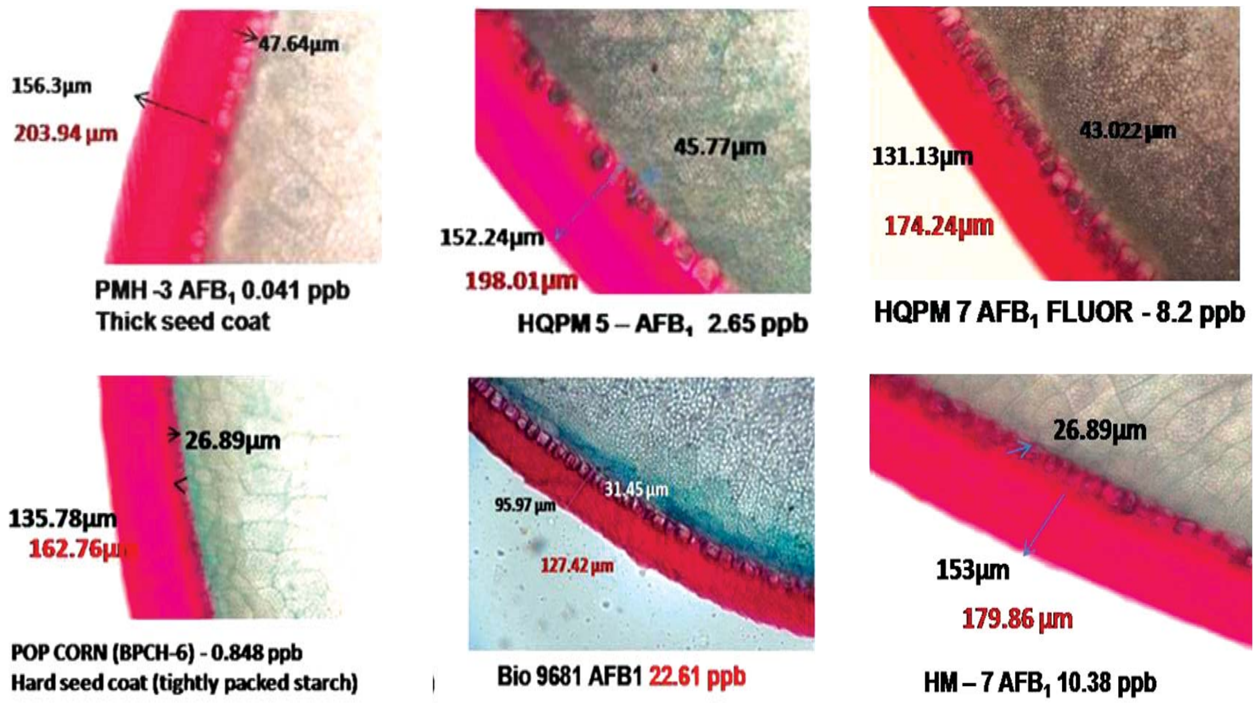


Figure 22. Morphological traits associated with resistant genotypes

been submitted and accession numbers 7204 and 7205 have been allotted to *T. asperellum* and *A. niger* by Indian Type Culture Collection, Identification/Culture Supply Services, Division of Plant Pathology, Indian Agricultural Research Institute, New Delhi – 110012

Morphological resistant traits

Morphological traits associated with resistant genotypes were identified as presence of thicker seed coat and aleurone layer as compared to susceptible genotypes (Figure 22). Genotypes PMH3 (203.94 µm), HQPM5 (198.01 µm), HM7 (179.86 µm) and BPCH6 (162.76 µm) exhibited less concentration of AFB$_1$ as the thickness of wall was more than 170 µm. Bio 9681 with thickness of wall – 127 µm exhibited high concentration (22.61 ppb) of AFB$_1$.

Identification of sources of resistance against Post Flowering Stalk Rot

A total of 51 inbred lines with diverse genetic background were evaluated at Delhi, Hyderabad, and Ludhiana for charcoal stalk rot and Udaipur for fusarium stalk rot (Figure 23). Out of them 22 lines were selected across the locations with disease score of <3.5 (1-9 rating scale). In total 10 PFSR resistant pools belonging to different maturity groups and grain types are being maintained and inbred lines from these pools are being extracted.

Identification of stable sources of resistance to major diseases of maize

A total of 113 elite lines were evaluated at identified hot spot locations under artificial inoculation condition (Table 11) were found promising. A high level of resistance to as many as 08 diseases has been developed. Based upon three years evaluation data (2010 to 2012), seventy seven lines were found resistant against one or more diseases (Table 12).

Biological control of maize pests

Field study was conducted to evaluate the efficacy of egg parasitoid *Trichogramma chilonis* (Ishii) against *Chilo partellus* and *Sesamia inferens*



Charcoal Stalk Rot **Fusarium Stalk Rot** **Resistant line**

Figure 23. Symptoms of Post Flowering Stalk Rot

Table 11. Total number of lines identified against important diseases

Disease	Number of lines identified
TLB	6
MLB	4
PFSR	21
Polysora rust	2
ESR	20
RDM	07
CLS	57
SDM	04

during *kharif* and *rabi*. Release of 2, 40,000 parasitoids of *T. chilonis* have been made on maize crop at 12 DAG. The plants infested by *Chilo partellus* was less (5.68%) in *T. chilonis* released plots compared to unreleased plots (14.15%). Total of 4, 80, 000 parasitoids of *T. chilonis* were released in an area of 8 acre of WNC maize fields at 12 DAG during *rabi* 2012-13. The plants infested by *Sesamia inferens* was less in *T. chilonis* released plots (14.52%) compared to unreleased plots (23.71%).

Management of *Sitophilus oryzae* (L.) and *Sitotroga cerealella* (Oliv.) infesting stored maize through Host Plant Resistance and plant origin pesticides

Laboratory study was conducted to determine the efficacy of medicinal plant powders against rice weevil *Sitophilus oryzae* (Coleoptera: Curculionidae) in stored maize. Three medicinal plants *Ageratum conyzoides* (L.) (Asteracea), *Cissus quadrangularis* L. (Vitaceae) and *Albezzia lebbeck* (L.) (Fabaceae) and one synthetic insecticide (Deltmethrin 2.5 WP @ 40 mg/Kg) along with three storage regimes (Aluminium foil bag, Jute bag and cloth bag) were tested for their effect on stored maize with respect to damage by *S. oryzae*. The results showed that medicinal plant powders @ 2% w/w and deltamethrin indicated highest mortality, reduced F_1 progeny emergence, lowest grain damage and grain weight loss compared to control at 40 and 80 days after treatment. Maize treated with *A. conyzoides* @ 2% w/w stored in Jute bag caused significantly higher per cent mortality (92.21) of S. *oryzae* at 15 days after

Table 12. Inbred lines exhibiting resistance against one or more diseases

Genotype	Resistant	Moderately resistant
Mas madu (*sh2sh2*)	BSDM	TLB, PFSR
Win sweet corn	BSDM	-
951-7	BSDM	PFSR
CUBA 380	BSDM	-
DMSC3	BSDM	MLB, PFSR
DMSC16-1	BSDM, MLB	-
DMSC-37-3	PFSR	-
HKI-PC-8-2-1	PFSR	-
WINPOP-3	CLS	-
WINPOP-21	BSDM	PFSR
HKI1040-5	CLS	PFSR, BSDM
ESM-11-3	BSDM	PFSR
PFSR/51016-1	BSDM, MLB	TLB, PFSR
Hyd05r/2-1	BSDM	MLB
Hyd05R/13-2	BSDM	-
LM12	BSDM	MLB
LM16	BSDM	MLB, PFSR
CM114	BSDM	TLB
CM121	PFSR	-
HKI C 78	BSDM	TLB, MLB, PFSR
HKI141-2	BSDM	-
HKI C 323	BSDM	TLB, PFSR
HKI1352-5-8-9	TLB, MLB,	-
Pool 16 BNSEQ. C3F6x38-1	BSDM,	TLB
ae-40	P. RUST	PFSR
CML141	TLB, MLB	-
CML 269	MLB	TLB, PFSR, BSDM
HKI34(1+2)-1	BSDM	PFSR
HKI164-7-4 ER-3	BSDM	MLB, TLB, PFSR
HKI164-4-(1-3)	BSDM	
HKI191-1-2-5	BSDM	MLB
HKI193-2-2-4	BSDM	PFSR
HKI193-1	BSDM, PFSR	TLB
CML172	BSDM, TLB, PFSR	MLB
HKI-MBR-139-2	BSDM, TLB	PFSR
CLQRCYQ47-B	BSDM, MLB	PFSR
CLQ-RCYQ30	BSDM, MLB	PFSR
CLQ-RCYQ36	BSDM, MLB	PFSR
CLQ-RCYQ41	BSDM, MLB	TLB, PFSR, P.RUST
02POOL 33 C24	BSDM	PFSR
PFSR-R2	BSDM	TLB, PFSR
PFSR-R3	TLB, MLB, PFSR	BSDM
PFSR-R9	MLB BSDM, RDM TLB, PFSR	ESR
PFSR-R10	BSDM, TLB, MLB, PFSR	-
PFSR-S2	BSDM, MLB	TLB, PFSR
PFSR-S3	MLB, BSDM, TLB	PFSR, RDM
JCY2-1-2-1-1B-1-2-3-1-1	BSDM, TLB, MLB, PFSR	RDM
JCY2-7-1-2-1-B-1-2-1-1	BSDM, MLB, PFSR	TLB
CM 117-3-4-1-2-2-1	BSDM, MLB, PFSR	TLB, RDM
CM 117-3-4-1-1-4-1	MLB, PFSR	TLB
CM 117-3-4-1-2-3-1	MLB	PFSR
42048-2-2-1-1-1-2	BSDM, MLB, PFSR	-
SW-93D-313-23-POP.49-S4-1	BSDM	TLB, MLB, PFSR
JCY3-7-1-2-1-B-2-3-2-1-3-1	BSDM	-
JCY2-2-4-1-1-1-3-PFSR, 1-3-1	BSDM	TLB, MLB, RDM
42050-1-1-2-1-3	TLB, MLB, PFSR	-
JCY3-7-1-2-1-B-1-1-2-3-1-1	BSDM, MLB, PFSR	TLB
CM117-3-4-1-2-5-2	PFSR,	MLB
JCY3-7-1-2-2-1-3-1-1-2-7-1-1-1	TLB, MLB, PFSR	-
LM13	TLB, MLB, PFSR	-
CM117-3-4-1-2-2-3	BSDM TLB, MLB, PFSR	-
JCY3-7-1-2-1-B-2-1-2-1	BSDM, PFSR, RDM	-
LTP4	BSDM, MLB, PFSR	-

BLSB-Banded leaf and sheath blight; BSDM-Brown stripe downy mildew; ESR-Erwinia stalk rot; MLB-Maydis leaf blight; PFSR- Post Flowering stalk rots; RDM-Rajasthan downy mildew; SDM – Sorghum downy mildew; TLB-Turcicum leaf blight treatment next to synthetic pesticide deltamethrin (100.00).

Inheritance study of pink borer resistance

The biometrical analysis in the form generation means analysis (GMA) was done using six parameter model. The resistant and susceptible parents differed significantly with respect to Stem and Leaf Injury Rate (SLIR) and two F_1 cross combinations (CM202 X CML 287, CML451 X CM202) have shown over dominance. Cross combination, CML451 X CM202 is a cross involving two susceptible lines but it has shown over dominance with respect to yield was positive, whereas for LIR and egg load was negative. This proves that even a cross between susceptible inbred lines can also give moderately tolerant phenotypes depending on gene(s) combinations they carry. The type of gene action involved for determination of Stem and Leaf Injury Rate was estimated through generation means analysis. The results suggest that the significance of scaling test indicates the presence of all type of gene interactions. In general dominance, additive x additive and additive type of gene interactions contribute largely to SLIR with gradual decreasing magnitude respectively. The direction of contribution is negative indicating that these three gene actions (dominance, additive x additive and additive) actually impart resistance mechanism. However, the other two types of gene actions namely additive x dominance and dominance x dominance also contributes for LIR but positively, which suggests that, these two (additive x dominance and dominance x dominance) types of gene actions actually contributes to susceptibility.

Unlike SLIR, gene action for egg load on plant does not indicate any specific type of gene actions. It is highly unlikely that any one kind of gene action will determine the egg load on plants/seedlings because, it is a mixed type of gene actions which includes all types of gene actions both positive and negative and differ depending on the cross combinations involved. Therefore based on the results obtained it is very difficult to pin point that any specific kinds of gene action is involved.

Upscaling 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 programme and exhibitions. DMR is looking after planning, implementation, monitoring, evaluation and reporting extension activities such as front line demonstrations.

Dissemination and utilization of maize information

Maize AGRI*daksh* provides expert agricultural advice to the farmers in a timely and personalized manner. The agricultural experts generate advice by using the available agricultural technology and latest information related to the maize through internet in the form of both text and images. Presently, it has four subsystems: variety selection, cultural practices, disease diagnosis, insect identification, and post harvest technology. The variety selection subsystem advises location specific varieties whereas cultural practices advise on aspects of irrigation, application of chemical and the overall package of practices. Disease diagnosis and insect identification subsystems help the stake-holders to diagnose the disease and insects affecting the maize crop thereby suggesting preventive and control measures. Post harvest technology subsystem deals with storage and processing of maize for developing value added products.

Organising Trainings/Workshops/Demonstrations/Field days

DMR has conducted several programme to cater the extension, training and technology needs of farmers living in different geographical locations, scientists and other related officers (Annexure 9). Participants acquired knowledge and skill about cultivation of *kharif* maize, *rabi* maize, quality protein maize, baby corn, sweet corn, popcorn, intercropping, seed production, value addition and industrial utilization.

Project Director interacting with farmers

Tribal Sub Plan (TSP) is a programme funded by Government of India to uplift the economic condition of tribal farmers. This plan lays emphasis on the integrated development of the tribal areas and communities. DMR is implementing TSP across the various tribal belts of the country from 2011 onwards. DMR provides skill oriented trainings and demonstrations in hybrid maize production and post-harvest maize technologies at national and

Officers training programme at Banswara (Rajasthan)

regional levels involving AICRP centres (Annexure 9). DMR conducted seven national level training programmes at head quarter. 229 participants from various states *viz*., Madhya Pradesh, Andhra Pradesh, Assam, Rajasthan, Sikkim *etc*. attended the programme. Under TSP Scheme, location specific and need-based maize technologies were supported at regional level for socio-economic upliftment of tribal communities. More than 2000 farmers especially from North eastern India and Jammu and Kashmir reaped the benefits from thirteen regional level trainings. AICRP centres (Jammu and Varanasi) were also active in conducting a total of five awareness cum training programmes in their tribal belts and benefited 300 farmers. Hybrid seed, fertilizer, pesticides, maize shellers, weeders, sprayers, seed storage bins and booklets *etc*. on maize were distributed to 1169 farmers by DMR and AICRP centres.

Demonstrations have one of the most powerful tools for proving the worth of the technology, since the result itself tells about it. DMR has been involved in conducting demonstrations at the farmer's field. For the past few years these have been intensified as a result DMR and its AICRP centres conducted 973 demonstrations in various states at tribal farmer's field. Each demonstration was conducted in one acre of land using public sector hybrids. The average yield was 6105.58 kg/ha in *rabi* 2011-12 and 4752.95 kg/ha in *kharif* 2011-12 demonstrations. The national yield of maize is 3765 kg/ha and 2234 kg/ha in *rabi* 2011-12 and *kharif* 2012 respectively.

Seed distribution in Uttar Pradesh

Distribution of sprayers in Andhra Pradesh

Seed distribution in Jhabua, Madhya Pradesh

Distribution of power operated sheller and storage bins in Jammu & Kashmir

Insecticide distribution in Gwalior, Madhya Pradesh

Distribution of inputs

Regional training in Ambikapur and Banswara

Frontline demonstrations (FLDs) have emerged as effective transfer of technology tools for promoting applicability and profitability of the recommended technology with the cooperation and participation of the farmers and under the personal guidance of the scientists /or extension personnel. Demonstrations of the productive potential of newly released hybrids/ technologies in farmer's conditions are carried out. Keeping this in view a total of 8515 frontline

Demonstrations in North East and Andhra Pradesh

India International Trade Fair (IITF), Pragati Maidan, New Delhi (14 – 27 November, 2012)

Second Association of South East Asian Nations-India Ministerial meeting on Agriculture, NASC, New Delhi (17-19 October, 2012)

demonstrations (FLDs) comprising 2664 in *rabi;* 788 in *spring* and 5063 in *kharif* were conducted in coordination with DMR. These demonstrations were laid out in twenty three states by forty eight centres /agencies/NGOs. An average grain yield of 5074 kg/ha was recorded with an increase of 104.76 % over national maize yield.

Field days provide the forum for getting rich learning experience by large groups of farmers visiting demonetization plots and interacting with scientists. A series of six general field days covering many single cross hybrids, specialty corn, and maize production technology oriented field days were organized periodically by DMR and its AICRP centres. Villages Aterna and Manauli in Haryana were visited for demonstration of baby corn and sweet corn cultivation.

DMR has been organising *Kisan Melas* and exhibitions at institute as well as the various national and international platforms. Nine such events were held.

DMR organized Farm Innovators Day on 10th October, 2012. Twenty five progressive farmers took part in Farm Innovators Day. In the Agricultural Education Day celebration at DMR on 12th October, 2012 thirty students from Government Boys Senior Secondary School, IARI, Pusa Campus, New Delhi participated the event.

Farm Innovators Day (10 October, 2012)

Agricultural Education Day (12 October, 2012)

All India Coordinated Research Project

All India Coordinated Research Project (AICRP)

All India Coordinated Research Project (AICRP) on maize was launched in 1957 with the objective to develop and disseminate superior cultivars and production/protection technologies. AICRP on Maize is the 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 23) constituting 29 centres (Table 13) 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 13. Locations and soil characteristics of the various AICRP Maize Research Centres

Zone	States	Centres	Latitude	Longitude	Altitude (masl)	Soil Type
Zone 1	Himachal Pradesh	CSK, HPKV, Bajaura	33°22' N	77°0' E	1090	Grey wooded Podzolic soil
		HPKVV, Dhaulakuan	30° 30' N	77° 20' E	468.0	Brown alluvial and grey brown podzolic soil
		CSK, HPKV, 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 Agrucltural 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

Zone	States	Centres	Latitude	Longitude	Altitude (masl)	Soil Type
	Uttarakhand	G B Pant Agricultural University, Pantnagar	29°6' N	79°30' E	243	Clay loam
Zone III	Bihar	Rajendra Agricultural University, Dholi	25°54' N	85°36' E	51.8	Sandy loam
	Jharkhand	Bisra Agricultural University, Ranchi	23°21' N	85°20' E	652	Sandy loam
	Orissa	Orissa University of Agricultural 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
		UAS, 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

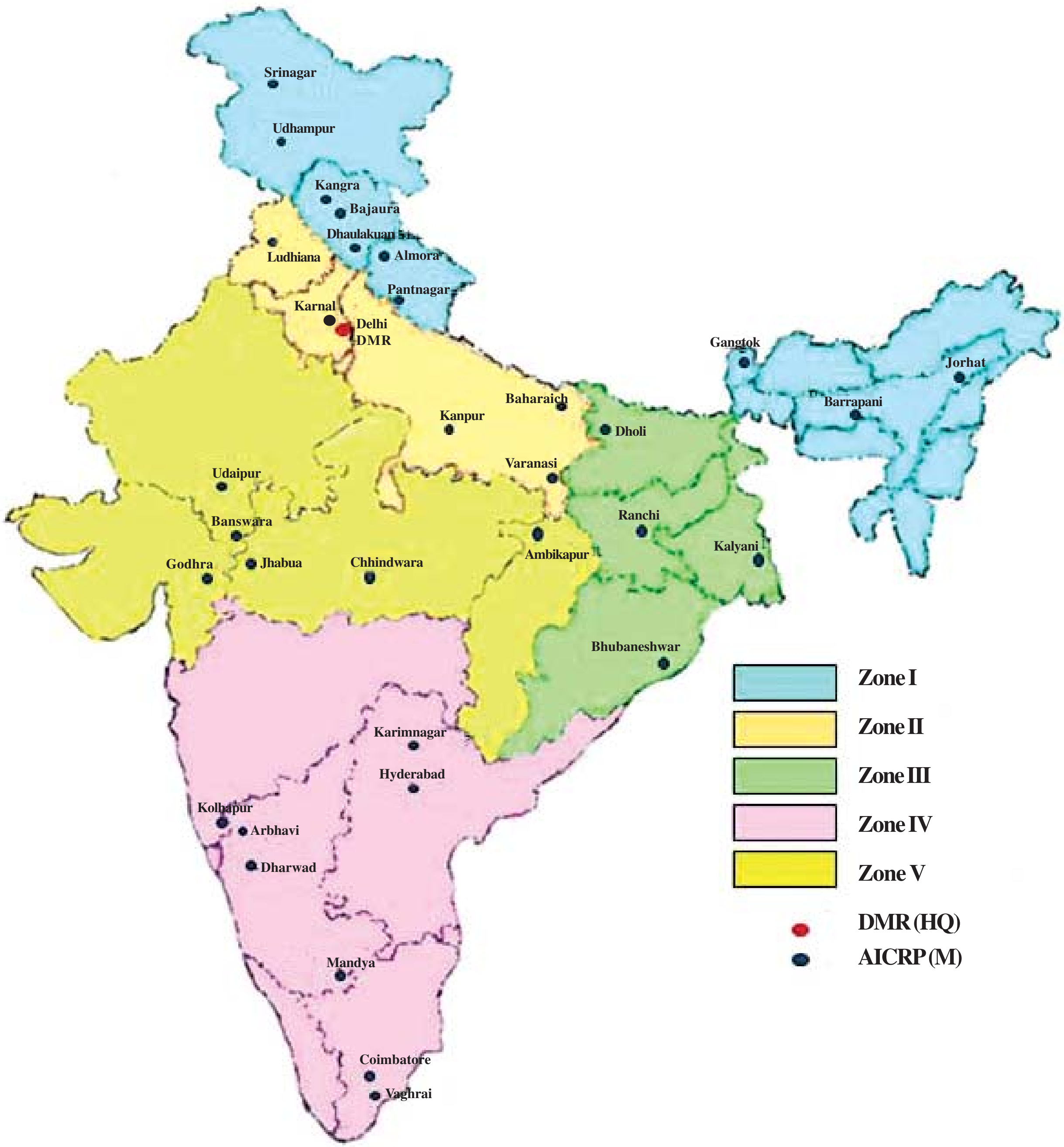


Figure 23. Zones and centres of AICRP (Maize)

Breeding

Evaluation of new experimental cultivars

A total of 275 entries were received during *kharif*, for evaluation in coordinated trials. Of these, 136 entries were contributed by public sector and 139 from private sector. All the entries were evaluated in 16 different breeding trials at 29 locations across the country using 20 checks of different maturity groups (Table 14).

In *rabi*, a total of 122 entries were received for evaluation in coordinated trials. Out of them 56 entries from public and 66 from private sector were received. All the entries were evaluated in 09 different breeding trials at 19 locations across the country using 10 checks of different maturity groups (Table 15).

Release of new hybrids

Nineteen hybrids of maize were released by Central Sub Committee on Crop Standard and Notification of Varieties for different agro-climatic conditions of the country. Of these, ten are medium-maturing, seven are late-maturing and two are extra-early maturing hybrids (Annexure 1). While eighteen hybrids were identified during 55th Annual Maize Workshop (Annexure 2).

Table 14. Number of public/private maize hybrids received for testing under *kharif* AICRP Trial

	Initial Evaluation Trial (IET)			
	Late Maturity	**Medium Maturity**	**Early Maturity**	**Extra Early Maturity**
Public	14	39	24	16
Private	45	29	2	0
Checks	5	5	2	2
Total	64	73	28	18
	Advance Evaluation Trial-I (AET-I)			
	Late Maturity	**Medium Maturity**	**Early Maturity**	**Extra Early Maturity**
Public	4	3	3	6
Private	22	5	3	0
Checks	4	2	2	2
Total	30	10	8	8
	Advance Evaluation Trial-II (AET-II)			
	Late Maturity	**Medium Maturity**	**Early Maturity**	**Extra Early Maturity**
Public	1	7	3	2
Private	6	18	4	1
Checks	4	2	2	2
Total	11	27	9	5
	Specialty Corns Trials			
	QPM 1, 2, 3	**Sweet Corn 1, 2, 3**	**Pop Corn-1**	**Baby corn-1**
Public	7	4	2	1
Private	0	4	0	0
Checks	4	1	1	1
Total	11	9	3	2

Table 15. Number of public/private maize hybrids received for testing under *rabi* 2011-12 AICRP Trial

	Initial Evaluation Trial (IET)		
	Late Maturity	**Medium Maturity**	**Early Maturity**
Public	16	13	9
Private	28	9	1
Checks	3	3	1
Total	47	25	11
	Advance Evaluation Trial-I (AET-I)		
	Late Maturity	**Medium Maturity**	**Early Maturity**
Public	1	8	2
Private	14	1	0
Checks	3	3	2
Total	18	12	5
	Advance Evaluation Trial-II (AET-II)		
	Late Maturity	**Medium Maturity**	**Early Maturity**
Public	2	0	NA
Private	11	2	NA
Checks	3	3	NA
Total	16	5	NA
	QPM1-2	**SC 1-2-3/PC 1-2-3/BC 1-2-3/Extra early maturity**	
Public	5	No trials were conducted for Extra early, sweet corn, popcorn and baby corn during *rabi* season	
Private	0		
Checks	3		
Total	8		

Agronomy

Evaluation of pre-release genotypes under varying nutrient levels

Forty one genotypes of different maturity groups were evaluated under three nutrient levels *i.e.* 100:40:30, 150:50:40 and 200:60:50 kg/ha N: P_2O_5: K_2O for medium, early and extra early maturity while for late maturity group the nutrient levels were 150:50:40, 200:65:50, 250:80:60 at all 22 centres of different zones. In general, late maturity genotypes responded up to 150:50:40 kg/ha N: P_2O_5: K_2O level at 2 locations, 200:65:50 at eight locations and 250:80:60 at seven locations. Similarly the response of medium maturity genotypes was recorded up to 100:40:30, 150:50:40 and 200:60:50 kg/ha at 1, 7 and 11 locations, respectively. The early maturing genotypes responded up to 150:50:40 Kg/ha N: P_2O_5: K_2O at seven locations and 200:60:50 at six locations. In extra early maturity genotypes, the response to different N, P_2O_5 and K_2O level was recorded up to 150:50:40 kg/ha at three locations and 200:60:50 kg/ha at four locations.

Evaluation of plant density, intercropping and residue management in maize under rain-fed conditions

Paired row planting (84:50cm) produced significantly higher yield of maize compared to uniform row planting (67cm) at Ambikapur, Kolhapur, Banswara and Udaipur. Similarly, residue retention as mulch @ 5t/ha, found beneficial at Ambikapur, Bajaura, Udhampur, Ranchi, Karimnagar and Banswara. The improvement in maize yield was found with intercropping of green gram compared to cowpea at Karimnagar and black gram compared to soybean at Banswara. Increasing planting density upto 83,333 plants/ha significantly improved the maize yield at Bajaura, Srinagar and Udaipur over 60,000 plants/ha.

Drip irrigation and nitrogen fertigation in sweet corn

Irrigation and nitrogen management through drip in sweet corn hybrid was evaluated at Hyderabad during *rabi* 2012-13 and significant increase in yield to the tune of 12.8, 32.6, 58.4 and 66.2% was obtained with drip irrigation at 60% Epan, 80% Epan, 100% Epan and 120% Epan over conventional surface irrigation, respectively (Figure 24). The net return increased from Rs19489 (Conventional surface irrigation) to Rs 57266 in 120 % Epan irrigation through drip irrigation. A significant interaction between drip irrigation and nitrogen fertigation @ 200 kg/ha was observed with 100% Epan which was statistically at par with 240 kg N/ha with 120% Epan drip treatment.

Sweet corn performance under drip irrigation and nitrogen fertigation levels

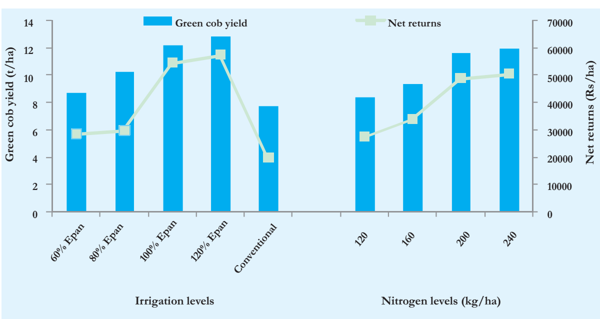


Figure 24. Influence of drip irrigation and nitrogen fertigation levels on yield and economics of sweet corn

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

Pre-emergence application of Metribuzin @ 0.25 kg/ha was found the most effective weed management treatment at Kangra (6.5 t/ha). While, at Srinagar (6.5 t/ha), Pantnagar (3.4 t/ha), Ranchi (5.5 t/ha), Arbhavi (9.2 t/ha), Jhabua (4.1 t/ha) and Udaipur (4.0 t/ha), atrazine application @1.0 kg/ha as pre-emergence was found the best treatment in controlling the weed flora and getting highest yield of maize. At Karnal, organic mulch @ 6t/ha as cover crop (cowpea in two rows) was found to be the most effective in controlling the weeds, comparable to two hand weeding.

Nutrient management in maize systems under different tillage practices

In maize-wheat-greengram cropping system, permanent bed planting with site specific nutrient management (SSNM) proved to be the best practise in maize at Pantnagar (3.0 t/ha), Udaipur (6.7 t/ha) and Banswara (5.8 t/ha). However, at Karnal 100% of recommended dose of fertilizer (RDF) yielded (6.6 t/ha) more than SSNM (6.2 t/ha) and 50% of RDF (3.8 t/ha). In maize-chickpea cropping system, permanent bed planting produced the highest yield of maize compared to zero and conventional tillage practises at Banswara (3.6 t/ha) and Chhindwara (6.5 t/ha). Regarding nutrient management, SSNM proved superior over both 50 and 100% of RDF. However, in rice-maize cropping system at Dholi conventional tillage gave the highest yield of rice (4.4 t/ha), which was statistically on par with bed planting and superior over zero tillage.

Tillage, residue management and mulching in maize systems

The maximum yield of maize (5.03 t/ha) was recorded under zero tillage in maize-wheat cropping system at Udaipur, which was significantly higher over bed planting and conventional tillage. Residue management recorded 8.3% higher yield over without residue management. However, at Srinagar, among the tillage practices, conventional tillage was superior over zero tillage.

Development of agro-techniques for single cross hybrid seed production

The female and male plant row ratio of 4:1(5.0 t/ha) was found significantly superior over 3:1 row ratio (4.2 t/ha). Similarly, reducing plant spacing from 60 x 25 to 60 x 20 cm with the application of 250N: 90 P_2O_5: 90K_2O kg/ha and 200 N: 75 P_2O_5: 75 K_2O kg/ha and 15t/ha FYM significantly improved the seed yield.

Pathology

Survey and surveillance

Extensive surveys were conducted under survey and surveillance programme in maize growing areas of Rajasthan, Andhra Pradesh, Karnataka and Tamil Nadu during the year. The most common diseases from the areas were Turcicum leaf blight (TLB) in Karnataka, Banded leaf and sheath blight (BLSB) in Rajasthan. This year Curvularia leaf spot (CLS) has shown widespread occurrence in Rajasthan as compare to its moderate occurrence last year. TLB and Charcoal rot were prevalent in Andhra Pradesh. The most common diseases from Tamil Nadu were Sorghum downy mildew (SDM) followed by TLB. Polysora rust and CLS are emerging as a potential threat in Karnataka and Rajasthan respectively. Based on the survey surveillance, the disease map was updated (Figure 25).

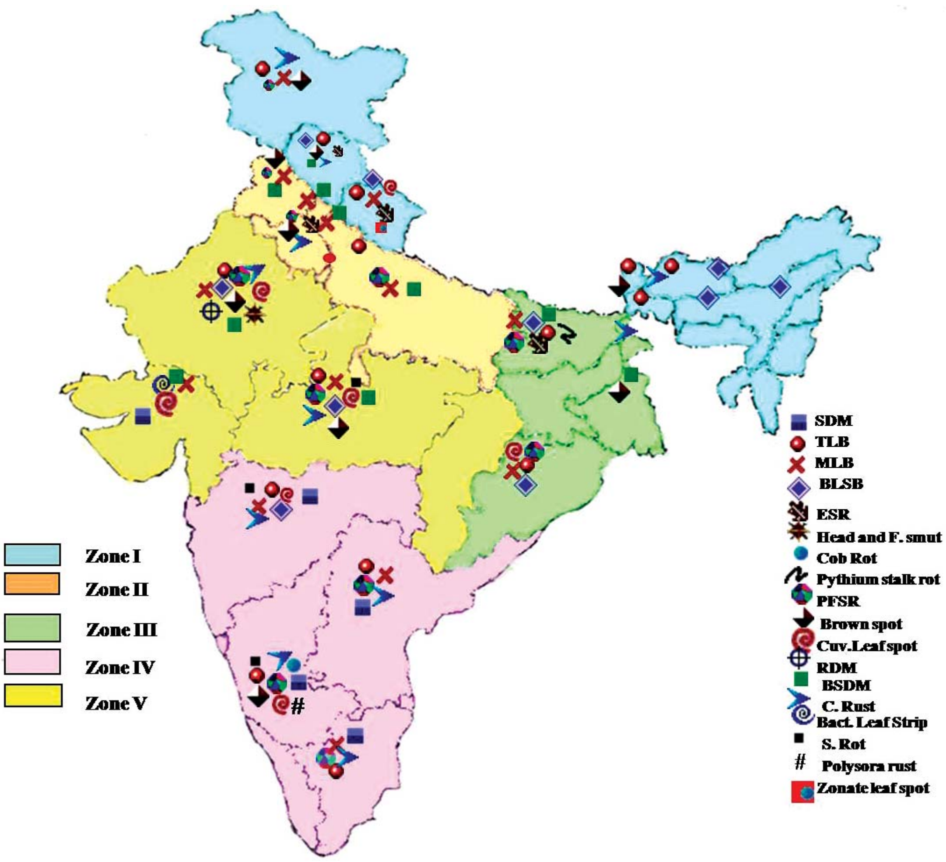


Figure 25. Disease distribution map of India based on survey surveillance 2012

A total of 293 maize genotypes and 39 specialty corn in nine different trials comprising of various maturity groups were evaluated against major disease of maize *viz*, 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), Post-flowering stalk rots (PFSR), Common rust (C. Rust), Polysora rust (P. Rust) and Erwinia stalk rot (ESR). The Curvularia Leaf Spot (CLS) was screened only in IET (late, medium, early, extra early maturity) genotypes. Evaluation of these genotypes was carried out under artificially inoculated conditions in the various hot spots located in different agro climatic zones of the country. The most promising genotypes (Table 16) with combined resistance to various diseases are:

Table 16. Promising genotypes with combined resistance

Diseases	Number of entries tested	Maturity groups	Number of entries identified	Promising entries with multiple diseases resistance
MLB, ESR, CLS	64	IET (Late maturity)	44	AMH477
MLB, ESR				Bisco X 4296
MLB, TLB, P.RUST				DADA
PFSR, P.RUST				KDMH4086
MLB, TLB				KMH510
TLB, PFSR, P.RUST				NMH3493
MLB, RDM, CLS				Rasi863
PFSR, P.RUST				LTH20
ESR, , P.RUST, CLS				X35B396
SDM, RDM, DM, PFSR				JH31601
MLB, TLB, PFSR				CMH10-546
MLB, P.RUST				REH2011-06
MLB, C.RUST	75	IET (Medium Maturity)	45	FMH603
MLB, C.RUST, P.RUST				Rasi3033
MLB, RDM, C.RUST				NMH1281
RDM, P.RUST				NMH1588
MLB, TLB, RDM, P.RUST				JKMH4511
MLB, CLS				KMH7148
PFSR, RDM				EHL2211
MLB, PFSR, RDM, CLS				PRO387
RDM, C.RUST, P.RUST				X35B403
RDM, PFSR, C.RUST				CMH10-529
MLB, P. RUST	32	IET (EarlyMaturity)	17	KMH7021
MLB, PFSR				FH3605

Diseases	Number of entries tested	Maturity groups	Number of entries identified	Promising entries with multiple diseases resistance
PFSR, ESR, P. RUST, C.RUST				CMH10-537
MLB, ESR, P. RUST,C. RUST				CMH10-484
MLB, RDM, PFSR, P. RUST				CMH10-527
MLB, PFSR, ESR				CMH10-531
PFSR, P. RUST, C. RUST				BIO6008
PFSR, C. RUST, P. RUST	18	IET (Extra early maturity)	8	REH2011-7
MLB, PFSR, C.RUST	40	AET (Late maturity)	27	CMH08-381
TLB, PFSR, P.RUST				CP333
MLB, P.RUST				DASMH-102
TLB, RDM				DMH7705
MLB, RDM, ESR,C.RUST, P.RUST				MCH45
MLB, RDM, PFSR, P.RUST				MCH46
MLB, P.RUST				NMH1247
RDM, PFSR, ESR,C.RUST, P.RUST				P4546
PFSR, P.RUST, C.RUST	38	AET (Medium maturity)	25	B53
PFSR, P.RUST, C.RUST				JH31470
MLB, TLB				PRO383
MLB, RDM, P.RUST, C.RUST				CMH08-350
P.RUST, C.RUST				IMH666
RDM, P.RUST, C.RUST				KNMH401061
RDM, P.RUST, C.RUST				S6217
MLB, TLB, P.RUST, C.RUST				VMH4106
TLB, PRSR, P.RUST, C.RUST	15	AET (EarlyMaturity)	05	CMH10-525
MLB, RDM, P.RUST, C.RUST				FH3513
MLB, RDM, P.RUST, C.RUST				KDMH755
TLB, PFSR, P.RUST, C.RUST				REH2009-12
TLB, P.RUST, C.RUST	11	AET (Extra EarlyMaturity)	05	FH3555
MLB, P.RUST, C.RUST				FH3556
DM, RDM				FH3510
MLB, PFSR				FH3525

Assessment of yield losses due to various diseases of maize

Assessment of yield losses due to TLB, MLB, BLSB and SDM diseases of maize was conducted at Arabhavi, Delhi, Pantnagar, and Coimbatore for PFSR (Charcoal rot) at Delhi and Hyderabad using paired plot technique, under artificial inoculation conditions. The extent of losses due to important diseases is given in Table 17.

A total of 84 maize genotypes were evaluated during *rabi*. The details of promising genotype identified, are given in Table 18.

Out of 200 elite lines screened, 17 lines were resistant to PFSR and 48 lines to TLB.

Nematology

293 maize entries in different maturity groups were screened against cyst nematode, *Heterodera zeae*. Maize entries *viz.* KDMH 4086, X35B396, JH 31555, Meghan-G, CMH 10-473, CMH 10-485, REH 2011-1, CMH-10-527 and REH 2011-8 exhibited moderately resistant reaction to *H. zeae*.

Survey results showed that maximum nematode population (16.42 cyst/plant, 12.92 cyst/100 cc soil and 460.83 larvae/100 cc soil) was observed in samples from Rajsamand district with occurrence of 70.59% while minimum nematode population (9.00 cyst/plant, 7.25 cyst/100 cc soil and 282.50 larvae/100 cc soil) was

Table 17. Extent of losses due to important diseases

Genotype	Location	Disease	Disease score (AV)		Yield Kg/ha		Yield losses (%)
			P	NP	P	NP	
HQPM7	Delhi	MLB	2.4	2.8	4102	3582	12.67
Local	Dhaula.	MLB	26.8*	66.4*	2503	1255	49.86
DMH 2	Arabhavi	TLB	2.0	3.0	6866	5750	19.40
EHEH434042	Arabhavi	TLB	1.5	3.2	7060	6670	5.85
Bio9681	Arabhavi	TLB	2.4	3.5	6470	5242	23.43
Gaurav	Pant Nagar	BLSB	2.3	4.5	3694	2420	34.48
QPM 9	Delhi	BLSB	2.8	3.7	4597	3938	14.33
CP 818	Mandya	SDM	0.00	100.0	5381	000	100.0
PMH1	Ludhiana	C. Rot	3.7	4.7	7999	7110	11.1
Vivek hybrid 9	Delhi	C. Rot	2.3	4.6	6059	4843	20.07
30V92	Hyd.	C. Rot	2.8	3.9	8433	6688	20.68

* Disease Index; P – Protected; N P – Non Protected

Table 18. Promising genotype during Rabi

Disease	Resistant entries	Promising entries
TLB	28	CMH08-239, CMH08-287, NMH713, HKH402, HTMH5105, X35B349
PFSR	25	DMRNH 2, PRO379, S7720, BIO151, Biscox5141, KH B 54, JH367
PFSR & TLB		CMH08-239, CMH08-287, RJMH2, PRO380, JH289

obtained from Ajmer with 57.14% occurrence. Over all the occurrence of maize cyst nematode, *H. zeae* was 64.15% in maize growing areas of Rajasthan.

Entomology

Four trials comprising 104 entries from different maturity groups were evaluated for resistance against *Chilo partellus* under artificial infested condition at seven locations. The following entries were identified on the basis of leaf injury rating (LIR) (Table 19).

Table 19. Promising genotypes

Late Maturity	A7501, BIO562, M9977, NMH 713, X35A176
Medium Maturity	B63, Bio688, CMH08-350, CMH08-433, EC3161, IMH 666, JH31404, JKMH7004, KDMH176, PFMH96 I41, PFMH96, N46, S6217, VMH4106, X35A173, Yuvraj Gold
Early Maturity	FH 3513, KDMH 755
Extra Early Maturity	FH 3525, FH 3510

Screening of inbred lines against stem borer, Chilo partellus

A total of 212 inbred lines were evaluated for resistance against *C. partillus* among which CML261, CML152 and CML59 entries were found least susceptible, moderately susceptible and highly susceptible respectively.

Study on oviposition behaviour of Sesamia inferens

Study was conducted to supplement/ complement evaluation of germplasm for resistance under artificial infestation on 20 germplasm. It was observed that different germplasm are statistically different for their attraction by *S. inferens* females for oviposition. Further, it was also found that twelve days old maize plants attracted maximum number of eggs.

Determination of relationship between leaf injury rating and grain yield

A significant yield reduction with increase of LIR was observed. This information can be used for crop loss assessment. Assessment of crop loss caused by *C. partellus* was calculated using the formula

$$\text{Percent loss} = \left\{\frac{\left(\frac{\text{Yield loss}}{\text{sample size}}\right)}{\text{Yieldof LIR 1}}\right\} = 100\left\{\frac{\Sigma(fi*xi)}{\Sigma fi}\right\}/y$$

where, fi = frequency of plants with LIR (2-9)

xi = crop loss (%) at LIR (2-9)

y = yield of LIR (1)

Economic loss = Percent loss x Yield potential x Market rate of maize

During *rabi,* a total of 212 inbred lines along with one susceptible and resistant check were evaluated against *S. inferens* by releasing 10-12 neonate larvae on 12 day old plants. LIR was recorded thirty days after infestation. Out of them two genotypes *viz.*, WNZPBTL5 (2.17) and WNZPBTL9 (2.11) recorded LIR less than resistant check CM500 (2.60) and thirty three recorded LIR between 2.6 and 5.0. One hundred fifty six genotypes recorded LIR between 5.01 and susceptible check CML451 (7.60). Twenty one genotypes recorded LIR more than the susceptible check CML451 (7.60). A total of 212 lines were screened during *kharif* under artificial infestation against *C. partellus* out of them selected inbred lines *viz.*, WNZEXOTIC POOL1 Ä, AEBYC555-1-1, E60 FC, WNZPBTL8, AEBY1, PFSR5106/1, AEBY2Ä, AEBCYC534-3-1, WINPOP8, WNZPBTL5, CM501, AEBY2 SELECTION, HKI484-5, CML261, E62FC, PFSRS3, LM16 recorded LIR less than resistant check CM500 (LIR 2.8).

Significant Events

Annual Maize Workshop

The 55th Annual Maize Workshop was held at the Chaudhary Charan Singh, Haryana Agricultural University (CCSHAU), Hisar, during 20-22 April, 2012. It was inaugurated by Dr. R.S. Paroda, Chairman, Haryana Kisan Ayog. The occasion was also graced by dignitaries Dr. S.K. Datta (Deputy Director General, Crop Science), Dr. K.S. Khokhar (Vice Chancellor, CCSHAU),

Inauguration of Maize Workshop

Felicitation of Dr. Sain Dass

Release of Maize Journal

Felicitation of Dr. N.N. Singh

Chairman addressing Maize Workshop

Glimpses of Maize Workshop

Dr. R.P. Dua (ADG, FFC), Dr. S.K. Vasal, World Food Prize recipient and former distinguished scientist CIMMYT, Dr. N.N. Singh (Former Project Director, DMR and former Vice Chancellor, Birsa Agricultural University, Ranchi), Dr. Sain Dass (Former Project Director, DMR, President IMDA and Advisor Hybrid Crops, National Seed Corporation), Dr. R.S. Balyan (Project Director CCSHAU, Hisar) and Dr. R. Sai Kumar (Project Director, DMR). The address of chief guest Dr. R.S. Paroda was focussed on productivity enhancement through hybrid breeding and channelizing efforts to achieve 40 million tonnes production in next five years. In the Presidential address, Dr. S.K. Datta highlighted the need of basic and strategic research in the present maize scenario. He emphasized on the exploitation of tremendous variability present in maize genome.

'Maize Journal' exclusively devoted to publish maize research was released.

Quinnquennial Review team (QRT) Meeting

Quinnquennial review (2006-2010) of DMR was organized under the chairmanship of Dr. R. R. Hanchinal, Vice Chancellor, UAS, Dharwad with Dr. N. S. Malhi, Dr. R. K. Malik, Dr. K. T. Pandurange Gowda, Dr. S. J. Rehman, Dr. M. C. Wali and Dr. R. Sai Kumar as members and Dr. P. Kumar as Member Secretary. The team visited different AICRP (Maize) centres and reviewed the progress made during the past five years. The members were impressed with the growth of maize in India and attributed its success to the deployment of hybrid technology.

Quinnquennial Review Team meeting

Research Advisory Committee (RAC)

Research Advisory meeting of DMR was held on 3 June, 2012 under the chairmanship of Dr. B. S. Dhillon, Vice Chancellor, PAU, Ludhiana. The Chairman addressed the scientists and congratulated them for publishing technical bulletins covering wide topics of maize and the Maize Journal. He apprised the scientists of the challenges that Indian agriculture is facing and the role of maize in food security. He also underlined the importance of maize based agro-industries and mentioned the challenges and opportunities due to climate change. Dr. R. Sai Kumar, Project Director presented the overview of significant research achievements of the Directorate. Research highlights of the work done during 2011-12 were presented by the Principal Investigators of respective disciplines. The committee appreciated the ongoing research work.

Research Advisory Committee meeting

Institutional Research Council (IRC)

Institute Research Council meeting of DMR under the chairmanship of Dr. R. Sai Kumar, Project Director was conducted on the 18th June, 2012. Dr. R Sai Kumar welcomed the experts and the participants and presented an overview of maize research in India. Scientists of DMR presented the significant achievements of their respective *in house* projects and work plan. Six new projects were proposed and approved. The experts put forth their valuable suggestions to improve the projects.

Institutional Research Council meeting

Institute Management Committee (IMC) Meeting

The fourth meeting of IMC was held on 11th July, 2012 at Directorate of Maize Research, New Delhi under the chairmanship of Project Director, DMR. The team comprised of Drs. A. P. Saini, P. S. Sabharwal, P. Kumar, Pratibha Sharma, S. Venila and Mohan Singh as members and Shri. A. K. Mathur. At the out-set, the chairman welcomed all the members and presented the annual progress report of the directorate; the member-secretary presented information on utilization of non - plan, plan as well as AICRP fund budget for the year 2011-12. Various administrative as well as research issues were discussed. The members expressed satisfaction over the achievements made and hoped the trend to continue in future as well.

Institutional Bio Safety Committee (IBSC)

IBSC meetings were held on 9 July, 2012 and 9 January, 2013 at DMR for discussion on the bio safety aspects of the ongoing and forthcoming projects of DMR. IBSC was briefed on the biosafety measures being adopted in different laboratories/projects. The undergoing projects have no biosafety issues except use of ethidium bromide which is disposed in the IARI disposal facility. The IBSC committee members discussed on this issue and they were satisfied by the Directorate functioning in compliance with IBSC guidelines. The members visited biotechnology and entomology laboratories and green house facility.

Institutional Technology Management Unit (ITMU) Committee

At DMR, ITMU is established to take care of all the cases/ procedures related to Intellectual Property (IP) as per ICAR guidelines for Intellectual Property Management and Technology transfer/Commercialization. The ITMU meetings were held on 28 August 2012, 11 December 2012 and 23 January 2013 for discussing issues on share benefits of consultant scientist in the project baseline susceptibility as well as in commercialized technologies for scrutinizing the MoU with syngenta and for laboratory test on maize samples suitable for starch industry, Mott MacDonald Pvt. Ltd., respectively.

Result Frame Document (RFD) meeting

A one day meeting on "Action Points & Success Indicators for RFD 2013-2014" of Crop Science Division Institutes of ICAR was organized at DMR, New Delhi on 14 January, 2013.

मक्का अनुसंधान निदेशालय में हिन्दी पखवाड़ा के समापन समारोह का आयोजन

- मक्का अनुसंधान निदेशालय में 14–28 सितम्बर, 2012 तक मनाए गए हिन्दी पखवाड़े का 11 अक्तूबर, 2012 को समापन समारोह का आयोजन किया गया। समापन समारोह की अध्यक्षता करते हुए परियोजना निदेशक ने हिन्दी को बढ़ावा देने के लिए सभी को उत्साहित किया एवम् सभी विजेताओं को पुरूस्कार वितरण

किए गए। निदेशालय के सभी अधिकारी एवम् कर्मचारियों ने इसमें बढ़–चढ़ कर भाग लिया।

- वर्ष के दौरान मक्का निदेशालय में आदिवासी उपयोगजना के अर्न्तगत प्रशिक्षण कार्यक्रम, प्रदर्शन कार्यक्रम भम्रण आदि कार्यक्रम आयोजित किया गया। इन सभी कार्यक्रमों में हिन्दी भाषा का उपयोग किया गया।
- निदेशालय के वैज्ञानिकों द्वारा विभिन्न किसान मेला व प्रर्दशनी का आयोजन किया गया जिसमें सभी किसान भाइयों को हिन्दी भाषा में उन्नत मक्का की खेती का ज्ञान दिया गया।
- राजाभाषा र्कायान्वन समिति की बैठन दिनांक 5 सितम्बर 2012 एंव 5 जनवरी 2013 को आयोजित किया गया। गत वर्ष में मक्का अनुसंधान निदेशालय में हिन्दी पखवाडा दिवस मनाया गया जिसका उद्घाटन माननीय डा॰ नरसिंह नारायण सिंह, पूर्व परियोजना निदेशक एव पूर्व कुलपति बिरसा कृषि विश्वविघालय रॉची द्वारा किया गया। इस अवधि के दौरान विभिन्न प्रतिस्पर्धओं/ प्रतियोगिताओं का आयोजन किया गया। प्रतियोगिता जीतने वाले कार्मचारी/अधिकारी गण को पुरस्कार देकर सम्मानित किया गया।


पुरस्कार वितरण समारोह

Sports Activities

ICAR central zone sports meet was held in New Delhi from 26 - 30 September, 2012. DMR team comprising eight members participated in the event. Mr. Yatish, K. R., Scientist, won best athlete award. He stood first in 400m race, in 100m race, 200m race and long jump events.


ICAR Central Zone Sports Meet

Awards and Recognition

Dr. J. C. Sekhar, Principal Scientist (Entomology), received the best Scientist Award in 55th Annual Maize Workshop for his contributions as a Scientist and Research Manager.

Dr. Ashok Kumar, Principal Scientist (Agronomy), has been honored as Chancellor Nominee in Career Advancement Meeting, Satna (Madhya Pradesh). He was also awarded Fellow of Indian Society of Agronomy.

Dr. Pradyumn Kumar, Principal Scientist (Entomology) was nominated as one of the members of Research Advisory Board of Institute of Pesticides Formulation Technology, Gurgaon, Haryana.

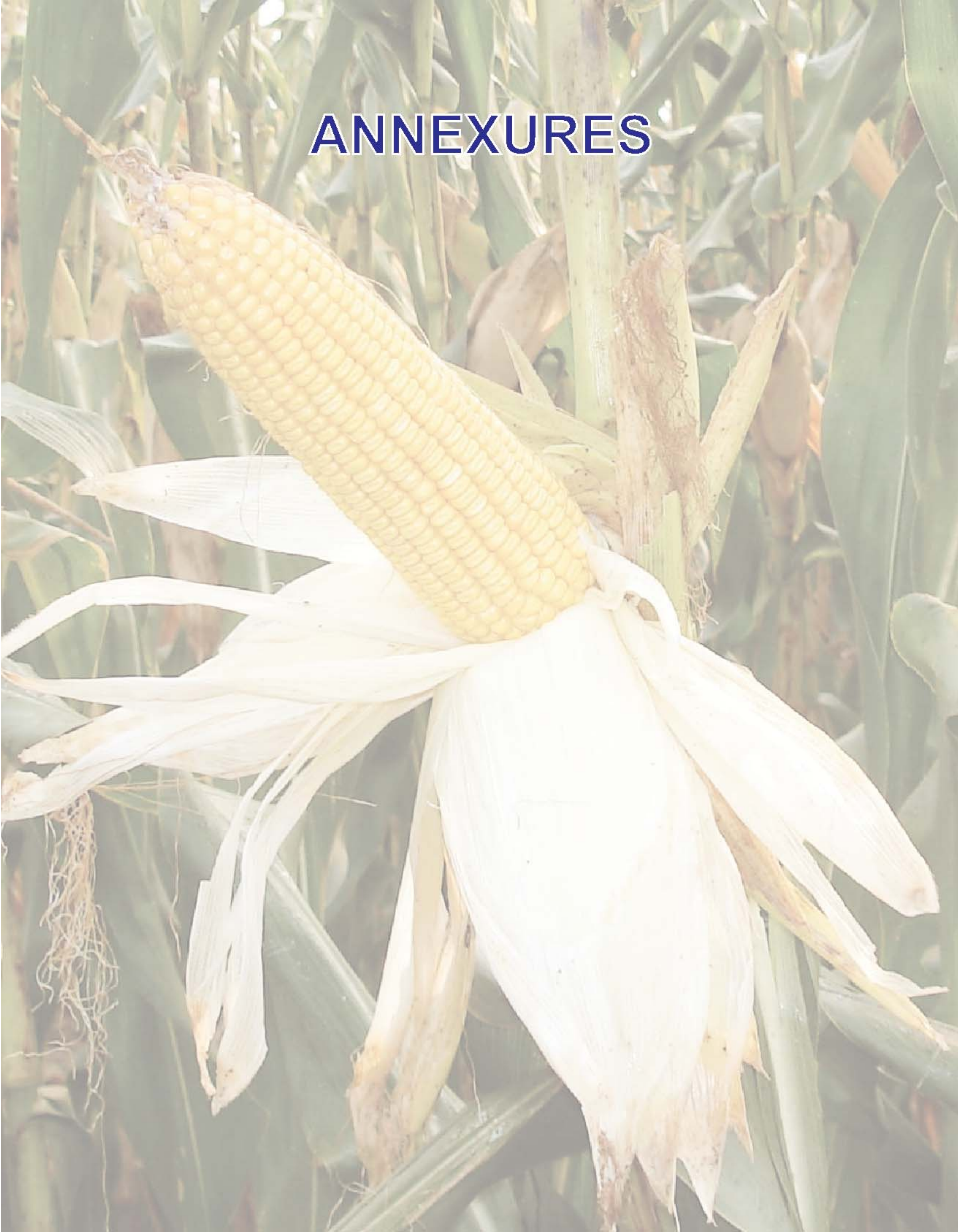
Dr. Jyoti Kaul, Principal Scientist (Plant Breeding) has been nominated as one of the members of Institute Management Committee of Indian Institute of Pulses Research, Kanpur (2012-2015).

Dr. Ramesh Kumar, Scientist (Plant Breeding) has been nominated as Member, Scientific Advisory Committee, KVK (Khagaria, Bihar) and Sharam Bharati khadigram KVK (Jamuai, Bihar).

Dr. Ishwar Singh, Principal Scientist (Plant Physiology)

- Joint Secretary of the Indian Society for Plant Physiology, New Delhi for a period of three years (2013-2015).
- Managing Editor of the Indian Journal of Plant Physiology for a period of three years (2013-15).
- Secretary of the Maize Technologists Association of India, New Delhi for a period of two years (2011-2012).

ANNEXURES



Annexure I: Hybrids Notified

During 2012-13, nineteen hybrids of maize were notified for general cultivation in different parts of the country. Of these, seven are late, 10 medium and two extra-early hybrids.

Cultivar	Pedigree	AICRP Centre / Pvt. Company	Notification Date	Notification No.	Maturity	Area of adaptation	Average Yield t/ha	Other characteristics
Co 6	UMI-1200 X UMI-1230	TNAU, Coimbatore	26/07/2012	1708 (E)	Late	Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	6.0	Orange-yellow, semi-dent
SMH 3904	MI-201 x MI-211	Shakti seeds	26/07/2012	1708 (E)	Late	Punjab, Haryana, Delhi, Uttar Predesh, Bihar, Jharkhand, Orissa, Karnataka, AP, T N, Maharashtra, Rajasthan, Gujarat, Chhattisgarh & Madhya Pradesh	7.0	Yellow-orange, semi-flint
NMH 731	NM-206 X NM-85	Nuziveedu	10/9/2012	2125 (E)	Late	Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	5.4	Orange-yellow, semi-dent
NMH 920	NM-81 X NM-45	Nuziveedu	10/9/2012	2125 (E)	Late	Uttar Pradesh, Bihar, Orissa and Jharkhand	7.7	Orange-yellow, semi-dent
NK30	NK191 X NK 132	Syngenta	10/9/2012	2125 (E)	Late	Punjab, Haryana, Delhi, Western Uttar Pradesh, Karnataka, Andhra Pradesh, Tamil Nadu & Maharashtra	7.0	Yellow-orange, flint, nutrient responsive
NK6240	NK125 X NK 128	Syngenta	10/9/2012	2125 (E)	Late	Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, Orissa, Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Rajasthan, Gujarat, Chhattisgarh & MP	7.0	Yellow, flint

Cultivar	Pedigree	AICRP Centre / Pvt. Company	Notification Date	Notification No.	Maturity	Area of adaptation	Average Yield t/ha	Other characteristics
P3501	-	Pioneer	16/03/2012	456 (E)	Late	Uttar Pradesh, Bihar, Orissa, Jharkhand, Madhya Pradesh, Rajasthan and Gujarat	6.5	Yellow, dent
KMH 218 Plus	(KML 2257 X KML 2003) X KML 5163	Kaveri Seeds	10/9/2012	2125 (E)	Medium	Uttar Pradesh, Bihar, Jharkhand and Orissa	6.3	Yellow, dent
KMH 3426	(KML 5277 X KML 5164) X KML 5253	Kaveri Seeds	10/9/2012	2125 (E)	Medium	Uttar Pradesh, Bihar, Jharkhand, Orissa, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	6.5	Orange, semi-dent
NMH 803	(NM-124 X NM-250) X NM 161	Nuziveedu	10/9/2012	2125 (E)	Medium	Uttar Pradesh, Bihar, Jharkhand, Orissa, Rajasthan, Gujarat, Madhya Pradesh & Chhattisgarh	6.2	Yellow, dent
HM12	HKI-1344 X HKI-1378	CCSHAU, Uchani	10/9/2012	2125 (E)	Medium	Uttar Pradesh, Bihar, Jharkhand and Orissa	5.8	White, Semi-dent
KMH 25K60	KML-2254 X KML-2168	Kaveri Seeds	10/9/2012	2125 (E)	Medium	Andhra Pradesh, Maharashtra, Karnataka & TN	8 .6	Yellow, dent
KML 3712	KML X KMH	Kaveri Seeds	10/9/2012	2125 (E)	Medium	Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, West Bengal, Orissa, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	7.7	Orange-yellow, semi-dent
Bisco X 1 (Bisco 506)	BSI 245 X BSI 263	Bisco Biosciences	10/9/2012	2125 (E)	Medium	Uttar Pradesh, Bihar, Jharkhand, Orissa, Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu	9.0	Yellow, dent,

Cultivar	Pedigree	AICRP Centre / Pvt. Company	Notification Date	Notification No.	Maturity	Area of adaptation	Average Yield t/ha	Other characteristics
P3441 (X8B691)	PH1N20 X PHD1A	Pioneer	10/9/2012	2125 (E)	Medium	Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, Orissa, Rajasthan, Gujarat, Madhya Pradesh & Chhattisgarh	8.0	Orange, flint
P3502 (X8B562)	PHE2Y/ PHM6T	Pioneer	10/9/2012	2125 (E)	Medium	Rajasthan, Gujarat, Madhya Pradesh & Chhattisgarh	5.7	Orange, flint
Bio9682	-	Sriram Bioseed	10/9/2012	2125 (E)	Medium	Madhya Pradesh, Rajasthan, Gujarat, Uttar Pradesh, Punjab & Haryana	-	-
Vivek Maize Hybrid 43	V-373 x CM 212	VPKAS, Almora	16/03/2012	456 (E)	Extra-early	Uttar Pradesh, Bihar, Jharkhand, Orissa, Chhattisgarh, WB, Rajasthan, Gujarat, Madhya Pradesh & Chhattisgarh	4.8	Yellow, semi-flint
Vivek Maize Hybrid 39	V-373 x V-341	VPKAS, Almora	16/03/2012	456 (E)	Extra-early	Uttarakhand and Himachal Pradesh	7.1	Yellow, semi-flint

Annexure II: Hybrids Identified

At the 55th Annual Maize Workshop held at CCSHAU, Hisar, 20-22 April, 2012, a total of 18 hybrids were identified for release.

Hybrid	Maturity group	Area of Adaptation
MCH40	Late	Zones 2 and 3 (Punjab, Delhi, Haryana, Western Uttar Pradesh, Eastern Uttar Pradesh, Bihar, Jharkhand and Orissa)
NMH920	Late	Zone 3 (Eastern Uttar Pradesh, Bihar, Jharkhand and Orissa)
CMH08-282	Late	Zone 5 (Gujarat, Rajasthan, Madhya Pradesh and Chhattisgarh)
NMH731	Late	Zone 5 (Gujarat, Rajasthan, Madhya Pradesh and Chhattisgarh)
X8B 562	Late	Zone 5 (Gujarat, Rajasthan, Madhya Pradesh and Chhattisgarh)
HKH313	Medium	Zone 3 (Eastern Uttar Pradesh, Bihar, Jharkhand and Orissa)
KDMH017	Medium	Zone 2 and 3 (Punjab, Haryana, Delhi, Western Uttar Pradesh, Eastern Uttar Pradesh, Bihar, Jharkhand and Orissa)
X8B 691	Medium	Zone 2, 3 and 5 (Punjab, Delhi, Haryana, Western Uttar Pradesh, Eastern Uttar Pradesh, Bihar, Jharkhand, Orissa, Gujarat, Rajasthan, Madhya Pradesh and Chhattisgarh
KMH3426	Medium	Zone 3 and 5 (Eastern Uttar Pradesh, Bihar Jharkhand, Orissa, Gujarat, Rajasthan, Madhya Pradesh and Chhattisgarh)
KMH218 Plus	Medium	Zone 3 (Eastern Uttar Pradesh, Bihar, Jharkhand and Orissa)
NMH803	Medium	Zone 3 and 5 (Eastern Uttar Pradesh, Bihar, Jharkhand, Orissa, Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh.)
JH31292	Medium	Zone 3 and 5 (Eastern Uttar Pradesh, Bihar, Jharkhand, Orissa, Rajasthan, Gujarat and Chhattisgarh)
MCH42	Medium	Zone 5 (Gujarat, Rajasthan, Madhya Pradesh and Chhattisgarh)
REH2003	Early	Zone 1 (Jammu and Kashmir, Himachal Pradesh, Uttarakhand and North East hills)
Bio605	Early	Zone 1 and 4 (Jammu and Kashmir, Himachal Pradesh, Utterakhand and North east hills, Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu)
FH3483	Extra-early	Zone 1, 2, 3 and 4 (Jammu and Kashmir, Himachal Pradesh, Utterakhand, Punjab, Haryana, Delhi, Western Uttar Pradesh, Eastern Uttar Pradesh, Bihar, Jharkhand, Orissa, Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka)
Bisco506	Late	Zone 3 and 4 (Eastern Uttar Pradesh, Bihar, Jharkhand, Orissa, Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka)
BPCH 6	Medium	All five zones

Annexure III: Germplasm Registration

Two promising inbred lines registered at NBPGR.

Inbred line	Centre	INGR #	Source germplasm	Unique trait/s
KDTML-82 	ANGRAU, Karimnagar	13003	Tuxpenosequia population (Temperate material)	Drought tolerance (normal maize)
DMRQ-103 	DMR, Delhi	13023	CLQ41 (Exotic germplasm)	Early, low Anthesis –silking interval, high tryptophan (>0.6 %)

Annexure IV: Seed Production

Breeder seeds of parental lines of hybrid HQPM1 (HKI193-1 and HKI163) and DHM117 (BML6 and BML7) were produced in Regional Maize Research and Seed production Centre, Begusarai (Bihar) during *rabi* and *kharif*. A total of 181.71 q breeder seed was supplied to different public and private seed producing agencies (Table I). Seeds of regionally important crops like wheat and soybean generated revenue of ₹ 50.00 lakhs.

Table I. Breeder seed supply from Begusarai Centre during 2012-2013

Organisation	Seed Production (kg)		Total
	HKI193-1	**HKI163**	
RSSC, Jaipur	200	100	300
DWSR, Jabalpur	100	56	156
N S C , Kolkata	600	200	800
N S C , Patna	1200	400	1600
RSSC, Banswara	3000	600	3600
NSC, Jaipur	600	200	800
SFCI, Kolkata	100	50	150
Govt. of Bengal, District: Nadia	13	5	18
Biswa Bharati Krishi Swambar Gosthi, Kulgachi, Nadia (West Bengal)	3000	800	3800
AAU, Godhra (Gujarat)	-	20	20
Balaji Seeds, Kurnool (Andhra Pradesh)	150	80	230
NSC, Sambalpur (Orissa)	300	100	400
Victory Seeds, Kurnool (Andhra Pradesh)	10	5	15
Hindustan Insecticide Ltd., kolkata	1600	400	2000
FLD in Bihar	250	150	400
Total	11413	3166	14579
	BML6	**BML7**	
AP Seed Corporation, Hyderabad	1600	700	2300
Sampoorna seeds, (Andhra Pradesh)	30	18	48
Sampath Rao, Karimnagar(Andhra Pradesh)	990	194	1184
MPUA&T, Udaipur	40	20	60
Total	2660	932	3592

Breeder Seed Production

A total of 9900 kg of breeder seed was indented through Department of Agriculture and Co-operation, Ministry of Agriculture. The indent was honoured and 11855 kg of seed was produced (Table II).

Table II. Breeder seed production of maize varieties and inbred lines during *kharif*-2012

Center	Inbred/Variety	DAC Indent (Kg)	Actual Allotment as per BSP-I (Kg) Indented	BSP IV (Kg)	Surplus (+)/ Deficit(-)
Bajaura	EARLY COMPOSITE	5	5	250	245
BAU, Ranchi	Birsa Vikas Makka-2	300	300	300	0
	BIRSA MAKKAI-1	30	30	30	0
CCSHAU, Karnal	HQPM4 (HKI-193-2) (F)	400	400	15	-385
	HQPM4 (HKI-161) (M)	200	200	0	-200
	HQPM7 (HKI-161) (M)	45	45	0	-45
	HQPM7 (HKI-193-1) (F)	115	115	50	-65
	HQPM5 (HKI-163) (F)	415	415	0	-415
	HQPM5 (HKI-161) (M)	205	205	0	-205
	HM8 (HKI-1105) (F)	15	15	0	-15
	HM8 (HKI-161) (M)	5	5	20	15
	HQPM1 (HKI-193-1) (F)	665	665	25	-640
	HQPM1 (HKI-163) (M)	275	275	20	-255
Chindwara	JAWAHAR MAKAI-216 (JM-216)	4110	4110	4200	90
	JAWAHAR COMPOSITE MAKKA-12	100	100	65	-35
Godhra	Gujarat Makai-6	50	50	800	750
	NARMADA MOTI (IC-9001)	20	20	400	380
Hyderabad	PRIYA SWEETCORN	15	15	50	35
	TRISHULATA	50	50	0	-50
IARI	PEHM1 (CM-135) (F)	10	10	10	0
	PEHM1 (CM-136) (M)	20	20	20	0
	PEHM2 (CM-137) (F)	10	10	10	0
	PEHM2 (CM-138) (M)	20	20	20	0
	PEEHM5 - (CM-150) (F)	400	400	1200	800
	PEEHM5 - (CM-151) (M)	200	200	200	0
	Pusa Composite3 (Composite-85134)	300	300	400	100
	Pusa Composite4(Composite-8551)	40	40	400	360
Kanpur	Azad Kamal (R 9803)	20	20	20	0
	AZAD UTTAM (COMPOSITE R-2)	100	100	100	0
Mandya	NAC6004	560	560	560	0

Center	Inbred/Variety	DAC Indent (Kg)	Actual Allotment as per BSP-I (Kg) Indented	BSP IV (Kg)	Surplus (+)/ Deficit(-)
MPUAT, Udaipur	Pratap Hybrid Maize1 (EI-116) (F)	200	200	0	-200
	Pratap Hybrid Maize1 (EI-364) (M)	100	100	0	-100
	PRATAP MAKKA5 (EC-3116)	200	200	650	450
MPUAT, Banswara	Pratap Kanchan2 WC-236(Y)	100	100	100	0
Pantnagar	AMAR (D-941)	20	20	20	0
	SURYA	80	80	250	170
	NAVIN (D-741)	5	5	100	95
PAU, Ludhiana	PMH5 (JH 3110) (LM16) (F)	10	10	70	60
	PMH5 (LM18) (M)	5	5	20	15
	NAVJOT	100	100	700	600
	VIJAY COMPOSITE MAKKA	100	100	240	140
VPKAS, Almora	Vivek QPM9 (FQH 4567) (VQL1) (F)	10	10	100	90
	Vivek QPM9 (VQL2) (M)	5	5	40	35
	Vivek Maize Hybrid23 (FH-3529) (V351) (F)	10	10	10	0
	Vivek Maize Hybrid-23 (V341) (M)	5	5	5	0
	Vivek Maize Hybrid17 (FH-3186) (CM153) (F)	10	10	15	5
	Vivek Maize Hybrid17 (CM212) (M)	5	5	5	0
	VIVEK MAIZE HYBRID9 CM212 (F)	160	160	160	0
	VIVEK MAIZE HYBRID9 (CM145) (M)	5	5	5	0
	Vivek Hybrid9 (CM-145) (M)	50	50	50	0
	Vivek Sankul Makka31(VL-103)	20	20	250	230
	Total	9900	9900	11855	2055

Annexure V: DUS Testing

During the year 2012 *kharif*, DUS test was conducted at two locations, Delhi and Hyderabad. Of these, 41 hybrids and 17 were inbreds. Data was recorded on traits as specified under DUS guidelines.

Inbreds DUS trial 2012

Number of entries	17 Candidate and 9 reference
Number of rows	4
Row length	6 m
Row to row distance	75 cm
Plant to plant distance	20 cm
Number of replications	3

Hybrid DUS trial 2012

Number of entries	41 Candidate and 15 reference
Number of rows	4 or 8
Row length	6 m
Row to row distance	75 cm
Plant to plant distance	20 cm
Number of replications	3

Table 1. Inbred DUS trial 2012

Sl. No.	Entries	
1	KML 5263	Candidate Inbred
2	KML 5264	-do-
3	KML 112	-do-
4	KML 2276	-do-
5	KML 5015	-do-
6	NM-161	-do-
7	KML 5080	-do-
8	NSCL-15 (SWEET CORN)	-do-
9	KML 5004	-do-
10	KML 133	-do-
11	KML 5013	-do-
12	PHRRC	-do-
13	PHDMK	-do-
14	PH698	-do-
15	PHM6T	-do-
16	M 15-1	-do-
17	M 101	-do-
18	HKI-193-1	Reference Inbred
19	HKI-1105	-do-
20	V 341	-do-
21	HKI323	-do-
22	V 345	-do-
23	HKI161	-do-
24	CM141	-do-
25	HKI163	-do-
26	CM152	-do-

Table 2. Hybrids DUS trial 2012

Sl. No.	Entries	
1	Bajaura Makka 1	Candidate Hybrid
2	V Sankul Makka 35	-do-
3	NMH 713	-do-
4	KMH3426	-do-
5	HM11	-do-
6	NMH 731	-do-
7	MIM002	-do-
8	IG8011	-do-
9	BISCO 555 (BISCO UJALA)	-do-
10	BISCO X 5129 (BISCO SUPER X 92)	-do-
11	KMH-225	-do-
12	VIVEK SANKUL MAKKA 31	-do-
13	JAWAHAR POP CORN-11	-do-
14	VIVEK SANKUL MAKKA 37	-do-
15	BISCO 4564 (BISCO NR X 7)	-do-
16	BIO 50265 H	-do-
17	DHM 117	-do-
18	NSCH12 (SWEET CORN)	-do-
19	NMH-1242	-do-
20	KMH-2446	-do-
21	KMH-3712	-do-
22	HQPM-4	-do-
23	PMH 4	-do-
24	P3502	-do-

Sl. No.	Entries	
25	P3470	-do-
26	BISCO 731 (BISCO X 9)	-do-
27	P3441	-do-
28	VIVEK MAIZE HYBRID 43	-do-
29	BISCO 777	-do-
30	Nirmal27 (NMWH-27)	-do-
31	VIVEK MAIZE HYBRID 39	-do-
32	KMH7148	-do-
33	31Y45	-do-
34	M 34	-do-
35	M 104	-do-
36	MOHINI	-do-
37	P3785	-do-
38	P3501	-do-
39	IG7806	-do-
40	IH8006	-do-

Sl. No.	Entries	
41	BIO-22027 H	-do-
42	HM 4	Reference Hybrid
43	HQPM 1	-do-
44	ST 2324	-do-
45	Prakash	-do-
46	Vivek 9	-do-
47	African tall	-do-
48	PMH 3	-do-
49	HM8	-do-
50	Vivek 25	-do-
51	Vivek 27	-do-
52	Shaktimaan 2	-do-
53	Win Orange Sweet Corn	-do-
54	Vivek 15	-do-
55	Shaktimaan 1	-do-
56	Narmada Moti	-do-

Annexure VI: Overseas Visits

Dr. D.P. Chaudhary	International conference on 'Experimental Biology 2012'	San Diego, United States of America	April 21-25, 2012.
Dr. S.L. Jat	Advanced Conservation Agriculture Course 'Laying the groundwork for sustainable and productive cropping systems'	CIMMYT Head Quarter, El Batan, Mexico	May 21 - June 22, 2012
Dr. V.K. Yadav Dr. Avinash Singode Dr. Ramesh Kumar	Annual Review Meeting of BMZ-ATMA Project on 'Abiotic stress tolerant of maize for food and income security among the poors in South and South-East Asia' and Training on Doubled Haploid in Maize Breeding	Institute of Plant Breeding, University Hohenheim, Stuttgart, Germany	June 11-16, 2012
Dr. O.P. Yadav	Training programme on Leadership for 21st Century - Chaos, Conflict and Courage. To get a first-hand assessment on the potential of using doubled haploid technology in maize breeding	Harvard Business School, Harvard University, Cambridge, MA, USA International Centre for Maize and Wheat Research (CIMMYT), Mexico City, Mexico	January 26-February 2, 2013 March 4-8, 2013

Annexure VII: Trainings conducted to disseminate technology

Venue	Date	Number of participants
Officers training programme		
Assam Agricultural University, Jorhat, Assam	March 16-17, 2012 March 22-23, 2012 March 26-27, 2012	37 22 39
ANGRAU, Hyderabad, Andhra Pradesh	February 7-8, 2012 February 17-18, 2012 February 23-24, 2012 March 5-6, 012	30 30 30 30
IGKV RMD CARS, Ambikapur, Chattisgarh	January 6-7, 2012 March 22-23, 2012 March 27-28, 2012	23 24 24
CSK HPKV, Bajaura, Himachal Pradesh	February 13-14, 2012 February 16-17, 2012	30 30
MPKV, Kolhapur, Maharashtra	March 2-3, 2012 March 5-6, 2012	30 30
Farmers training programme		
Central Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands	August 13, 2012	30
Agronomy training on 'Nutrient expert based SSNM and data management for maize systems in India		
DMR, Pusa Campus, New Delhi	May 16, 2012	20
PPV & FRA Training cum Awareness programme		
Haryana Agro Industries Corporation (HAIC), Murthal	February 11, 2013	70
DUS testing in maize		
Winter Nursery Centre, Hyderabad	March 9-10, 2013	
Maize germplasm day		
Winter Nursery Centre, Hyderabad	March 10, 2013	
National Level Training Programme, DMR, Pusa Campus	March 3-4, 2012 March 17-19, 2012 March 22-24, 2012 March 26-28, 2012 March 29-31, 2012 December 22-24, 2012 December 27-29, 2013	48 56 15 48 62 48 48

Venue	Date	Number of participants
Regional level training programme		
SKUAST-Kashmir	March 13, 2012	300
Chhindwara, Madhya Pradesh	December 4, 2011 October 3, 2012 March 30, 2013	106 110 125
KVK, Dimapur, Nagaland	July 10-11, 2012	52
Assam	February 15-17, 2012	40
ICAR, Sikkim	March, 22-23, 2012	102
Manipur	March, 20-21, 2012	50
Barapani, Meghalaya	March 1, 2012	60
Agricultural Research Station, Banswara	March 16, 2012 October 19, 2012 October 21, 2012	250 700
Ambikapur, Madhya Pradesh	October, 12 - 13 2012	150
SKUAST, Jammu	April 15, 2012 April 16, 2012 November 12, 2012	
Agricultural Research Farm at Banaras Hindu University, Varanasi	March 19-20, 2012	
Rajiv Gandhi South Campus Barkacha, Mirzapur	September 17-20, 2012	
DMR (Aterna and Manauli villages, Haryana)	March 18, 2012 March 23, 2012 March 27, 2012 March 30, 2012	
SKUAST- Kashmir (Farmers field at village Nagolta, Kashmir valley)	June 27, 2012 May 22, 2012	

Annexure VIII: Human Resource Development

Name	Programme	Venue	Date
Dr. A.K. Singh Dr. S.L. Jat Dr. Ashok Kumar Dr. C.M. Parihar	Third International Agronomy Congress on Agriculture Diversification, Climate Change Management and Livelihoods	IARI, New Delhi	November 26-30 2012.
Dr. Abhijit Kumar Das Dr. Ramesh Kumar	Awareness cum training programme on Plant Variety Protection and Farmer's Rights with Special Reference to Maize	Rai (Haryana)	February 3 , 2013
Dr. Abhijit Kumar Das Dr. Yatish	Recent advances in designing and analysis of agricultural experiments	IASRI, New Delhi	January 8 - 28, 2013
Dr. Ashok Kumar	Biennial workshop of AICRP on micro and secondary nutrients and pollutant elements in soils and plants	BCKV, Kalyani (West Bengal)	February 10-12, 2012
	ICAR- CIMMYT work plan meeting	NASC Complex , New Delhi	October 18, 2012
	National Seminar on Indian Agriculture: Preparedness for Climate Change	NASC Complex New Delhi	March 24-25, 2012
	IPNI Research Cooperators Meeting	NASC Complex , New Delhi	May 14-15, 2012
	Defining the research agenda for BISA	NASC Complex , New Delhi	October 15-17, 2012
Dr. Avinash Singode	Genotyping by Sequencing	ICRISAT, Patancheru, Hyderabad	February 26 - March 01, 2013
Dr. Chikkappa G K	Quantitative Methods in Maize Breeding	CIMMYT-Global Maize Program, Hyderabad	September 4 - 12, 2012
Dr. Ganapati Mukri	FLD training program	Maize Research Centre, ANGRAU	February 7 - 8, 2012
	Redefining frontline demonstrations – Maximizing the impact	Rajendra nagar, Hyderabad	March 28, 2012
Dr. Ganapati Mukri Mr. Vishal Singh	Conservation of Plant Germplasm including Registered Varieties in Genebank	NBPGR, New Delhi	March 18 - 21, 2013
Dr. Ishwar Singh Dr. Pranjal Yadava	National Seminar on 'Physiological and ' Molecular Approaches for Development of Climate Resilient Crops	ANGRAU, Hyderabad	December 12-14, 2012
Dr. Jyoti Kaul	Intellectual Property and PPV&FR Act 2001	NASC, New Delhi	November 22-24, 2012

	Import and Export Procedures of Agri-commodities	NIPHM, Hyderabad	March 11-15, 2013
Dr. K.S. Hooda	Management Program on Leadership Development	NAARM, Hyderabad	October 8-19, 2012
Dr. K.P. Singh Dr. Pranjal Yadava	Statistical Approaches for Genomic Data Analysis	IASRI, New Delhi	January 7-19, 2013
Dr. K.P. Singh	Workshop-cum-Installation Training for NAIP Consortium 'Strengthening Statistical Computing for NARS' Meeting on 'Prioritization of Research Activities for Agricultural Bioinformatics/ Computational Biology in Crop Sciences' DST - Lockheed Martin India Innovation Growth Programme 2013	IASRI, New Delhi IASRI, New Delhi FICCI Federation House, Tansen Marg, New Delhi	June 25, 2012 January 24, 2013 February 4, 2013
Dr. Lakshmi Soujanya	New Frontiers in Integrated Pest Management in Rice and Rice based cropping systems	DRR, Hyderabad.	September 13 - October 3, 2012
Dr. Lakshmi Soujanya Dr. Abhijit Kumar Das Dr. S.B. Singh Dr. Yathish Dr. Ramesh Kumar Dr. Chikkappa G.K.	Germplasm day cum training on DUS testing in maize	WNC, Hyderabad	March 9 - 10, 2013
Dr. Meena Shekhar	General Management Training Programme for Women Scientist	Administrative Staff college of India, Hyderabad	March 4 – 15, 2013
Dr. Pradyumn Kumar	Advanced Techno-management Program for F and G level Scientists	Administrative Staff College of India, Hyderabad	September 17- October 19, 2012
Dr. Pranjal Yadava Dr. K.P. Singh	National workshop on 'Foresight and future pathways of agricultural research through youth in India'	NASC, New Delhi	March 1 - 2, 2013
Dr. Pranjal Yadava	Seventh Review Meeting of 'ICAR Network Project on Transgenics in Crops'	NRCPB, New Delhi 2013.	January 15-16,
Dr. Ramesh Kumar Dr. Bhupender Kumar	Precision Phenotyping for Abiotic Stresses in Maize	CIMMYT, Hyderabad	August 29 - September 1, 2012
Dr. Ramesh Kumar	Annual Review Meeting of Mega Seed Project on Seed Production in Agricultural crops	NASC Complex, New Delhi	July 25-26,2012
Ms. Sapna	TSP Training-cum-farmers day	Nutritional Security at AICRP centre, Banswara	October 21, 2012

	Workshop on Scientific Paper Writing	National Academy of Science, Allahabad	November 8-10, 2012
Ms. Sapna Dr. C.M. Parihar	Project formulation, Risk Assessment, Scientific Report Writing and Presentation	IARI, Delhi.	August 27 - 31, 2012
Dr. V.K. Yadav	Development of Expert System through AGRIdaksh	IASRI, New Delhi	February 14-March 6, 2013
Dr. Vinay Mahajan	MDP for Leadership Development: Pre-RMP Program	NASC, New Delhi	October 8 -19, 2012
Mr. Vishal Singh Dr. Yathish	Awareness cum training programme on Plant Variety Protection and Farmer's Rights	WNC, Hyderabad	February 11, 2013.
Mr. Vishal Singh	Recent Advances in Quantitative Genetics and Statistical Genomics	IASRI, New Delhi	November 6 - 26, 2012

Annexure IX: Lectures/T.V./Radio Talks Delivered

Scientist	Topic	Purpose	Venue	Date
Lectures delivered				
Dr. Ashok Kumar	Problems and prospects of maize production in India	National workshop on solid state fermentation technology in aquaculture production	Central Institute of Fresh water Aquaculture, Bhubaneshwar	May 29, 2012
	Maize Production Technologies	Seed production, cultivation and value addition of maize	DMR, New Delhi	March 22 - 24, 2012
Dr. Pranjal Yadava	Artificial microRNAs in crop engineering	CSTUP and DBT sponsored Faculty Training Programme on Application of Biotechnological tools and Bioinformatics in Agriculture	Sardar Vallabh Bhai Patel University of Agriculture and Technology, Meerut	December 19, 2012- January 08, 2013
	Genetic engineering for a greener environment: prospects, predicament and path ahead	National seminar on eco-friendly environment	GVMG College, MD University, Sonepat	March 12, 2013
	Genetic engineering for plant health management: Bt and Beyond	Tenth National Symposium on Biotechnological Approaches for Plant Protection: Constrains and Opportunities	ICAR Research Complex for Goa, Old Goa	January 27-29, 2013
Dr. Ramesh Kumar	Maize based entrepre-neurships in Bihar	TSP regional training programme	Samastipur	September 08, 2012
Dr. K P Singh	Carbon nanotube and its bio-sensing applications	PAU Science Club Seminar	PAU, Ludhiana	August 7, 2012
Dr. D P Chaudhary	Preservation of fodder maize	Field day	RMR & SPC, Begusarai	July 30, 2012
	Field day	Demonstration of baby corn hybrid HM-4	Baroli, district Palwal (Haryana)	September 2, 2012

	Maize as fodder to the farmers	TSP Training Programme on Seed Production, Cultivation and Value Addition of maize	DMR	December 22-24, 2012
	Preservation of fodder Maize to the farmers	TSP Training Programme on Seed Production, Cultivation and Value Addition of maize	DMR	December 27-29, 2012
T.V./Radio Talks				
Dr. Ashok Kumar	*Makka fasal ki dekhbhal*			September 12, 2012
Dr. Ramesh Kumar	Maize hybrid seed production techniques	Doordarshan Kendra, Patna		September 24, 2012

Annexure X: Publications

During the year 2012-13, DMR scientists published nearly 102 scientific publications including 55 papers in refereed journals, 19 abstracts in proceedings of conferences, seminars and symposiums, seven popular articles, one book and four book chapters and 16 technical bulletins.

Research Papers

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Choudhary J, Dadheech RC and Jat SL. 2012. Effect of intercropping and weed management on weed dynamics and nutrient uptake by weeds and crops. *Maize Journal* **1**: 61-66

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Jat SL, Shivay YS, Parihar CM and Meena HN. 2012. Evaluation of summer legumes for their economic feasibility, nutrient accumulation and soil fertility. *Journal of Food Legumes* **25**: 239-242

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Annual Report 2011-12

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DMR Newsletter (January – June 2012 ; July – December 2012)

Annexure XI: On-going Projects

Projects	Principal Investigator	Co-Principal Investigator	Duration
Plant Breeding and Genetics			
Molecular characterization of elite maize inbred lines	Dr. Avinash Singode	Dr. Jyoti Kaul	May 2010 to April 2015
In-vitro characterization of regeneration capacity of maize genotypes	Dr. Yathish K R	Dr. Vishal Singh Dr. Avinash Singode Dr. Ganpati Mukri Mr. Abhijith Kr. Das	May 2010 to April 2015
Development of normal and quality protein maize hybrids for winter season	Dr. Ramesh Kumar	Dr. Jyoti Kaul Dr. G.K. Chikkappa Dr. Nirupma Singh Dr. Bhupender Kumar Dr. Pradyumn Kumar Dr. K.S. Hooda Dr. Dharam Paul	May 2011 to April 2016
Germplasm development and enhancement for cold tolerance in maize	Dr. Nirupma Singh	Dr. Ambika Rajandren Dr. Avinash Singode Dr. Ramesh Kumar Dr. J.C. Sekhar Dr. Ishwar Singh Dr. Meena Shekhar	July 2011 to June 2016
Breeding for drought tolerance in Maize	Dr. Bhupender Kumar	Dr. G.K. Chikkappa Dr. Vinay Mahajan Dr. Ishwar Singh Dr. S.L. Jat Dr. Ganpati Mukri Mr. Yathish K.R.	April 2011 to March 2016
Genetic enhancement of medium duration normal maize germplasm	Dr. G K Chikkappa	Dr. J.C. Sekhar Dr. K.S. Hooda Dr. Bhupender Kumar Dr. Ganapati Mukri Dr. C.M. Parihar Dr. Ramesh Mr. Abhijeet Dass	June 2011 to May 2016
Genetic enhancement of early maturing maize	Dr. Vinay Mahajan	Dr. Avinash Singode Dr. R. Amibika Rajendran Dr. Meena Shekhar Dr. J.C. Sekhar Dr. Ashok Kumar	April 2012 to March 2017

Projects	Principal Investigator	Co-Principal Investigator	Duration
Development and enhancement of Quality Protein Maize germplasm	Dr. Jyoti Kaul	Dr. Ramesh Kumar Dr. Dharam Paul Dr. K.S. Hooda	May 2012 to April 2017
Genetic enhancement of late duration normal maize germplasm	Dr. Bhupender Kumar	Dr. J.C. Sekhar Dr. K.S. Hooda Dr. G.K. Chikkappa Mr. Vishal Singh Dr. C.M. Parihar Dr. Ramesh Kumar Mr. Abhijeet Kumar Dass	June 2012 to May 2017
Genetic enhancement of white maize germplasm	Dr. Ganapati Mukri	Dr. Ambika Rajandren Dr. Bhupender Kumar Dr. K.S. Hooda Dr. G.K. Chikkappa Mr. Vishal Singh Dr. S.L. Jat Mr. Abhijit Kumar Das	June 2012 to May 2017
Genetic enhancement for provitamin – A in maize	Mr. Abhijit Kumar. Das	Dr. Bhupender Kumar Dr. G.K. Chikkappa Dr. Ganapati Mukri Mr. Yatish K.R. Dr. Avinash Singode Ms. Sapna Mr. Vishal Singh Dr. Pranjal Yadava	Oct.2012 to Oct. 2017
Genetic enhancement and development of high oil and baby corn traits in maize	Dr. Ambika Rajendran	Dr. Nirupma Singh Dr. Vinay Mahajan Dr. Dharam Paul Dr. Ganapati Mukri Dr. Meena Shekhar Dr. Lakshmi Saujanya	Nov. 2012 to Dec. 2016
Germplasm enhancement of maize for high starch and methionine content	Mr. Vishal Singh	Ms. Sapna Dr. Bhupender Kumar Mr. Yatish K.R. Mr. Abhijit Kumar. Das Mr. Ganpati Mukari Dr. G.K. Chikkappa	June 2012 to May 2017
Plant Pathology			
Post harvest management of losses due to microbial colonization in stored maize grains.	Dr. Sangit Kumar	Dr. Meena Shekhar Dr. K.S. Hooda	June 2008 to May 2013

Projects	Principal Investigator	Co-Principal Investigator	Duration
Identification of stable sources of resistance to major diseases of maize.	Dr. K.S. Hooda	Dr. R. Sai Kumar Dr. Sangit Kumar Dr. Meena Shekhar Dr. J.C. Sekhar Dr. Jyoti Kaul Dr. Avinash Singode Dr. G.K. Chikkappa	April 2010 to March 2015
Host-Pathogen interaction between *Macrophomina phaseolina* and *Fusarium moniliforme* (stalk rot pathogens) in maize and Identification of sources of resistance.	Dr. Meena Shekhar	Dr. K.S. Hooda Dr. Nirupma Singh Dr. Dharam Paul	Jan. 2013 to Dec.2018
Entomology			
Study on biochemical basis of resistance against major pests of maize	Ms. Suby S.B.*/ Dr. Pradyumn Kumar from 5.8.11	Dr. Pradyumn Kumar Dr. Dharam Paul Dr. J.C. Sekhar Mr. Aditi Kundu	April 2010 to March 2015
Biological control of maize pests	Dr. P. Lakshmi Soujanya	Dr. Pradyumn Kumar Dr. J.C. Sekhar	June 2011 to April 2016
Identification of Multiple Borer Resistant Genotypes in Maize	Dr. J.C. Sekhar	Dr. Pradyumn Kumar Dr. P. Lakshmi Soujanya Dr. G.K. Chikkappa	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	Dr. P. Lakshmi Soujanya	Dr. Pradyumn Kumar Dr. J.C. Sekhar Dr. Dharam Paul Dr. G.K. Chikkappa Mrs. Suby S.B.	June 2012 to April 2017
Management of maize insect pests	Dr. Pradyumn Kumar	Dr. R. Sai Kumar Dr. J.C. Sekhar	Jan. 2008 to Dec. 2013
Agronomy			
Evaluating conservation tillage practices for Improving resources use efficiency in maize based cropping system	Dr. C.M. Parihar	Dr. Pradyumn Kumar Dr. Sangit Kumar Dr. S.L. Jat Dr. A.K. Singh Dr. G.K. Chikkappa	July 2008 to June 2013
Diversified maize based cropping system for higher productivity and sustained soil health	Dr. Ashok Kumar	Dr. A.K. Singh Dr. Ishwar Singh Dr. Dharam Paul Dr. C.M. Prihar Dr. S.L. Jat Dr. G.K. Chikkappa	July 2011 to June 2016

Projects	Principal Investigator	Co-Principal Investigator	Duration
Site specific nutrient management in maize based cropping system	Dr. Aditya Kumar Singh	Dr. S.L. Jat Dr. C.M. Parihar Dr. Ashok Kumar	June 2012 to June 2017
Nitrogen Management under Conservation Agriculture in Maize Based Cropping System	Dr. S.L. Jat	Dr. A.K. Singh Dr. C.M. Parihar Dr. Ashok Kumar	June 2012 to June 2017
Biochemistry			
Biochemical studies on shelf-life of carotenoids in maize	Mrs. Sapna	Dr. Dharam Paul Dr. Nirupma Singh	April 2011 to March 2016
Biochemical Characterization of Normal and Specialty Corn Germplasm	Dr. Dharam Paul	Dr. Jyoti Kaul Dr. Ramesh Kumar Dr. Bhupinder Kumar Ms. Sapna	April 2012 to March 2017
Social Science			
Strengthening and Refinement of Maize AGRIdaksh	Dr. Virendra Kumar Yadava	Dr. K.P. Singh Dr. K.S. Hooda Dr. Jyoti Kaul Dr. Avinash Singode Dr. G.K. Chikkappa Dr. S.L. Jat Dr. R. Ambika Rajendran	April 2011 to March 2016
Data mining and management of data generated through AICRP on maize	Dr. K.P. Singh	Dr. Vinay Mahajan Dr. Bhupender Kumar Dr. G.K. Chikkappa Dr. Meena Shekhar Dr. C.M. Parihar Dr. Pradyumn Kumar Dr. Dharam Paul	April 2012 to March 2017
Biotechnology			
Cloning and characterization of abiotic stress regulated genetic elements from maize	Dr. Pranjal Yadava	Dr. Ishwar Singh Dr. Pradyumn Kumar Dr. Avinash Singode	September, 2012 to September, 2017
Plant Physiology			
Identification, characterization and utilization of source of tolerance to drought and high temperature stress in maize	Dr. Ishwar Singh	Dr. M.L. Jat	April 2008 to March2013

Projects	Principal Investigator	Co-Principal Investigator	Duration
Externally funded projects			
ICAR-CIMMYT/BMZ sponsored - Abiotic stress tolerant maize for increasing income and food security in Eastern India and Bangladesh		Dr. Jyoti Kaul Dr. Ishwar Singh Dr. C.M. Parihar Dr. V.K. Yadav Dr. K.P. Singh	
Syngenta Bio-sciences India. Pvt. Ltd. sponsored - Baseline susceptibility of multiple populations of *Chilo partellus, Sesamia inferens* and *Helicoverpa aringera* for two Bt insecticidal proteins	Dr. Pradyumn Kumar	-	January 2013 - December 2014
ICAR- Network Project sponsored - Development of Maize Transgenic for Stem Border Resistance	Dr. Pradyumn Kumar	Dr. Pranjal Yadava	April 2007 - March 2013
PPV&FRA sponsored -Strengthening of DUS centers for implementation of PVP legislation	Dr. Jyoti Kaul		2004 (Cont..)
PPV&FRA sponsored -Special Test in Maize	Dr. Jyoti Kaul		
DSR/ICAR sponsored - Mega seed project		Dr. Jyoti Kaul	2007 (Cont..)
ICAR- Network Project sponsored - Functional genomics of drought tolerance in maize	Dr. Ishwar Singh	Dr. Pranjal Yadava	April 2007 - March 2012 (extended up to March 2013)
NBPGR sponsored - Multi-location evaluation of germplasm	Dr. Jyoti Kaul	Dr. S.L. Godawat, Dr. S.M. Khanorkar, Dr. G. Nallathambi, Dr. S.S. Verma	2009 (Cont..)

* On study leave.

Annexure XII: Financial Statement

Head of Account	Sanctioned Budget (₹ in Lakhs)				2012-13 Expenditure (₹ in Lakhs)			
	Plan	Non-Plan	AICRP on Maize	Total	Plan	Non-Plan	AICRP on Maize	Total
Establishment	-	383.76	911.61	1295.86	-	380.45	911.61	1292.06
OTA	-	0.50	-	0.50	-	0.44	-	0.44
TA	17.00	4.00	2307	44.07	17.00	4.00	23.07	44.07
Rec. Conti.	306.45	195.00	164.32	665.77	306.45	192.22	164.32	662.99
Minor Works	27.71	-	-	27.71	27.71	-	-	27.71
Equipment	47.18	9.00	-	56.18	47.18	8.93	-	56.11
Other Items/HRD	51.66	1.84	-	53.50	51.66	1.29	-	52.95
Total	**450.00**	**593.10**	**1099.00**	**2142.10**	**450.00**	**587.33**	**1099.00**	**2136.30**

Resource Generation

Particulars	(in Lakh)
Sale of farm produce	₹ 39.94
Standard License Fee	₹ 1.61
Analytical and Testing Fee	₹ 20.85
Receipts from Services Rendered	₹ 0.34
Interest earned on short term deposits	₹ 9.08
Training Miscellaneous receipts	₹ 1.33
Total	**₹ 71.82**

Funds Received for Externally Funded Projects

Particulars	(in Lakh)
DUS Testing	₹ 9.59
Transgenic Project	₹ 11.34
IPR	₹ 5.85
Total	**₹ 26.78**

Annexure XIII: Appointments/Promotions/Transfers/Retirements

Appointments

Dr. O.P. Yadav	Project Director
Dr. S.B. Singh	Principal Scientist
Ms. Chinkey Agarwal	Assistant

Promotions

Name	Promoted Post
Dr. Jyoti Kaul	Principal Scientist
Dr. A.K. Singh	Principal Scientist
Dr. Ishwar Singh	Principal Scientist
Dr. Meena Shekhar	Principal Scientist
Dr. Ashok Kumar	Principal Scientist
Dr. K.P. Singh	Scientist RGP Rs. 8000

Transfers

Name	Transfered from	Transfered to
Dr. Ramesh Kumar	RMR & SPC, Begusarai	DMR, New Delhi
Dr. Chikkappa G.K.	DMR, New Delhi	WNC, Hyderabad
Mr. Abhijeet Kumar Das	RMR & SPC Begusarai	DMR, New Delhi

Superannuation

Dr. R. Sai Kumar, superannuated on 31 August, 2012 after serving as Project Director for a period of two years (28 July, 2010 – 31 August, 2012). He supported single cross hybrid technology in maize and emphasized on development of source germplasm, genetically diverse inbred lines and high yielding hybrids. His coordinated approach has enriched AICRP (Maize) including DMR.

Annexure XIV: Personnel

Name	Designation	Discipline
Dr. R. Sai Kumar	Project Director till 31.8.2012	Plant Breeding
Dr. O.P. Yadav	Project Director since 07.09.2012	Plant Breeding
Dr. Sangit Kumar	Principal Scientist	Plant Pathology
Dr. Pradyumn Kumar	Principal Scientist	Entomology
Dr. Vinay Mahajan	Principal Scientist	Plant Breeding
Dr. K.S. Hooda	Principal Scientist	Plant Pathology
Dr. Ashok Kumar	Principal Scientist	Agronomy
Dr. Aditya Kumar Singh	Principal Scientist	Agronomy
Dr. Jyoti Kaul	Principal Scientist	Plant Breeding
Dr. Ishwar Singh	Principal Scientist	Plant Physiology
Dr. Meena Shekhar	Principal Scientist	Plant Pathology
Dr. M.L. Jat*	Senior Scientist	Agronomy
Dr. V.K. Yadav	Senior Scientist	Agricultural Extension
Dr. Dharam Paul Chaudhary	Senior Scientist	Biochemistry
Dr. Ramesh Kumar	Senior Scientist	Plant Breeding
Dr. K.P. Singh	Scientist (Senior Scale)	Computer Application
Dr. Nirupma Singh	Scientist	Plant Breeding
Dr. Avinash Singode	Scientist	Plant Breeding
Dr. C.M. Parihar	Scientist	Agronomy
Ms. Suby S.B.**	Scientist	Entomology
Mr. Manivannan A.**	Scientist	Genetics
Dr. R. Ambika Rajendran	Scientist	Plant Breeding
Dr. Shanker Lal Jat	Scientist	Agronomy
Ms. Sapna	Scientist	Biochemistry
Dr. Bhupender Kumar	Scientist	Plant Breeding
Dr. Pranjal Yadava	Scientist	Agricultural Biotechnology
Dr. Ganpati Mukri	Scientist	Plant Breeding
Mr. Vishal Singh	Scientist	Plant Breeding
Mr. Yathish Kumar	Scientist	Genetics
Dr. Abhijit Kumar Das	Scientist	Genetics

Name	Designation	Discipline
Administrative staff		
Sh. A.K. Mathur	Administrative Officer	
Sh. Dharambir Singh	Senior Clerk	
Smt. Seema Khatter	Personal Assistant to Director	
Smt. Kamlesh Malik	Assistant	
Ms. Chinkey Agarwal	Assistant	
Mr. Mirnal Darshan	Assistant	
Ajay Kumar Singh	T-1	
Raj Kishore Singh	T-1	
Shri Amarnath	SS Grade-1	
Shri Anwar Ali	SS Grade-1	
Shri Ram Kishan	SS Grade-1	
Winter Nursery Centre, Hyderabad		
Dr. J.C. Sekhar	Principal Scientist	Entomology
Dr. Laxmi Saujanya	Scientist	Entomology
Dr. Chikappa G. Karjagi	Scientist	Plant Breeding
Regional Maize Research and Seed Research Centre, Kushmahout Farm, Begusarai, Bihar		
Dr. S B Singh	Principal Scientist	Plant Breeding
Sh. Sameer K. Rai	T-2	
Sh. Kamal Vats	T-2	
Sh. Rahul	T-2	

*on deputation; ** study leave

भाकृअनुप
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