# वार्षिक प्रतिवेदन
# ANNUAL REPORT

## 2007-08


मक्का अनुसंधान निदेशालय

**DIRECTORATE OF MAIZE RESEARCH**

(Indian Council of Agricultural Research) (भारतीय कृषि अनुसंधान परिषद्)

PUSA CAMPUS NEW DELHI-110012 (INDIA) पूसा कैम्पस, नई दिल्ली–110 012 (भारत)

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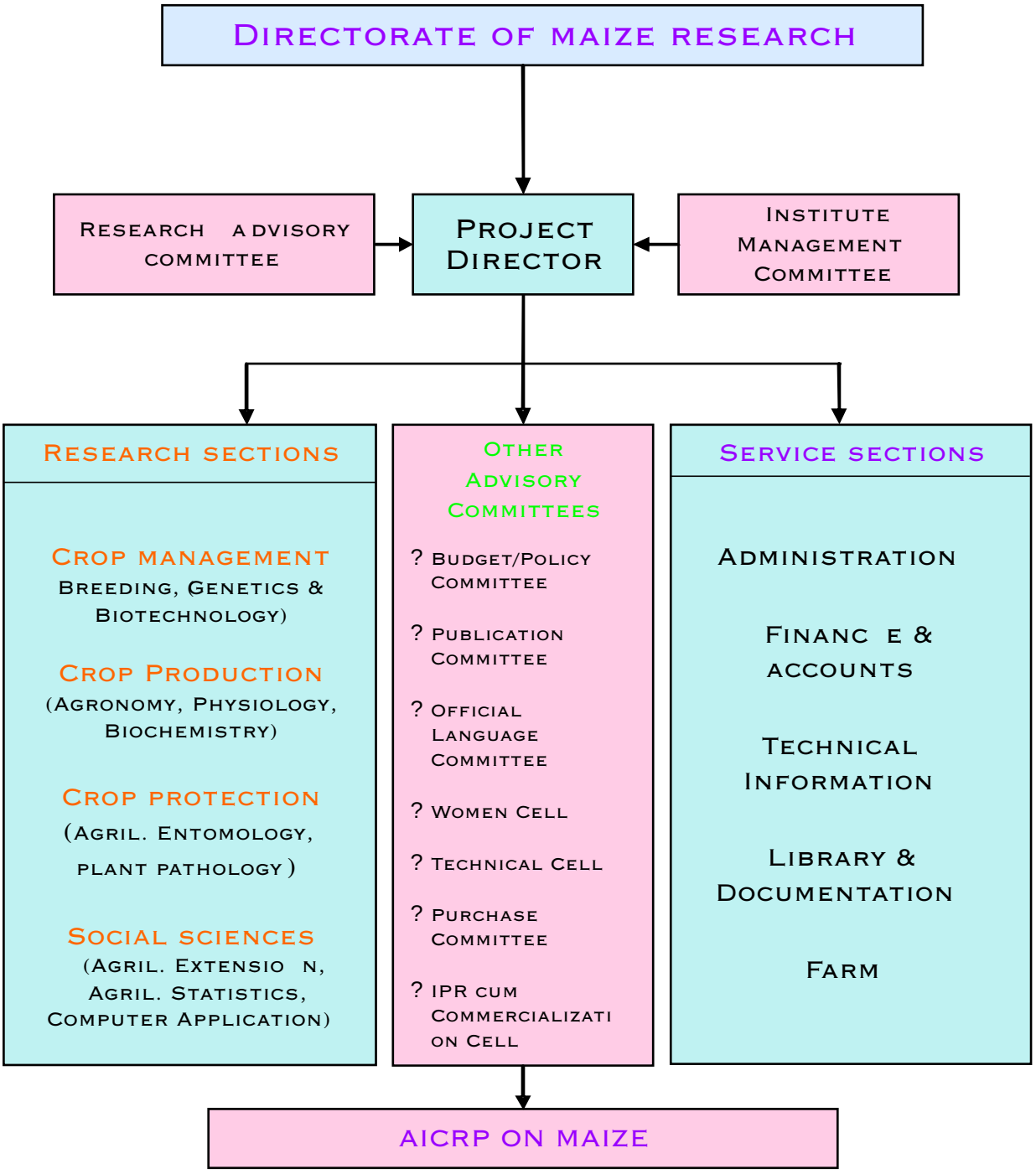
# PREFACE

Maize research paradigm in India has shifted to single cross hybrid. Adoption of single cross hybrid is largely responsible for the unprecedented increase in the productivity, production and area during the period under report. The Directorate has taken into account the growing demand of specialty corn, quality protein maize and normal maize while fixing the priority in its research program. Development of inbreds for the development of promising single cross hybrids suitable for different agro climatic zone is one of the most important activities of maize research. Integrated pest management is another area of attention. Crop losses have been substantially reduced during the validation of IPM strategy developed by Directorate. Importance on site specific nutrient management and the hybrid specific agronomy of the newly released hybrids is another area which is receiving special attention of Directorate. Transfer of technology to the extension specialists, farmers, private sectors, etc. and value addition of baby corn and quality protein maize had been promoted on large scale.

We profoundly express our gratitude to Dr. Mangala Rai, Secretary, DARE and Director General, ICAR, Dr. P.L. Gautam, Deputy Director General (Crop Science), Dr. S.N. Shukla, Assistant Director General (Food and Fodder Crops) for their continuous technical and financial support and constructive suggestions in pursuing these mandated activities. I am delighted to place on record the resolute efforts made by the dedicated scientists of Directorate and its coordinating centres without which the improvement in maize productivity, production could not be possible. The concerted efforts made by technical, supporting and administrative staff to provide assistance to the scientists in various ways to enable them carrying out their research so efficiently is also praise worthy.

(SAIN DASS)
Project Director

# CONTENTS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RESEARCH ADVISORY COMMITTEE
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INSTITUTE MANAGEMENT COMMITTEE
RESEARCH SECTIONS
CROP MANAGEMENT
BREEDING, GENETICS & BIOTECHNOLOGY)
CROP PRODUCTION
(AGRONOMY, PHYSIOLOGY, BIOCHEMISTRY)
CROP PROTECTION
(AGRIL. ENTOMOLOGY, PLANT PATHOLOGY)
SOCIAL SCIENCES
(AGRIL. EXTENSIO N, AGRIL. STATISTICS, COMPUTER APPLICATION)
OTHER ADVISORY COMMITTEES
? BUDGET/POLICY COMMITTEE
? PUBLICATION COMMITTEE
? OFFICIAL LANGUAGE COMMITTEE
? WOMEN CELL
? TECHNICAL CELL
? PURCHASE COMMITTEE
? IPR CUM COMMERCIALIZATI ON CELL
SERVICE SECTIONS
ADMINISTRATION
FINANC E & ACCOUNTS
TECHNICAL INFORMATION
LIBRARY & DOCUMENTATION
FARM
AICRP ON MAIZE

# विशिष्ट सारांश

धान्य फसलों में मक्का विश्व भर में अनेकों कारणों से आकर्षण का केन्द्र है। स्टार्च एवं मांस आधारित उद्योगों में मक्का के बढ़ते उपयोग के कारण मक्का की खपत एवं मांग में लगातार वृद्धि होती रही है। संयुक्त राज्य अमेरिका एवं चीन में मक्का आधारित जैविक ईंधन (बायोफ्यूल) के सुनहरे भविष्य से भारत में मक्का का निर्यात बढ़ने के आसार हैं।

मक्का की उत्पादकता एवं उत्पादन उछाल क्रमशः 23.37 क्विं/हे0 और 19.31 मीलियन टन हो गया है। इस प्रकार विगत वर्ष की तुलना में उत्पादकता में 22.55% और उत्पादन में 27.9% की वृद्धि हुई है।

मक्का अनुसंधान निदेशालय द्वारा एकल क्रॉस संकर मक्का पर जोर देने से देश में मक्का उत्पादन वृद्धि में गति आई है। एकल क्रॉस संकर मक्का के विकास के लिए वैज्ञानिकगण इनब्रेड का विकास एवं उनके लक्षणों का अध्ययन कर रहे हैं। एकल क्रॉस संकर मक्का के अन्तर्गत क्षेत्रफल को बढ़ाना एवं किसान भाइयों के लिए पर्याप्त बीज उपलब्ध कराना निदेशालय का प्रमुख कार्य है। देश में बीज उत्पादन के लिए प्रयास किया गया है और इस दिशा में पश्चिम बंगाल में सराहनीय प्रगति हुई है। इस राज्य में 2005-06 में 14.31 क्विं. बीज उत्पादन हुआ जो बढ़कर 2006-07 में 33 क्विं. हो गया और आने वाले खरीफ ऋतु में 8000 क्विं से अधिक बीज उत्पादन का लक्ष्य रखा गया है।

सन् 2007 में चौ. चरण सिंह हरियाणा कृषि विश्वविद्यालय के करनाल केन्द्र, काशी हिन्दू विश्वविद्यालय, वाराणसी, पंजाब कृषि विश्वविद्यालय, लुधियाना, विवेकानन्द पर्वतीय कृषि अनुसंधानशाला अल्मोड़ा, तमिलनाडु कृषि विश्वविद्यालय कोयम्बटूर, जवाहर लाल कृषि विश्वविद्यालय, छिंदवाड़ा, सिन्जेन्टा और बायोसीड द्वारा मक्का की 16 संकर एवं संकुल किस्मों को अधिसंशत किया गया। ये संकर एवं संकुल किस्में सभी सश्य पारिस्थिति के क्षेत्रों (एग्रो-इकोलोजिकल जोन) में बीज की जरूरतों की पूर्ति करेंगी। विभिन्न प्रकार के 1851 जननद्रव्य (जर्मप्लाज्म) जैसे - सामान्य पीला, सामान्य सफेद, क्यू पी एम पीला, क्यू पी एम सफेद, मधुमक्का, पॉप कॉर्न, अधिक तेलयुक्त मक्का, रूई एवं वैक्सी, शीत एवं अनेक नवीन इन्ट्रोडक्शन का मूल्यांकन किया गया। आर्टिफिशियल इन्फेसटेशन द्वारा 271 लाइन का तना भेदक के प्रति मूल्यांकन किया गया जिसमें से 38 लाइन कम ससेप्टीबल पायी गयीं।

मक्का के रोगों के लिए हॉट स्पाट पर कृत्रिम इन्फेक्शन द्वारा एक सौ नब्बे लाइन का मूल्यांकन किया गया। अनेक रोगों के लिए प्रतिरोधी लाइनों में प्रमुख एच के आई 287, एच के आई 1532, एल एम 13, एल एम 14, विन पिंक एल 63, जे सी वाई 3-7-1-2-1 बी-1-1-4-1, सी एम एल 31, सी एम एल 269, एच के आई 1352-5-8-9, डी एम एस सी 7 तथा एच के आई 193-1 पाये गये।

विभिन्न समन्वय केन्द्रों से एकत्रित किये गये सात सौ तिरानवे विभिन्न प्रकार के जननद्रव्य का शीत नर्सरी, हैदराबाद में मूल्यांकन किया गया और मुख्यालय तथा समन्वय केन्द्रों पर एकल क्रॉस संकर मक्का के विकास के लिए चयन किया गया।

अग्र पंक्ति प्रदर्शन में अधिक उपज देने वाली संकर किस्में, क्वालिटी प्रोटीन मक्का, मधु मक्का, पॉप कार्न, इंटर क्रॉपिंग आदि किसानों के खेतों पर प्रदर्शित की गई। अठारह सौ से अधिक प्रदर्शन में क्वालिटी प्रोटीन मक्का की किस्में एच क्यू पी एम 1, शक्तिमान 1, 2, 3 एवं 4 को प्रदर्शित किया गया। अधिक उपज देने वाली किस्म एच. एम. 4 के प्रयोग से बेबीकॉर्न अधिक प्रचलित हुई है। माधुरी और पॉपकॉर्न-11 किस्में छिन्दवाड़ा में प्रचलित हो रही हैं।

प्रशिक्षण कार्यक्रम में क्यू.पी.एम. और बेबी कॉर्न के अनेक मूल्य संवर्धन उत्पाद प्रदर्शित किये गये हैं। विविध उपयोग और वर्तमान तकनीकी द्वारा निदेशालय किसान और ग्राहक की आवश्यकताओं की पूर्ति करने में सक्षम होगा।

# EXECUTIVE SUMMARY

Among cereals, maize is in sharp focus world over for more than one reason. There has been continuous increase in the consumption and demand of maize mainly owing to increase in demand from meat and starch sectors. The prospects of producing biofuel from maize in USA and China will improve maize export prospects of India mainly to neighboring countries.

The productivity and the production of maize has spurted and reached new heights of 23.37 q/ha and 19.31 m tones respectively thus registering 22.55% increase in productivity and 27.9% in production over the previous year.

The country has poised to give further fillip to the pace of production with the new impetus of the Directorate on single cross hybrids. Scientists are striving for the development of inbreds and characterize them which could be used for the development of high yielding single cross hybrids. To increase the area under single cross hybrid maize; availability of adequate seed to meet the farmers' requirement is another important area of our emphasis. Efforts have been made to boost the seed production in the country for which the progress made in West Bengal is noteworthy. Seed production in this state has increased 14.31 q in 2005-06 to 33.1 q in 2006-07 and has targeted more than 8000 q in the coming kharif season.

During 2007-08, sixteen hybrids and varieties from CCS HAU Karnal, BHU, Varanasi, PAU, Ludhiana, VPKAS Almora, TNAU, Coimbatore, Syngenta, Bioseed and JNKVV, Chhindwara were released during 2007. These hybrids and varieties will cater to the need of all agro-ecological zones of the country. One thousand eight hundred fifty-one germplasm of different types such as normal yellow, normal white, QPM yellow, QPM white, sweet corn, pop corn, high oil corn, ae and waxy, temperate and a sizeable number of new introductions were evaluated. Out of 271 lines evaluated under artificial infestation for *Chilo partellus* thirty-eight have been found less susceptible. Germplasm which showed less than 2.8 LIR (Leaf injury rating on 1-9 scale) are HKI 164-7-6, ESM-8, HKI-PC-8, DMSC 4, HKI-PC-7, LM-14, DMSC 8, HKI-PC-8, ae-40 and JCY 3-7-1-2-1-b'-2-1-2-1. For various maize diseases, 190 lines were evaluated under artificial infection at hot spots. Most promising lines with multiple disease resistance were recorded as HKI 287, HKI 1532, LM 13, LM 14, Win Pink L 63, JCY 3-7-1-2-1'b-1-1-4-1, CML 31, CML 269, HKI 1352-5-8-9, DMSC 7 and
HKI 193-1.

At Winter Nursery Hyderabad, 793 germplasm of various types collected from different coordinating centres were evaluated and selected for development of single cross hybrids at head quarters and coordinating cenres.

Frontline demonstrations have popularized the promising hybrids and specialty corns. Over 1800 FLDs were conducted using Quality Protein Maize (QPM) HQPM-1, Shaktiman-1, 2, 3 and 4. Baby corn has been gaining popularity because of high yielding HM-4 (14.66 q/ha). Madhuri and Pop Corn-11 are getting in Chhindwara, MP.

Value-addition by producing an array of products from QPM and baby corn have been demonstrated during training programmes.

In the light of growing demand, its diversified use and the present strategy to meet the ever increasing demand DMR is expected to live up to the need of both the farmers and consumers.

# INTRODUCTION

Maize is finding newer dimensions in its use to improve the quality of human life. Consequently its demand and price are galloping in international market. The Directorate of Maize Research has mandate to organize conduct and coordinate the research activities for the improvement and enhancement of maize productivity *vis-a-vis* production with an ultimate objective of meeting the ever increasing demand for diversified use of this important crop. The Directorate has the responsibility to generate and popularize appropriate and suitable technologies to be adopted by the maize growers. To begin with major emphasis was laid on the development of double and double top cross hybrids as also for the development of composite/open-pollinated varieties. Today the major emphasis is being laid on the adoption of single cross hybrid technology which is perhaps the only mean for rapid increase in the productivity and production. Also, emphasis is being laid on the development of quality protein maize to ameliorate the nutritional quality for weaker section of the society whose staple food is maize.

## Area, Production and Productivity

There has been a continuous increase in area under maize cultivation. Maize was cultivated in 5.88 and 6.66 m ha during 2005-06 and 2006-07 respectively. During 2007-08 the area under maize cultivation increased by 23.6% over previous year and reached to 8.23 m ha. The productivity also increased by 22.6% and farmers reaped 23.37 q/ha. With the increased area and productivity, production increased by 27.9% and touched new height of 19.31 mt.

## Soil and Weather Conditions

Maize is successfully cultivated under varying environmental conditions throughout the country especially during *kharif, rabi* and spring seasons in peninsular India; *kharif* and spring seasons in Indo-Gangetic plains and only during *kharif* season in hilly regions. Geographically, the area spreads from 11.0 to 34.0'N and 74.14 to 94.16'E and also at 9.73 to 2680 m above MSL. The soil is generally neutral in most maize growing regions except in few like Nagenahalli (pH 5.4), Udaipur and Bahraich (pH 8.5). The soil type where maize is generally cultivated varies from sandy clay, medium black to silty clay loam. However, the pattern of distribution of maize area in India has contributed to low productivity. Also, about 80 per cent of the maize belt being rain dependent remains exposed to vagaries of weather, either excess water of drought.

## MANDATE

(a) To undertake basic and strategic research activities with respect to germplasm enhancement like tolerance to abiotic and biotic stresses, quality improvement, specialized uses, etc.

(b) To coordinate interdisciplinary research activities as follows :
   (i) strategic and applied researches for genetic improvement in yield, quality and resistance to biotic and abiotic stresses.
   (ii) development of efficient package of practices for increasing productivity.
   (iii) tailoring maize for diversified uses for industry and other sectors.

(c) To organize activities related to overall development of maize, for example: training programmes, on-farm research, frontline demeonstrations, etc.

(d) To render and undertake consultancy services and programmes on maize research and developement for needy agencies/institutions in India or abroad.

(e) To develop effective collaborative programme in maize research and development with national and international institutions.

## THRUST AREA

- Development of single cross hybrids
- Development of specialty corns
- Development of quality protein maize
- Development of IPM strategy and its promotion
- Value addition in specialty corns.

## STAFF POSITION

Staff Position as on 31st March, 2008

| Category | Sanctioned | Filled | Vacant |
|---|---|---|---|
| RMP | 1 | 1 | 0 |
| Scientist | 21 | 16 | 5 |
| Technical | 11 | 3 | 8 |
| Administrative | 9 | 8 | 1 |
| Supporting | 4 | 0 | 4 |
| **Total** | **46** | **28** | **18** |

### Financial statement (2007-08)

| | Sanctioned Budget | | | 2007-08 Expdt. | | |
|---|---|---|---|---|---|---|
| Head of Account | Plan | Non-Plan | Total | Plan | Non-Plan | Total |
| Establishment | 790.00 | 110.40 | 900.40 | 749.69 | 106.18 | 855.87 |
| TA | 22.00 | 2.00 | 24.00 | 95.00 | 2.00 | 97.00 |
| Other Charges | 310.00 | 118.35 | 428.00 | 309.60 | 118.35 | 427.95 |
| Minor Works | 0.00 | 19.25 | 19.25 | 0.00 | 19.24 | 19.24 |
| Other Items/HRD | 5.00 | 0.00 | 5.00 | 0.63 | 0.00 | 0.63 |
| **Total** | **1127.00** | **250.00** | **1377.00** | **1154.92** | **245.77** | **1400.00** |

### Resource generation

| Particulars | Rs. (in Lakh) |
|---|---|
| Sale of farm produce | 0.31 |
| Sale of publications and tender forma | 0.00 |
| Rent | 0.00 |
| Standard License Fee | 0.18 |
| Interest earned on loans and advances | 0.38 |
| Analytical testing charges | 20.10 |
| Training Miscellaneous receipts | 16.86 |
| **Total** | **37.83** |

### Funds Received for Externally Funded Projects

| Particulars | Rs. (in Lakh) | |
|---|---|---|
| AP Cess fund scheme | 13.66 | 16.42 |
| FLD | 295.40 | 260.05 |
| DUS Testing | 7.23 | 6.99 |
| Transgenic Project | 69.15 | 40.11 |
| **Total** | **385.44** | **323.57** |

# RESEARCH ACHIEVEMENTS

- BREEDING
- MAIZE ENTOMOLOGY
- PATHOLOGY & NEMATOLOGY
- BIOCHEMISTRY & QUALITY
- AGRONOMY & PHYSIOLOGY
- STATISTICS

# BREEDING

## YIELD EVALUATION TRIALS KHARIF 2007

A total of 275 hybrids/ composites of normal and specialty corn were evaluated in 25 yield trials during kharif 2007-08 in DMR New Delhi. Based on the yield data generated, as many as 70 normal hybrids/ composites were found superior to best check. Likewise, two QPM hybrids were superior to best check HQPM1.

The details of the trials are given in Table-1. The yield superiority of the promising test entries in comparison with the best checks is given in Table-2. The test hybrids/ composites with >10% yield superiority over the best checks are listed.

A brief description of each trial is given below:

## INITIAL EVALUATION TRIAL (IET)

### Trial 61 IET late maturity

Total of 44 hybrids were evaluated in this late maturity initial evaluation yield trial.The results indicated that the majority of the hybrids were superior in yield over the best check (Bio-9681). JH -11137, JH-11693, CP808, MDMH101, etc, were some of the most promising hybrids in this trial (Table 2).

### Trial 62 IET medium maturity

As many as 35 hybrids were evaluated in this trial, out of which 18 were found superior over the best check Bio 9637.The yield superiority ranged from 11.58% to 94.82%. JH-31153; JH-11508; BH-40625, BH-40702, BH-40704, etc. were the highest yielding hybrids (Table 2).

**Table 1: Details of the trials conducted during Kharif 2007, DMR New Delhi**

| Trial | Number of Test entries | Number of Checks | Best check |
|---|---|---|---|
| **Late** | | | |
| 61 | 40 | 4 | Bio 9681 |
| 65 zone 2 | 5 | 3 | Pro 311 |
| 65 zone 4 | 6 | 3 | Pro 311 |
| 65 A 2,3,4 | 2 | 4 | Parbhat, Seedtech 2324 |
| 69 zone 2 | 2 | 4 | Parbhat |
| 69 zone 3 | 1 | 4 | Bio 9681 |
| **Medium** | | | |
| 62 | 33 | 2 | Bio 9637 |
| 62 A | 4 | 2 | Bio 9637 |
| 66 ZONE 1,3 | 3 | 2 | Bio 9637 |
| 66 ZONE 2 | 4 | 2 | Bio 9637 |
| 66 ZONE 5 | 8 | 2 | Bio 9637, Navjot |
| **EARLY** | | | |
| 63 | 18 | 4 | Parkash |
| 67 ZONE 1,2,3 | 3 | 4 | X-3342 |
| 67 ZONE 4,5 | 6 | 4 | Parkash, Kiran |
| **EXTRA-EARLY** | | | |
| 64 | 15 | 3 | Nil |
| 68 ZONE 1 | 6 | 4 | Vivek 9, Surya |
| 68 ZONE 2 | 5 | 4 | Vivek 9 |
| 68 ZONE 3 | 7 | 4 | Vivek 9, Surya |
| 68 ZONE 4 | 9 | 4 | Vivek 9, Surya |
| 68 ZONE 5 | 5 | 4 | Vivek 9, Surya |
| **QPM** | | | |
| QPM-1 | 3 | 1 | Nil |
| QPM-2 | 3 | 1 | HQPM-1 |
| QPM-3 | 2 | 1 | HQPM-1 |
| SWEET CORN | 4 | 3 | Madhuri |
| BABY CORN | 4 | 4 | HM-4 |
| STATION TRIAL | 10 | 1 | - |

### Trial 62 A medium maturity

Six hybrids were evaluated in this trial. Only two hybrids, viz. Bisco 111 and Bisco 555 were found superior over the best check Bio-9637. The yield performance along with per cent superiority is given in Table 2.

### Trial 63 IET Early maturity

As many as 22 hybrids were evaluated. Of these only two, viz. JH-31110 and X-121 showed >10 % yield superiority over the best check, Parkash. The detail is given in Table 2.

### Trial 64 IET Extra early maturity

This trial consisted of 18 hybrids. On the basis of the yield data, only one hybrid i.e. FH-3433 was found > 10 % higher yielding over the best check Vivek hybrid -9.

## ADVANCED EVALUATION TRIAL (AET)
## Ist year ( late maturity)

### Trial 65 Zone 2 and Zone 4

Only eight entries were evaluated for yield and other traits in this Ist year advance stage late maturity trial. 30 R-88 was the only hybrid which showed very high yield superiority of 33 and 71.6 per cent over the best check PRO-311 in zone 2 and 4, respectively (Table 2).

### Trial 65 A Zone 2, 3, 4

Of the six genotypes evaluated in three zones , only two test entries namely, PAC740 and DMR Synthetic - 4 recorded very high yield superiority over the best check Pro 311. The per cent yield superiority in both the genotypes was > 40 (Table 2).

### Trial 66 AET Ist year medium maturity

**Zone 2**

Six genotypes were evaluated for yield and other attributes . The data indicated that three hybrids namely, BH-4062 and BH-4069 and EH-1491 recorded 66.8, 56.7 and 24%, respectively yield superiority over the best check Bio 9637 (Table 2).

### Trial 67 AET Ist year early maturity

**Zone 1, 2, 3**

Seven hybrids were evaluated in this trial. Only one hybrid JH-3978 gave more than 25 % higher yield over the best check Parkash (Table 2).

### Trial 68 AET Ist year extra early maturity

**Zone 2**

Six hybrids and three composites were evaluated for yield and other traits. Based on the data, two composites,viz. VL-113 and Comp.R 2005-5 were found superior to best composite check Surya. None of the hybrids showed more than 10 % yield superiority over the hybrid checks (Table 2).

**Zone 3**

Eight hybrids and three composites were evaluated in zone 3 trial. Two composites, viz. VL-114 and Comp. R 2005-5 were found 30.65% and 81.81%, respectively, superior in yield to the best check.

**Zone 5**

Six hybrids and three composites were evaluated .Two test entries namely VL 113 and Comp. R 2005-5 recorded yield superiority of > 20 % over the best check Surya (Table 2).

### Trial 69 AET 2nd year Late maturity

**Zone 2**

This trial consisted of six genotypes . On the basis of yield data , two genotypes , viz. 30 R 77 and JH-10704, were found superior to best check seed tech-2324, and out yielded by 18.10 and 19.36 per cent , respectively. (Table 2)

**Zone 3**

The trial consisted of five genotypes. Based on yield data, only one genotype ie 30 R 77 showed more than 36.07% higher yield than the best check seed tech 2324 (Table 2).

### Quality Protein Maize Hybrid trial 2

Three test genotypes were evaluated in this trial. Only one QPM hybrid, i.e. JHQPM 113 was found >10 % superior, to the best check HQPM1 (Table 2).

### Quality Protein Maize Hybrid trial 3

Two experimental QPM hybrids and one check HQPM1 were evaluated for yield and % tryptophan content .One test hybrid namely HQPM7 showed yield superiority of > 17 % over the check HQPM1 and possessed 0.72 % tryptophan in grains (Table 2).

## Table 2 : Superior hybrids/composites in different yield trials

| Trial 61 IET Late Maturity | | Yield Superiority Over Best Check | Yield (t/ha) |
|---|---|---|---|
| S. No. | Entry | | |
| 1 | JH-11137 | 186.0 | 8.3 |
| 2 | JH-11180 | 69.6 | 4.9 |
| 3 | JH-11422 | 73.0 | 5.0 |
| 4 | JH-11433 | 83.5 | 5.3 |
| 5 | JH-11449 | 59.4 | 4.6 |
| 6 | JH-11693 | 103.2 | 5.9 |
| 7 | BH-40707 | 56.2 | 4.5 |
| 8 | BH-40709 | 68.0 | 4.8 |
| 10 | BH-40710 | 22.1 | 3.5 |
| 11 | BH-40711 | 34.0 | 3.8 |
| 12 | BH-40712 | 39.8 | 4.0 |
| 13 | BH-40713 | 60.8 | 4.6 |
| 14 | BH-40714 | 47.2 | 4.2 |
| 16 | AH-511 | 39.6 | 4.0 |
| 19 | KAVERI 50 | 68.0 | 4.8 |
| 20 | MM-8255 | 83.2 | 5.3 |
| 21 | X 6B-269 | 23.1 | 3.5 |
| 22 | X 6B-271 | 81.4 | 5.2 |
| 23 | SINDHU-333 | 42.2 | 4.2 |
| 24 | AMAR-555 | 26.0 | 3.6 |
| 25 | OM-7676 | 52.6 | 4.4 |
| 26 | HYTECH'SHTCH-510 | 32.8 | 3.8 |
| 27 | PRO-372 | 48.4 | 4.3 |
| 28 | PRO-373 | 49.3 | 4.3 |
| 29 | CP-808 | 130.5 | 6.6 |
| 31 | M 01-062 | 61.5 | 4.7 |
| 34 | GK-3055 | 40.2 | 4.0 |
| 35 | GK-3056 | 53.6 | 4.4 |
| 36 | MDMH-101 | 96.2 | 5.7 |
| 37 | CP-848 | 39.1 | 4.0 |
| 38 | X-610 | 49.0 | 4.3 |
| 39 | X-640 | 27.7 | 3.7 |
| | BEST CHECK BIO-9681 | - | 3.1 |
| **TRIAL 62 IET MEDIUM MATURITY** | | | |
| 1 | EH-1810 | 34.8 | 4.8 |
| 7 | JH-31153 | 68.8 | 6.0 |
| 8 | JH-11320 | 38.2 | 4.9 |
| 9 | JH-11508 | 91.1 | 6.8 |

| Trial 62 IET Medium Maturity | | Yield Superiority Over Best Check | Yield (t/ha) |
|---|---|---|---|
| S. No. | Entry | | |
| 10 | JH-11535 | 47.1 | 5.2 |
| 11 | BH-40625 | 50.8 | 5.3 |
| 12 | BH-40702 | 58.2 | 5.6 |
| 13 | BH-40703 | 35.1 | 4.8 |
| 14 | BH-40704 | 94.8 | 6.9 |
| 16 | BH-40706 | 47.3 | 5.2 |
| 20 | AH-504 | 49.8 | 5.3 |
| 22 | AH-507 | 11.5 | 3.9 |
| 23 | AH-510 | 30.4 | 4.6 |
| 25 | KAVERI-218 | 27.8 | 4.5 |
| 26 | EURO-1201 | 18.6 | 4.2 |
| 27 | KDMH-1001 | 12.2 | 4.0 |
| 28 | CP-828 | 12.7 | 4.0 |
| 29 | CP-838 | 47.5 | 5.2 |
| | BEST CHECK BIO-9681 | - | 3.5 |
| **TRIAL 62 A IET MEDIUM MATURITY** | | | |
| 3 | BISCO-111 | 33.2 | 4.7 |
| 4 | BISCO-555 | 31.6 | 4.6 |
| | BEST CHECK BIO-9637 | - | 3.5 |
| **TRIAL 63 IET EARLY MATURITY** | | | |
| 6 | JH-31110 | 11.7 | |
| 18 | X-121 | - | |
| | BEST CHECK PARKASH | - | 6.4 |
| **TRIAL 64 IET EXTRA EARLY MATURITY** | | | |
| 7 | FH-3433 | 20.2 | 5.1 |
| | BEST CHECK VIVEK HYBRID 9 | - | 4.2 |
| **TRIAL 65 LATE AET 1ST YEAR ZONE 2, 4** | | | |
| 4 | 30 R 88 | 32.9 | 4.8 |
| | BEST CHECK PRO 311 | - | 3.6 |
| 4 | 30 4 88 | 71.6 | 5.3 |
| | BEST CHECK PRO 311 | - | 3.1 |

| | | | |
|---|---|---|---|
| **TRIAL 65 A ZONE 2,3,4** | | | |
| 1 | PAC 740 | 43.9 | 3.8 |
| 2 | DMR SYNTHETIC 4 | 46.6 | 3.9 |
| | BEST CHECK PRO 311 | - | 2.6 |
| **TRIAL 66 ZONE 2 MEDIUM MATURITY** | | | |
| 2 | EH-1491 | 23.9 | 4.4 |
| 3 | BH-4062 | 66.8 | 5.9 |
| 4 | BH-4069 | 56.7 | 5.6 |
| | BEST CHECK BIO 9637 | - | 3.5 |
| **TRIAL 67 ZONE 1,2,3 EARLY MATURITY** | | | |
| 1 | JH-3978 | 25.3 | 5.6 |
| | BEST CHECK PARKASH | - | 4.5 |
| **TRIAL 68 ZONE 2 EXTRA EARLY MATURITY** | | | |
| 2 | VL-113 | 35.3 | 3.1 |
| 3 | COMP-R-2005-5 | 72.6 | 4.0 |
| | BEST CHECK SURYA | - | 2.3 |
| **TRIAL 68 ZONE 3** | | | |
| 5 | VL-114 | 30.6 | 2.6 |
| 6 | COMP-R-2005-5 | 81.8 | 3.6 |
| | BEST CHECK SURYA | - | 2.0 |
| **TRIAL 68 ZONE 5** | | | |
| 3 | VL-113 | 20.3 | 1.9 |
| 4 | COMP-R-2005-5 | 22.3 | 2.0 |
| | BEST CHECK SURYA | - | 1.6 |
| **TRIAL 69 ZONE 2 AET 2nd Year** | | | |
| 1 | 30 R 77 | 18.1 | 4.8 |
| 2 | JH-10704 | 19.3 | 4.8 |
| | BEST CHECK SEED TECH 2324 | - | 4.0 |
| **TRIAL 69 ZONE 3 AET 2nd Year** | | | |
| 1 | 30 R 77 | 36.0 | 5.2 |
| | BEST CHECK BIO-9681 | | 3.8 |
| **TRIAL QPM 2** | | | |
| 2 | JHQPM-113 | 11.7 | 5.0 |
| | BEST CHECK HQPM1 | | 4.5 |
| **TRIAL QPM 3** | | | |
| 2 | HQPM 7 | 17 | 5.4 |
| | BEST CHECK HQPM1 | | 4.6 |

### Germplasm development, evaluation and maintenance

In the breeding programme single cross hybrid oriented germplasm development received top priority. The major breeding activities towards this direction were: development, evaluation and maintenance of inbred lines, increase of seeds of desirable lines and their distribution to different SAUs and other organizations for development of single cross hybrids (location specific and across the locations). Towards this direction, during kharif 2007, 1851 lines of different types of maize inbreds were evaluated for morphological, phenological, agronomical and quality traits, as well as against biotic and abiotic stresses. The lines were cleaned and maintained through hand pollination. All the selected lines were grouped according to maturity, grain colour and texture, pollen parent and seed parent etc. for their systematic use in hybrid programme. Germplasm screened and selected in different maize types are presented in Table 3.

**Table 3. Number of lines evaluated and selected during kharif 2007**

| Group | Lines evaluated | Lines selected | Group | Lines evaluated | Lines selected |
|---|---|---|---|---|---|
| Normal yellow | 297 | 125 | Popcorn | 78 | 27 |
| Normal white | 132 | 31 | High oil corn | 88 | 36 |
| QPM yellow | 87 | 69 | ae & waxy | 8 | 3 |
| QPM white | 34 | 11 | Temperate | 27 | 19 |
| Sweet corn | 188 | 39 | Introduction | 912 | 217 |

## Normal maize

As many as 297 lines of normal yellow maize were evaluated. Of these, the most promising 125 lines were selected for further breeding programme. Similarly, 132 white inbred lines were evaluated and only a set of 31 was retained and mintained through self pollination at Hyderabad. Some of the promising normal inbred lines selected are HKI 536, LM 11 , LM 6, LMP 3, CML 147, JCY3-7-1-2-1-'b-2-1-2-1, Lud-5644, Lud-5645, Lud-5647, Gen 6014 and Gen 6033 (Figs. 1, 2).

Fig. 1: A promising normal inbred line, LTP 3

Fig. 2: Cobs of promising normal inbred lines: HKI 536, HKI 577 and HKI 1344

## Temperate Germplasm

A set of 27 temperate lines was evaluated. Of these, 19 were selected and maintained. The seeds of desirable lines like NC 252, NC 318-1, NC 370 etc. were increased. These lines will be utilized for the introgression of cold tolerance as well as development of late maturing single cross hybrids. These lines will be given to the centres like Ludhiana, Karnal, Hyderabad, Bangalore, Dholi etc. where they have rabi maize and late maturing single cross hybrid development programme.

## Quality Protein Maize

Total of 121 QPM lines (87 yellow and 34 white) were evaluated for different traits. As many as 69 yellow and 11 white QPM lines were selected based on their agronomic desirability. Some of them are HKI 164-7-7 ER4, HKI 31-2, HKI 33-5-2(1-2), HKI 5072-2 - BT, CML 157, CML 171, CML 451, DMR QPM 164/161 (HKI 164-7-6 × 161), DMR QPM 161/451-28-2 (CML161×CML451), DMR QPM 165/02839-7-1-2 (CML165 ×CL-02839), DMR QPM G2501/170-16-2-1-2 (CL-G2501×CML170), DMR QPM G2501/170-2-2-4 (CL-G2501×CML170), DMR QPM G2501/170-2-3-5 (CL-G2501×CML170)2-3-5 and DMR QPM G2501/170-24-1-1-5 (CL-G2501×CML170) (Fig. 3).

Fig. 3: Cobs of promising QPM inbred lines: HKI 174-7-7 ER4, CML171/CML 451 derived line and CL-G2501/CML 170 derived line

Quality analysis was carried out on these lines for the confirmation of high tryptophan content. All the lines showing > 0.6% tryptophan were retained for further breeding programme.

## Specialty Corn

### A. Sweet Corn

As many as 188 sweet corn lines were evaluated. Most of these lines were not fixed. The desirable fixed lines with 20% and above brix value were selected. The generation of segregating lines was advanced, desirable plants were selfed and observations on sugar content were also recorded. The uniform lines with high sugar

content were utilized in the development of sweet corn hybrid (s). The same set was planted at Winter Nursery, Hyderabad for their seed increase, purification, advancing the generation and their further distribution to various AICRP centres.

Fig. 4: Ears of promising sweet corn line derived from Cuba 377

CUBA 377 (Fig. 4) and an advanced line from cross Dulce Amanillo (Su Su) x Dulce Blanco (Su Su) are the two most promising sweet corn lines. A set of selected lines will also be evaluated under hot spots for diseases and insect-pests in the coming season.

### B. Pop corn

Thirty three popcorn inbred lines along with 45 segregating lines were evaluated for various economic traits. As many as 27 uniform inbred lines were retained for their further use in breeding programme.

Fig. 5: Promising popcorn line PC 8

The most productive lines with high popping volume were involved in the development of pop corn single cross hybrid(s). All these selected lines along with a set of desirable segregating lines were evaluated under neutral climatic conditions at Hyderabad. The generation of promising segregating populations was advanced by selecting and selfing the desirable plants. HKI PC 8 (Fig. 5) is one very promising inbred line, which may be used both as male and female parent in hybrid combination. The seeds of fixed lines was increased for exchange with the selected SAU partners for the development of inter-institutional pop corn hybrid (s).

### C. High-oil corn

As many as 88 high oil lines were evaluated for various agronomic traits. Based on the agronomic desirability, 36 lines were selected. The chemical analysis revealed up to 7% oil content. However, only a few lines showed >6% oil. These lines will be further utilized in breeding programme. CUBA 13, HKI Tall 1-2-F, SHD-1 ER6, 02POOL 33 C24 are the three most promising high-oil lines.

### D. W*axy* and *ae* lines

Only eight *waxy/ae* lines were evaluated for agronomic as well as *waxy/ae* traits. More than 90% amylosepectin was recorded only in two lines.

### Introductions

A total of 293 introductions from CIMMYT and NBPGR were evaluated during the year. From these 217 introductions were purified and maintained through hand pollination. These lines were evaluated by the maize breeders from different SAUs, ICAR institutes and private seed companies during the Field Day at Winter Nursery, Hyderabad. The seeds of the selected lines were increased and distributed among the breeders of both public and private sectors. Some of the selected introductions are EC 598435, EC 598439, EC 598441, EC 598447, EC 598456, EC 598457, EC 598458, EC 598459, EC 598462, EC 598464, EC 598474, EC 598475, EC 598476, EC 598477, CLQRCYQ-47-B, CLQRCYQ-51-B, CML 287-B, CML 433-B, CML 433-B, CML 451-B, CML163-B, CML-413-B, CML-465-1, CML-469-1, IT-INA-011, CA00106-4, CA00360/ PIO3011F2-3-5-6-1-B-BBB-B-B-B-B and Pop.31DMR-88-3#-B*13-B-B-B-9.

### Evaluation of inbred lines under biotic and abiotic stresses

The most promising lines of various purposes were evaluated for biotic and abiotic stresses under artificial

conditions at different hot spots for identification of stable sources of resistance.

### Identification Of Multiple Disease Resistant Lines

A set of 190 promising lines was tested for major diseases at different hot spots across the country, viz. Delhi, Hyderabad, Udaipur, Mandya, Nagenahalli etc. for identification of stable sources of disease resistance. Some of the most desirable lines with multiple disease resistance are: HKI 287, HKI 1532, LM 13, LM 14, Win Pink L63, JCY3-7-1-2-1'b-1-1-4-1, CML 31, CML 269, HKI 1352-5-8-9, DMSC 7, DMHOC 9, HKI 164-4-(1-3), HKI 164-7-7 ER4, HKI 191-1-2-5, HKI 193-1, etc.

### Identification of Lines Resistant To *Chilo*

A set of 271 lines were evaluated against *Chilo partellus* in Delhi and Hyderabad. Thirty eight lines with low leaf injury level (LIR) score were identified. Some of the most promising tolerant entries are: HKI 164-7-6, ESM-8, HKI-PC-8, DMSC4, HKI-PC-7, LM 14, DMSC8, HKI PC 8, ae-40, JCY3-7-1-2-1-'b-2-1-2-1, etc.

### Identification of lines tolerant to moisture stress

A set of 271 lines was evaluated for water logging and drought to identify tolerant sources of moisture stress. Majority of the lines screened against water logging showed high susceptibility. Based on low ASI, HKI 551-2, JCY 3-7, HKI 335, LM 13, LM 9, HKI 162, HKI 3-4-8-6ER, were the most promising lines.

### Winter nursery maize programme

Large number of inbred and other segregating lines were evaluated during the kharif 2007 season in Delhi. Seven hundred fifty nine (759), most promising inbred lines for different purposes were selected for their evaluation, cleaning and acclimatization under neutral environment condition at Winter Nursery, Hyderabad during rabi 2007-08. The detail of the lines evaluated is given in Table 4. Some of the desirable segregating lines from normal maize, QPM, popcorn, sweet corn and high-oil were also evaluated and the generation of most desirable lines were advanced.

### Training

Practical Field Training on inbred and hybrid development was organized at Hyderabad from March 8-10, 2008, which was attended by 40 breeders from different SAUs and ICAR institutes (Fig. 6). During the training, the breeders were appraised on various practical aspects of maize breeding like roughing,

Fig. 6: On Hand Training at Winter Nursery, Hyderabad

selection of inbred lines, development of hybrids, DUS characterization of lines and hybrids, etc.

### Field Day

**A. Evaluation of inbreds:** The inbred lines planted in Winter Nursery, Hyderabad were monitored and evaluated by the breeders and pathologist from various SAUs and ICAR institutes. The breeders selected the lines for their use in breeding programme (Fig. 7). The seeds of selected lines as per their indent were supplied.

Table 4. Number of lines evaluated during rabi 2007 at Winter Nursery, Hyderabad

| Germplasm type | No. of lines | Germplasm type | No. of lines |
|---|---|---|---|
| Normal yellow | 125 | Popcorn | 27 |
| Normal white | 31 | High oil corn | 36 |
| QPM yellow | 69 | ae & waxy | 3 |
| QPM white | 11 | Temperate | 19 |
| Sweet corn | 59 | Introduction | 393 |

Fig. 7: Participants in the Field Day at Winter Nursery, Hyderabad

The detail of the number of lines supplied to each centre is given in Table 5. A set of selected lines was supplied to various hot spots for screening against different biotic and abiotic stresses and agronomic evaluation as detailed in Table 6.

**B. Evaluation of introduction:** The germplasm received from USA, Nigeria, Italy, CIMMYT etc. were purified, maintained and multiplied at Winter Nursery, Hyderabad. On March 10, 2008 breeders from public and private institutions were invited for selection of useful germplasm. The material selected by the breeders of various organization were supplied as per their indent. Details of the material supplied is given in Table 7 and 8.

### Single cross hybrid development programme

During the period under report the most promising lines in different groups were involved in combination breeding. About 200 single cross hybrids of normal, QPM, sweet corn, popcorn etc. were developed. These hybrids will be evaluated in different yield trials with suitable maturity groups in the coming Kharif season. One sweet corn hybrid was evaluated in different location of the country along with checks. The performance of the hybrid was encouraging with respect to yield and sugar content. This hybrid has yield superiority of >17% over the best check, Priya sweet corn with 23.7% sugar content.

### Molecular studies in maize

Two hundred nineteen (219) SSR primers were used to screen efficacy of the primers. A set of 24 diverse genotypes, which included 8 normal (HKI 209, HKI 1572, HKI 1025, LM 5, NAI 105, CM 111, CM 300, CM 400), 11 QPM lines (HKI 14-2, HKI 161-TR-5-2, HKI 1647-7-2, HKI 17-2, HKI 35-5-2, HKI 163, CML 175, CML 176, HKI 27-3, HKI 188, CLQRCY Q51), two high-oil lines

Table 5: Number of lines distributed to the breeders of different AICRP (M) centres and CIMMYT - India

| Sl.No. | Name of the Centre | Number | Sl.No. | Name of the Centre | Number |
|---|---|---|---|---|---|
| 1. | Hyderabad | 138 | 15. | Kolhapur | 72 |
| 2. | Banswara | 128 | 16. | Ambikapur | 71 |
| 3. | Udaipur | 128 | 17. | Varanasi | 71 |
| 4. | Almora | 108 | 18. | Coimbatore | 70 |
| 5. | Karnal | 108 | 19. | Bajaura | 66 |
| 6. | Ludhiana | 106 | 20. | Pantnagar | 56 |
| 7. | Pahalgam | 86 | 21. | Arbhavi | 56 |
| 8. | Srinagar | 84 | 22. | Mandya | 49 |
| 9. | Dholi | 83 | 23. | Delhi | 40 |
| 10. | Banswara | 81 | 24. | Kanpur | 36 |
| 11. | Chhindwara | 81 | 25. | Jorhat | 26 |
| 12. | Godhra | 75 | 26. | Belipar | 21 |
| 13. | CIMMYT | 75 | 27. | Poonch | 21 |
| 14. | Jashipur | 73 | 28. | Rajouri | 21 |

## Table 6: Number of lines supplied to hot spots for screening against biotic and abiotic stresses and agronomic evaluation

| S. No. | Name of the Centre | Number |
|---|---|---|
| **Agronomy** | | |
| 1 | DMR | 174 |
| 2 | Udaipur | 138 |
| 3 | Hyderabad | 120 |
| **Pathology** | | |
| 4 | DMR | 174 |
| 5 | Mandya | 74 |
| 6 | Nagenahalli | 50 |
| 7 | Delhi | 50 |
| 8 | Arbhavi | 33 |
| 9 | DMR | 155 |
| 10 | Karnal | 88 |
| 11 | Ludhiana | 83 |
| **Entomology** | | |
| 12 | Hyderabad | 67 |
| 13 | Udaipur | 66 |
| 14 | Ludhiana | 83 |
| 15 | Udaipur | 87 |
| 16 | Karimnagar | 83 |

## Table 7: Introductions supplied to public sector institutions

| S. No. | Name of the centre | Number | S. No. | Name of the centre | Number | S. No. | Name of the centre | Number |
|---|---|---|---|---|---|---|---|---|
| 1. | Hyderabad | 96 | 11. | Belipar | 70 | 21. | Coimbatore | 19 |
| 2. | Delhi | 93 | 12. | Kanpur | 48 | 22. | Rajouri | 17 |
| 3. | Varanasi | 93 | 13. | Kolhapur | 46 | 23. | Varanasi | 15 |
| 4. | Mandya | 93 | 14. | Chhindwara | 35 | 24. | Almora | 13 |
| 5. | Arbhavi | 93 | 15. | Udhampur | 30 | 25. | Godhra | 11 |
| 6. | Karnal | 93 | 16. | Ludhiana | 25 | 26. | Srinagar | 9 |
| 7. | Ambikapur | 93 | 17. | Banswara | 25 | 27. | Pantnagar | 6 |
| 8. | Jorhat | 93 | 18. | Poonch | 22 | 28. | Udaipur | 5 |
| 9. | Bajaura | 93 | 19. | Dholi | 20 | 29. | Nagenahalli | 4 |
| 10. | Karimnagar | 82 | 20. | Jashipur | 20 | | | |

## Table 8: Introductions supplied to private sector institutions

| S. No. | Name of the centre | Number | S. No. | Name of the centre | Number |
|---|---|---|---|---|---|
| 1. | S.M. Sehgal Foundation, ICRISAT | 128 | 10. | VNR Seeds, Hyderabad | 56 |
| 2. | Super Agrinova Seeds P. Ltd. | 110 | 11. | Brahmaputra Seeds | 48 |
| 3. | Zuari Seeds, Bangalore | 86 | 12. | Manisha Agri Biotech | 44 |
| 4. | Emergent Seeds | 86 | 13. | Amaaraeswara Agritech, | 43 |
| 5. | Annadata Seeds | 86 | | Hyderabad | |
| 6. | Ajit Seeds | 86 | 14. | Kanchan Ganga Seeds | 34 |
| 7. | Nuziveedu Seeds | 86 | 15. | Vibha Seeds | 33 |
| 8. | Sri Ram Bioseed Research | 86 | 16. | Amar Biotech, Hyderabad | 33 |
| 9. | Nitya Seeds, Hyderabad | 84 | 17. | Nusun Seeds | 31 |

| S. No. | Name of the centre | Number | S. No. | Name of the centre | Number |
|---|---|---|---|---|---|
| 18. | Narmada Agritech | 29 | 28. | Dhanuka, Hyderabad | 19 |
| 19. | Yaaganti Seeds | 29 | 29. | Vikas Agri Sciences | 19 |
| 20. | Krishidhan Seeds, Jalana | 28 | 30. | Namdhari Seeds, Bangalore | 18 |
| 21. | Ganga Kaveri Seeds, Hyderabad | 25 | 31. | PHS Agritech | 18 |
| 22. | Uniphos Seeds & Biogenetics, Secunderabad | 25 | 32. | Kaveri Seeds | 16 |
| 23. | Syngenta Seeds, Bangalore | 24 | 33. | Nunhems India, Bangalore | 14 |
| 24. | Adanta India, Secunderabad | 24 | 34. | C.P. Seeds, Bangalore | 8 |
| 25. | Atash Seeds | 22 | 35. | J.K. Agrigenetics, Bangalore | 6 |
| 26. | Spic. Hosur, Tamil Nadu | 20 | 36. | MAHYCO, Dowalwadi, Jalna, Aurangabad | 4 |
| 27. | Basant Agrotech | 20 | | | |

(HKI 48-3-2, SHD 1ER-10), two popcorn lines (HKI PC-8, HKI PC-BT-3) and one sweet corn line (HKI 1827W-1) was used. The selection criteria for the efficacy of the primer used were: i) chromosomal location of primers, ii) reliability of the primers and iii) polymorphism information content (PIC) and discrimination rate (DR) values of each primer. Based on these criteria 46 primers were finally selected for large scale screening of the inbred lines. The primers selected are as listed Table 9.

These 46 primers were used for screening 133 inbred lines representing various groups, viz. 90 normal, 32 QPM and 11 specialty corn. The details of these lines are given in the Table 10. Normal inbred lines gave an average Jacards' similarity coefficient of 0.34, which ranged from 0.16 to 0.59. The 89 normal lines, under study, were placed in 8 clusters (Fig. 8). Cluster I and II were further subdivided into two sub-groups, a and b. Cluster I and II were represented by 23 and 18 genotypes, respectively. Cluster III consisted of 10 genotypes, while Cluster IV was represented by 17 genotypes. Remaining clusters, V, VI, VII and VIII were small with 5, 3, 8 and 5 genotypes, respectively. The details of the clusters carrying different inbred lines are given below (Table 11).

Thirty two QPM lines were evaluated which revealed the genetic diversity among them. Jacards' similarity coefficient among QPM lines ranged from 0.16 to 0.53 with an average of 0.27. The QPM lines were clustered in five groups (Fig. 9). Cluster I was represented by 8 inbred lines (HKI 163, CML 163, CML 142, CML 150, CML 161, CLQRCYQ 51, HKI 14-2, HKI 161-TR-5-2), while cluster II was the biggest with 12 inbed lines (CML 165, CML 175, CML 176, HKI 164-7-2, HKI 1647-7-2, HKI 17-2, HKI 188, HKI 193-2-1, HKI 26-2-4(1-4), HKI 27-3, HKI 35-5-2, HKI 5072-2-BT). Cluster III with 3 inbred lines (HKI 34-(1+2)-1, HKI 586-1 WG33, HKI 31-2). Clusters IV and V were represented by 5 (HKI 170(H-2, HKI 164-1-4, HKI 15-2-2 (1-3), HKI 164-D-3-3-2, HKI 191-1-2-5) and 4 (HKI 162, CML 140, CL02457, HKI 193-1) inbred lines, respectively.

Studies on speciality corn inbred lines revealed the genetic variation between the lines in different groups. Lines representing each group were clustered separately (Fig. 10). High-oil lines derived from Shahid (Shd 1ER-10, Shd 1ER-6) were genetically different from Talar derived lines (HKI Tallar, HKI Tallar 8-1 and HKI Tall 1-2F). We can involve these lines in combination breeding for developing high-oil single cross hybrids. The sweet corn lines, viz. HKI 1827W-1 and HKI 1831-5-3-2 were different from each other and can be used in hybrid combination. The popcorn lines were also divergent from each other.

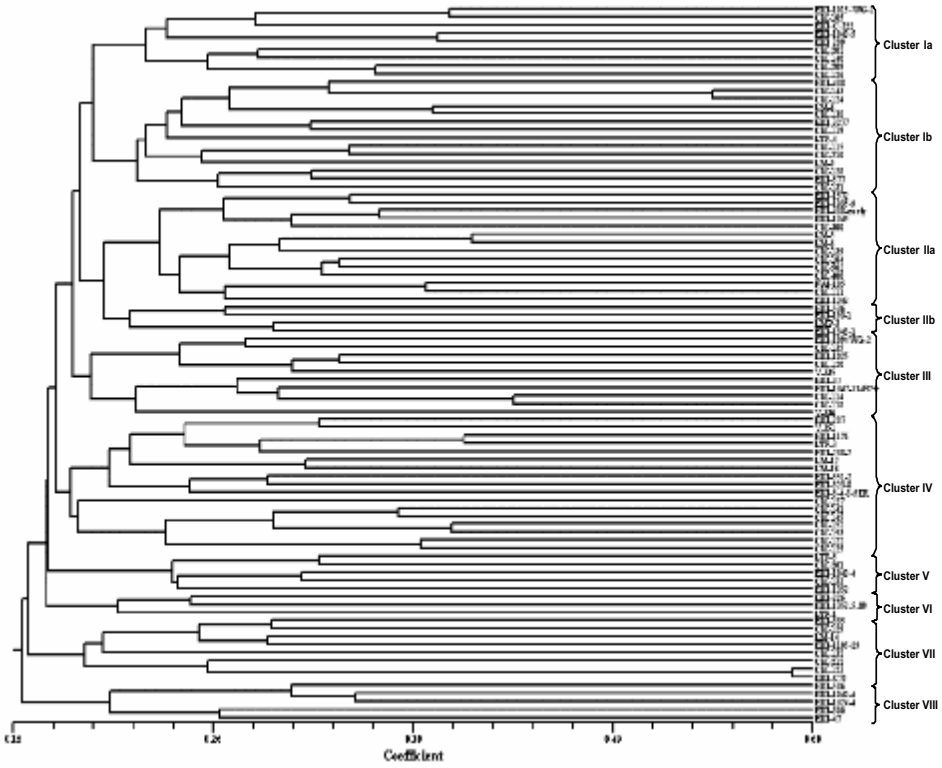



**Fig. 8: Dendogram depicting the variability among normal inbred lines**

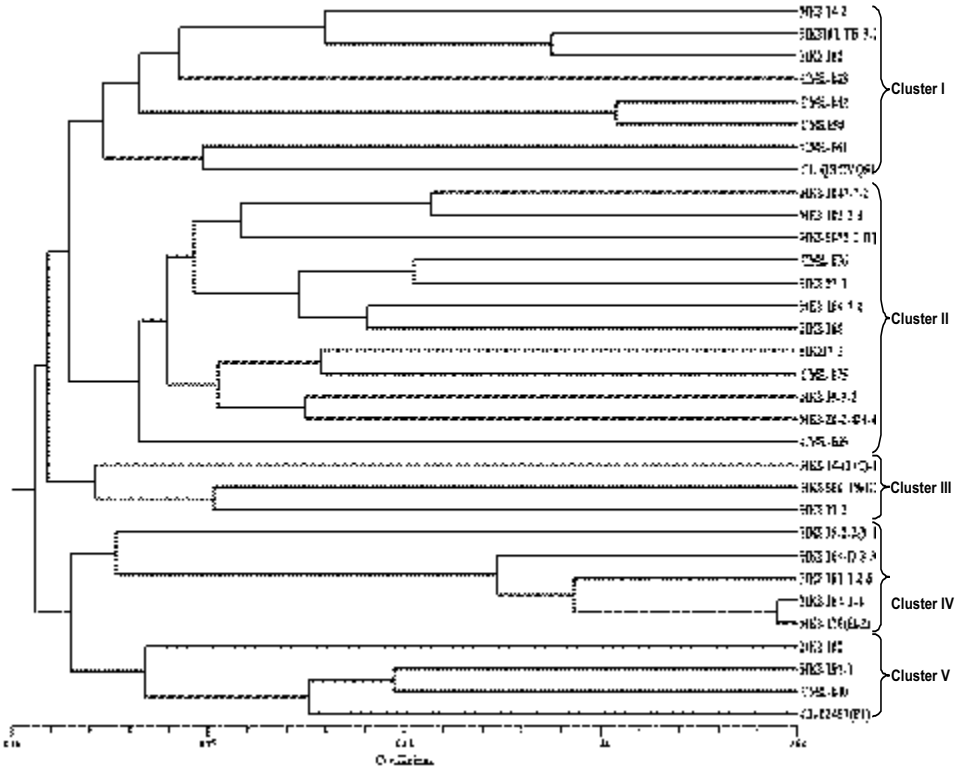



**Fig. 9: Dendogram depicting the variability among QPM inbred lines**

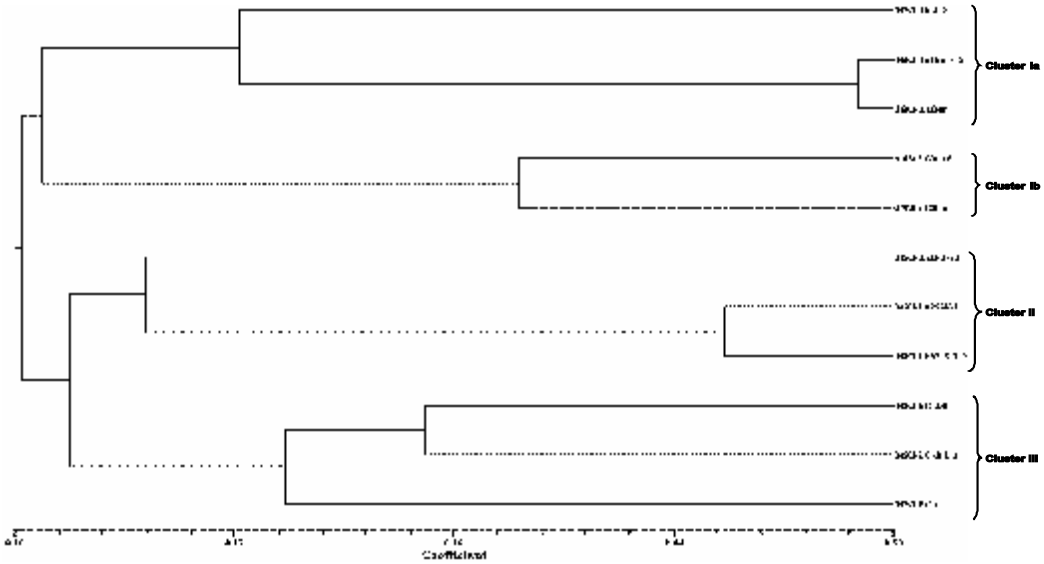



Fig. 10: Dendogram depicting the variability among speciality corn lines

## Table 9: List of 46 selected primers used in diversity study

| Sl. No. | Marker | Location | PIC value | DR value | Sl. No. | Marker | Location | PIC value | DR value |
|---|---|---|---|---|---|---|---|---|---|
| 1 | bnlg1429 | 1.02 | 0.65 | 0.61 | 24 | bnlg105a | 5.02 | 0.54 | 0.62 |
| 2 | bnlg1866 | 1.03 | 0.63 | 0.68 | 25 | mmc0081 | 5.05 | 0.65 | 0.75 |
| 3 | bnlg2238 | 1.04 | 0.74 | 0.79 | 26 | bnlg2305 | 5.07 | 0.67 | 0.65 |
| 4 | bnlg2238 | 1.04 | 0.74 | 0.79 | 27 | bnlg1043 | 6.00 | 0.77 | 0.71 |
| 5 | bnlg615 | 1.07 | 0.66 | 0.61 | 28 | bnlg1371 | 6.01 | 0.78 | 0.80 |
| 6 | phi064 | 1.11 | 0.74 | 0.76 | 29 | mmc0241 | 6.05 | 0.66 | 0.73 |
| 7 | mmc0063 | 2.00 | 0.64 | 0.68 | 30 | umc1414 | 6.06 | 0.64 | 0.65 |
| 8 | bnlg2248 | 2.03 | 0.74 | 0.80 | 31 | phi089 | 6.08 | 0.68 | 0.59 |
| 9 | bnlg381 | 2.04 | 0.52 | 0.63 | 32 | bnlg2132 | 7.00 | 0.65 | 0.75 |
| 10 | bnlg1662 | 2.08 | 0.76 | 0.80 | 33 | bnlg1200 | 7.01 | 0.68 | 0.65 |
| 11 | umc1551 | 2.09 | 0.46 | 0.49 | 34 | bnlg1808 | 7.02 | 0.64 | 0.79 |
| 12 | umc1746 | 3.00 | 0.64 | 0.68 | 35 | bnlg1863 | 8.03 | 0.74 | 0.83 |
| 13 | bnlg1523 | 3.03 | 0.63 | 0.60 | 36 | bnlg1651 | 8.05 | 0.78 | 0.79 |
| 14 | bnlg1904 | 3.04 | 0.69 | 0.80 | 37 | bnlg1056 | 8.08 | 0.76 | 0.99 |
| 15 | bnlg1456 | 3.05 | 0.61 | 0.62 | 38 | bnlg1724 | 9.01 | 0.65 | 0.69 |
| 16 | umc1136 | 3.10 | 0.34 | 0.62 | 39 | bnlg430 | 9.03 | 0.66 | 0.77 |
| 17 | nc004 | 4.03 | 0.62 | 0.61 | 40 | umc1357 | 9.05 | 0.69 | 0.69 |
| 18 | bnlg1265 | 4.05 | 0.73 | 0.77 | 41 | bnlg1129 | 9.08 | 0.67 | 0.62 |
| 19 | bnlg1917 | 4.10 | 0.61 | 0.63 | 42 | phi041 | 10.00 | 0.63 | 0.65 |
| 20 | bnlg1337 | 4.11 | 0.75 | 0.87 | 43 | phi059 | 10.02 | 0.59 | 0.68 |
| 21 | bnlg1890 | 4.11 | 0.61 | 0.77 | 44 | bnlg1079 | 10.03 | 0.65 | 0.72 |
| 22 | bnlg1006 | 5.00 | 0.64 | 0.86 | 45 | umc1077 | 10.04 | 0.71 | 0.75 |
| 23 | bnlg1382 | 5.01 | 0.70 | 0.74 | 46 | bnlg1074 | 10.05 | 0.64 | 0.68 |

## Table 10: List of genotypes used in the molecular diversity study

| Sl. No. | Inbred line | Sl. No. | Inbred line | Sl. No. | Inbred line |
|---|---|---|---|---|---|
| **Normal** | | 46 | CM 122 | 91 | HKI 161-TR-5-2 |
| 1 | HKI 1015 WG-2 | 47 | CM 125 | 92 | HKI 1647-7-2 |
| 2 | HKI 1040-5 | 48 | CM 115 | 93 | HKI 17-2 |
| 3 | HKI 1094WG-2 | 49 | CM 210 | 94 | HKI 193-2-1 |
| 4 | HKI 209 | 50 | HKI 3-4-8-5 ER | 95 | HKI 35-5-2 |
| 5 | HKI 335 | 51 | CM 202 | 96 | HKI 163 |
| 6 | HKI 47 | 52 | HKI 193 | 97 | HKI 5072-2-BT |
| 7 | HKI 1572 | 53 | LTP 5 | 98 | CML 175 |
| 8 | HKI 1025 | 54 | LTP 3 | 99 | CML 176 |
| 9 | LM 5 | 55 | CM 209 | 100 | HKI 164-7-2 |
| 10 | LM 6 | 56 | HKI 3277 | 101 | HKI 27-3 |
| 11 | NAI 105 | 57 | CM 140 | 102 | HKI 188 |
| 12 | CM 139 | 58 | CM 123 | 103 | HKI 15-2-2 (1-3)-3 |
| 13 | CM 104 | 59 | CM 135 | 104 | HKI 164-D-3-3-2 |
| 14 | CM 111 | 60 | CM 126 | 105 | HKI191-1-2-5 |
| 15 | HKI 488 | 61 | CM129 | 106 | HKI 34 (1+2)-1 |
| 16 | HKI 536 | 62 | LM 14 | 107 | HKI 586-WG × 33 |
| 17 | HKI 1347-1-L/H2+3 | 63 | HKI 1105-29 | 108 | HKI MBR -139 |
| 18 | HKI 1035-9 | 64 | HKI 1040-4 | 109 | HKI 162 |
| 19 | HKI 226 | 65 | LM 9 | 110 | HKI 164-1-4 |
| 20 | HKI 287 | 66 | HKI 323-8 | 111 | HKI 170 (H-2) |
| 21 | HKI C322 | 67 | CM 201 | 112 | HKI 193-1 |
| 22 | HKI 551-2 | 68 | CM 128 | 113 | CL 02457 |
| 23 | HKI 586 | 69 | CM 131 | 114 | CML 140 |
| 24 | HKI 1040-4 | 70 | HKI 577 | 115 | CML161 |
| 25 | HKI1324-4 | 71 | LTP 4 | 116 | CML142 |
| 26 | HKI 300 | 72 | CM 133 | 117 | CML150 |
| 27 | HKI 47 | 73 | CM 143 | 118 | CML 165 |
| 28 | HKI 1126 | 74 | CM 124 | 119 | HKI 31-2 |
| 29 | HKI 288-2 | 75 | CM 119 | 120 | HKI 26-2-4 (1-4) |
| 30 | LM 12 | 76 | LTP 1 | 121 | CML163 |
| 31 | LM 16 | 77 | CM 132 | 122 | CL-QRCYQ51 |
| 32 | LTP 3 | 78 | HKI 488 early | ***High-oil*** | |
| 33 | V 336 | 79 | LM 6 | 123 | HKI 48-3-2 |
| 34 | V 351 | 80 | CM 138 | 124 | HKI Tall 1-2F |
| 35 | CM 127 | 81 | V 335 | 125 | SHD-1ER 10 |
| 36 | CM 141 | 82 | HKI 1348-1 | 126 | SHD-1ER 6 |
| 37 | CM 145 | 83 | CM 300 | 127 | HKI Tall 8-1-1 |
| 38 | CM 152 | 84 | CM 400 | 128 | HKI Taller |
| 39 | CM 153 | 85 | HKI 1342 | ***Pop corn*** | |
| 40 | CM 212 | 86 | HKI 1345 | 129 | HKI PC 4B |
| 41 | CM 502 | 87 | HKI C-78 | 130 | HKI PC 8 |
| 42 | CM 105 | 88 | HKI1352 | 131 | HKI PC BT-3 |
| 43 | CM 114 | 89 | HKI 1352-5-89 | ***Sweet corn*** | |
| 44 | CM 118 | ***QPM*** | | 132 | HKI 1827W-1 |
| 45 | CM 120 | 90 | HKI 14-2 | 133 | HKI 1831-5-3-2 |

HKI PC-8 was more divergent from the remaining two inbred, viz. HKI PC-4B and HKI PC-BT-3. Therefore, HKI PC-8 can be combined with the other two lines in better way for utilizing heterosis.

### DUS testing:

DUS trials were conducted on 21 hybrids, 35 composites and 67 inbred lines (Fig. 11). Data on various characters were recorded at respective growth stages. Expression of traits was good in majority of cases except in some inbred lines and composites due to dry spell at the time of flowering leading to poor seed setting. In these cases, post-flowering data could not be recorded. In some cases heterogeneity in the material was encountered, which could either be attributed to the inadequate maintenance breeding or inherent nature of the material like the composites as such are variable in nature. Consensus and majority data for the hybrids, composites and inbred lines are presented in (Annexure-1).

Fig. 11: DUS trial LM 14

Table 11: Clustering of normal inbred lines

| Cluster | Name of inbred lines |
|---|---|
| Ia | CM 105, CM 126, CM 140, CM 202, CM 209, HKI 1015 WG-2, HKI 1040-5, HKI 209, HKI C322 |
| Ib | CM 115, CM 119, CM 124, CM 128, CM 131, CM 138, CM 143, CM 210, HKI 3277, HKI 488, HKI 577, LM 6, LM 9, LTP 4 |
| IIa | CM 114, CM 118, CM 120, CM 135, HKI 1025, HKI 1094 WG-2, HKI 1347 -1L/H2, HKI 47, V 335 |
| IIb | CM 104, CM 111, CM 139, CM 300, CM 400, CM 502, HKI 1035-9, HKI 1342, HKI 1345, HKI 1572, HKI 488 early, LM 5, LM 6, NAI 105, LM 12, LM 16, CM 122, CM 125, HKI MBR139 |
| III | CM 127, CM 141, CM 145, CM 152, CM 153, HKI 1126, HKI 287, HKI 288-2, LTP 3, V 351, V 336 |
| IV | HKI 226, HKI 1352-5-89, LTP 1 |
| V | HKI 1348-1, HKI 193-1, HKI 536, LMP 3, HKI 551-2, HKI 323-8, HKI 3-4-8 -5ER, LTP 5, CM 201, HKI 1040-4, CM 133, HKI 1352 |
| VI | CM 123, CM 129, CM 132, CM 212, HKI 1105-29, HKI 335, HKI C78, LM 14 |
| VII | HKI 1040-4, HKI 1324-4, HKI 300, HKI 47, HKI 586 |

## Registration of new and extant hybrids and composites

Application totaling 79 of extant as well as new hybrids and composites for registration have been filed at Protection of Plant Variety and Farmer Rights (PPP&FR) Authority, New Delhi through NBPGR for their protection. Of these, 15 are for new releases and 64 for extant varieties/hybrids. The centre-wise number of applications processed and filed is given below :

**CCS HAU Karnal :**

HHM-1, HHMS-2, HM-4, HM-5, HQPM-1, HQPM-5, HM-8, HM-9;

**ANGRAU Hyderabad :**

DHM-107, DHM-109, Priya Sweet Corn;

**IARI Delhi :**

Pusa Early Hybrid Makka-3, Pusa Extra-Early Hybrid Makka-5, Pusa Composite-3, Pusa Composite-4;

**VPKAS Almora :**

HIM-129, Vivek Hybrid-4, Vivek Hybrid-5, Vivek Maize Hybrid-9, Vivek Maize Hybrid-15, Vivek Maize Hybrid-17, Vivek Maize Hybrid-21, Vivek Maize Hybrid-23, Vivek Maize Hybrid-25, Vivek Maize Hybrid-27, Vivek QPM-9, Vivek Sankul Makka 31, Vivek Sankul Makka-11, VL Baby Corn-1;

**PAU Ludhiana :**

Parkash, Buland, PMH-1, PMH-2, PAU352;

**BHU Varanasi :**

Malviya Hybrid Makka-2;

**TNAU Coimbatore :**

COH-3, COH(M)-4, COH(M)-5, COBC-1;

**RAU Dholi :**

Shaktiman-1, Shaktiman-2, Shaktiman-3, Shaktiman-4, Dewaki Composite Makka;

**AAU Godhra :**

Gujrat Makai-6, Gujrat Makai-4, Gujrat Makkai-2, Narmada Moti;

**MPUA&T Bhanswara :**

Mahi dhawal, Mahi Kanchan;

**Dharwad :**

Matungha, DMH-2;

**DMR :**

Shakti-1, Win Orange Sweet Corn;

**GBPAU&T Pantnagar :**

D-994, Gaurav, Amar;

**BAU Ranchi :**

Birsa Makai-1, Birsa Vikas Makka-2;

**CSUA&T Kanpur :**

Azad Kamal;

**JNKVV Chhindwara :**

JM-8, Jawahar Composite Makka-12, Jawahar Makka-216, Jawahar Vikas Maize-421, Jawahar Pop Corn-11;

**SKUAS&T Srinagar :**

C-8, C-14, Shalimar KG Maize-1 Shalimar KG Maize-2;

**UAS Nagenahalli :**

NAC-6002, NAC-6004;

# MAIZE ENTOMOLOGY

## A. IDENTIFICATION OF SOURCES OF RESISTANCE

### a. Inbred evaluation

Six hundred and seventy two Inberd lines collected from various sources viz. SAUs, DMR, CIMMYT, etc. were evaluated under artificial infestation against *Chilo partellus* and *Sesamia inferens* during kharif and rabi respectively at different locations of the country to identify stable resistant sources of pests.

Fig. 1: Artificial infestation by *C. partellus*

Fig. 2: Black- headed stage of *C. partellus* eggs

Resistant plants from the infested rows were selected and selfed. The selfed seeds of selected lines were evaluated to establish the level of resistant among the lines. Majority of the lines were found susceptible. LM-11, HKI-1352-5-8-9, HKI-3-4-8-1 and HKI-1348 T-2 were the most promising lines. Only lines upto three LIR are listed in the Table 1. These lines will be further evaluated in the coming season under artificial infestation at different locations in the country.

### b. Evaluation of hybrids and composites

Eighty six hybrids and composites were evaluated under artificial infestation at seven different agro ecological zones of the country. At Ludhiana and Udiapur the level of leaf injury under artificial infestation was observed relatively higher than that of Delhi and Hyderabad. Most of the hybrids and varieties showed almost similar kind of reaction against *C. partellus.*

## B. HABITAT MANAGEMENT TO SUPRESS THE PEST INFESTATION

The habitat management or ecological engineering is an important component of IPM. It is eco-friendly and suppresses pest populations by promoting natural

Fig. 3: Scientists working for habitat management in field

## Table 1: The least susceptible lines

| S. No. | Pedigree | LIR |
|---|---|---|
| 1 | LM 11-1003 | 1 |
| 2 | HKI-1352-5-8-9-1004 | 1 |
| 3 | HKI 586-1007 | 3 |
| 4 | HKI-3-4-8-1-1010 | 1.5 |
| 5 | HKI-3-4-8-7-1016 | 2.2 |
| 6 | HKI-3-4-8-6ER-2-1018 | 2.5 |
| 7 | HKI-3-4-8-6ER-3-1019 | 1.9 |
| 8 | CM 500-1026 | 1.8 |
| 9 | HKI- 1348-T-1-1039 | 1.6 |
| 10 | HKI- 1348-T-2-1040 | 1.4 |
| 11 | KDM 332-2-1066 | 2.7 |
| 12 | HVZM 329-1-1070 | 2.6 |
| 13 | HVZM 329-2-1071 | 2.6 |
| 14 | DMRQPM-58-1091 | 3.0 |
| 15 | HKI-3-4-8-2-1110 | 2.0 |
| 16 | HKI-3-4-8-6-1114 | 2.0 |
| 17 | HKI 164-7-3-1-1119 | 2.5 |
| 18 | HVZM 253-1135 | 1.8 |
| 19 | HVZM 368-1136 | 2.1 |
| 20 | DMRQPM-58-35-1138 | 1.5 |
| 21 | WIN-PINK L4-2-YF-1146 | 1.9 |
| 22 | WIN-PINK L9-1-YF-1179 | 2.3 |
| 23 | WIN-PINK L63-2-OF-1219 | 2.7 |
| 24 | WIN-SYN-1230 | 2.8 |
| 25 | WIN-SYN-1231 | 2.9 |
| 26 | WIN-SYN-1237 | 3.0 |
| 27 | WIN-SYN-1243 | 2.4 |
| 28 | BJI 06-10-1072 | 1.9 |
| 29 | JCY3-7-1-2-1-'b-2-1-2-1-1266 | 2.8 |
| 30 | LM 14-1054 | 2.5 |
| 31 | DMSC 4-1378 | 2.4 |
| 32 | DMSC 8-1413 | 2.5 |
| 33 | WINPOPIIXAPC-1506 | 3.0 |
| 34 | HKIPC 8-1225 | 2.7 |
| 35 | HKIPC 7-1475 | 2.4 |
| 36 | HKIPC 8-1476 | 2.3 |
| 37 | ae-40-1546 | 2.7 |
| 38 | HKI 164-7-6-1126 | 1.8 |

enemy populations. Maize when intercropped with cowpea shared substantial load of *C. partellus* eggs. Interestingly, the larvae are unable to feed on cowpea. The neonates have to migrate to maize for survival which might die before they could settle in maize plant. Same phenomenon was observed when napier-bajra hybrid was used as trap crop in maize at Ludhiana. The associate crops also supplement the farmers' income.

### a. Cowpea intercropped with maize substantially share the egg load of *Chilo partellus*

Graph showing different intercrops have significant influence on ovipositional preference of *C. partellus* on maize plants. Number of eggs received per plant was least when maize intercropped with cowpea. The highest number of eggs was recorded on maize intercropped with soybean, followed by maize black gram intercropping and maize groundnut intercropping. The least number of eggs per plant was found when maize intercropped with cowpea followed by green gram. There is no significant advantage when maize is intercropped with soybean, black gram and groundnut (Fig. 5).

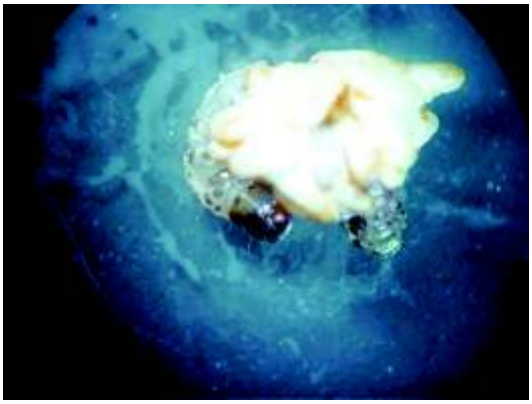


Fig. 4: *Cotesia flavipes* a potential larval parasitoid of *Chilo partellus*

### b. Napier bajra hybrids as trap crop against *Chilo partellus* at Ludhiana

Napier bajra hybrid PBN 83 and PBN 233 when used as trap crop takes major share of *C. partellus* egg load. Sorghum should not be used as trap crop as is evident from table give below. Further, the leaf area consumed by neonate and 15 day old larvae was much less in case of both the napier bajra hybrids than maize or sorghum which suggest that the *C. partellus* larvae do not thrive on these trap crops are given in Table 2 and Fig. 6 & 7.

**Table 2 : a. Ovipositional preference of *Chilo partellus* female moths to susceptible maize cultivar (PMH 1) and different host plants in two choice tests**

| Host plants | No. of egg batches on maize vs. each host plant | Total no. of eggs on maize vs. each host plant |
|---|---|---|
| Maize | 0.40 ± 0.16 a | 17.80 ± 8.06 a |
| PBN 83 | 3.60 ± 0.60 b | 129.30 ± 23.39 b |
| Maize | 0.80 ± 0.25 a | 30.60 ± 10.73 a |
| PBN 233 | 2.70 ± 0.61 b | 99.20 ± 23.18 b |
| Maize | 3.75 ± 2.19 | 75.25 ± 41.04 |
| Sorghum | 0.75 ± 0.53 ns | 46.25 ± 31.40 ns |

**b. Leaf area fed by *Chilo partellus* larvae on different host plants**

| Host | Leaf area fed ($mm^2$) by the larvae ± SE | |
|---|---|---|
| | Neonate | 15-days-old |
| Maize | 59.14 ± 9.01b | 209.57 ± 31.68b |
| PBN 83 | 27.71 ± 3.93a | 63.99 ± 13.33a |
| PBN 233 | 20.71 ± 7.69a | 102.85 ± 26.18a |
| Sorghum | 56.42 ± 8.43b | 203.14 ± 20.43b |

Fig. 5: *Chilo partellus* eggs shared by intercrops

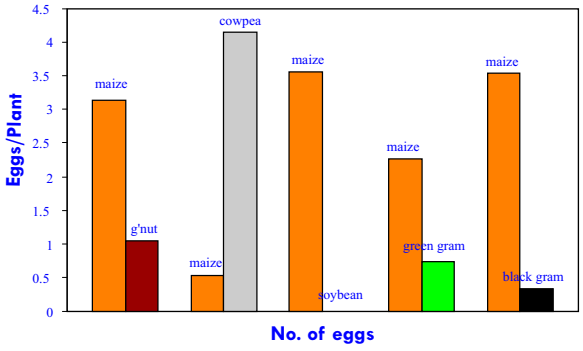



Fig. 6: Ovipositional preference of *Chilo partellus* female moths to susceptible maize cultivar (PMH 1) and different host plants at Ludhiana

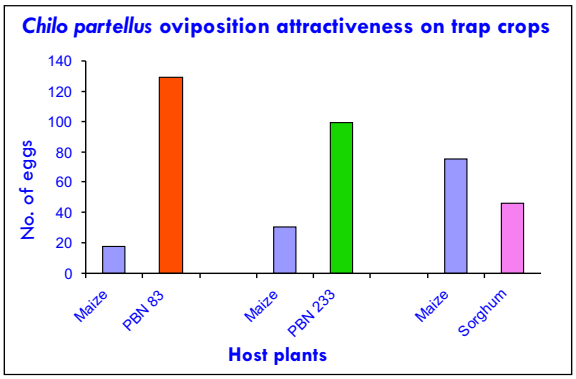
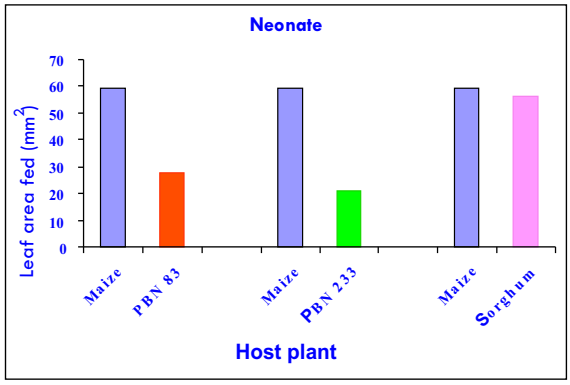
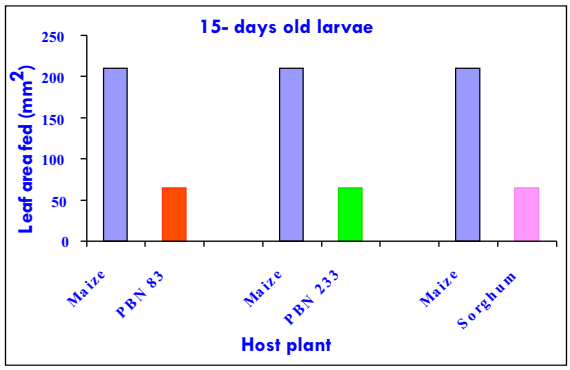



Fig. 7: Leaf area fed by *Chilo partellus* larvae on different host plants at Ludhiana

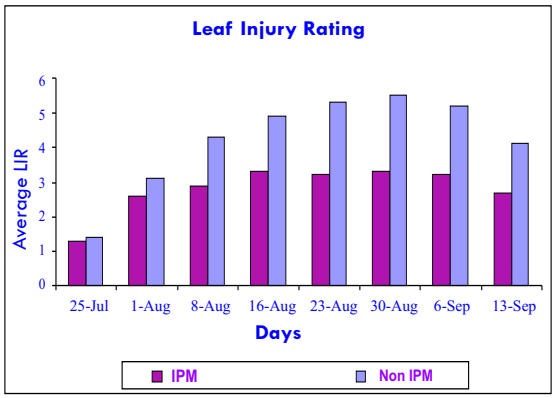


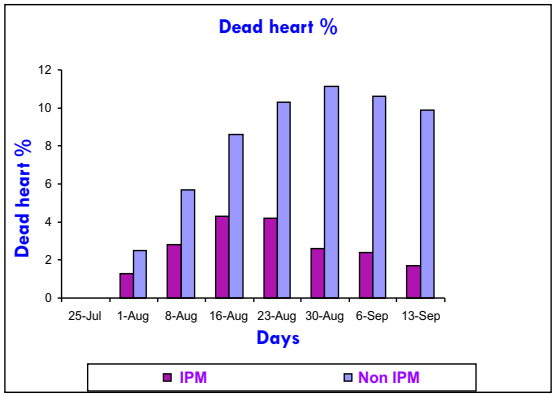




## c. Multi-location Validation of IPM Strategy

A core IPM strategy, developed by DMR has been validated at different places. Selection of seed and pest management approach was modified as per spatial and temporal requirement. There have been consistent reduction in pest severity and consequently increase in yield. The increase in yield in IPM field over farmers practice have been recorded as 24% at Ludhiana, 44.8% at Udiapur both in kharif and 27.9% at Dholi, 5-6% at Hyderabad in rabi 2006-07. The graph represented the same trend during rabi 2006-07 and kharif 2007 (Fig. 8 & 9)

Fig. 8: Reduction in LIR, Dead heart % & stem borer infested plants % in IPM fields



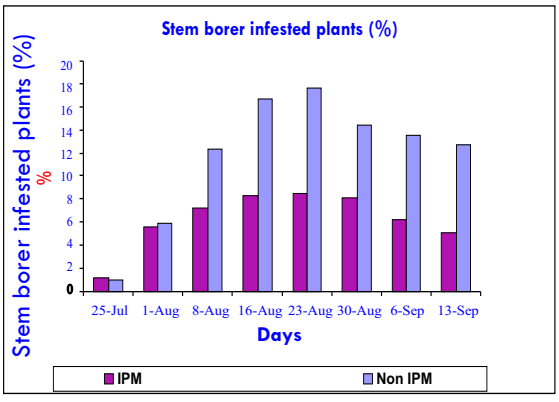
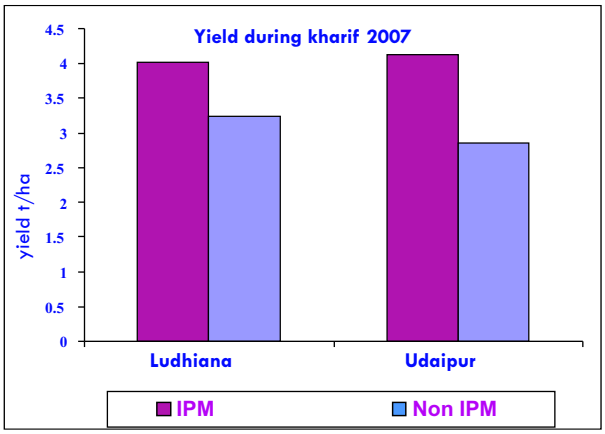
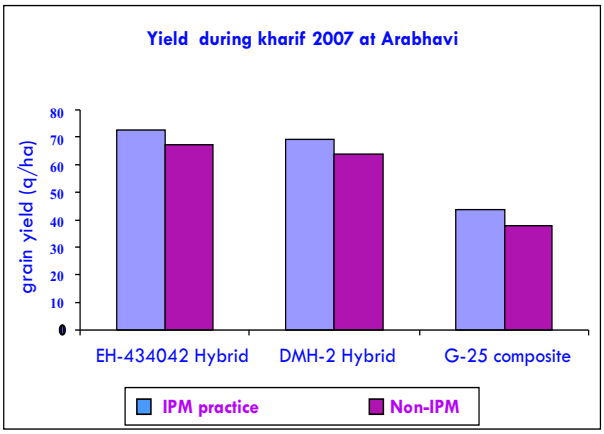



Fig. 9: Effect of IPM on Yield




Shootfly incidence was found to start in mid February which reaches alarming properties in the month of March.

**Identification of sources of resistance -**

Identification of sources of resistance has received a renewed impetus from last two years. Promising inbreds were collected from different sources. These lines were evaluated for resistance against insect pests, diseases and other characteristics. The promising ones were selfed and other rejected. The evaluation selection was done for 2006 kharif, 2006-07 rabi, 2007 kharif and material has been sown for 2007-08. Given below are the results of season wise selection (Table 3 & 4).

Table 3 : Identification of resistance source during Kharif 2007 at Delhi (253 lines)

| Plot No | Pedigree | Origin | LIR kharif 2007 |
|---|---|---|---|
| 1001 | CM 501 | Hyd 2006R/47 | 6 |
| 1003 | LM 11 | Hyd 2006 R/77 | 1 |
| 1004 | HKI-1352-5-8-9 | Hyd 2006 R/128 | 1 |
| 1007 | HKI 586 | Hyd 2006 R/154 | 3 |
| 1009 | HKI-1040C2-2 | Hyd 2006 R/164 | 7 |
| 1010 | HKI-3-4-8-1 | Hyd 2006 R/169 | 1.5 |
| 1013 | HKI-3-4-8-4 | Hyd 2006 R/169 | 3.8 |
| 1016 | HKI-3-4-8-7 | Hyd 2006 R/169 | 2.2 |
| 1017 | HKI-3-4-8-6ER-1 | Hyd 2006 R/171 | 4.6 |
| 1018 | HKI-3-4-8-6ER-2 | Hyd 2006 R/171 | 2.5 |
| 1019 | HKI-3-4-8-6ER-3 | Hyd 2006 R/171 | 1.9 |
| 1025 | CM 133 | Hyd 2006 R/22 | 5.6 |
| 1026 | CM 500 | Hyd 2006 R/46 | 1.8 |
| 1028 | V 354-2 | Hyd 2006 R/68 | 4.8 |
| 1034 | KDM 331 | Hyd 2006 R/92 | 3.2 |
| 1039 | HKI- 1348-T-1 | Hyd 2006 R/125 | 1.6 |
| 1040 | HKI- 1348-T-2 | Hyd 2006 R/125 | 1.4 |
| 1044 | HKI 577-1 | Hyd 2006 R/153 | 4.25 |
| 1050 | CM133 | DL 2006K/22 | 3.8 |

| | | | |
|---|---|---|---|
| 1051 | CM 500 | DL 2006K/46 | 4.2 |
| 1052 | CM 501 | DL 2006K/47 | 3.5 |
| 1057 | LM 10-2 | DL 2006K/76 | 3.8 |
| 1058 | LM 12-1 | DL 2006K/78 | 4.6 |
| 1066 | KDM 332-2 | DL 2006K/93 | 2.7 |
| 1070 | HVZM 329-1 | DL 2006K/104 | 2.6 |
| 1071 | HVZM 329-2 | DL 2006K/104 | 2.6 |
| 1075 | HKI- 1348-(8-2) | DL 2006K/122 | 4.4 |
| 1078 | HKI-C 287-2 | DL 2006K/132 | 3.7 |
| 1083 | HKI 577 | DL 2006K/153 | 5.0 |
| 1083 | HKI 577 | DL 2006K/153 | 5.0 |
| 1086 | HKI-170 (H-2) | DL 2006K/195 | 3.2 |
| 1087 | DMRQPM-03-121- -# | DL 2006K/207 | 6.0 |
| 1089 | DMRQPM-60-#- -# | DL 2006K/210 | 5.4 |
| 1091 | DMRQPM-58- - -#-3- - | DL 2006K/214 | 3.0 |
| 1092 | DMRQPM-58- - -#-12- - | DL 2006K/218 | 6.3 |
| 1093 | DMRQPM-03-121- -# | DL 2006K/8-1 | 5.8 |

**Table 4 : Identification of resistance source during Kharif 2007 at Delhi (51 lines)**

| Plot No | Pedigree | Origin | LIR kharif 2007 |
|---|---|---|---|
| 1110 | HKI-3-4-8-2 | Hyd 2006 R/10 | 2.0 |
| 1111 | HKI-3-4-8-3 | Hyd 2006 R/10 | 3.7 |
| 1114 | HKI-3-4-8-6 | Hyd 2006 R/12 | 2.0 |
| 1116 | HKI-3-4-8-6ER-1 | Hyd 2006 R/13 | 3.6 |
| 1119 | HKI 164-7-3-1 | Hyd 2006 R/18 | 2.5 |
| 1124 | CM 133 | Hyd 2006 R/38 | 3.1 |
| 1129 | LM 12 | Hyd 2006 R/229 | 3.1 |
| 1135 | HVZM 253 | Hyd 2006 R/230 | 1.8 |
| 1136 | HVZM 368 | Hyd 2006 R/230 | 2.1 |
| 1138 | DMRQPM-58- - -#-35- - -1 | Hyd 2006 R/231 | 1.5 |

Five inbred lines were developed for resistance against pink borer, sesamia inferens. These lines were characterised for their distinctness, uniformity and stablity. The details are given in table 5.

**Table 5 : Five lines resistant against pink borer, *Sesamia inferens* walker were developed and characterised for their distinctness, uniformity and stability (DUS)**

| Traits | WNZPBTL2 | WNZPBTL3 | WNZPBTL6 | WNZPBTL8 | WNZPBTL9 |
|---|---|---|---|---|---|
| Leaf: angle between blade and stem (on leaf just above upper ear) | Small (3) | Small (3) | Small (3) | Small (3) | Small (3) |
| Leaf: attitude of blade | Drooping (9) | Absent (1) | Drooping (9) | Drooping (9) | Drooping (9) |
| Stem: anthocyanin colouration of brace root | Absent (1) | Present (9) | Present (9) | Present (9) | Present (9) |
| Tassel: time of anthesis | Medium (5) | Medium (5) | Medium (5) | Medium (5) | Medium (5) |
| Tassel: anthocyanin colouration at base of glume | Present (9) | Present (9) | Absent (1) | Absent (1) | Absent (1) |
| Tassel: anthocyanin colouration of glumes excluding base | Present (9) | Present (9) | Present (9) | Present (9) | Present (9) |
| Tassel: anthocyanin colouration of Anthers | Present (9) | Absent (1) | Absent (1) | Absent (1) | Present (9) |
| Tassel: density of spikelets | Sparse (3) | Sparse (3) | Sparse (3) | Sparse (3) | Sparse (3) |
| Tassel: angle between main axis and lateral branches | Narrow (3) | Narrow (3) | Narrow (3) | Narrow (3) | Narrow (3) |
| Tassel: attitude of lateral branches | Curved (5) | Straight (1) | Straight (1) | Straight (1) | Curved (5) |
| Ear: time of silk emergence | Medium (5) | Medium (5) | Medium (5) | Medium (5) | Medium (5) |
| Ear: anthocyanin colouration of silks | Present (9) | Absent (1) | Absent (1) | Absent (1) | Present (9) |
| Leaf: anthocyanin colouration of sheath | Absent (1) | Absent (1) | Absent (1) | Absent (1) | Absent (1) |
| Tassel: length of main axis above lowest side branch | Medium (5) | Medium (5) | Medium (5) | Medium (5) | Medium (5) |
| Plant length (up to flag leaf) | Medium (5) | Short (3) | Medium (5) | Medium (5) | Medium (5) |
| Plant: ear placement | Medium (5) | Medium (5) | Medium (5) | Medium (5) | Medium (5) |
| Leaf: width of blade | Broad (7) | Broad (7) | Medium (5) | Medium (5) | Narrow (3) |
| Ear: length without husk | Medium (5) | Medium (5) | Medium (5) | Medium (5) | Short (3) |
| Ear: diameter | Small (3) | Small (3) | Small (3) | Small (3) | Small (3) |
| Ear: shape | Conico-Clindrical-(2) | Conico-cylindrical (2) | Conical (1) | Conical (1) | Conco-cylindrical (2) |
| Ear: number of rows of grains | Medium (5) | Medium (5) | Medium (5) | Medium (5) | Many (7) |
| Ear: type of grain | Semi-flint (2) | Flint (1) | Flint (1) | Flint (1) | Semi-flint (2) |
| Ear: colour of top of grain | Yellow (3) | Yellow (3) | Yellow (3) | Yellow (3) | Orange (5) |
| Ear: colouration of glumes of cob*# | White (1) | White (1) | White (1) | White (1) | White (1) |
| Kernel row arrangement | Straight (1) | Strainght (1) | Strainght (1) | Irregular (3) | Irregular (3) |
| Kernal Poppyness | Absent (1) | Absent (1) | Absent (1) | Absent (1) | Absent (1) |
| Kernal Sweetness | Absent (1) | Absent (1) | Absent (1) | Absent (1) | Absent (1) |
| Kernal Waxiness | Absent (1) | Absent (1) | Absent (1) | Absent (1) | Absent (1) |
| Kernel Opaqueness | Absent (1) | Absent (1) | Absent (1) | Absent (1) | Absent (1) |
| Kernel shape | Round (2) | Round (2) | Round (2) | Round (2) | Round (2) |
| Kernel 1000 - weight | Small (3) | Medium (5) | Small (3) | Small (3) | Small (3) |
| Mean leaf injury rating (1-9 scale) | 2.7 | 3.2 | 3.5 | 2.6 | 2.73 |

**Mean LIR of resistant check CM 500 : 4.8, susceptible check CM 300 : 6.6**

# PATHOLOGY & NEMATOLOGY

## Survey and Surveillance

Extensive surveys were conducted under survey and surveillance programme in maize growing areas of Karnataka, Rajasthan, Mysore, Tamil Nadu and Uttarakhand and Himachal Pradesh. The most common diseases of the areas were TLB in Uttarakhand, Karnataka and H. P. BLSB is prevalent in Rajasthan, Uttarakhand and H. P. Polysora rust is emerging as a potential threat in Karnataka. Based on the survey surveillance the disease map was updated. (Fig.1)

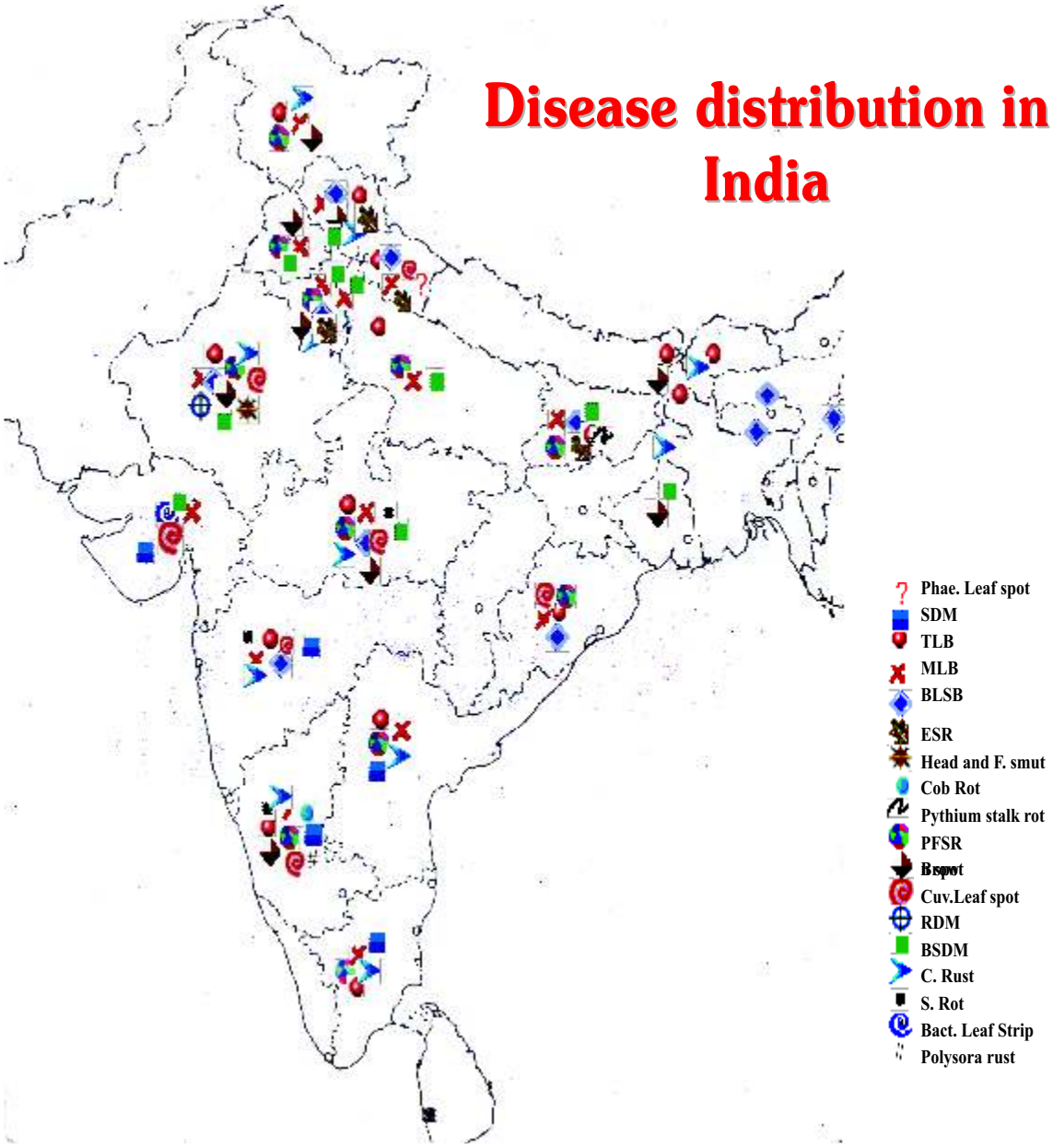



Fig. 1: Disease Distribution

## Occurrence of Maize Diseases based on Survey and Surveillance 2007

| States | TLB | MLB | BLSB | Brown spot spot | Cuv. leaf | BSDM | RDM | SDM | ESR | PFSR spot | Phae Leaf | P. rust | C. rust | Head smut |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rajasthan. Maize Local | ++ | +++ | ++ | ++ | ++ | ++ | +++ | | | +++ | | | | ++ |
| Tamil Nadu (Knee high and grain filling stage) | + | | | | | | | ++ | | + | | | + | |
| Karnataka (Grain filling stage) | +++ | + | + | + | ++ | | | +++ | | ++ | + | +++ | ++ | |
| H. P. (grain filling stage) Local, KH 9451 | +++ | +++ | +++ | ++ | | +++ | | | ++ | | | | | |
| Uttarakhand | +++ | ++ | +++ | | ++ | +++ | | | +++ | | ++ | | + | |

**TLB=Turcicum leaf blight, MLB=Maydis leaf blight, BLSB=Banded leaf and sheath blight, Cuv. Leaf spot = Curvularia Leaf Spot, BSDM=Brown stripe downy mildew, RDM=Rajasthan downy mildew, ESR=Erwinia stalk rot, PFSR= Post Flowering stalk rots, Phae. Leaf spot = Phaeosporia Leaf Spot.**

**+ Mild, ++ Moderate, +++ Severe**

## Evaluation of genotypes

A total of 205 materials and 11 QPM genotypes of 12 different trials comprising various maturity groups were evaluated against different maize diseases 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 rot (PFSR), Common rust (C. Rust), Polysora rust (P. Rust) and Erwinia stalk rot (ESR). The screenings of these genotypes were carried out against economically important maize diseases under artificially inoculated conditions in the various hot spots, identified for these diseases. The most promising genotypes with combined resistance to various diseases are:

## The most promising genotypes with multiple disease resistance identified

| | |
|---|---|
| CP 818 | MLB, TLB, SDM, RDM, BSDM, PFSR |
| CK 3055 | MLB, TLB, BSDM, PFSR, P.RUST.C.RUST |
| MO1-825 | SDM, RDM, BSDM, PFSR, |
| JH-11422 | TLB, PFSR, |
| CP 808 | BSDM, PFSR, ESR, P.RUST |
| BH-40703 | MLB, TLB, BSDM, PFSR, ESR |
| EURO-1201 | TLB, BSDM, ESR, P.RUST.C.RUST |
| HKM-30M | TLB, P.RUST, C.RUST |
| CP-828 | SDM, RDM, PFSR, ESR |
| CP 848 | BSDM, PFSR, C.RUST |
| CP 808 | BSDM, PFSR, ESR, PRUST |
| KMH-2268 | ESR, P.RUST.C.RUST |
| BISCO-111 | MLB, P.RUST, C.RUST, BSDM |
| BH-40701 | BSDM, PFSR, ESR |
| X-3342© | BSDM, PFSR, P.RUST, C.RUST |
| BH-4065 | MLB, TLB |
| BH-4064 | BSDM, PFSR, ESR |
| BH-4070 | MLB, BSDM, ESR |
| JH-1116 | TLB, BSDM, ESR |
| JH1117 | BSDM, ESR |
| PRO-371 | MLB, BSDM, ESR |
| PAC-740 | MLB, SDM, RDM |
| BH- 4068 | MLB, BLSB, BSDM |
| MCH-35 | SDM, BSDM, PFSR, ESR |

## Resistant Maize genotypes in Trial 61(IET full season maturity) -

- JH-11137, JH-11449, JH-11693, KAVERI-2288 SUPER - TLB
- JH-11180 - BLSB
- KAVEREI-50, SINDHU-333, GK-3056 - BSDM
- BH-407014, X6B 269, GK-3018 - PFSR
- JH-11433, JH-11693, KAVERI-50, G-TECH 5101, M01 -825 - ESR
- JH-11137, JH-11693, BH-40707, BH-407014 X6B 271, PRO-372, KAVERI-2288 SUPER - P.RUST
- JH-11433, BH-40707, BH-407013, AH-511, C-555 KAVERI-2288 SUPER KAVERI-50, AMAR -555 G-TECH 5101 - C.RUST

**Resistant Maize genotypes in Trial 62 (IET medium maturity) -**

- AH-504, AH-505 - BSDM
- BH-40705 - PFSR
- KAVERI-218 - ESR
- HYBRID MAIZE C-302 - P. rust and C. rust

**Trial 62A (IET medium maturity) -**

- KLM-1 - ESR
- HKH 302 - TLB

**TRIAL 63 (IET early maturity) -**

- EH-1856, FH-3438, JAU-PMC-1, JH-395, JH-31056, AH-7536 KAVERI SUPER -2020, EURO - 1202 - BSDM

**TRIAL 64 Resistant (IET extra early maturity) -**

- DEH-151, DEH-153, AH 502, AH 514 - BSDM
- FH-3433, AH 506, DEH - 515, AH 501 - ESR

**TRIAL 75 (AET full season maturity) -**

- SMH-3904, 22K40, 30 R 77, JH - 10704 - MLB
- 30 R 88 - TLB
- BH-4066, SMH-3904, 22K 40, JKMH -502, 22K 40 JKMH -502, 30R 88 - BSDM
- 30 R 77, JH-10704 - PFSR
- 22K 40, 3K MH-502, JH-10704 - ESR

**Moderately resistant for BLSB**

- JH -11422, JH -11433, JH -11693, PRO-373 in Tr. No 61
- 30 R 88 in Tr. No. 75
- 25 K 60 in Tr. No. 76

**In QPM-1 promising genotypes identified**

- HQPM - 13, HQPM 14 - MLB

**In QPM-2 promising genotypes identified**

- JH QPM-193 - MLB and PFSR

**In QPM-3 promising genotypes identified**

- HQPM - 1 - TLB
- HQPM - 6 - MLB

## Inbred Line Evaluation

A total of 197 inbred lines were evaluated against major diseases under artificial epiphytotic conditions at various hot spot locations i. e. PFSR at Hyd, Udp, Del, MLB at Delhi, TLB & P. rust at Nagenahalli, BLSB at Delhi and SDM at Mandya. Resistant lines identified - 132.

| Resistant | Disease |
|---|---|
| **Normal yellow medium** | |
| HKI 287 | PFSR, MLB, BLSB, TLB, P.RUST |
| HKI 488, HKI 536, HKI 577, HKI 586 | PFSR |
| HKI 1025, HKI 1040-4, HKI 1040-5, HVZM 371 | TLB, P.RUST |
| HKI 1040-11, HKI 1324-4 | TLB, P.RUST, MLB |
| HKI 1105-29 PFSR, TLB, P.RUST | |
| HKI 1532, LM 13 | PFSR, MLB, TLB, P.RUST |
| LTP I | PFSR, MLB, |
| **Normal yellow Late** | |
| LM 6 | PFSR, MLB, P.RUST |
| LM 14 | PFSR, MLB, BLSB, TLB, P.RUST, SDM |
| LM 16 | PFSR |
| CML 152 | MLB, BLSB, TLB, P.RUST |
| **Normal White medium** | |
| P 7421, HKI 1342, CML 141, CML 269 | PFSR, MLB, TLB, P.RUST |
| HKI 1345 | MLB, BLSB |
| HKI 1352-5-8-9 | MLB, BLSB, TLB, P.RUST |
| HKI C 78, HKI C 322. HKI C 323 | MLB, TLB, P.RUST |
| CM 300 | MLB |
| **Normal White Late** | |
| CML 140 | PFSR, TLB, P.RUST |
| CML 147 | MLB, TLB, P.RUST |
| CML 147 | PFSR, MLB, TLB, P.RUST |
| CML 395 | PFSR, MLB, BLSB, TLB, P.RUST |
| **Sweet Corn Early** | |
| DMSC1, DMSC4, DMSC8, DMSC15 | MLB |
| DMSC2, DMSC3, DMSC14 | MLB, TLB, P.RUST |
| DMSC5, DMSC9 | TLB, P.RUST |
| DMSC6, DMSC16 | PFSR, MLB |
| DMSC7 | PFSR, MLB, TLB, P.RUST |
| **Sweet Corn Medium** | |
| HKI-1827W-1, Gen1858, DMSC 18, DMSC 19, | MLB |
| DMSC 24 DMSC 28 | |
| DMSC 20, Win orange SCI, DMSC 29, | MLB, TLB, P.RUST |

| | |
|---|---|
| DMSC 30, DMSC 35 | |
| DMSC 26, DMSC 27, DMSC 33, DMSC 37 | PFSR, MLB |
| **Pop Corn Early** | |
| WINPOP-3 | PFSR, TLB, P.RUST |
| WINPOP-47 | PFSR, P.RUST |
| **Pop Corn Medium** | |
| HKI PC 4B, HKI-PC-7 | TLB, P.RUST |
| HKI PC 4B | PFSR, TLB, P.RUST |
| HKI PC 8 | PFSR |
| WINPOP-26 | PFSR, MLB |
| WINPOP-45 | PFSR, MLB, BLSB |
| **High Oil Corn Early** | |
| DMHOC 1, HKI Tall-8-1-1 | TLB, P.RUST |
| CM-104, CM-210 | MLB |
| DMHOC 2 | PFSR, MLB |
| **High Oil Corn Medium** | |
| SHD-1ER6, DMHOC 15 | PFSR, MLB |
| HOPII, DMHOC 9 | PFSR, MLB,TLB, P.RUST |
| DMHOC 12 | MLB, TLB, P.RUST |
| DMHOC 14 | PFSR |
| **Waxy** | |
| Sukhothai-1-waxy-1 | PFSR |
| **AE** | |
| ae-40 | MLB, TLB, P.RUST |
| **ENT Lines** | |
| Ent 1 | TLB, P.RUST |
| Ent 2 | MLB, TLB, P.RUST |
| WinPink L5, WinPink L63 | PFSR, MLB, TLB, P.RUST |
| **Pathology Lines** | |
| JCY3-7-1-2-1-'b-1-1-4-1 | MLB, BLSB, TLB, P.RUST, SDM |
| JCY3-7-1-2-1-'b-2-1-2-1 | PFSR, MLB, TLB, P.RUST |
| JCY3-7-1-2-1-'b-2-1-3-1 | PFSR, MLB,TLB, P.RUST |
| JCY3-7-1-2-1-'b-6-1-2-1 | PFSR, MLB,TLB, P.RUST |
| CML 31 POB 27 C5 HC 117 | PFSR, MLB, BLSB, TLB, P.RUST |
| **Plant Physiology Lines** | |
| ESM-11 | PFSR, MLB, TLB, P.RUST |
| DTPWC9-F115-1-4 | MLB, BLSB, TLB, P.RUST |
| Pool 16 BNSEQ.C3F6x38-1 | MLB, TLB, P.RUST |

| QPM Yellow Early | |
|---|---|
| HKI 26-2-4-(1-2) | MLB |
| HKI 164-4-(1-3) | PFSR,MLB,TLB,P.RUST |
| HKI 164-7-2 | MLB,TLB,P.RUST |
| HKI 164-7-7 ER4 | PFSR,MLB,BSLB,TLB,P.RUST |
| DMRQPM 60 | PFSR |
| **QPM Yellow Medium** | |
| HKI 34(1+2)-1, HKI 163, HKI 164-7-6, HKI 164-7-6 x 161 | TLB, P.RUST |
| HKI 162, HKI 164-7-4 | PFSR |
| HKI 164-4-(1-3)-2, HKI 164-D-3-3-2, HKI 164-D-4-O | PFSR, TLB, P.RUST |
| HKI 164-TB3-4-7 | MLB, TLB, P.RUST |
| HKI 191-1-2-5, HKI 193-1, HKI 193-2-2, (CML161 ´CML 451) | PFSR, MLB, TLB, P.RUST |
| CML 161 | PFSR, MLB |
| [CL-G2501 ´ CML170], [CML421 ´ CML170] | MLB, TLB, P.RUST |
| (CML165 x CL-02839) | MLB |
| [CL-G2501 ´ CML170], (CML161 ´ CML451), | MLB, TLB, P.RUST |
| (CML161 ´ CML451), (CML161 ´ CML451), CML 164, | |
| HKI 164-3 (2-1)-1 HKI 164-4-(1-3)-2, HKI 170 (1+2) | |
| HKI 164-7-4 ER-3, HKI 164-7-7 ER2 | PFSR, MLB, TLB, P.RUST |
| CL-QRCYQ51 | TLB |
| (CML165 ´ G26SEQC3) | PFSR, TLB |
| (CML161 ´ CML451) | PFSR |
| (CML150 ???CL-03618) | PFSR, TLB |
| CML 171, CML 172, CML142, CML176, CML 157, | TLB |
| WCP 2, WCP 6 | |
| HKI MBR-139 | PFSR, TLB |
| WCP 4 | PFSR, TLB |
| **MODERATELY RESISTANT** | **Disease** |
| HKI 488, HKI 577, HKI 1040-5, HVZM 371, CML 147, | |
| HKI-1827W-1, JCY3-7-1-2-1-'b-2-1-2-1, JCY3-7-1-2-1-'b-2 | |
| -1-3-1 JCY3-7-1-2-1-'b-6-1-2-1, HKI 163, HKI 164-TB3-4-7 | BLSB |
| LM 13 | BLSB, SDM |

## PFSR Research Programme

Eighty six maize genotypes were evaluated at 4 hot spot locations i.e. Hyderabad, Udaipur, Ludhiana and Delhi against PFSR in "Synthesis of gene pools and improvement of inbred lines resistant to PFSR" programme. Only five resistant lines (1) JCY3-7-1-2-1-'b-1-1-4-1, (2) JCY3-7-1-2-1-'b-2-1-2-1, (3) JCY3-7-1-2-1-'b-2-1-3-1, (4) JCY3-7-1-2-1-'b-6-1-2-1. (5) CML 31 POB 27 C5 HC 117 is being maintained for future study. Seven resistant pools, against PFSR are being maintained and selfing is being done in resistant genotypes from the pools for deriving inbred lines.

## Nematology

Two hundred thirty maize entries were screened against cyst nematode, *Heterodera zeae* maize entries viz. JH 11180, M 01-062, X-610, EH- 1810, HYB R-2006, X-789, HKH 302, KAVERI SUPER-2020, AH 502, JH-11116, JKMH-502, BISCO-855, MCH-30, AH-56191 exhibited moderately resistant reaction.

To study the distribution of maize cyst nematode, soil and root samples were collected from maize growing areas of Udaipur, Dungarpur and Tonk district of Rajasthan. Apart from this two samples received from Haryana and Uttarakhand. Survey results showed that maximum occurrence (76.19%) of *H. zeae* was observed from Rajsamand followed by Dungarpur (55.55%) and Tonk (50.00%) district of Rajasthan. Maize cyst nematode was noticed in both the samples received from Karnal (Haryana) and Almora (Uttarakhand) sample. Maximum nematode population was recorded from Udaipur (16.25 cyst/plant, 11.00 cyst /100 cc soil and 850.80 larvae/100cc soil). On the whole occurrence of *H. zeae* was observed 63.16%.

## In House Project

### ➢ Management of post-flowering stalk rots of maize through host resistance and other direct control

On the basis of experiments conducted during last 5 years the following management module was developed;

1. Seed treatment with carbendazim 50WP @2.5g/kg seed.

Plant affected with PFSR *(M. phaseolina)*

2. In stalk rot affected field, balance soil fertility especially application of the potash level up to 80 kg/ha is effective in minimizing the disease.

3. Use of biocontrol agent *Trichoderma* Formulation in furrows after mixing with FYM @ 10g/kg FYM (1kg/100 kg FYM/acre) at least 10 days before its use in the field in moist condition.

## Management of microbial spoilage of stored maize grains.

1. A total of 60 maize genotypes were screened under normal storage condition for nine months storage period. The Quality protein maize Shaktiman - 1, Shaktiman - 4, and normal maize KMH - 1701 were found promising by showing negative reaction for mycotoxin production at 12.0 and 11.4 % grain moisture level.

2. Shaktiman - 1 with thick seed coat (90-100µ) with thick Aleurone layer (40µ) and increased chitinase activity when challenged with *Aspergillus flavus* was found promising one as showed the negative reaction for mycotoxin contamination and having maximum seed coat thickness as compared to susceptible genotypes i.e. Navjot (80-90).

3. Biocontrol agents viz. *A. niger*, *T. harzianum* and *T. viride* isolated from maize grains were tested, all were effective in reducing the concentration of aflatoxin. *T. harzianum* was found most effective by giving 100% reduction in HQPM-1, 96% in HM-4 @ 8 gm/kg seeds.

## Under externally funded projects, the following AP cess & network projects are in operation during the year 2007-08;

### ➢ Prevention and management of Mycotoxin in agriculturally important commodities (Network project taken up DMR and TNAU centre)

A total of 50 strains of *A. flavus* have been maintained and deposited to NRCG Junagarh for future use. Out of them sixteen strains are highly toxic, thirteen are moderately, eighteen are mildly and 3 are non-toxic strains of *A.flavus* (Table 2). The highest number of toxic strains were identified from Delhi (7) followed by Karnal with six strains. Only one strain from Hyderabad was identified as toxic.

## Characterization of toxic and nontoxic strains of *Aspergillus flavus*

| Place | Highly Toxic | Moderately Toxic | Mild Toxic | Non Toxic | Total |
|---|---|---|---|---|---|
| Delhi | 7 | 4 | 1 | 2 | 14 |
| Karnal | 6 | 5 | 3 | 0 | 14 |
| Hyderabad | 1 | 0 | 1 | 0 | 2 |
| Begusarai | 2 | 4 | 13 | 1 | 20 |
| **Total** | **16** | **13** | **18** | **3** | **50** |

| Toxicity | Name of strains |
|---|---|
| Highly toxic | Af 4, Af 6, Af 9, Af 11, Af 13, Af 15, Af 18, Af 20, Af 22, Af 23, Af 24, Af 28, Af 30, Af 37, Af 46, Af 50. |
| Moderately Toxic | Af 1, Af 3, Af 8, Af 10, Af 12, Af 14, Af 19, Af 25, Af 26, Af 34, Af 35, Af 41, Af 49. |
| Mild toxic | Af 2, Af 5, Af 16, Af 17, Af 27, Af 31, Af 32, Af 33, Af 36, Af 38, Af 39, Af 40, Af 42, Af 43, Af 44, Af 45, Af 47, Af 48. |
| Non toxic | Af 7, Af 21, Af 29, |

### Polymorphism study in toxigenic and non-toxigenic strains of *aspergillus flavus*

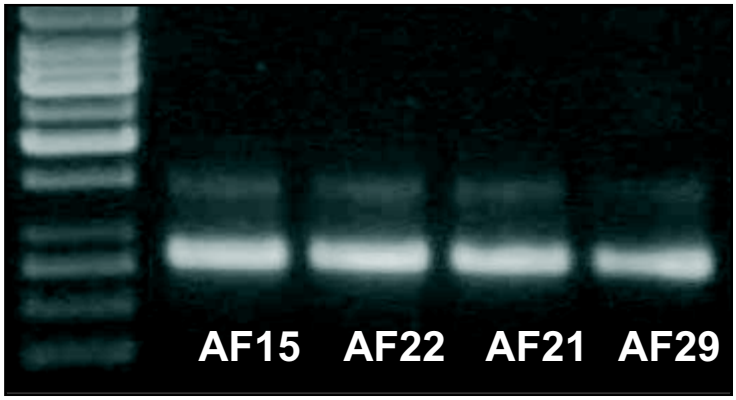
To study the genetic nature of toxic and non toxic strains of *A. flavus*, sequencing was done in two toxic AF15, AF22 and non toxic AF21, AF29 and following observation were taken:

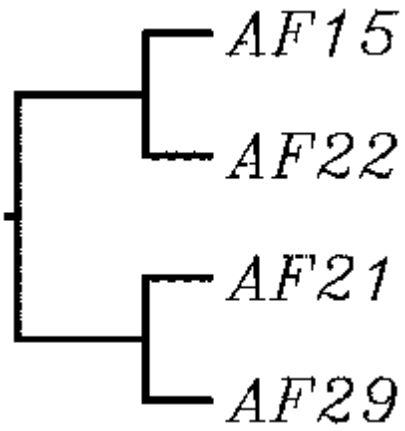
- Whole ITS region _~230 bp) was amplified from AF15, AF22 (toxic) and AF21, AF29 (non-toxic)
- PCR products were directly sequenced
- Sequence alignment result showed one SNP between toxic and non-toxic strains

From the sequences obtained by ITS regions, further studies were carried out by designing primers, considering that the particular region will amplify only for toxic or non toxic isolate so that a diagnostic tool can be developed to identify the toxic and nontoxic strains of *A. flavus*. The designed primers could not amplify the SNP in the toxic strains and were non-specific.

### Mechanism of resistant and susceptible in maize genotype

The mechanism of resistance and susceptibility was studied in 5 cultivars of maize under artificially inoculated with *A. flavus* and uninoculated condition



**Alignment result of ITS:**

```
AF21_ITS-4      CCGTGCTTGATGGGCAGCAATGACGCTGGACAGGCATGCCCCCCG
AF29_ITS-4      CCGTGCTTGATGGGCAGCAATGACGCTGGACAGGCATGCCCCCCG
AF15_ITS-4      CCGTGCTTGATGGGCAGCAATGACGCTGGACAGGCATGCCCCCCG
AF22_ITS-4      CCGTGCTTGATGGGCAGCAATGACGCTGGACAGGCATGCCCCCCG
                ****************************************************

AF21_ITS-4      AAAGACTCGATGATTCACGGAATTCTGCAATTCACACTAGTTATCGCA
AF29_ITS-4      AAAGACTCGATGATTCACGGAATTCTGCAATTCACACTAGTTATCGCA
AF15_ITS-4      AAAGACTCGATGATTCACGGAATTCTGCAATTCACACTAGTTATCGCA
AF22_ITS-4      AAAGACTCGATGATTCACGGAATTCTGCAATTCACACTAGTTATCGCA
                ****************************************************

AF21_ITS-4      TTTCGCTGCGTTCTTCATCGATGCCGGAACCAAGAGATCCTTGTTGAAAGTTTTAACTGA
AF29_ITS-4      TTTCGCTGCGTTCTTCATCGATGCCGGAACCAAGAGATCCTTGTTGAAAGTTTTAACTGA
AF15_ITS-4      TTTCGCTGCGTTCTTCATCGATGCCGGAACCAAGAGATCCTTGTTGAAAGTTTTAACTGA
AF22_ITS-4      TTTCGCTGCGTTCTTCATCGATGCCGGAACCAAGAGATCCTTGTTGAAAGTTTTAACTGA
                ****************************************************

AF21_ITS-4      TTGCGATACAATCAACTCAACTTCACTAGATCAGACGAGTTGTGGTGTCTCCGCGGGCGC
AF29_ITS-4      TTGCGATACAATCAACTCAACTTCACTAGATCAGACGAGTTGTGGTGTCTCCGCGGGCGC
AF15_ITS-4      TTGCGATACAATCAACTCAACTTCACTAGATCAGACGAGTTGTGGTGTCTCCGCGGGCGC
AF22_ITS-4      TTGCGATACAATCAACTCAACTTCACTAGATCAGACGAGTTGTGGTGTCTCCGCGGGCGC
                ****************************************************

AF21_ITS-4      GGGCCCGGGGCTGAGAGCCCCCGGCGGCCAGAATGCGGGGCCCGCCAAGCAACTAAGGT
AF29_ITS-4      GGGCCCGGGGCTGAGAGCCCCCGGCGGCCAGAATGCGGGGCCCGCCAAGCAACTAAGGT
AF15_ITS-4      GGGCCCGGGGCTGAGAGCCCCCGGCGGCCAGAATGCGGGGCCCGCCAAGCAACTAAGGT
AF22_ITS-4      GGGCCCGGGGCTGAGAGCCCCCGGCGGCCAGAATGCGGGGCCCGCCAAGCAACTAAGGT
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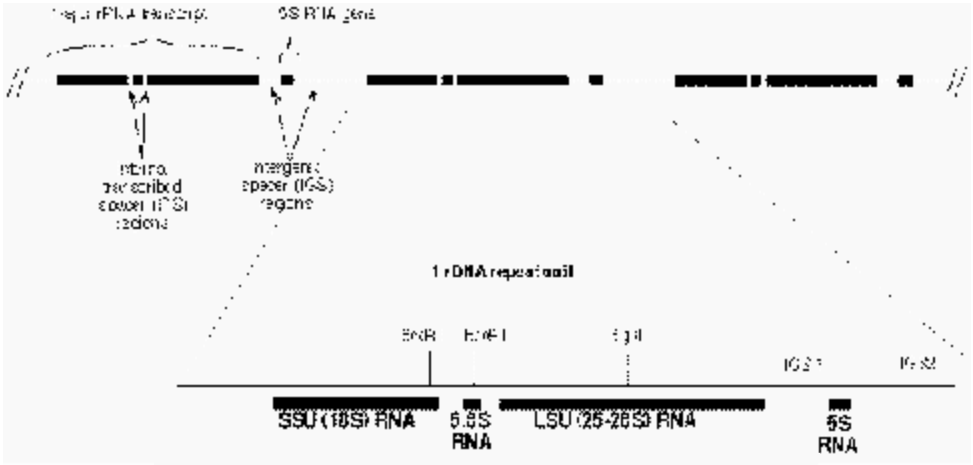
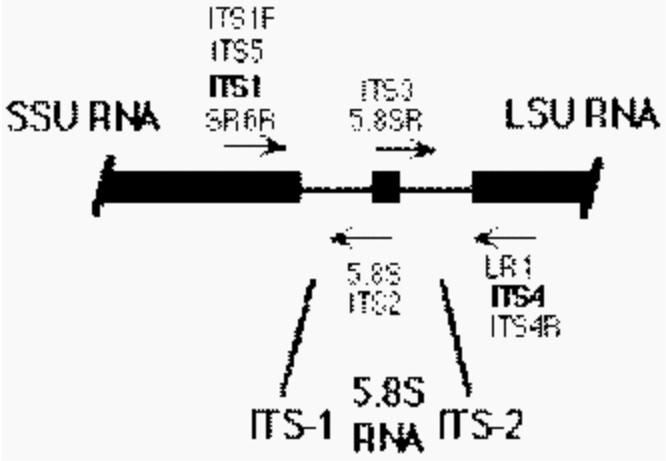


studied through western blot test. It was observed that more chitinase activity was found in shaktiman-1 when it was inoculated as compared to uninoculated grains (Plate 2). No chitinase activity was found in Pro 311 which is susceptible by showing high concentration of AFB1 i.e. 25.08 ppb at 12.4 % moisture and 2.80 ppb at 11.7 % moisture which is higher then that of shaktiman - 4 (0.30 ppb) at 11.0 moisture and 0.60 ppb at 12.0 % moisture.

1. Inoculated - MADHURI - 1
2. Uninoculated - MADHURI - 1
3. Inoculated - PRO 311
4. Uninoculated - PRO 311
5. Inoculated - SHAKTIMAN-1
6. Uninoculated - SHAKTIMAN-1
7. Inoculated - WIN POPCORN
8. Uninoculated - WIN POPCORN
9. Inoculated - NAVJOT

## Management strategies for Mycotoxins

### Evaluation of different chemicals (Organic acids and inorganic salts) for reducing aflatoxin levels

A total of eight non toxic chemicals comprising inorganic acids and organic salts were tested in post harvest storage for reducing the AFB1 level in eight months storage period on artificially inoculated maize grains of HQPM - 1 and HM - 4, 900 M, Bio 9681 and BH-2187 (inoculated with *Af* no.8 strain @2 gm/kg grains). Salts were used @ 4gm/kg whereas acids were used @ 4 ml/kg grains. The estimation of aflatoxin was done at 4 and 8 months interval.

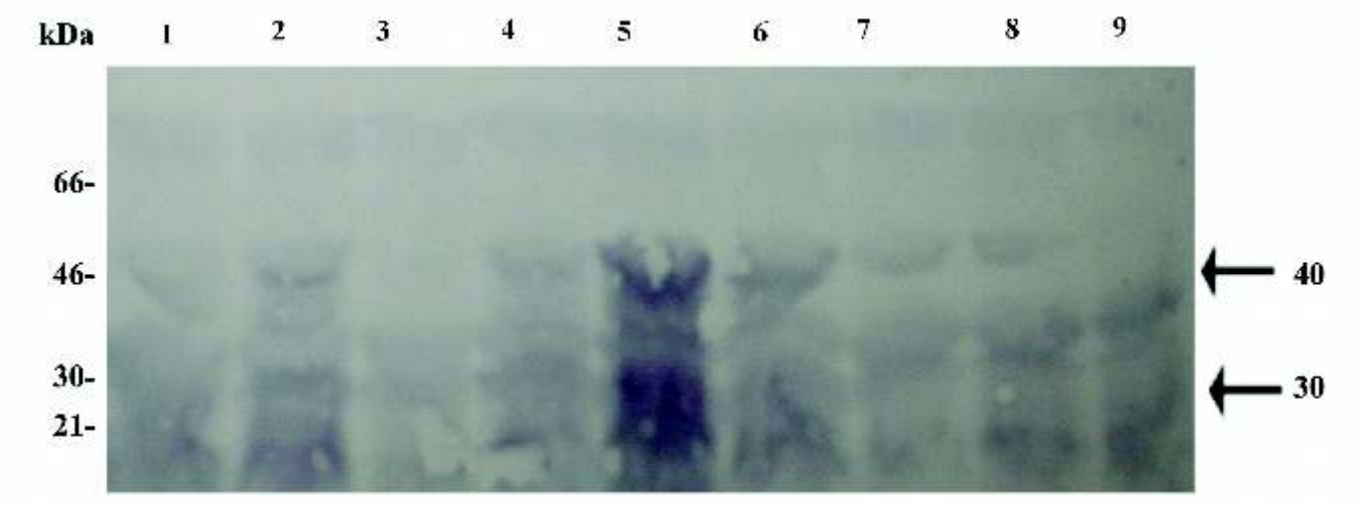
1. Among the inorganic salts tested, Potassium Carbonate @ 4 gm/kg seed was most effective in reducing AFB1 conc. by 88.0 % followed by Sodium tripoly phosphate Ammonium Carbonate, Sodium Bicarbonate etc

2. Among the organic acids tested, Propionic acid @ 4 gm/kg seed was most effective by reducing 47.9 % followed by Sodium Propionate and Acetic acid.

## Management strategies for mycotoxins through biocontrol agents

Some biocontrol agents viz. *A. niger*, *T. harzianum* and *T. viride* isolated from stored maize grains

Plate 3: *Trichoderma harzianum* and *Aspergillus niger* inhibiting the growth of *A. flavus*




Western blots showing more Chitinase activity in Maize kernels (Shaktiman) when inoculated *aspergillus flavus*

were used to see the effect of radial growth of these biocontrol agents on growth of mycotoxin producing fungi by dual culture plate technique. It was observed that they suppressed the growth of *F. moniliforme* and *A. flavus* and as a result they could inhibit the production of mycotoxins.

Biological control offers several advantages over chemical control like there are no pollution problems and health hazards.

1 It is more stable without any problem of resistance development in pathogen

2 Biological control agents are not phytotoxic

3 It may have the growth promoting effect and

4 It causes little disturbance in ecological balance

## Effect of Biocontrol agents @ 8 g/kg seeds inoculated by A. flavus on production of AFB1 after 3 months storage period

Effect of biocontrol agents on management of mycotoxin contamination were studied after four months storage period. Maize grains of HQPM, HM-4 and Bio-9681 were inoculated with highly toxic strains of A. flavus (Af no. 8). Bioagents viz *T. harzianum,T. virede, A. niger,A. flavus* were tested on these inoculated grains @ 2 gm, 4 gm and 8 gm/kg grains. All the bioagents were found effective in minimizing the conc. of AFB1.

*T. harzianum* was found most effective by giving 100% in HQPM-1, 96% in HM-4 and 93 % reduction in Bio 9681 @ 8 gm/kg seeds.

## Salient findings

- Quality maize genotypes Shaktiman-1, Shaktiman-4 and HQPM-1 identified as highly tolerant by showing minimum conc. of AFB1 in nine months storage condition (<10ppb), QPM-2-136, KMH-1701 are tolerant (< 20 ppb) and RP-4, Him-129, Pro-311 are susceptible to Aflatoxin contamination by giving 70.1 & 48.8 ppb AFB1 level.

- Biocontrol agents viz. A. niger, T. harzianum and T. viride isolated from maize grains were tested, T. harzianum was found most effective by giving 100% in HQPM-1, 96% in HM-4 and 93 % reduction in aflatoxin concentration in Bio 9681 @ 8 gm/kg seeds over the check.

- Inorganic salts & organic acids tested, Potassium Carbonate @ 4 gm/kg seed was most effective by reducing AFB1 conc. by 88.0 % followed by Sodium tripoly phosphate Ammonium Carbonate, Sodium Bicarbonate. Propionic acid @ 4 gm/kg seed was most effective by reducing 47.9 % followed by Acetic acid.

- Morphological and biochemical traits associated with resistant genotypes were identified as presence of more chitinase activity and thick seed coat and Aleurone layer in case of Shaktiman.1 a QPM hybrid.

## Gene Pyramiding for Resistance to Turcicum Leaf Blight and Polysora Rust in Maize.

Gene Pyramiding - A set of 19 $BC_2$ F1 populations with TLB numbers were evaluated for their responses to TLB under artificial inoculations at UAS-ARS, Nagenahalli and VPKS experimental farm, Hawalbagh, Almora during kharif 2007. Similarly, a set of 10 $BC_2$ F1 populations were phenotyped for responses to polysora rust at UAS. ARS, Nagenahalli in an independent block under artificially inoculated conditions.

Based on the responses (1-5 rating Scale: 1- Highly resistants ; 5 = Highly Susceptible), a set of 112 plants have been identified and harvested from TLB block at Nagenahalli, 54 Plants from polysora rust block, Nahenahalli, and 190 plants from the TLB block as Hawal bagh.

TLB Resistant Plant

TLB Susceptible Plant

Polysora rust susceptible Plant

# BIO CHEMISTRY AND QUALITY

## 1. Evaluation of Quality Protein Maize germplasm for quality parameters

Seventy one QPM inbred lines from Hyderabad programme were evaluated protein and tryptophan in protein. The range of % Protein was 6.43 to 12.95 in CM140xDMRQPM-03-124-2and CM140xDMRQPM-03-124-1 respectively. The range of % tryptophan in protein was 0.48 to 0.95 in CML95xCML323xSO/SN comp (p p)cate'o'-#-#-#-Bulk-1-1-#- -3 and DMRQPM-03-115-#-11 respectively. As many as 41 were having ≥ 9% Protein and ≥ 0.6% Tryptophan in protein. The list of these selected lines is presented in Table: 1.

Eighty four QPM lines from Hyderabad programme were evaluated protein, tryptophan in protein, test weight and specific gravity. The data presented in table: 2. The range of % Protein was 7.00 to 12.46 in CML 161 x(CM140 x CML 161)- -2 and CM139 x (cm139 x DMR QPM -03-124- - -#-#) -5 respectively. The range of % tryptophan in protein was 0.33 to 0.75 in PEHM-5-1(SC.7-2)x DMR QPM 58 .# # # -8)Xcm 150-1 and CM137 x (cm137 x DMR QPM -03-124- - )- -16 respectively. The range of 100 kernel weight was 11.77 to 31.90 in PEHM-5-2(PA510)x DMR QPM 58 # # # -9)Xcm 151-4 and CM151 x (cm151 x DMR QPM -58- - -#-#) -1 respectively. The range

**Table 1: Evaluation of QPM inbred lines from Hyderabad programme were evaluated protein and tryptophan in protein.**

| S. No | Pedigree | % Protein | Try (g/16g N) |
|---|---|---|---|
| 1. | CM138xDMRQPM-58-3 | 10.60 | 0.67 |
| 2. | CM138xDMRQPM-58-6 | 9.83 | 0.72 |
| 3. | CM139xDMRQPM-58-7 | 9.91 | 0.63 |
| 4. | CM139xDMRQPM-58-8 | 9.54 | 0.80 |
| 5. | PEHM-5-2(PA510)xDMRQPM-58-1 | 9.07 | 0.70 |
| 6. | PEHM-5-2-(PA510)xDMRQPM-58-15 | 11.15 | 0.60 |
| 7. | CML-171 | 9.00 | 0.72 |
| 8. | DMRQPM-58 | 9.22 | 0.68 |
| 9. | DMRQPM-75 | 10.30 | 0.65 |
| 10. | DMRQPM-17 | 9.83 | 0.79 |
| 11. | DMRQPM-03-101 | 12.00 | 0.60 |
| 12. | DMQPM03-119 | 9.28 | 0.76 |
| 13. | DMRQPM-03-104 | 10.30 | 0.61 |
| 14. | DMRQPM-03-105 | 11.73 | 0.71 |
| 15. | DMRQPM-28-5 | 9.22 | 0.88 |

| | | | |
|---|---|---|---|
| 16. | DMRQPM-03-107 | 9.73 | 0.71 |
| 17. | DMRQPM-03-113 | 9.22 | 0.88 |
| 18. | DMRQPM-03-124 | 10.00 | 0.65 |
| 19. | DMRQPM-60 | 11.00 | 0.64 |
| 20. | DMRQPM-28-3 | 9.17 | 0.77 |
| 21. | MRQPM-58- - -#-5D | 10.01 | 0.69 |
| 22. | DMRQPM-58- - -#-#-11-37 | 10.77 | 0.72 |
| 23. | DMRQPM-58- - -#-25 | 9.26 | 0.69 |
| 24. | DMRQPM-58- - -#-26 | 10.11 | 0.61 |
| 25. | DMRQPM-58- - -#-27 | 9.83 | 0.64 |
| 26. | DMRQPM-58- - -#-36 | 10.37 | 0.81 |
| 27. | DMRQPM-03-118-#-37 | 9.17 | 0.77 |
| 28. | DMRQPM-03-118-#-38 | 9.45 | 0.73 |
| 29. | DMRQPM-60-#-#- -#-1 | 10.02 | 0.64 |
| 30. | DMRQPM-53-#-#-B- -1 | 9.92 | 0.71 |
| 31. | DMRQPM-53-#-#-B- -9 | 9.73 | 0.71 |
| 32. | DMRQPM-53-#-#-B- -10 | 9.73 | 0.70 |
| 33. | DMRQPM03-111-#-8 | 11.81 | 0.60 |
| 34. | DMRQPM03-115#-10 | 9.92 | 0.76 |
| 35. | DMRQPM03-116-#14 | 9.54 | 0.74 |
| 36. | DMRQPM03-118-#-3 | 10.03 | 0.83 |
| 37. | DMRQPM03-118-#-8 | 9.92 | 0.74 |
| 38. | DMRQPM03-118-#-37 | 9.17 | 0.72 |
| 39. | DMRQPM03-118-#-38 | 9.07 | 0.74 |
| 40. | P502C1-#-315-3-1-1-B-2-6-BB×CML142 | 9.32 | 0.71 |
| 41. | SLW-HG888-CHG-3-2-2-BBBBBXCML-142 | 9.82 | 0.69 |

of specific gravity was 0.88 to 1.89 in PEHM-5-1(SC.7-2) x DMR QPM 58 .###-8) X cm 150-3 and CM140 x (cm140 x DMR QPM -03-124- - )- -8 respectively. Only 8 was selected for high protein & tryptophan. As many as 41 were having ≥ 9% Protein and ≥ 0.6% Tryptophan in protein. The list of these selected lines is presented in table: 2.

## 2. Starch evaluation of ae and waxy germplasm and its fractions (Amylose and Amylopectin)

Two high amylose lines and two waxy lines at Hyderabad programme for carbohydrate profiles. Ae and waxy germplasm all are more than 65% starch. Out of 4 germplasms, which were evaluated, two germplasm Waxy corn - - - -#-# and Waxy corn composite-#-3- - - - -#-# carries 91.47 and 87.27 % amylopactin in starch.

**Table 2: Evaluation of QPM lines from Hyderabad programme were evaluated protein, tryptophan in protein, test weight and specific gravity.**

| S. No | Pedigree | % Protein | Try (g/16g N) | 100 Kernel wt. | Sp. Gravity |
|---|---|---|---|---|---|
| 1. | CM137 x (cm137 x DMR QPM 58- - -#-#)- -5 | 10.85 | 0.61 | 23.60 | 1.24 |
| 2. | CM137 x (cm137 x DMR QPM 58- - -#-#)- -6 | 10.33 | 0.64 | 20.70 | 1.09 |
| 3. | CM137 x (cm137 x DMR QPM 58- - -#-#)- -8 | 11.11 | 0.72 | 24.70 | 1.30 |
| 4. | CM138 x (cm138 x DMR QPM -03-124- - )- -2 | 10.14 | 0.65 | 13.90 | 0.99 |
| 5. | CM138 x (cm138 x DMR QPM -03-124- - )- -3 | 9.28 | 0.64 | 16.90 | 1.30 |
| 6. | CM151 x (cm151 x DMR QPM -58- - -#-#) -2 | 11.00 | 0.66 | 18.50 | 1.23 |
| 7. | CM151 x (cm151 x DMR QPM -03-124- - )- -24 | 9.08 | 0.68 | 25.70 | 1.28 |
| 8. | CML 161 x(CM140 x CML 161)- -1 | 9.89 | 0.59 | 24.04 | 1.20 |

### 3. Estimation of lipid content in high oil germplasm

Four high oil lines analyzed for oil estimation. The % oil on dry basis ranged from 4.56 to 6.12 in Temp.xTrop.HighOilQPM14-#- -3-#- - - - -#-# and Temp.xTrop. HighOil QPM 14 -#- -4-#- - - - - # respectively. Only two germplasm selected with ≥ 6% oil on dry basis.

### Uchani, Karnal Center

Twenty released maize germplasm from Uchani, Karnal were evaluated. The % Protein ranged from 7.37 to 13.32 in Him-129 and Ageti-76. The % sugar ranged from 3.30 to 5.40 in Surya and Pusa composite. The % Try (g/16g N) ranged from 0.31 to 0.82 in Ageti-76 and Shaktiman-1. The % moisture ranged from 7.05 to 10.48 in 76 and HQPM-5. The % starch ranged from 57.57 to 74.48 in HKI-295 and 89. The % oil ranged from 3.13 to 5.94 in Pro-311 and Shakti-1 respectively.

A set of Fifty QPM lines from HAU, Uchani, Karnal were analysed for quality parameter. The range of % Protein was 7.50 to 12.00 in 194-6 and 194-6 respectively. The range of % Tryptophan in protein was 0.31 to 0.97 in 57-1 and HKI 164-7-2-1 respectively. The The range of 100 kernel weight was 9.43 to 31.08 in HKI 35(3-6) and HKI 161 respectively. The range of specific gravity was 0.69 to 1.32 in 164-7-4 and 57-6-1 respectively. Majority of the lines were having ≥ 9% protein and ≥ 0.6% tryptophane in protein.

One hundred four normal germplasm from HAU, Uchani, Karnal were analysed for quality parameter. The range of % Protein was 8.21 to 13.04 in HKI - 326 and HKI-1140-ER-1-WG-1 respectively. The range of % Tryptophan in protein was 0.30 to 0.76 in HKI - 46 and HKI - 536 respectively. 25 lines recorded for ≥ 9% protein. 24 lines recorded for ≥ 10% protein. 25 lines recorded for ≥ 11% protein. 17 lines recorded for ≥ 12% protein. 3 lines recorded for ≥ 13% protein. The detail is given in table: 3.

Seventeen normal yellow germplasm from HAU, Uchani, Karnal were analysed for quality parameter. The range of % Protein was 8.98 to 12.52 in HKI C124 and HKI 115-1-1ER-3. The range of % Tryptophan in protein was 0.33 to 0.51 in 1160-5-6-7 and 1532. The range of % Tryptophan in protein was 0.30 to 0.76 in HKI - 46 and HKI - 536 respectively. 2 lines recorded for ≥ 9% protein. 6 lines recorded for ≥ 10% protein. 5 lines recorded for ≥ 11% protein. 3 lines recorded for ≥ 12% protein. The detail is given in table: 4.

Table 3: Evaluation of normal germplasm from HAU, Uchani, Karnal were analysed for quality parameter.

| S. No | Pedigree | % Protein | Try (g/16g N) | 100 kernel wt. | Sp. Gravity |
|---|---|---|---|---|---|
| **Line with ≥ 9 % Protein** | | | | | |
| 1. | HKI - 325-17AN | 9.00 | 0.47 | 26.86 | 1.22 |
| 2. | HKI - 325-17AN ER-1 | 9.00 | 0.49 | 19.80 | 1.17 |
| 3. | HKI - 488-1-WGER-2 | 9.08 | 0.65 | 26.00 | 1.13 |
| 4. | HKI -645-2 | 9.13 | 0.42 | 25.00 | 1.15 |
| 5. | HKI - 332 | 9.14 | 0.53 | 24.40 | 1.27 |
| 6. | HKI -562 | 9.14 | 0.48 | 18.24 | 1.12 |
| 7. | HKI-1040C2 | 9.23 | 0.44 | 20.40 | 1.25 |
| 8. | HKI - 288 D (0) | 9.33 | 0.42 | 29.71 | 1.30 |
| 9. | HKI-1105 | 9.33 | 0.42 | 25.44 | 1.27 |
| 10. | HKI-1040-6T | 9.35 | 0.35 | 24.46 | 2.08 |
| 11. | HKI-1105-6 | 9.49 | 0.44 | 29.04 | 1.16 |
| 12. | HKI-659-3 | 9.50 | 0.45 | 27.06 | 1.09 |
| 13. | HKI - 413 | 9.52 | 0.40 | 22.94 | 1.22 |
| 14. | HKI - 488 -T-3 | 9.52 | 0.45 | 20.04 | 1.13 |
| 15. | HKI-645-WG-13 | 9.58 | 0.47 | 25.19 | 1.10 |
| 16. | HKI-1035-3 | 9.64 | 0.41 | 15.76 | 1.14 |
| 17. | HKI - 536 CYN(Tall) | 9.74 | 0.44 | 26.27 | 1.14 |
| 18. | HKI-1035-10 | 9.77 | 0.35 | 15.49 | 1.28 |
| 19. | HKI -577 | 9.83 | 0.45 | 13.85 | 1.13 |
| 20. | HKI - 488-1RG(+) | 9.89 | 0.52 | 29.24 | 1.25 |
| 21. | HKI-1-2MLD | 9.92 | 0.45 | 21.57 | 1.27 |
| 22. | HKI-1040-4 | 9.95 | 0.35 | 19.80 | 1.26 |
| 23. | HKI-1105-2 MLY | 9.95 | 0.48 | 31.02 | 1.18 |
| 24. | HKI - 209 | 9.98 | 0.53 | 25.96 | 1.23 |
| 25. | HKI - 326-1 | 9.98 | 0.44 | 18.98 | 1.15 |
| **Line with ≥10 % Protein** | | | | | |
| 26. | HKI-1015-6 | 10.04 | 0.32 | 25.65 | 1.30 |
| 27. | HKI - 325 | 10.10 | 0.44 | 20.12 | 1.25 |
| 28. | HKI-1025 | 10.12 | 0.51 | 15.96 | 1.26 |
| 29. | HKI-1094 WG-2 | 10.15 | 0.32 | 16.92 | 1.23 |
| 30. | HKI-1032-3 | 10.16 | 0.54 | 25.00 | 1.22 |
| 31. | HKI -586-3 | 10.22 | 0.40 | 20.60 | 1.18 |
| 32. | HKI-1011 | 10.23 | 0.31 | 23.08 | 1.22 |
| 33. | HKI-788-ERG | 10.24 | 0.33 | 25.49 | 1.23 |
| 34. | HKI - 326-3 | 10.30 | 0.43 | 22.75 | 1.33 |
| 35. | HKI - 139 | 10.32 | 0.37 | 22.68 | 1.29 |
| 36. | HKI-1015-1 | 10.32 | 0.31 | 14.80 | 1.15 |
| 37. | HKI - 536 CST | 10.35 | 0.51 | 15.27 | 1.16 |
| 38. | HKI-1105-5 | 10.37 | 0.39 | 25.00 | 1.20 |

| | | | | | |
|---|---|---|---|---|---|
| 39. | HKI -551-2 | 10.39 | 0.31 | 23.09 | 1.10 |
| 40. | HKI -645-9 | 10.59 | 0.43 | 17.91 | 1.20 |
| 41. | HKI-1035C | 10.68 | 0.37 | 21.73 | 1.22 |
| 42. | HKI-699 (0) | 10.76 | 0.38 | 12.69 | 1.17 |
| 43. | HKI -536 A - 39(3+4) | 10.79 | 0.32 | 28.04 | 1.09 |
| 44. | HKI - 335 | 10.83 | 0.48 | 25.11 | 1.19 |
| 45. | HKI-766-2 | 10.83 | 0.38 | 22.84 | 1.78 |
| 46. | HKI-1040-6DA | 10.83 | 0.34 | 16.74 | 1.23 |
| 47. | HKI - 3-4-8-6 ER | 10.89 | 0.30 | 27.84 | 1.16 |
| 48. | HKI-1128 | 10.96 | 0.43 | 24.79 | 1.27 |
| 49. | HKI - 536 CYN | 10.97 | 0.45 | 21.08 | 1.18 |
| **Line with ≥11 % Protein** | | | | | |
| 50. | HKI - 47 | 11.03 | 0.34 | 23.60 | 1.27 |
| 51. | HKI-877 | 11.16 | 0.35 | 22.24 | 1.02 |
| 52. | HKI-1040-7 | 11.18 | 0.38 | 24.76 | 1.23 |
| 53. | HKI - 327 T | 11.19 | 0.39 | 31.00 | 1.24 |
| 54. | HKI -586 | 11.19 | 0.38 | 22.04 | 1.17 |
| 55. | HKI - 295 | 11.24 | 0.36 | 21.02 | 1.25 |
| 56. | HKI-766RG | 11.25 | 0.40 | 26.27 | 1.08 |
| 57. | HKI-766(0)WG | 11.25 | 0.42 | 24.90 | 1.15 |
| 58. | HKI -586-1 | 11.27 | 0.32 | 14.84 | 1.15 |
| 59. | HKI-1126 | 11.29 | 0.34 | 31.48 | 1.33 |
| 60. | HKI - 316 | 11.30 | 0.43 | 16.38 | 1.15 |
| 61. | HKI 586 -1D | 11.30 | 0.37 | 14.76 | 1.11 |
| 62. | HKI-659-4 | 11.45 | 0.38 | 15.06 | 1.13 |
| 63. | HKI-808YP-1 | 11.45 | 0.37 | 17.31 | 0.92 |
| 64. | HKI - 536 CBT | 11.52 | 0.56 | 19.82 | 1.25 |
| 65. | HKI - 488 E | 11.55 | 0.35 | 15.69 | 1.35 |
| 66. | HKI - 451 | 11.59 | 0.40 | 32.58 | 1.29 |
| 67. | HKI -645-3 | 11.64 | 0.37 | 19.80 | 1.12 |
| 68. | HKI - 3 -4-1 A | 11.68 | 0.37 | 29.81 | 1.29 |
| 69. | HKI - 323 | 11.70 | 0.32 | 15.68 | 1.64 |
| 70. | HKI-1035-4 | 11.70 | 0.32 | 21.51 | 1.31 |
| 71. | HKI - 295 WG | 11.73 | 0.34 | 17.45 | 1.11 |
| 72. | HKI - 536 A -39(1+2) | 11.75 | 0.42 | 23.27 | 1.22 |
| 73. | HKI-690 | 11.85 | 0.35 | 23.92 | 1.08 |
| 74. | HKI - 3-4-8-5 ER | 11.95 | 0.33 | 29.41 | 1.25 |
| **Line with ≥ 12 % Protein** | | | | | |
| 75. | HKI-1035-ERG | 12.01 | 0.32 | 10.21 | 1.25 |
| 76. | HKI-1140 ER-2 | 12.02 | 0.30 | 25.62 | 1.25 |
| 77. | HKI - 300 | 12.06 | 0.41 | 14.58 | 1.14 |
| 78. | HKI-1035RG | 12.06 | 0.32 | 15.20 | 1.32 |
| 79. | HKI - 327 D | 12.14 | 0.36 | 27.45 | 1.42 |
| 80. | HKI-1139 ER - 2 | 12.21 | 0.39 | 21.30 | 1.24 |

| | | | | | |
|---|---|---|---|---|---|
| 81. | HKI - 3-4- 8 | 12.31 | 0.31 | 23.36 | 1.26 |
| 82. | HKI - 46 | 12.33 | 0.30 | 18.54 | 1.35 |
| 83. | HKI - L-287 | 12.35 | 0.35 | 21.81 | 1.35 |
| 84. | HKI-1040-3 | 12.45 | 0.36 | 22.74 | 1.21 |
| 85. | HKI-1140 ER-1 RG | 12.45 | 0.40 | 24.44 | 1.21 |
| 86. | HKI - 287 | 12.55 | 0.34 | 23.11 | 1.30 |
| 87. | HKI-1140 - ERE-1WG | 12.56 | 0.30 | 24.92 | 1.31 |
| 88. | HKI - 285-2F | 12.63 | 0.32 | 29.80 | 1.25 |
| 89. | HKI-1015-WG-8 | 12.69 | 0.30 | 18.20 | 1.53 |
| 90. | HKI - 288-2 | 12.79 | 0.36 | 19.70 | 1.20 |
| 91. | HKI-1324-4 | 12.80 | 0.30 | 20.58 | 1.25 |
| **Line with ≥ 13 % Protein** | | | | | |
| 92. | HKI - 368 | 13.01 | 0.32 | 20.00 | 1.25 |
| 93. | HKI-1332 | 13.01 | 0.36 | 20.20 | 1.33 |
| 94. | HKI-1140-ER-1-WG-1 | 13.04 | 0.31 | 21.52 | 1.24 |

**Table 4: Evaluation of yellow germplasm from HAU, Uchani, Karnal were analysed for quality parameter.**

| S. No | Pedigree | % Protein | Try (g/16g N) | 100 kernel wt. | Sp. Gravity |
|---|---|---|---|---|---|
| **Line with ≥ 9 % Protein** | | | | | |
| 1. | 1532 | 9.37 | 0.51 | 19.22 | 1.28 |
| 2. | 1162-2 | 9.91 | 0.33 | 11.5 | 1.28 |
| **Line with ≥ 10 % Protein** | | | | | |
| 3. | 1572 ER-2 | 10.07 | 0.43 | 25.38 | 1.26 |
| 4. | HKI-6 | 10.39 | 0.39 | 15.44 | 1.3 |
| 5. | HKI-9 | 10.43 | 0.4 | 20.75 | 1.33 |
| 6. | 1610G | 10.46 | 0.39 | 20.37 | 1.18 |
| 7. | HKI-7 | 10.58 | 0.33 | 23.45 | 1.27 |
| 8. | 1160 | 10.83 | 0.38 | 13.62 | 1.39 |
| **Line with ≥ 11 % Protein** | | | | | |
| 9. | 1155-2 | 11.38 | 0.37 | 10 | 1.42 |
| 10. | HKI-11 | 11.73 | 0.38 | 19.33 | 1.26 |
| 11. | 1160-5-6-7 | 11.76 | 0.33 | 12.56 | 1.4 |
| 12. | HKI 188 | 11.77 | 0.42 | 16.67 | 1.37 |
| 13. | HKI-10-1 | 11.85 | 0.41 | 17.2 | 1.24 |
| **Line with ≥ 12 % Protein** | | | | | |
| 14. | HKI-8 | 12.28 | 0.42 | 23.85 | 1.2 |
| 15. | HKI 1155-1-3 | 12.29 | 0.37 | 18.82 | 1.24 |
| 16. | HKI 115-1-1ER-3 | 12.52 | 0.39 | 13.2 | 1.3 |

Table 5: Evaluation of normal white germplasm from HAU, Uchani, Karnal were analysed for quality parameter.

| S. No | Pedigree | % Protein | Try (g/16g N) | 100 kernel wt. | Sp. Gravity |
|---|---|---|---|---|---|
| **Line with ≥9 % Protein** | | | | | |
| 1. | HKI 1378 | 9.35 | 0.50 | 17.28 | 1.23 |
| 2. | HKI 1322 | 9.51 | 0.33 | 20.04 | 1.22 |
| 3. | HKI 1352 -58-9(1+2) | 9.59 | 0.44 | 12.35 | 1.44 |
| 4. | HKI 1348 (8+2) | 9.68 | 0.36 | 11.62 | 1.29 |
| 5. | HKI 1323 | 9.75 | 0.38 | 19.62 | 1.25 |
| 6. | HKI 1344 | 9.77 | 0.46 | 28.19 | 1.23 |
| 7. | HKI 458 | 9.79 | 0.45 | 13.92 | 1.30 |
| 8. | HKI 1352-58-9-2 | 9.87 | 0.45 | 19.76 | 1.33 |
| 9. | HKI 1345 | 9.88 | 0.45 | 21.73 | 1.25 |
| **Line with ≥ 10 % Protein** | | | | | |
| 10. | HKI 1347-1 LT HKI (1+2+3) | 10.02 | 0.45 | 22.36 | 1.25 |
| 11. | HKI 1352-2 FLT (19+20) | 10.03 | 0.31 | 11.78 | 1.22 |
| 12. | HKI 1348-1 | 10.07 | 0.30 | 24.80 | 1.22 |
| 13. | HKI 1351-1-1 | 10.23 | 0.39 | 18.98 | 1.32 |
| 14. | HKI 1352-58-9 (2) | 10.30 | 0.47 | 18.14 | 1.31 |
| 15. | HKI 1350 (1+3-2-2A-1) | 10.35 | 0.36 | 27.43 | 1.33 |
| 16. | HKI 1348-1 ERT | 10.44 | 0.31 | 21.33 | 1.26 |
| 17. | HKI 1261 | 10.49 | 0.37 | 23.42 | 1.27 |
| 18. | HKI 1352-58-9-3 | 10.54 | 0.46 | 20.16 | 1.28 |
| 19. | HKI 1348T | 10.59 | 0.38 | 15.14 | 1.34 |
| 20. | HKI 1354-2 | 10.60 | 0.41 | 22.73 | 1.26 |
| 21. | HKI 1448 | 10.81 | 0.42 | 29.38 | 1.22 |
| 22. | HKI 1352-58-9 | 10.83 | 0.35 | 26.78 | 1.22 |
| 23. | HKI 1107-1 | 10.87 | 0.34 | 12.86 | 1.20 |
| **Line with ≥ 11 % Protein** | | | | | |
| 24. | HKI 1352 | 11.36 | 0.33 | 22.67 | 1.22 |
| 25. | HKI 1241 | 11.49 | 0.41 | 21.54 | 1.28 |
| 26. | HKI 1348-6-2 | 11.55 | 0.35 | 21.06 | 1.25 |
| 27. | MBR139 | 11.67 | 0.34 | 23.89 | 1.23 |
| 28. | HKI 459 | 11.96 | 0.33 | 15.09 | 1.20 |
| **Line with ≥ 12 % Protein** | | | | | |
| 29. | HKI 1352-58-9-1-1 | 12.02 | 0.37 | 23.64 | 1.28 |
| 30. | HKI 1352-2PLT (3+8+11) | 12.36 | 0.32 | 12.90 | 1.36 |
| 31. | HKI 1348 | 12.60 | 0.31 | 27.16 | 1.25 |

Thirty eight normal white germplasm from HAU, Uchani, Karnal were analysed for quality parameter. The range of % Protein was 7.20 to 12.60 in HKI 1342 and HKI 1348. The range of % Tryptophan in protein was 0.30 to 0.83 in HKI 1348-1 and HKI 1110-1-2. 9 lines recorded for ≥ 9% protein. 14 lines recorded for ≥ 10% protein. 5 lines recorded for ≥ 11% protein. 3 lines recorded for ≥ 12% protein. The detail is given in table: 5.

### 4. Evaluation of sugar content in sweet corn germplasm

Ten sweet corn germplasm received from Uchani, Karnal 2007 Kharif for sugar estimation. Percent total sugar ranged from 6.70 to 16.82 in SCST and 1831-3-5-6-7-8-9 respectively. Only three germplasm selected with ≥ 13% total sugar.

Four waxy lines from Uchani, Karnal for carbohydrate profiles. The data presented in table: 12. In waxy germplasm all are more than 70% starch. Out of 4 germplasms, which were evaluated, one germplasm 3322-2 carries 86.82 % amylopactin in starch.

Eleven high oil lines analyzed for oil estimation. The % oil on dry basis ranged from 3.99 to 7.60 in SHD-1 ER-2 and SHD-1 ER-12 respectively. Only three germplasm selected with ³ 6% oil on dry basis.

Ten high oil lines analyzed for oil estimation. The % oil on dry basis ranged from 3.96 to 6.05 in ShdER-6× tallar PF-1-2 and Tallar-1-2-3x Tallar PF -1-2x respectively. Only one germplasm selected with ≥ 6% oil on dry basis.

### Effect of grain storage on aflatoxin contamination and quality parameters in Different Genotypes.

Storage experiments conducted over a period of 6 months under ambient conditions to study the effect of biocontrol agents and grain molds on aflatoxin contamination and different quality parameters. Three genotypes viz. HQPM-1 (Quality protein maize), HM-4 and Bio-9681 (Normal hybrids) were stored in a replicated trial with or without treatments of toxigenic isolate of *Aspergillus flavus* and biocontrol agents viz. *Tricoderma harzianum, T.viride and A.niger.*

The results indicated that grains of all the genotypes with or without the treatment exhibited a reduction in sp.gravity and decline in tryptophan (g/16 N) over a 6 month storage period.

No.significant difference in starch %, Oil% were observed in all the 3 genotypes after 6 months of storage in different treatements.

However with regard to aflatoxin contamination grains treated with the biocontrol agent *T.harzianum*@ 8gm/kg of grains exhibited no mycotoxin contamination during storage while grain treatement@2g/kg & @4gm/kg were also effective in reducing mycotoxin levels within the acceptable limits(<20ppb). Biocontrol agents *T.viride* and *A. niger* were not effective in minimizing aflatoxin contamination.

# AGRONOMY & PHYSIOLOGY

## Crop management strategies for improving productivity of maize under abiotic stresses

Abiotic stresses like drought and water logging caused great losses in maize production in India. A study for evaluating the agronomic management practices of water logging (WL) was conducted during Kharif 2007 at IARI, New Delhi. Two hybrids with susceptible (HQPM-7) and tolerant (HQPM-6) were taken from the study. Seven management practices, (i) Conventional flat sowing (T1), flat sowing followed by earthingup 1 week after WL (T2), bed plating (T3), bed planting with 180 kg N/ha-60 basal, 60 kg each before and after WL (T4), bed planting with 3% urea spray after WL (T5), bed planting with 120 kg N/ha as 0:30:60:30 at basal:V3:V8:VT (T6) and bed planting with 120 kg N/ha as 0:30:60:30 at basal:V3:V8:VT along with 3% urea spray after WL (T7) were compared for two hybrids (HQPM-6 and HQPM-7) both under normal (NM) and water logged conditions for various agronomic and physiological parameters and grain yield.

Results indicated that the grain yield of HQPM-6 was higher under waterlogged conditions whereas in HQPM-7, it was higher under normal conditions (Figure1) and hence, HQPM-7 had more yield penalty under waterlogged conditions compared to HQPM-6. Among different management practices, bed planting

either with recommended N (T3) or with skipping basal N (0:30:60:30 at basal:V3:V8:VT) (T6) or T6 supplemented with post WL foliar spray of N (3 % urea) (T7) were found equally effective strategies for higher yields under waterlogged conditions. The anthesis-silking interval (ASI) behaved in similar fashion as of yield of the either of the hybrids under different management practices (Figure 2).

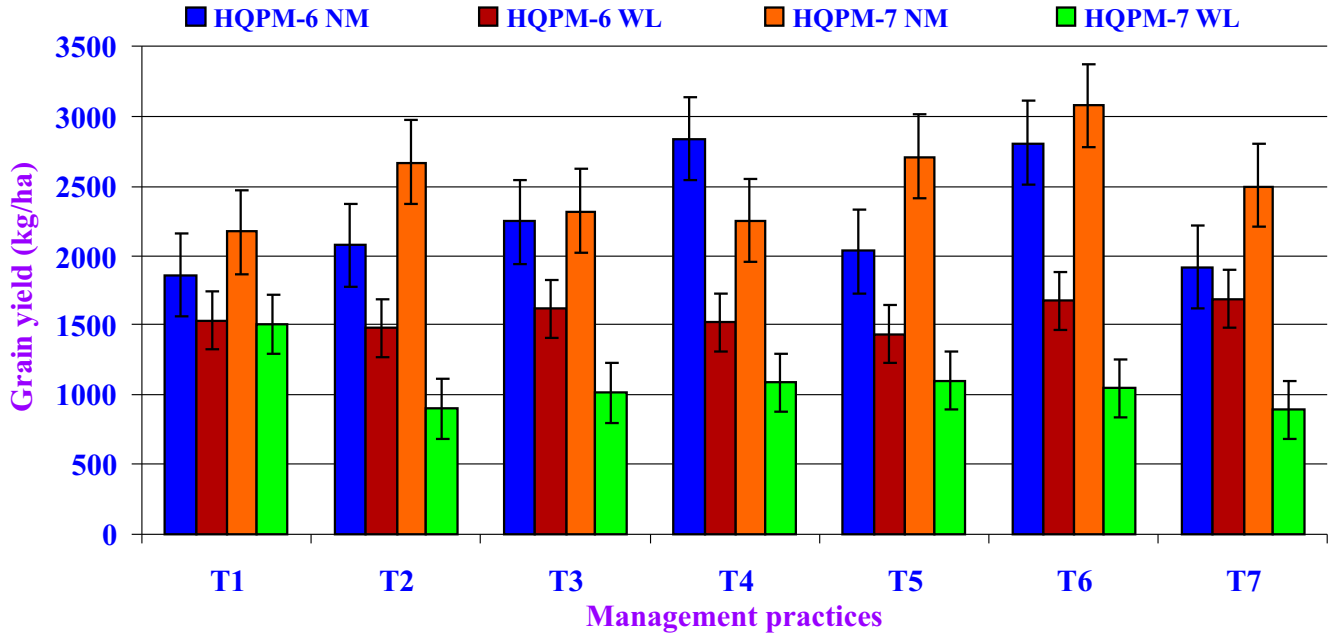



**Figure 1 Management practices effects on yield performance of tolerant and susceptible hybrids under normal and waterlogged conditions**

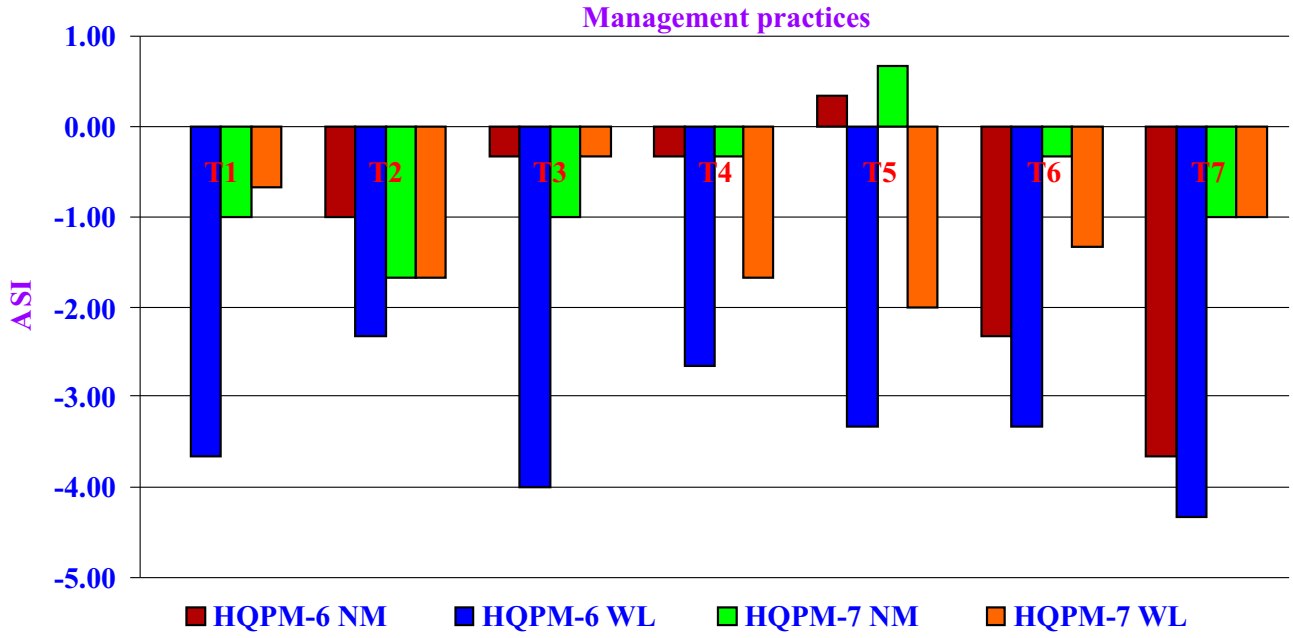



**Figure 2 Effect of different management practices on ASI of tolerant and susceptible hybrids under normal and waterlogged conditions**

The chlorophyll (SPAD values) recorded at 40 and 50 days after sowing (DAS) did not varied remarkably with respect to hybrids but management practices had a great bearing on the chlorophyll in either of the hybrids (Figure 3). At 40 DAS, irrespective of the management practices, the SPAD valued were higher under waterlogging compared to normal conditions. However, it was reverse at 50 DAS. The chlorophyll content was reduced significantly under water logged conditions compared to normal moisture condition. The leaf senescence of two hybrids varied significantly under waterlogged conditions and was higher under HQPM-6 compared to HQPM-7 (Figure 4). Management practiced reduced the leaf senescence under water logging conditions and the bed planting alongwith post WL application of N either as broadcast or foliar spray significantly reduced the senescence compared to other treatments.

## All India Coordinated Research Project on Maize

The salient achievements of coordinated agronomic trials conducted during winter 2006-07 and kharif 2007 at different centres of AICRP on maize are summarized in this section. The trials were mainly focused on genotypic response to nutrients, development of inbred agronomy, specialty corn, crop geometry, nutrient management and diversification/intensification in maize and maize based cropping system under different agro-ecologies.

### 1. GENOTYPIC RESPONSE TO NUTRIENTS:

In NxG trials during winter 2006-07 with medium and early maturity group conducted at Karnal, Bahraich, Dholi, Hyderabad, Kolhapur, Ludhiana and Banswara, increasing levels of N had significantly higher grain yield across genotypes and locations with maximum yield under 240 kg N ha-1. Among different medium and early maturity genotypes, HKH-1200 was significantly superior over the best check at Dholi and Ludhiana, whereas at Bahraich and Hyderabad PHS-90 (W) SMH-4005, at Karnal AH-24010 and at Kohlapur and Banswara JKMH-702 were significantly

superior over the best check. Full season maturity NxG QPM trials were conducted at Karnal, Bahraich, Dholi and Banswara wherein HQPM-4 was compared with Shaktiman-4 (QPM) and Seedtech-2324 (non-QPM). Yield performance of HQPM-4 was significantly superior over the best check (Shaktiman-1) at all the locations. However, the yield performance of non-QPM (Seedtec 2324) was superior than HQPM-4 at Bahriach and Banswara.

During Kharif, 2007, the N x G trials were conducted with genotypes of different maturity groups under all the five zones. Trials on full season maturity were conducted at Delhi, Kanpur, Karnal, Ludhiana (zone-II), Ambikapur, Bahraich, Jashipur, Ranchi, Varanasi (zone III) and Arbhavi, Hyderabad, Kolhapur and

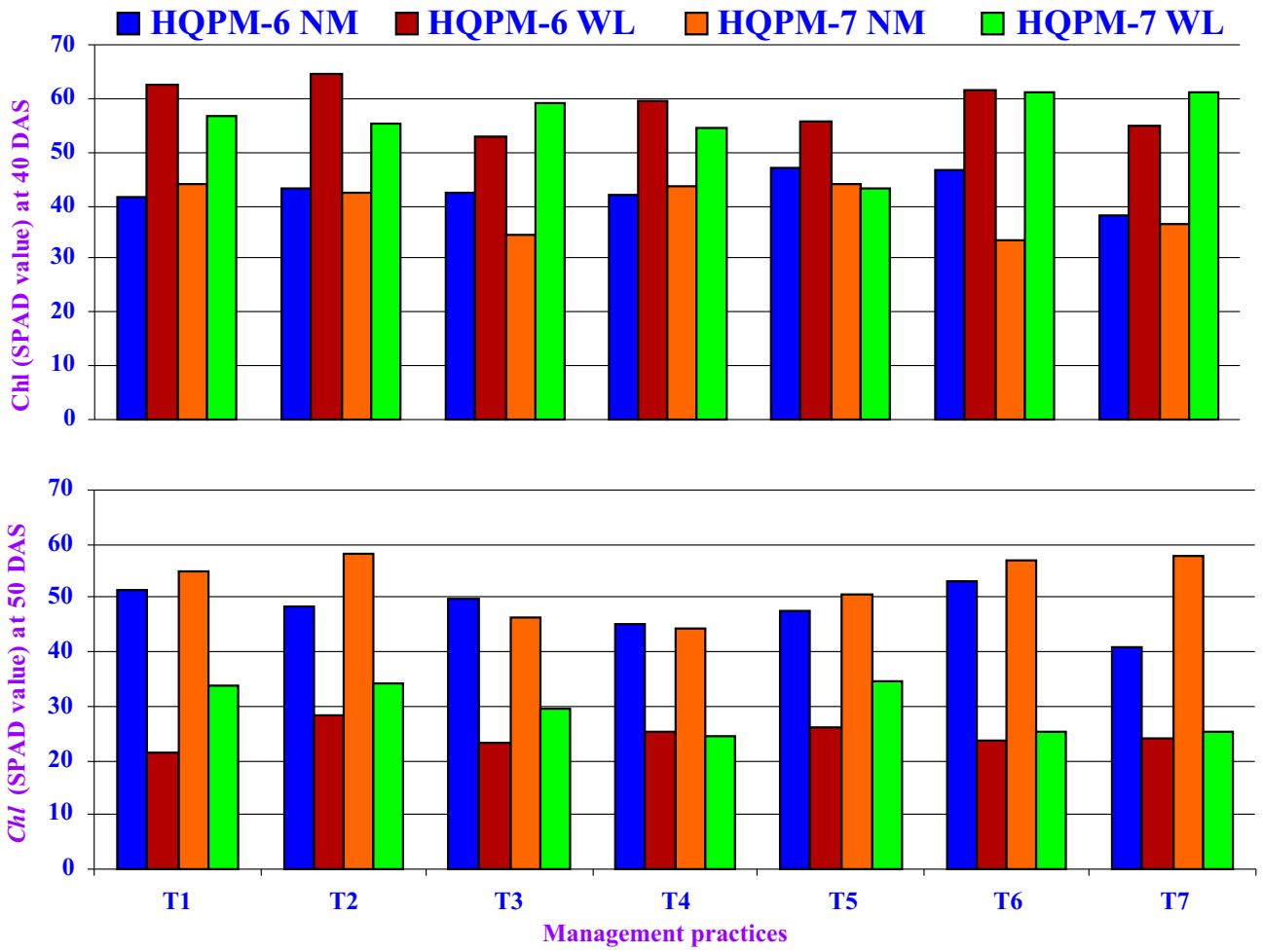



Figure 3 Effect of management practices on chlorophyll (SPAD) values of tolerant and susceptible hybrids at 40 and 50 days after sowing (DAS) under normal (NM) and waterlogged (WL) conditions

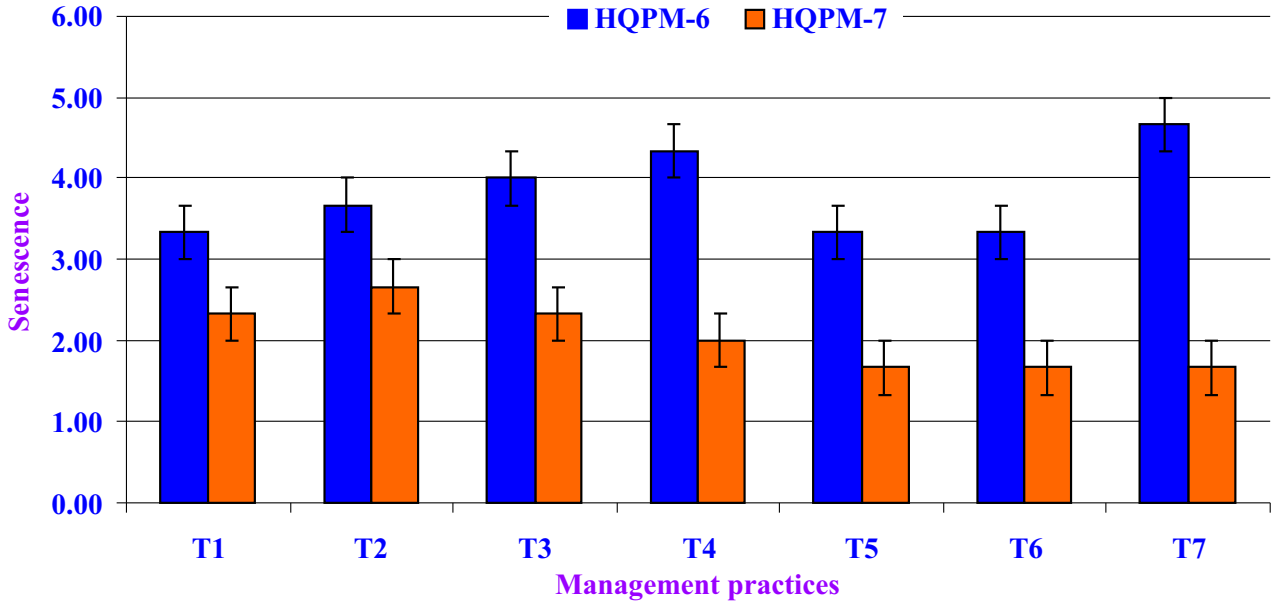



Figure 4 Management practices effects on leaf senescence of different hybrids under waterlogged conditions

Karimnagar (zone-IV). N application at 180 kg/ha resulted in significantly higher yield over 60 kg N/ha but was remained at par with 120 kg/ha almost at all the locations in all the maturity group trials. Among different genotypes of full season maturity, the yield performance of 30 R 77 was found superior over rest of the genotypes at Delhi, Karnal (Zone-II), Ambikapur, Jashipur, Varanasi (zone III) and Hyderabad and Karimnagar (zone IV), where as JH-10704 outyielded all the genotypes at Kanpur and Ludhiana. The trials on medium maturity genotypes were conducted at Bajaura, Jorhat, Kangra (zone-I), Ambikapur, Bahraich, Jashipur, Ranchi, Varanasi (zone III), Arbhavi, Hyderabad, Kolhapur and Karimnagar (zone-IV) and Chhindwara, Banswara, Godhra, Udaipur (zone-V). In zone-I at Bajaura and Jorhat, the grain yield of MCH-30 was significantly superior over the checks (Navjot and BIO-9637) where as in zones-III, the yield of check (BIO-9637) was superior at all the locations. Similarly in zone-IV and V at Hyderabad, Karimnagar, Banswara & Udaipur, BIO-9637 had higher productivity, and at Kolhapur & Chhindwara, yield of JKMH-702 was found superior.

Trials on early season maturity were conducted at Almora, Bajaura (zone-I), Arbhavi, Hyderabad, Kolhapur and Karimnagar (zone-IV) and Chhindwara, Banswara, Godhra, Udaipur (zone-V). At Almora, Bajaura (zone-I), Hyderabad, Kolhapur (zone-IV) and Banswara (zone-V), the yield performance of X-3342 was found superior to rest of the genotypes, where as genotype COMP. R-2005-2 out yielded rest of the genotypes at Arbhavi and PRO-368 at Chhindwara and Udaipur (zone-V). N xG trials on extra early genotypes were conducted at Almora and Bajaura (zone-I) and Arbhavi, Hyderabad, Kolhapur and Karimnagar (zone-IV) and among different genotypes, the FQH-4567 outyielded over rest of the genotypes at Almora, Bajaura, and Hyderabad, whereas at Kolhapur and Karimnagar, Vivek Hybrid-17 had higher yield over rest of the genotypes.

The trials on performance of pre-release QPM hybrids under varying levels of N were conducted at Arbhavi, Bajaura, Delhi, Hyderabad and Karnal. N application at 180 kg/ha resulted in significantly higher yield over 60 kg N/ha but was remained at par with 120 kg/ha almost at all the locations. The performance of HQPM-7 was found superior over best check (HQPM-1) at Bajaura, Delhi and Dholi whereas at Arbhavi and Hyderabad, HQPM-1 out yielded the rest of the hybrids. At Karnal, the yield of HQPM-6 was significantly higher over HQPM-1 and HQPM-7.

## 2. AGRONOMY OF INBREDS:

**(a) Fertility management:** Trials on development of agronomy of inbreds were conducted at Delhi and Karnal during Kharif 2007. At Delhi, high plant density (60 x 15 cm) accompanied with high fertilility (180 kg N + 6 t FYM ha-1) resulted in significantly higher yield. Further, application of N in five splits (5 % basal, 30 % at V4, 40 % at V8, 15 % at tasseling, and 10 % at early grain filling) resulted in significant yield increase compared to 3 splits wherein 50 % N was applied as basal. Similar results were reported at Karnal.

**(b) Crop geometry:** Row and plant geometry had significant effect on yield performance of inbred lines during winter 2006-07 wherein closer plant spacing (70 x 15 cm) resulted in significantly higher grain yield. Among different inbred lines, HKI-161 had significantly higher yield over rest of the lines.

## 3. AGRONOMY OF HYBRIDS:

**(a) Crop geometry:** During Kharif, a trial to study the effect of plant density and N levels on performance of different hybrids was conducted at Karnal. All the hybrids (HQPM-1, HQPM-6, HQPM-7, HM-1602, HM-1604, HM-4) responded to high plant density (60 x 15 cm) at both N levels (200 and 150 kg ha-1) but the yield was significantly higher at 200 kg ha-1 with closer spacing (60 x 15 cm).

**(b) Nutrient management:**

**(i) Nitrogen scheduling:** Trials on N scheduling in maize were conducted during kharif 2007 at different locations to study the nitrogen use efficiency under different N schedules. Nitrogen application in 5 splits (20 % basal, 25 % at V4, 30 % at V8, 20 % at tasseling, 5 % at grain filling) resulted in significantly higher grain yield over recommended N scheduling (50 % basal, 25 % V8, 25% at flowering) across the locations (Figure 5). The agronomic efficiency of N (AEN) at different locations was 3-16 % higher with 5 splits compared to 3 splits.

**(ii) Integrated nutrient management (INM):**

**INM in quality protein maize (QPM):** Trials on INM in QPM were conducted at Kangra, Bajaura, Hyderabad, Ambikapur, Arbhavi, Chhindwara, Ranchi, Jashipur, Bahraich, Varanasi, Banswara and Udaipur. Application FYM at 6 t ha-1 along with 125 % RDF resulted in significant yield advantage over no FYM and state recommendations of nutrients at all the locations except Kangra and Arbhavi where there was negative response to FYM.

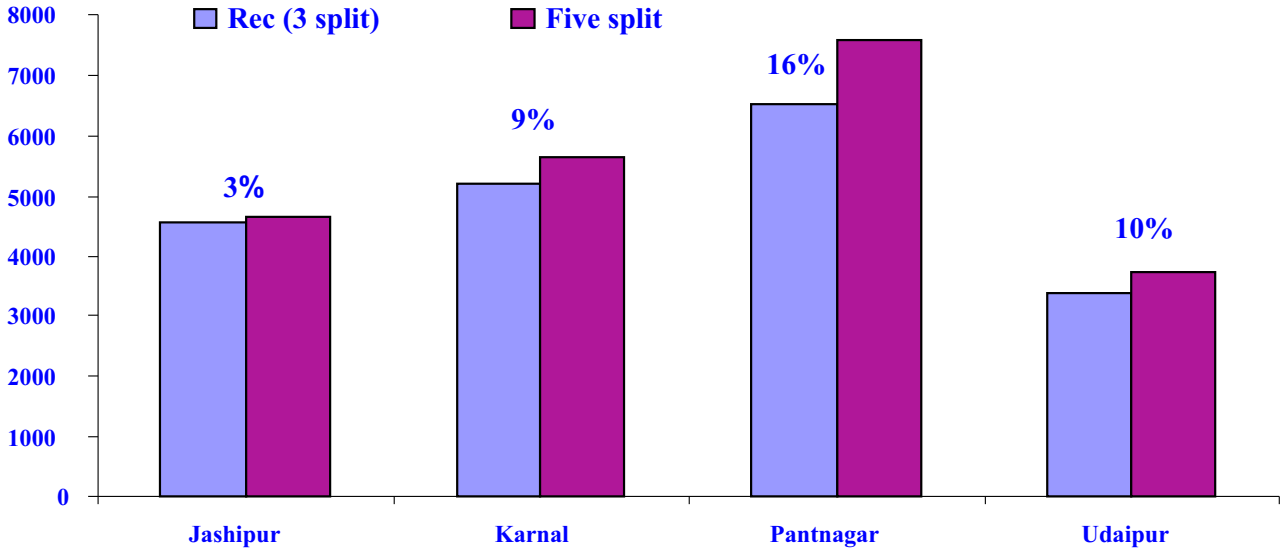



Figure 5. Comparative yield performance of maize under 3 and 5 N splits

**INM in Baby corn:** Trials on INM in baby corn were conducted at Ambikapur, Arbhavi, Bajaura, Chhindwara, Dholi, Jorhat, Karnal, Ranchi, and Udaipur. Application of FYM @ 6 t ha-1 along with 150 % recommended dose of fertilizers (RDF) resulted in significant yield advantage almost at all locations except at Arbavi and Dholi wherein there was no response to FYM and higher fertility levels.

**INM in Sweet Corn:** Trials on INM in sweet corn were conducted at Arbhavi, Chhindwara, Delhi, Pantnagar and Udaipur. The yield of sweet corn with application of FYM @ 6 t ha-1 along with 150 % RDF resulted in significant increase in productivity over state recommendations at all the locations.

**INM in Pop corn:** A trial on INM in pop corn was conducted at Bahraich wherein application of 150 % dose of recommended nutrients through inorganic sources resulted in significantly higher yield of pop corn.

## (4) DIVERSIFICATION/INTENSIFICATION IN MAIZE SYSTEMS:

The winter maize offers horticultural diversification through intensification. Trials on maize based high value intercropping trials were conducted in different zone at Jashipur, Jorhat, Chhindwara, and Bahraich. At Jashipur, sale maize was compared with maize intercropped with cabbage, cauliflower and tomato at varying levels of nitrogen. Increasing levels of N had significant yield advantage. The maize yield was significantly lower under intercrops compared to sole crop but among the intercrops cabbage and cauliflower had equally good compatibility compared to tomato.

At Jorhat, among the different intercrops, coriander, amaranthus, fenugreek and peas had better compatibility over rest of the intercrops and highest maize equivalent yield (10.98 t ha-1) was recorded with maize + coriander intercropping system. However, the

maize equivalent yield of all the intercropping systems was significantly higher than sole maize. At Chhindwara, sweet corn intercropped with different cut

flowers did not produce any significant yield penalty on cob yield of sweet corn and resulted in additional benefit with cut flowers. Similarly at the same location, sweet corn intercropped with onion in different row geometry also resulted in comparable yield of sweet corn both under sole and intercropping. At Bahraich, maize intercropped with radish and palak in different row ratio resulted in significant yield variation in maize and the intercrops. Among the intercrops, maize yield was

significantly higher when it was intercropped with palak than radish and for maize yield 1: 1 row ratio was better but for intercrops, 1: 2 ratio was superior.

In the kharif 2007, maize based intercropping trial were conducted at Arbhavi, Bahraich, Banswara, Udaipur and Pantnagar. Intercropping of Kharif legumes in maize either in uniform row or paired row system, helped in significant increase in maize equivalent yield and profitability almost at all the locations. Among the different legumes, groundnut had better compatibility with maize.

## Functional genomic aspect for drought tolerance in maize

Under ICAR Network Project on Functional Genomics for Drought Tolerance in Maize, large scale phenotyping and identification of the available genotypic variability for flowering stage drought tolerance was carried out during rabi 2006-07 and kharif 2007. During Rabi 2006-07 a total 181 maize inbred lines including 32 early maturing, 60 medium maturing, 48 late maturing & 41 waterlogging lines and 40 single cross hybrids were phenotyped at ICRISAT, Hyderabad, where drought stress can be simulated through management of irrigation schedule. The top ranking selected inbred lines along with few susceptible checks

were evaluated for Kharif 2007 drought in rain-out-shelter at IARI, New Delhi. The selection of entries was done on the basis of there genetic background and per se performance under normal moisture and drought stress.

**(i) Early maturity lines:** Analysis of variance for the 32 early maturity lines along with two check entries for drought stress showed that the genotypic variation was statistically significant for all the characters, except for ears per plant and days to 50% anthesis. Anthesis-silking interval (ASI) showed highest coefficient of variation (CV=129 %) because at one end the tolerant entries were able to maintain ASI <5.0 days while at another end susceptible entries could not produce silk at all. Performance of most of the lines was very poor under drought stress. However, selected fraction of best lines was distinctly superior from the worst fraction of entries with reasonably good performance. Comparison of the best and worst entries with mean of the population indicates that the deviation in chlorophyll content in the distinctly different genotypes was nominal from the population mean, i.e. tolerant (+2.8%) and susceptible (-6.7%). Similarly, in case of anthesis also the difference of tolerant and susceptible group of lines was small, i.e.- from -1.8 and +2.2%, respectively. However, in case of other traits the deviation of distinctly tolerant and susceptible genotypes from population mean was remarkable. The leaf rolling score was 26.3% less in tolerant lines, while it was 18.4% higher in susceptible lines in comparison to population mean. The deviation in ears per plant was +40.4% in tolerant and -441.7% in case of susceptible genotypes. Though, days to anthesis was least affected under drought stress, but deviation in ASI from population mean was +26.5% in susceptible, while it was -156.8% with tolerant group of entries. This indicates that ASI increased under drought stress was due to delayed silk emergence.

The distinct differences among various secondary traits eventually resulted in highly significant deviation in yield attributes and grain yield. The average ears per plant was 1.09 in selected tolerant entries, while it was 0.12 in susceptible entries, which eventually resulted in average yield 1.459 t/ha in tolerant entries and the susceptible entries ended with yield level of 0.15 t/ha.

**(ii) Medium maturity lines:** A total 58 entries of advance generation lines along with two checks from c9 of the new drought tolerant population (DTP-white and yellow) from CIMMYT, Mexico along with Indian materials of similar characteristics were screened for mid-season drought stress tolerance.

Analysis of variance showed that the genotypic variation was statistically significant for all the characters, except for days to 50% anthesis. Grain yield under stress showed highest coefficient of variation (CV= 84 %) followed by ears per plant (CV= 70. %). Performance of large number of lines was poor under drought stress. However, selected fraction of best lines was distinctly superior from the worst fraction of entries. Comparison of the best and worst entries with mean of the population indicates that the deviation in chlorophyll content in the distinctly different genotypes was slightly higher from the population mean, i.e. tolerant (+13.3%) and susceptible (-25.9%). Tolerant group of entries showed tendency of earliness because 50% anthesis was 1.2 and 2.6 days earlier in these entries in comparison to population mean and susceptible group of entries, respectively. However, in case of other traits the deviation of distinctly tolerant and susceptible genotypes from population mean was remarkable. The senescence was 16.0% less in tolerant lines, while it was 33.8% higher in susceptible lines in comparison to population mean. Similarly, deviation in leaf rolling score was +17.2% in susceptible and -25.3% in case of tolerant genotypes. Though, days to anthesis was least affected under drought stress, but deviation in anthesis-silking interval (ASI) from population mean was +27.9% in susceptible, while it was -41.1% with tolerant group of entries. This indicates that increased under drought stress was due to delayed silking. The distinct differences among various secondary traits eventually resulted in highly significant deviation in yield attributes and grain yield. The average ears per plant was 29.9% higher in selected tolerant entries, while it was 285.1% less in susceptible entries in comparison to population mean. Overall variation in genotypes was strongly expressed in terms of extreme variability in final grain yield under drought. Average yield of tolerant group of entries was 1.63 t/ha higher that population mean yield (0.69t/ha), while the susceptible entries ended with zero yield under stress.

**(iii) Full-season maturity lines:** Total 48 lines derived from the population La Posta Sequa C7 and Tuxpeno Sequia C8 of CIMMYT, Mexico along with Indian materials of similar characteristics, with known reaction to flowering stage drought stress during last year trial, were screened for mid-season drought stress tolerance.

Analysis of variance showed that the genotypic variation was statistically significant for all the characters, except for chlorophyll content and days to 50 % anthesis. However, selected fraction of best lines was

distinctly different from the worst fraction of entries. ASI showed highest coefficient of variation (58.3%) followed by grain yield (49.9%). Comparison of the best and worst entries with mean of the population indicates that the deviation in chlorophyll content in the distinctly different genotypes was statistically non-significant. However, in case of other traits the deviation of distinctly tolerant and susceptible genotypes from population mean was remarkable. Plant senescence score was 23.3% less in tolerant lines, while it was 10.2% higher in susceptible lines in comparison to population mean. Similarly, deviation in leaf rolling score was +20.9% in susceptible and -19.9% in case of tolerant genotypes. Tolerant group of entries showed tendency of earliness because 50% anthesis was 1.22 and 0.80 days earlier in these entries in comparison to population mean and susceptible group of entries, respectively. Irrespective of reaction to drought stress, days to anthesis was least affected under drought stress in all the genotypes, but deviation in anthesis-silking interval (ASI) from population mean was +34.4% in susceptible (average ASI 5.7 days), while it was -19.1% with tolerant group of entries (average ASI 3.1 days). This indicates that increased under drought stress was largely due to delayed silking. The distinct variation among various secondary traits eventually resulted in highly significant deviation in yield attributes and grain yield. Average ears per plant were 0.98 in selected tolerant entries, while it was 0.12 in susceptible entries. Overall variation in genotypes was strongly expressed in terms of extreme variability in final grain yield under drought. Average yield of tolerant group of entries was 2.44 t/ha higher that population mean yield (0.89 t/ha), while poor entries ended with 190 kgha-1 under stress.

***(iv) Waterlogging tolerant lines:*** Selected best inbred lines under waterlogging stress were screened for flowering stage drought stress, along with few waterlogging susceptible entries. This trial was conducted with an objective to assess the relationship between the two important stresses for Indian maize production, and to establish the level of spill-over from waterlogging to drought stress.

Analysis of variance for the 39 lines along with 2 check entries for drought stress showed that the genotypic variation was statistically significant for all the characters. Ears per plants (EPP) showed highest coefficient of variation because at one end the tolerant entries were able to maintain effective ears, while at another end susceptible entries could not produce any effective ear. Performance of most of the lines was highly poor under drought stress. However, selected fraction of best lines was distinctly superior from the worst fraction of entries with reasonably good performance. Though, performance of WL-lines was relatively inferior to the lines derived from drought tolerant populations. Comparison of the best and worst entries with mean of the population indicates that the deviation in chlorophyll content in the distinctly different genotypes was nominal from the population mean, i.e. tolerant (+7.3%) and susceptible (-9.1%). Similarly, in case of anthesis also the difference of tolerant and susceptible group of lines was small, i.e.- from -0.2 and +1.6%, respectively. However, in case of other traits the deviation of distinctly tolerant and susceptible genotypes from population mean was remarkable. The leaf rolling score was 20.9% less in tolerant lines, while it was 4.7% higher in susceptible lines in comparison to population mean. The deviation in ears per plant was +29.7% in tolerant and -68.5% in case of susceptible genotypes. Though, days to anthesis was least affected under drought stress, but deviation in anthesis-silking interval (ASI) from population mean was +14.6% in susceptible, while it was -75.9% with tolerant group of entries. This indicates that ASI increased under drought stress was due to delayed silk emergence. The distinct differences among various secondary traits eventually resulted in highly significant deviation in yield attributes and grain yield. The average ears per plant was 0.73 in selected tolerant entries, while it was 0.30 in susceptible entries, which eventually resulted in average yield 1.30 t/ha in tolerant entries and the susceptible entries ended with yield level of 0.27 t/ha.

**(v) Single Cross Hybrids:** A total 40 entries of single cross hybrid, Indian origin were screened for flowering-stage drought stress during Rabi-2007. Analysis of variance for the 40 hybrids for drought stress showed that the genotypic variation was statistically significant for all the characters, except ASI (Table-1). Anthesis-silking interval (ASI) showed highest coefficient of variation because at one end the tolerant entries were able to maintain ASI <5.0 days while at another end susceptible entries could not produce silk at all. Performance of most of the hybrids were highly poor under drought stress. However, selected fraction of best lines was distinctly superior from the worst fraction of entries with reasonably good performance. Comparison of the best and worst entries with mean of the population indicated.

**Table-1: Performance of single cross hybrids under flowering stage drought stress during Rabi 2007.**

| ENT | Pedigree | Days to 50% anthesis | Days to 50% silking | ASI | Chlorophyll (SPAD unit) | Leaf rolling (1-5) | Senescence (1-10) | Ears per plant | Grain yield (t/ha) |
|---|---|---|---|---|---|---|---|---|---|
| | **BEST** | | | | | | | | |
| 38 | HKH-1608 | 78.3 | 82.3 | 4.0 | 41.1 | 2.1 | 3.9 | 0.8 | 3.90 |
| 40 | HKH-1188 | 72.7 | 76.3 | 3.6 | 44.5 | 2.4 | 3.0 | 0.5 | 3.75 |
| 25 | HQPM-9 | 81.5 | 86.5 | 5.0 | 37.1 | 2.3 | 3.7 | 0.9 | 3.53 |
| 23 | HQPM-7 | 81.1 | 86.2 | 5.1 | 38.3 | 2.3 | 3.6 | 0.9 | 3.52 |
| 35 | HKH-1605 | 77.0 | 80.3 | 3.3 | 43.4 | 1.5 | 3.4 | 1.0 | 3.39 |
| 22 | HQPM-6 | 83.0 | 88.1 | 5.1 | 33.7 | 4.4 | 3.2 | 1.0 | 3.35 |
| 21 | HQPM-5 | 87.1 | 92.7 | 5.6 | 33.6 | 3.3 | 3.9 | 0.9 | 3.32 |
| 27 | HQPM-12 | 81.3 | 84.9 | 3.6 | 41.0 | 2.3 | 3.7 | 2.0 | 3.21 |
| 34 | HKH-1604 | 84.5 | 89.3 | 4.8 | 37.2 | 1.5 | 3.1 | 1.0 | 3.14 |
| 13 | DMR-804 CML327- | 77.5 | 83.8 | 6.3 | 40.8 | 2.2 | 3.9 | 0.8 | 3.06 |
| 5 | 3-2XWL36-*-*-4-2 | 75.1 | 80.1 | 5.0 | 39.6 | 2.7 | 3.6 | 0.9 | 2.63 |
| 24 | HQPM-8 | 79.1 | 82.2 | 3.1 | 33.8 | 3.0 | 4.2 | 0.8 | 2.62 |
| | DL-15-2XWL36- | | | | | | | | |
| 3 | *-*-4-2 | 70.4 | 71.5 | 1.1 | 38.9 | 3.1 | 4.0 | 1.1 | 2.60 |
| 29 | HQPM-14 | 77.0 | 81.7 | 4.7 | 35.0 | 2.8 | 3.9 | 0.8 | 2.58 |
| 12 | DMR-803 | 82.5 | 88.9 | 6.4 | 40.0 | 2.4 | 2.6 | 0.7 | 2.54 |
| | **Worst** | | | | | | | | |
| 36 | HKH-1606 | 78.7 | 85.8 | 7.1 | 39.6 | 2.4 | 3.9 | 0.8 | 1.20 |
| 6 | DL-16XWL36-*-*-4-2 | 69.5 | 81.3 | 11.7 | 37.3 | 2.8 | 4.1 | 0.8 | 1.06 |
| | CML429XCML3 | | | | | | | | |
| 7 | 11-B-B | 68.9 | 88.9 | 20.0 | 33.9 | 2.2 | 3.5 | 0.6 | 1.00 |
| | CML226-B-B | | | | | | | | |
| 8 | XCML228-B-B | 73.6 | 92.9 | 19.3 | 36.0 | 2.2 | 4.0 | 0.6 | 0.88 |
| 16 | DMR-807 | 71.7 | 74.3 | 2.6 | 43.6 | 2.1 | 3.3 | 1.0 | 0.76 |
| 26 | HQPM-11 | 81.2 | 91.6 | 10.4 | 42.0 | 2.5 | 4.2 | 0.8 | 0.42 |
| | CML226-B- | | | | | | | | |
| 2 | BXHKI323 | 72.2 | 84.0 | 11.8 | 34.7 | 3.9 | 3.2 | 0.3 | 0.35 |
| | MEAN | 76.53 | 84.14 | 7.61 | 37.8 | 2.60 | 3.60 | 0.80 | 2.16 |
| | LSD | 6.6 | 8.5 | 1.6 | 5.0 | 1.4 | 0.9 | 0.2 | 1.1 |
| | CV | 4.2 | 4.9 | 50.2 | 10.5 | 28.7 | 11.2 | 36.6 | 25.4 |
| | FSIG | 1.0 | 1.0 | 0.0 | 5.0 | 5.0 | 5.0 | 5.0 | 1.0 |
| | REFF | 1.6 | 1.3 | 1.1 | 1.6 | 3.3 | 1.5 | 1.0 | 1.7 |

## Screening of genotypes for drought stress under under rain-out shelter during Kharif-2007:

On the basis of the performance of genotypes under Rabi drought, a total 22 entries were selected, including 6 highly tolerant, 12 tolerant, and 4 highly susceptible (Table-1), for revalidation and confirmation of the response under Kharif drought, and to work-out the spill-over between two season for drought tolerance in maize. In the rain-out shelter experiment the entries were planted in 1 row plot (2.5m) with row-to-row 0.75cm and plant-to-plant 0.25 cm spacing. Planting was done in last week of June using ALPHA (0, 1) lattice design with two replications. Stress treatment was applied by closing the top of rain-out shelter at two weeks before male flowering till 2 weeks after female flowering.

### (i) Drought stress-induced changes in soil and plant moisture status:

Using profile probe the moisture level in the soil at different soil profiles was monitored regularly (Fig. 1). Moisture content in different soil profiles decreased gradually with increasing the duration of drought stress. However, the effect of moisture stress was pronounced up to 30 cm depth, a mild effect was observed at 40 cm depth, but at 60 and 100 cm there was nominal change, even after 26 days of drought stress. Stress treatment was withdrawn when plant available water depleted below 15%. Imposed drought stress significantly affected the soil and plant water potential (Fig. 2). The effect was more pronounced after 10 days of stress treatment, and it was most severe on drought susceptible lines.

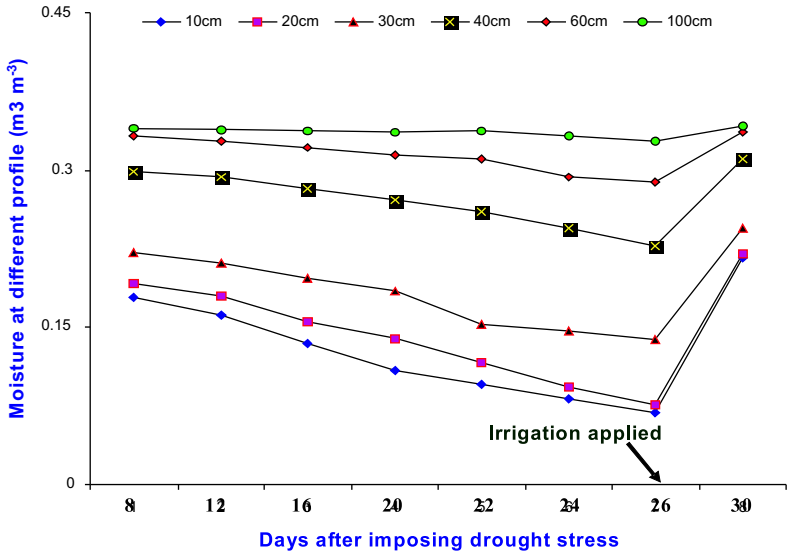



Fig. 1: Change in moisture content in soil profiles after imposing the drought stress.

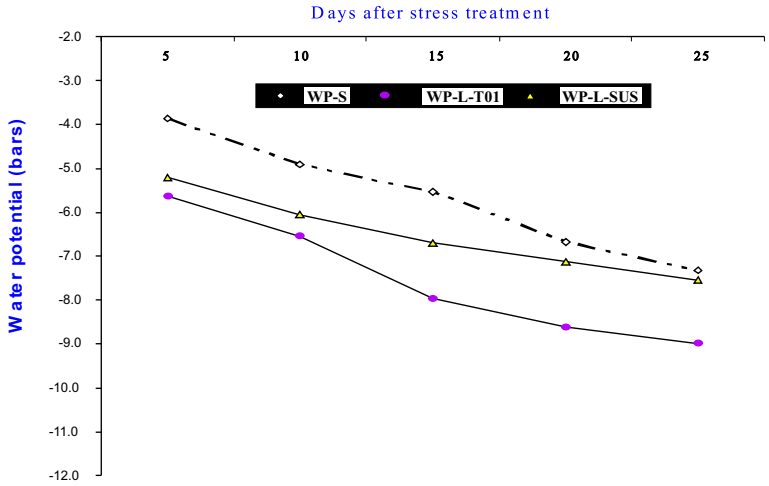



Fig. 2: Change in soil and plant (L-Tol = Leaf of tolerant line, L-Sus = Leaf of susceptible line) after imposing the drought stress.

**ii) Effect of drought stress on growth and yield traits:**

Data recorded on various morpho-physiological traits along with grain yield (Table-3), and the entries were grouped into highly tolerant, tolerant and highly susceptible. Comparison of the response across the two season of drought stress indicates that there was significant spill-over. Out of total 22 lines tested across season, 17 genotypes have shown similar response in both the seasons (spill-over 77.3%). Out of total six highly HT lines in Rabi, 3 were again performed as HT during Kharif, while 3 were grouped as tolerant lines to drought. All the four HS in Rabi and were found HS during Kharif drought as well. However, one tolerant entry (entry 12) under Rabi drought was found susceptible under Kharif drought conditions

**iii) Effect of drought stress on physiological parameters:**

Phenotyping for key physiological traits, including RWC, cell membrane stability, sugar content and ABA showed strong genotypic variability for these traits.

**(a) Relative water content (%):** Under normal moisture the all the entries showed good level of RWC without any significant genotypic variability. However, under drought stress highly significant genotypic variability was observed among the entries tested, which ranges from 80.6 to 93.6%.

**(b) Cell membrane stability:** Analysis of cell membrane stability (CMS), in terms of injury percentage in the cell membrane, showed that under normal moisture most of the entries showed nominal membrane injury symptoms (Fig. 4). When the same genotypes are exposed to flowering stage drought stress severe membrane injuries were observed in most of the lines, except the tolerant entries.

**(c) Total sugar:** Total sugar concentration was analyzed in ear leaf, ear tip and silk tissues at the time 50% female flowering. In case of susceptible genotypes the loss in sugar content was highest in silk tissues, followed by ear tips. Similar, but relatively smaller effect was observed in case of tolerant entries. However, in case of highly tolerant lines the loss of sugar content was found highest in ear leaf, and least in silk followed by ear tips. The trend indicates strong silk capacity of developing ears of tolerant inbred lines, which maintain sugar level probably at the cost of ear leaf and tip.

**(d) Abscissic acid (ABA):** Estimation of ABA concentration in different tissues indicates that under drought stress it increased significantly in all the type of germplasm and plant parts (Fig. 6). However, the extent of increase in ABA content was quite variable in terms of both germplasm type and plant tissue. In general, the drought tolerant associated with relatively low ABA accumulation, particularly in silk tissues. In case of highly tolerant inbred lines maximum ABA content was estimated in ear tips followed by ear leaf. However, in case of moderately tolerant and susceptible lines the amount of ABA increased in order of ear leaf < ear tips < silk. Highest amount of ABA was found in silk tissues followed by ear tips of susceptible lines.

**Table-3: Response of selected maize inbred lines under Kharif drought.**

| Response | Moisture | Days to 50% Silking | ASI (days) (SPAD) | Chloro phy ll (1-10) | Senes cence (1-5) | Leaf rolling (%) | Plant logging plant | Ears per (t/ha) | Grain yield |
|---|---|---|---|---|---|---|---|---|---|
| Highly Tolerant (6) | NM | 56.3 | 2.3 | 40.2 | 1.0 | 1.0 | 0.0 | 1.11 | 2.46 |
| | DR | 55.9 | 4.6 | 32.4 | 2.8 | 2.2 | 21.4 | 0.86 | 1.39 |
| Tolerant (10) | NM | 58.9 | 3.1 | 41.2 | 1.0 | 1.0 | 0.0 | 1.02 | 2.59 |
| | DR | 56.3 | 5.8 | 33.4 | 3.9 | 3.2 | 26.4 | 0.67 | 0.89 |
| Highly susceptible (4) | NM | 57.3 | 2.7 | 42.3 | 1.0 | 1.0 | 0.0 | 1.21 | 2.48 |
| | DR | 58.3 | 10.4 | 28.9 | 6.7 | 4.5 | 59.6 | 0.09 | 0.07 |

Table-8: Response of maize inbred lines across Rabi and Kharif drought.

| S. No. | Entry | Origin HYD Rabi-07 | Rabi-07 REACTION | Kharif-07 REACTION |
|---|---|---|---|---|
| 1 | DML-40 | 508/26-1 | HT | HT |
| 2 | DML-14 | 508/7-1 | HT | T |
| 3 | DML-20 | 508/13-1 | T | T |
| 4 | DML-15 | 508/8-1 | T | T |
| 5 | DML-62 | 508/41-1 | T | T |
| 6 | DML-21 | 580/14-1 | HT | HT |
| 7 | DML-13 | 580/6-1 | HT | T |
| 8 | DML-1 | 508/1-1 | HT | T |
| 9 | DML-26 | 508/18-1 | HS | HS |
| 10 | EML-176 | 508/59-1 | HT | HT |
| 11 | DML-81 | 508/53-1 | T | T |
| 12 | DML-47 | 508/33-1 | T | HS |
| 13 | DML-53 | 508/37-1 | T | T |
| 14 | DML-25 | 508/17-1 | HS | HS |
| 15 | DML-7 | 508/4-1 | HS | HS |
| 16 | DML-54 | 508/38-1 | T | T |
| 17 | DML-30 | 508/20-1 | HS | HS |
| 18 | DML-32 | 508/22-1 | T | T |
| 19 | DML-16 | 508/9-1 | T | T |
| 20 | DML-28 | 508/19-1 | HT | T |
| 21 | DML-5 | 508/3-1 | T | T |
| 22 | DML-84 | 508/55-1 | T | T |

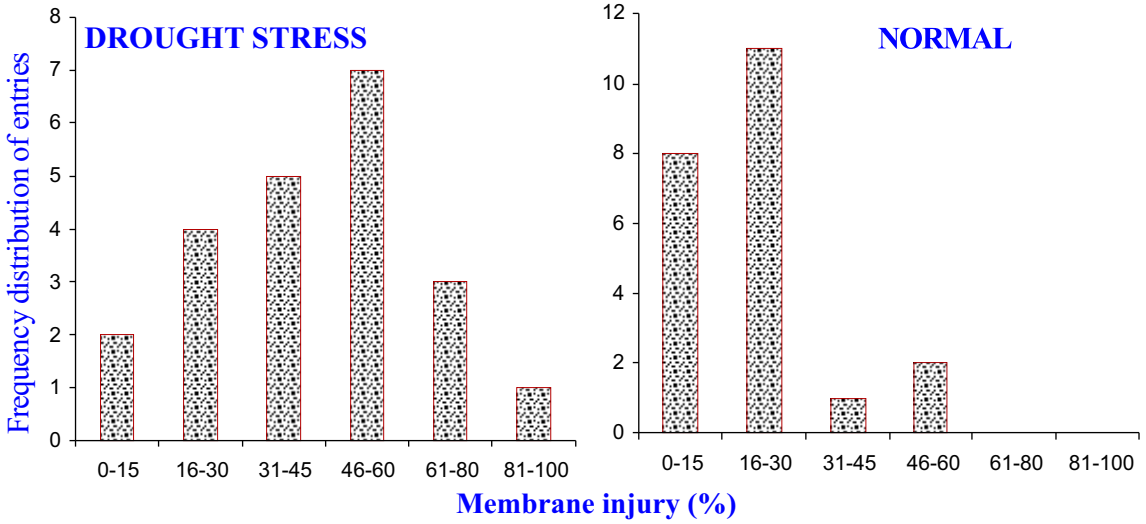



Fig. 4 : Genotypic response of maize inbred lines for cell membrane stability (CMS) under drought and normal moisture conditions.

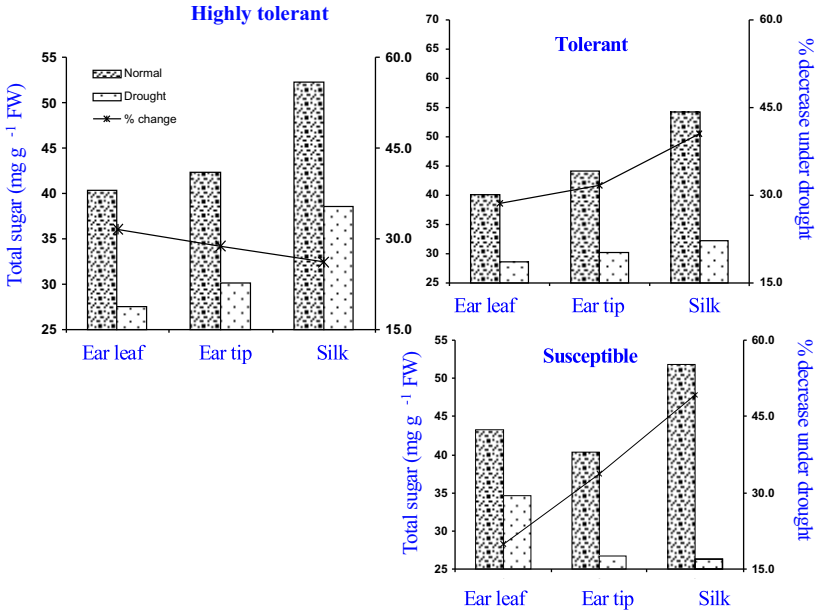



**Fig. 5 : Effect of flowering stage drought stress on sugar concentration ear leaf, ear tips and silk tissues of maize inbred lines.**

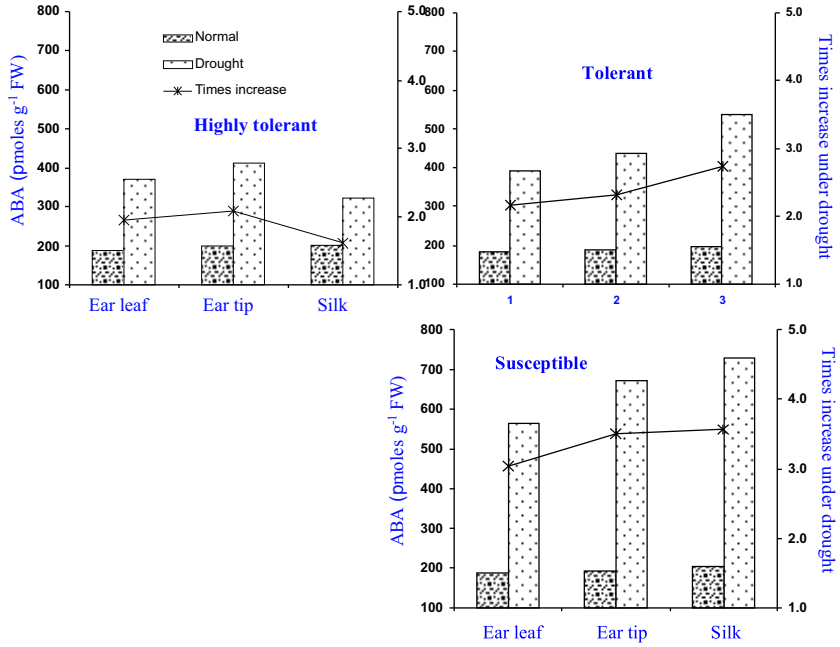



**Fig. 6 : Effect of flowering stage drought stress on ABA concentration (pmolg$^{-1}$ FW) ear leaf, ear tips and silk tissues of maize inbred lines.**

### iv) Development of recombinant inbred lines:

Three highly tolerant (,5406-119P28TSR-(S2)-3-1-2-2-B-###-B-B-B-B-B-B-B, DTPWC9-F104-5-1-B-B-B-B and DTPWC9-F115-1-4-B-B-B-B) and two highly susceptible lines (DTPYC9-F13-2-3-B-B-B-B and EW - DMR-G-C7-HS-(SIB)-9-B-1-BBB) across the seasons were crossed (L-HT x T-H S) and total six F1 progenies were developed during Kharif 2006. Out of six, three F1 families were planted during Rabi-2007 to generate F2 families. Out of three, seeds of two F2 families were harvested and planted to advance next generation. The same F2 families were planted during Rabi 2007-08 for advancing to F3. Single seed descent method shall be followed to develop recombinant inbred lines.

# STATISTICS

The production of maize in the country achieved a phenomenal level of 19.3 m. tonnes in 2007-08, which is an increase of 28 % over 2006-07. This is in true sense a Mini Revolution in maize. The analysis of area, production and productivity of maize (Table 1) shows an increasing trend with significant growth rates of 3.28 %, 5.49 % and 2.14 % respectively since the turn of century.

It is heartening to note that states like Rajasthan which occupies approx. 13 % of total area under maize has registered a growth rate of 5.85% from 2002-03 to 2007-08 (Table 2). Andhra Pradesh and Karnataka which contribute most significantly to the total production of maize in India, have shown yield growth rate of 7.92 % and 8.24 % respectively during the period 2002-03 to 2007-08. The growth rates in Orissa, Tamil Nadu and West Bengal are also very impressive during the period which indicates higher potential for expansion of maize production. But, the yield growth rates in Gujarat and Madhya Pradesh over the same period are respectively -9.66 % and -8.93 % which is major concern to researchers and policy makers. Bihar is also an important state which accounts for an average share of around 9 % of total area under maize in India, but its contribution to production is more than 11% of total maize production in the country. The maize is traditionally grown in Kharif season in the state, although the main contribution to increase overall productivity of maize comes from rabi maize. In order to realize the impact of the revolution in wider scale, the states of Gujarat, Madhya Pradesh and Uttar Pradesh require special attention since these states combined together occupy about 29 % of total cultivated maize area in the country. Productivity of maize can be further boosted if the necessary policy intervention is focused in these states, while sustaining the growth momentum in the performing states.

It may be noted that a proper understanding of the maize production system requires in-depth micro level analysis. Table 3 identifies some of the major maize growing districts (having more than 50,000 hactares areas under maize cultivation).

There are promising districts, where productivity is relatively low ranging between less than 1 ton/ha and 3 tons/ha. These districts though have low yield but higher potential. The efforts to enhance the productivity in these districts to a level of 4 ton, would provide a quantum jump in total production of maize in the country, which is an achievable target with innovative technology.

**Table 1: Area, Production and Yield with Growth Rates since the turn of century**

| All India | Area ('000 hactares) | Production ('000 tonnes) | Yield (kg/hectare) |
|---|---|---|---|
| 1999-00 | 6420 | 11510 | 1792 |
| 2000-01 | 6610 | 12040 | 1822 |
| 2001-02 | 6580 | 13160 | 2000 |
| 2002-03 | 6640 | 11150 | 1681 |
| 2003-04 | 7340 | 14980 | 2041 |
| 2004-05 | 7430 | 14172 | 1907 |
| 2005-06 | 7590 | 14710 | 1938 |
| 2006-07 | 7894 | 15097 | 1912 |
| 2007-08 | 8260 | 19300 | 2337 |
| Compound Annual Growth Rate (1999-00 to 2007-08) | 3.28 | 5.49 | 2.14 |

## Table 2: Yield of Maize and Compound Annual Growth Rate in major states from 2002-03 to 2007-08

| State/Year | 2002-03 | 2003-04 | 2004-05 | 2005-06 | 2006-07 | 2007-08 | C.A.G.R.* (2002-03 to 2007-08) |
|---|---|---|---|---|---|---|---|
| S. No. | 1 | 2 | 3 | 4 | 5 | 6 | |
| A. P | 2825 | 3436 | 3142 | 4073 | 3396 | 4606 | 7.92 |
| Bihar | 2236 | 2390 | 2386 | 2098 | 2678 | 2274 | 0.85 |
| Gujarat | 1706 | 1717 | 898 | 1124 | 698 | 1375 | -9.66 |
| Haryana | 1813 | 2412 | 2500 | 2125 | 2286 | 2643 | 4.56 |
| H.P. | 1612 | 2444 | 2272 | 1839 | 2326 | 2277 | 3.98 |
| J & K | 1412 | 1658 | 1526 | 1413 | 1505 | 1526 | 0.06 |
| Karnataka | 2068 | 1957 | 2955 | 2915 | 2829 | 2894 | 8.24 |
| M.P. | 1738 | 2052 | 1398 | 1450 | 976 | 1400 | -8.93 |
| Maharashtra | 2005 | 2038 | 1759 | 2106 | 1983 | 2689 | 4.57 |
| Orissa | 984 | 1420 | 1631 | 1602 | 1677 | 1986 | 12.08 |
| Punjab | 2039 | 2981 | 2740 | 2723 | 3123 | 3405 | 8.01 |
| Rajasthan | 885 | 1863 | 1211 | 1098 | 1086 | 1858 | 5.85 |
| Tamil Nadu | 1582 | 1568 | 1552 | 1189 | 3838 | 3831 | 21.59 |
| U.P. | 1107 | 1392 | 1705 | 1295 | 1335 | 1442 | 2.67 |
| West Bengal | 1996 | 2275 | 2977 | 2533 | 2968 | 3200 | 8.94 |
| All India | 1681 | 2041 | 1907 | 1938 | 1912 | 2337 | 4.28 |

*Compound Annual Growth Rate

## Table 3: Superior performance of maize in selected major districts in India

| State/District | Area (000 hactares) | Production (000 tonnes) | Yield (kg/hectare) |
|---|---|---|---|
| Andhra Pradesh (2005-06) | 758 | 3087 | 4073 |
| Karimnagar (2005-06)** | 175.3 | 729.7 | 4163 |
| Mahboobnagar | 105.1 | 355.5 | 3384 |
| Medak | 120.7 | 343.4 | 2844 |
| Nizamzbad | 62.6 | 255.3 | 4078 |
| Warangal (2004-05) | 71.9 | 262.8 | 3657 |
| Bihar(2006-07) | 642 | 1715 | 2671 |
| Begusarai (2006-07)** | 63.3 | 131.8 | 2082 |
| Khagaria | 54.7 | 224.9 | 4106 |
| Gujarat (2004-05) | 459.5 | 412.5 | 898 |
| Dohad (2004-05)** | 124.4 | 78.9 | 636 |
| Panch Mahals | 114.8 | 76.9 | 670 |
| Sabarkantha | 127.3 | 143.5 | 1127 |
| Vadodara | 52.0 | 58.2 | 1119 |
| Himachal Pradesh (2004-05) | 324.0 | 736.0 | 2272 |
| Kangra (2004-05)** | 58.1 | 90.9 | 1567 |
| Doda | 51.1 | 45.8 | 897 |

| | | | |
|---|---|---|---|
| Udhampur | 58.8 | 104.7 | 1782 |
| Karnataka (2004-05) | 850 | 2512 | 2955 |
| Bagalkot (2004-05)** | 51.0 | 178.2 | 3492 |
| Belgaum | 121.6 | 384.2 | 3161 |
| Bellary | 53.8 | 161.1 | 2996 |
| Chitradurga | 53.8 | 135.7 | 2521 |
| Devangere | 169.5 | 525.2 | 3098 |
| Haveri | 133.6 | 302.6 | 2266 |
| Shimoga | 60.1 | 221.1 | 3677 |
| Madhya Pradesh (2004-05) | 896.5 | 1252.6 | 1397 |
| Chhindwara (2004-05)** | 76.0 | 158.5 | 2086 |
| Dhar | 71.5 | 91.6 | 1281 |
| Jhabua | 112.8 | 108.8 | 965 |
| Mandsaur | 42.7 | 61.6 | 1443 |
| Ratlam | 64.5 | 118.5 | 1836 |
| Maharashtra (2004-05) | 428 | 753 | 1759 |
| Aurangabad (2004-05)** | 91.8 | 172.6 | 1880 |
| Jalana | 60.9 | 109.7 | 1801 |
| Punjab (2005-06) | 148.0 | 403.0 | 2723 |
| Hoshiarpur (2005-06)** | 66.0 | 172.0 | 2606 |
| Rajasthan (2004-05) | 1042.4 | 1262.6 | 1211 |
| Banswara (2004-05)** | 134.2 | 111.1 | 828 |
| Bhilwara | 180.9 | 297.3 | 1643 |
| Chittorgarh | 156.9 | 276.2 | 1761 |
| Dungarpur | 70.9 | 52.3 | 739 |
| Jhalawar | 55.1 | 67.3 | 1221 |
| Rajsamand | 65.8 | 56.9 | 865 |
| Udaipur | 179.3 | 217.6 | 1214 |
| Tamil Nadu (2004-05) | 189.9 | 294.7 | 1552 |
| Perambalur (2004-05)** | 57.4 | 68.0 | 1184 |
| Uttar Pradesh (2003-04) | 947.2 | 1318.5 | 1392 |
| Behraich (2003-04)** | 83.4 | 102.2 | 1225 |
| Bulandshahr | 66.4 | 129.1 | 1943 |
| Etah | 51.1 | 67.2 | 1315 |
| Gonda | 56.2 | 64.1 | 1141 |
| Hardoi | 52.3 | 68.5 | 1308 |
| Kannauj | 47.8 | 62.0 | 1296 |

** Latest figures available
Source of data: Directorate of Economics & Statistics

# EXTENSION ACTIVITIES

The Directorate of Maize Research is providing extension service to the nation through coordinating and conducting Frontline Demonstrations (FLDs) and Officers' Training Programme under Integrated Scheme on Oilseed, Pulses, Oilpalm and Maize (ISOPOM) funded by Technology Mission on Oilseeds, Pulses and Maize, Ministry of Agriculture, Government of India. DMR has allocated 3700 FLDs for rabi/spring 2006-07 and 8550 FLDs for kharif 2007. Out of these, various DMR centres, agencies and NGOs conducted 2152 during rabi 2006-07, 134 in spring 2007 and 6751 FLDs during kharif 2007 (Table 1). Thus, a total of 9037 FLDs were conducted against total allotment of 13050. These demonstrations were laid out in nineteen (19) states by thirty-eight (38) centres/agencies/NGOs and an average yield of 43.02 q/ha was recorded which showed an increase of 85 per cent over all India average yield of maize (Fig.1).

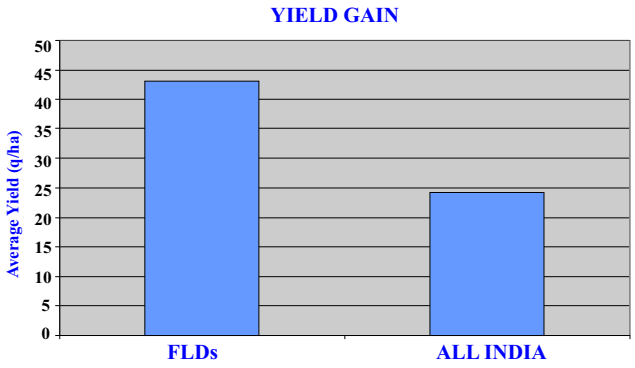



Fig.1. Yield gain in FLDs over all India average yield of maize

More than one thousand eight hundred FLDs were conducted during rabi 2006-07 and kharif 2007 (Table 2 & 3 and Fig. 2 & 3) using Quality Protein Maize hybrids HQPM 1, Shaktiman 1, 2, 3 and 4 in six states (Bihar, UP, NCR Delhi, Rajasthan, Jharkhand and WB).

Fig. 2. Shaktiman 4 in FLDs

Fig. 3. HQPM 1 in FLDs

Fifty (50) FLDs were conducted during kharif 2007 in NCR, Delhi and UP using HM 4 hybrid. An average yield (dehusked baby corn) of 14.66 q/ha was obtained besides green fodder. Madhuri and Sweet Corn-9 varieties were demonstrated in Rajasthan and MP respectively during kharif 2007. Pop Corn 11 was demonstrated in MP by ARS, Chhindwara centre. HQPM 1, Priya Sweet Corn and few private company hybrids (e.g. Pioneer Hy 32725, Hy 32 A 05 etc.) were used for demonstration of green cobs in UP, Bihar, Jharkhand, etc. Seed production and multiplication of parents of HQPM-1, Shaktiman-2, 3 and 4 were demonstrated by CIMMYT, India. Potato, pea, cowpea etc. were intercropped in several demonstrations in

Table 1. Coverage of FLDs

| S. No. | Seasons | No. of FLDs conducted | Average Grain Yield (q/ha) |
|---|---|---|---|
| 1 | Rabi 2006-07 | 2152 | 52.73 |
| 2 | Spring 2007 | 134 | 41.25 |
| 3 | Kharif 2007 | 6751 | 40.14 |
| **TOTAL** | | **9037** | **43.02** |

**Table 2. Performance of QPM hybrids during Rabi 2006-07**

| S. No. | State | Hybrid | No.of FLDs | Av.Yield (q/ ha) |
|---|---|---|---|---|
| 1 | Bihar | Shaktiman 1 | 100 | 48.17 |
| 2 | Bihar | Shaktiman 2 | 02 | 49.50 |
| 3 | Bihar | Shaktiman 3 | 186 | 63.60 |
| 4 | Bihar | Shaktiman 4 | 104 | 59.32 |
| 5 | U.P. | Shaktiman 4 | 20 | 56.40 |
| 6 | W.B. | Shaktiman 3 | 10 | 44.8 |
| 7 | W.B. | Shaktiman 4 | 05 | 53.75 |

**Table 3. Performance of QPM hybrids during Kharif 2007**

| S. No. | State | Hybrid | No. of FLDs | Av.Yield (q/ha) |
|---|---|---|---|---|
| 1 | Bihar | Shaktiman 2 | 188 | 31.63 |
| 2 | Bihar | Shaktiman 3 | 20 | 32.74 |
| 3 | Bihar | Shaktiman 4 | 806 | 37.69 |
| 4 | Bihar | HQPM 1 | 31 | 33.36 |

**Table 4. Frontline Demonstrations conducted by DMR**

| S.No. | States | Technologies demonstrated |
|---|---|---|
| 1 | A.P. | Seed production |
| 2 | Bihar | Quality Protein Maize, 900 M, Proagro 4640, multiplication of female parental line, intercropping, zero tillage, baby corn, sweet corn, etc. |
| 3 | NCR Delhi | Baby Corn (HM-4) |
| 4 | Punjab | HQPM 1 & Buland |

different states. Yield of intercrop was obtained as bonus. More than fifty Field days were organized in FLDs at several locations in different states.

## TRAINING PROGRAMMES UNDER ISOPOM

Training is a tool for imparting knowledge and skill about technologies, innovations, etc. to the participants. Officials of State Department of Agriculture deal with the transfer of technologies among farmers. They (officials) must be equipped with necessary knowledge and skill about various technologies and updated for better work performance. The Directorate of Maize Research is coordinating and conducting Officers' Training Programme for officials of State Department of Agriculture which is funded under Integrated Scheme on Oilseeds, Pulses, Oil Palm and Maize (ISOPOM). Sixty two (62) officers' training programme were allotted to different centres of AICRP on maize/ DMR in fifteen states during 2007-08. Out of sixty-two allotted training programmes, intimation report was received for

conduct of twentynine (29) trainings in ten (10) states by fifteen (15) centres. Five(5) Officers' training programmes (Table 5) were conducted by DMR.

Thirty or more than thirty participants attended each training programme. Besides officials of State Department of Agriculture of Delhi, Rajasthan, Punjab, Bihar, U.P. and W.B. few progressive farmers (men and women) also attended training programme (Fig. 4 & 5). They gained knowledge and skill about cultivation of kharif maize, rabi maize, quality protein maize, specialty corn (e.g. baby corn, sweet corn, pop corn), resource conservation technologies, intercropping, seed production, value addition, mechanization, industrial utilization, etc. There was significant increase in knowledge level of trainees about maize technologies as revealed by impact study conducted on knowledge gain of participants of training programme.

Fig.4. Officers' training programme at Begusarai

Fig. 5.Training on "Value addition of maize" at Aterna

These trained officials will impart training to the farmers in their respective states, regions and farming community will be benefited.

Table 5. Officers' Training Programme on Maize under ISOPOM conducted by DMR

| S.No. | Title | Venue | Dates (training held) |
|---|---|---|---|
| 1 | Seed Production, Cultivation and Utilization of Maize | Directorate of Maize Research, Pusa Campus, New Delhi-12 | August 22-23, 2007 |
| 2 | Baby Corn: Cultivation and Value Addition | Directorate of Maize Research, Pusa Campus, New Delhi-12 | August 24-25, 2007 |
| 3 | Seed Production, Cultivation and Value Addition in Maize | Directorate of Maize Research, Pusa Campus, New Delhi-12 | November 03-04,2007 |
| 4 | Value Addition of Maize | Regional Maize Research Station, DMR, Agriculture Farm, Bishnupur, Begusarai (Bihar) | February 25-26, 2008 |
| 5 | Seed Production, Cultivation and Utilization of Maize | Regional Maize Research Station, DMR, Agriculture Farm Bishnupur, Begusarai (Bihar) | February 27-28, 2008 |

## KISSAN MELAS AND EXHIBITIONS

Directorate of Maize Research (DMR) is also participating in Kissan Melas and Exhibitions. Kissan Mela and Exhibition is one of the best technology transfer systems for dissemination of recent advancement among people. In order to create awareness and motivate farmers, youths and businessmen to take maize cultivation, seed production, value addition etc., DMR actively participated by putting up stall (Fig. 6 & 7) in the following Kisan Melas and Exhibitions:

1. Exhibitions on the occasion of ICAR Foundation Day at NASC Complex, Pusa, New Delhi on July 16-17, 2007.

2. Exhibition at IIVR, Varanasi on the occasion of IIVR Foundation Day on 28-09-2007.

3. India International Trade Fair at Pragati Maidan, New Delhi from November 14-27, 2007.

4. Pusa Krishi Vigyan Mela, New Delhi from February 21-23, 2008.

5. Exhibition in Conference of SAARC countries in New Delhi from March 05-07, 2008.

Technical Bulletins on, "Cultivation and Value Addition in baby corn, single cross hybrid maize, seed production technology etc. were published both in Hindi and English and distributed among farmers, visitors and other needy persons.

Fig.6. Pusa Krishi Vigyan Mela

Fig.7. Exhibition at NASC Complex

## INSTITUTE FUNDED PROJECT:

Accelerating adoption of maize production technologies in India Socio-economic variables of the maize farmers in Bihar were studied which are mentioned in Table-1. The results on profile of the farmer respondents highlight their personal traits.

Majority of the farmers(68.75%) were to be found in middle-age group and having educational status of high school/intermediate. Regarding family education status (FES), majority of the farmers (51.25%) were found to be in low category, followed by high (40.00%) and medium (8.75%) category, respectively. FES contributes significantly in pursuing the scientific crop cultivation.

Joint family predominate in villages and the average family size of farmer respondents was found to be ten (10). Majority of the respondents were having medium (80.00%) family size, followed by large (11.25%) and small (8.75%) family size. All respondents were practicing crop cultivation. In addition to this, many farmers were engaged in dairy, fisheries, poultry, government service and other activities like business. Average social participation score was found to be 1.23.

The marginal farmers were predominating. The average annual income of a household was found to be Rs.28, 884/-. More than eightythree ( 83.75 ) percent of farmers were having low income, followed by 8.75 and 7.50 percent farmers who were falling under medium and high income group, respectively.

## Table 1. Socio-economic profiles of farmers in Bihar

| S. No. | Variables | Bihar (N=80) | | |
|---|---|---|---|---|
| | | Mean | Category | Frequency |
| 1. | Age | 43.91 | Young (<30) | 13 (16.25) |
| | | | Middle (30-57) | 55 (68.75) |
| | | | Old (>57) | 12 (15.00) |
| 2. | Education | - | Illiterate | 19 (23.75) |
| | | | Primary | 2 (2.50) |
| | | | Middle | 3 (3.75) |
| | | | High / Intermediate | 36 (45.00) |
| | | | Graduation and/or above | 20 (25.00) |
| 3. | Family Education Status (FES) | 2.33 | Low (<2.16) | 41 (51.25) |
| | | | Medium (2.16-2.49) | 7 (8.75) |
| | | | High (>2.49) | 32 (40.00) |
| 4. | Family Type | - | Nuclear | 25 (31.25) |
| | | | Joint | 55 (68.75) |
| 5. | Family Size | 10 | Small (<4) | 7 (8.75) |
| | | | Medium (4-16) | 64 (80.00) |
| | | | Large (>16) | 9 (11.25) |
| 6. | Occupation | - | Crop cultivation | 80 (100.00) |
| | | | Dairy | 80 (100.00) |
| | | | Fisheries | 6 (7.50) |
| | | | Poultry | 3 (3.75) |
| | | | Service | 15 (18.75) |
| | | | Others | 27 (33.75) |
| 7. | Social Participation | 1.23 | Low (<0.056) | 23 (28.75) |
| | | | Medium (0.056-2.39) | 53 (66.25) |
| | | | High (>2.39) | 4 (5.00) |
| 8. | Land holding | - | Marginal (<1 ha) | 40 (50.00) |
| | | | Small (1-2 ha) | 18 (22.50) |
| | | | Large (>2 ha) | 22 (27.50) |
| 9. | Annual income | Rs. 28884.00 | Low (<44000) | 67 (83.75) |
| | | | Medium (44000-94000) | 7 (8.75) |
| | | | High (>94000) | 6 (7.50) |

* Note : Figures in parenthesis indicate percentage.

# ANNUAL WORKSHOP MEETINGS

# 50th GOLDEN JUBILEE WORKSHOP MEETING HELD AT ANGRAU, HYDERABAD FROM APRIL 13-15, 2007.

Inaugural session was chaired by Dr. S.K. Vasal, distinguished scientist from CIMMYT. Dr. S.P. Tiwari, DDG (CS), ICAR was the Chief Guest and Dr. S. Raghuvardhan Reddy, Vice Chancellor, ANGRAU was Guest of Honour. Dr. P. Raghava Reddy, Director Research, ANGRAU welcomed the dignitaries and the delegates. Dr. Sain Dass, Project Director (Maize) presented the progress report for the previous year. He informed the house that 5 hybrids, 3 from public and 2 from private sectors were released for different agro-climate zones. Four inbred lines were registered with NBPGR which are resistant to PFSR. As many as 632 inbreds were maintained at Winter Nursery, Hyderabad for evaluation, multiplication and distribution of seed to breeders. A field day was organized to monitor Winter Nursery germplasm. Eighty-three quintals of breeders' seed was indented and 119.5 quintals were produced. Eight genotypes were found resistant against various diseases. Seventeen germplasms were found least susceptible against *Chilo partellus*. A patent has been filed for insect handling device.

Following recommendations were made at the end of three day workshop.

## BREEDING

1. All the centres will provide the list of seed material to be tested in initial evaluation trial from zonal trial materials tested in their zones showing more than 10% yield superiority with the best check.

2. Untreated seeds for all trials including checks will be sent by the centres to DMR for formulation of different trials.

3. Seed material should be properly packed indicating stage of testing and maturity from which it belongs.

4. The seed material from private sectors should be sent specifying maturity group and stage in which it has to be tested along with the draft of Rs. 30, 000/- in the name of Project Director (Maize) payable at New Delhi.

5. A comprehensive breeding programme will be prepared for Godhra, Jashipur, Chhindwara and Kanpur centres in consultation with breeders of DMR for development of inbred lines for hybrid programme.

6. Released early maturity hybrids specially developed by Almora centre for hill zones will be formulated in a trial for testing in hilly regions by Bajaura, Kangra, Srinagar and Barapani centres. The inbred lines will be provided by Almora centres for development of hybrids after testing.

7. The last date of receipt of the seed material for formulation of coordinated trials will be May 1, 2007.

## AGRONOMY

1. It was decided that all the centres should stick to the decided level of nitrogen (i.e. full season & medium maturity 60, 120, 180 kg N/ha and for early and extra early maturity 40, 100, 160 kgN/ha). The plant population in the experimental plots shall be maintained >80%.

2. The group decided to focus to generate the resource use efficient technologies, such as bed planting and zero-tillage for some of the parts of Bihar and Coastal areas.

3. INM for QPM hybrids and specialized maize such as - baby corn and sweet corn should be worked out.

4. To enhance profitability of maize based cropping system specially in rainfed areas, the best suited and remunerative intercropping option need to be found out.

5. High crop water productive technologies in terms of generating water saving agronomic practices should be developed to sustain the productivity under low water availability and drought prone areas.

6. Keeping in view the recent changes in weed flora and weed dynamics, the IWM should be focused to reduce the crop due to weeds.

## PATHOLOGY AND NEMATOLOGY

1. Some of the new diseases are not receiving due attention. Every center should take initiative in identifying emerging problems and generate information. There is need for the Pathologist to be vigilant, and alert and they should not be tied up by the routine work.

2. The centres should conduct station trials on disease management and decide the treatments according the need of the region.

3. The Sugarcane wilt caused by *Cephalosporium sacchari* and lat wilt in maize causal organism *C. maydis* may be the same organism. Identification and cross inoculation at Hyderabad and Udaipur centre to be done. To confirm the identity of these two species biotechnological tools can also be used.

4. Reporting of survey and surveillance data need to have emphasis on comparative disease scenario during previous seasons and metrological data prevailing during the crop season.

5. Yield loss assessment trials for important diseases using proper methodology should be conducted and data should be generated.

6. The possibility of screening maize materials against BSDM c.o. *Sclerophthora rayssiae* var. *Zeae* should be explored at IARI, Regional Station of Indore where the symptom expression is very severe.

7. In IPM trials quality of experimentation should improve and farmer interaction should be encouraged.

8. Exotic potential/recognized inbred lines resistant to various diseases should be obtained from CIMMYT, and other sources with the help of Dr. S.K. Vasal, for disease screening nursery.

9. The collection of elite resistance inbreds lines which have out performed the other materials should be taken up.

10. To meet the contingent nature and other necessary necessities and to enhance the quality of indepth research and evaluation under AICRIP maize, a budget line for need based research and evaluation through contractual work assignment for contractual/scientific and technical nature may be proposed in XI plan EFC.

## ENTOMOLOGY

1. Evaluation of germplasm against maize borer
   a) Coordinated trials
   b) Comparison of specialty maize (QPM, baby corn, sweet corn) with normal maize The average leaf Injury rating (1-9) for each germplasm will be studied along with the average yield of germplasm and this yield will be corrected at 12% moisture level.

Action : All Centres

2. Testing of insecticides for seed treatment against *Chilo partellus* and Termite

Two insecticides namely Fipronil and Imidacloprid will be tested as seed treatment against *C. partellus* and termites. There will be four treatments and one check of Chlorpyriphos and one untreated control. The

experiment will be conducted in four replications of two rows each having 10 plants in each row. The maize stem borer will be released for testing the efficacy as it is done in evaluation of germplasms. However, the evaluation for termite will be based on natural infestation.

### 3. Studies on phytotoxicity and natural enemies

In another experiemnt the above mentioned two insecticides will be tested for phytotoxicity and their impact on natural enemies. There will be two dosages (2X and 4X), two locations and four natural enemies namely *Cotesia,* Coccinellids, spiders and *Paederus*. Each replications will have 3 rows of 10 plants. One row will be infested by *C. partellus* for parasitization by *Cotesia*. The observations on *Cotesia* parasitisation will be taken 25 days after of release. The weekly observations for other natural enemies will be taken in remaining two rows.

Action : Delhi and Karnal

### 4. Investigations in changing insect pest scenario

The staggered sowing at 15-day interval will be done one month before and one month after the recommended sowing period of the crop. For each sowing, the plot size will be 5 x 4 m. Weekly observations on insect fauna will be initiated one week after germination and will continue till harvest. For such observations, ten plants will be randomly selected. Besides, the observations on neighboring crop and weather parameter will also be recorded.

### 5. Validation of IPM trials

The IPM strategy chalked out earlier will be validated and C: B ratio will be determined. The funds for this study will be met from either contingency or a separate budget line will be created by the centre as suggested by DDG (CS) during the workshop.

Action : Udaipur, Ludhiana, Lolhapur, Dholi, Ranchi, Hyderabad, Karnal, Nagenhalli, Arbhavi and Pantnagar.

### 6. Evaluation of insecticides for seed treatment against shootfly

Two insecticides namely Fipronil and Imidacloprid will be tested as seed treatment against natural infestation of shootfly. There will be four treatments and one check of Chlorpyriphos and one untreated control. The experiment will be conducted in four replications of two rows each having 10 plants.

Action : Delhi, Ludhiana and Karnal

# OTHER ACTIVITIES

**Training imparted to students-**

This Directorate offered 2-5 months training to M.Sc. & B.Tech. students from several colleges of Haryana, Rajasthan and other states as a project work for the partial fulfillment of degree courses.

Smriti Sangwan, CITM, Faridabad from 04.06.07-21.07.07
Alpna Lamba, Prati Krishna, Sobhasaria Eng. College, Sikar from 01.07.07-16.08.07
Mohit C. Kamthania, Bundelkhand Univ., Jhansi from 20.07.07-20.01.08
Nivedita, Vinoba Bhabe Uni. from 16.01.08-15.03.08

**Following courses were taught in PG School, IARI**

1. Insect nutrition and Host Plant Resistance
2. Principles of Insect Ecology
3. Insect Pest Management
4. Principles of Cytogenetics
5. Mutagenesis
6. Instructor and Development of Gene Concept

**The following students are pursuing their research in maize are**

1. Shivananda naikwadi- "Studies on the ovipositional behaviour of *Chilo partellus* (Swinhoe) in maize agro-ecosystem".
2. Anup Chandra- "Mycoinsecticides for the Management of Maize Stem-borers".
3. Dhanya K M- "Potential of microbial control agents for the management of *Chiloloba acuta* in maize agro-ecosystem".
4. H.B. Santosh- "Genetic diversity analysis among pink borer resistant and susceptible maize inbred lines".
5. Akhilesh P. Singh- "Molecular diversity, heterosis and combining ability studies in maize (*Zea mays* L.)".
6. Ravinder Nath- "Biochemical, molecular and morphogenetics studies on high oil maize (*Zea mays* L.)".
7. Zarka Rashid- "Regeneration and transformation studies in Indian maize (*Zea mays* L.)".

**TRANSFER/RETIREMENT/PROMOTION**

1. Dr. (Mrs.) Jyoti Kaul Sr. Scientist pl. Breeding joined DMR on 6.11.07 on transfer from IIPR Kanpur.
2. Dr. P.H. Zaidi was relieved on 30.11.07 to join CIMMYT
3. Dr. Ishwar Singh, Sr. Scientist Physiology joined on 1.3.08 on transfer from IISR Lucknow.
4. Dr. H.O. Gupta, Principal Scientist Biochemistry retired on 31.7.07.

**Training programmes organized:**

| S No | Training programme | Duration | Place | No of participants |
|---|---|---|---|---|
| 1 | Officers training on Seed Production, Cultivation and Utilization of Maize | August 22-23, 2007 | DMR New Delhi | 30 |
| 2 | Officers training on Baby Corn: Cultivation and Value Addition | August 24-25, 2007 | DMR New Delhi | 30 |
| 3 | Officers training on Seed Production, Cultivation and Utilization of Maize | November 25-26, 2007 | DMR New Delhi | 30 |
| 4 | Officers training on Value Addition of Maize | February 25-26, 2008 | Regional Maize Research Station (DMR), Begusarai, Bihar | 30 |
| 5 | Officers training, on Seed Production Cultivation and Utilization of Maize | February 27-28, 2008 | Regional Maize Research Station, Begusarai, Bihar | 30 |

## Research Programmes & Projects-

| S.No. | Funded Agency | Project Title | Project Leader |
|---|---|---|---|
| 1 | ICAR | Development of stem borer resistant-transgenic maize | Pradyumn Kumar |
| 2 | Institute | Integrated management in maize with major thrust on pest resistance and biological control | - do - |
| 3 | Bayer Crop Sciences Ltd. | Effect of Fipronil and Imidacloprid as seed treatment on incidence of *Chilo partellus* and termite in maize | - do - |
| 4 | Bayer Crop Sciences Ltd. | Evaluation of sunato (fipronil 180g + imidacloprid 360g- 550 FS) against shoot fly and termite in maize | - do - |
| 5 | DST | Development of technology for the commercial production of *Cotesia* sp.- a potential parasitoid of lepidopteran pests | Meenu Agarwal |
| 6 | ICAR AP-CESS | Net work project on Prevention and management of Mycotoxin in agriculturally important commodities | Sangit Kumar |
| 7 | ICAR AP-CESS | Network Project on Gene Pyramiding; Pyramiding genes for resistance to Turcicum Leaf Blight and Polysora Rust in maize | - do - |
| 8 | ICAR AP-CESS | Assessment of vulnerability of crop yields to pest damage in global climate change | - do - |
| 9. | ICAR-NPTC | Functional genomics of drought tolerance in maize | M.L. Jat, Sujay Rakshit |
| 10 | ICAR AP-CESS | Technological transformation for improved and stable productivity of Kharif maize under multiple abiotic stresses | R.P. Singh |
| 11 | ICAR | DUS Testing | S.B. Singh |
| 12 | Institute | Studies on crop management strategies for improving productivity under drought and water logging stress | R.P. Singh, M.L. Jat, Ishwar Singh, SB Singh |
| 13 | Institute | Evaluating conservation tillage practices for improving resource use efficiency in maize based cropping systems | M.L. Jat, R.P. Singh. Ishwar Singh, M. Shekhar, P. Kumar, K.P. Singh |
| 14 | Institute | Evaluation of elite lines of maize for heat tolerance | Ishwar Singh, M.L. Jat, R.P. Singh. Sain Dass |
| 15 | Institute | Post-harvest management of losses due to microbial colonization in stored maize grains | Sangit Kumar |

| | | | |
|---|---|---|---|
| 16 | Institute | Studies on variability among the isolates of *Macrophomina phaseolina* and *Fusarium moniliforme* in maize and Identification of sources of resistance against Post Flowering Stalk Rots of maize | Meena Shekhar |
| 17 | Institute | Chemical and biological evaluation and nutritional quality of specialty corn | Om Prakash |
| 18 | Institute | Development of Web Based Maize Information System | K. P. Singh |
| 19 | Institute | Accelerating adoption of maize production technologies in India | V. K. Yadav |

## ARIS CELL

Redesigned the DMR home page and added new features as per the following screen shot. The DMR website has continued to be popular. The site has been updated regularly and the databases are also kept up-to-date. We used the DHTML, JSP and flash web designing software for the development of the site.

## Web based maize information system:

The database for the maize production statistics, varieties, hybrids and protection technologies has been designed.

# PUBLICATIONS/ HONOURS/ AWARDS

## (i) Research Articles:


1. Anuj Kumar, Ram Chand, Randhir Singh and V.K.Yadav. 2007. Impact of TAR-IVLP on crop cultivation. Indian Research *Journal of Extension Education*, Volume 7, No. 2 & 3, pp.1-5.

2. Dass, S, Jat, M.L., Singh, KP and Rai, HK. 2008. Ago-economic analysis of maize based ropping systems in India. *Indian Journal of Fertilizers*. 4 (4): 53-62.

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1. Dass, S., Jat, M.L., and Singh, K.P. 2007. Resource management in maize based cropping systems, Paper presented in Summer School on Resource Conserving technologies, Division of Agronomy, IARI, New Delhi, September 11, 2007.

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5. Jat, M.L.; Dass, S., and Singh, KP. 2008. Maize based high value intercropping systems for diversified farming in peri-urban agriculture. (in) *Proc National Workshop--cum-Symposium on tree spice cultivation and sustainable development of home garden for decent livelihood and environmental protection in Andman & Nicobar Islands,* February 4-6, 2008, CARI, Port Blair, pp. 43-44.

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8. Ramasundaram, P., Mishra, R.P., Jat, M.L. and Gill, M.S. 2007. On-farm conservation griculture: application of laser leveling. (in): *Proceedings of the National symposium on Integrated Farming Systems and its role towards livelihood improvement*, October 26-28, 2007, ARS, RAU, Durgapura, Jaipur Rajasthan, pp. 122.

9. Singh, Gurbachan, Singh, S. and Jat, M.L. 2007. Precision input management for improving water productivity and nitrogen use efficiency. In: *Proc. 10th Inter-regional conference on water and environment, enduring water and environment for prosperity and posterity*, October 17-20, 2007, New Delhi, India

## Participation In Conferences / Symposia /seminars /other Fora:

1. National symposium on Integrated Farming Systems and its role towards livelihood improvement, October 26-28, 2007, ARS, RAU, Durgapura, Jaipur Rajasthan- M.L. Jat, Senior Scientist.

2. Biennial Conference of Indian Society of Weed Science, November 2-3, 2007, CCSHAU, Hisar (Haryana)- M.L. Jat, Senior Scientist.

3. National Workshop-cum-symposium on tree spice cultivation and sustainable development of home garden for decent livelihood and environmental protection in Andman & Nicobar Islands, February 4-6, 2008, CARI, Port Blair- M.L. Jat, Senior Scientist.

4. SAARC Conference-2008, NASC Complex, New Delhi- Dr Sain Dass, Project Director, M.L. Jat and V.K. Yadav.

5. Meeting on Strategies for Hybrid Maize Research, January 11-12, 2008, Directorate of Maize Research, New Delhi-- All Scientists of DMR.

6. National Technical Coordination Committee (NTCC) Meeting of Rice-Wheat system, February, 6, 2008, DMR, New Delhi- Sain Dass, Project Director and M.L. Jat, Sr Scientist.

7. Field day-cum-infield training on maize, Winter Nursery Centre, DMR, Rajendra Nagar Hyderabad, March 9-11, 2008- Sain Dass, Project Director, Sangit Kumar, P. Kumar, Rajpal Singh, J.C Shekar, Jyoti Kaul, Sujay Rakshit, and M.L. Jat.

8. Research Advisory Committee Meeting of DMR, March 12-13, 2008, DMR New Delhi- All scientists of DMR.

9. Winter School on "Dynamics of Entrepreneurship Development in Agriculture: Basics to Advances" held at Department of Extension Education, Institute of Agricultural

Sciences, BHU, Varanasi from 17.11.2007 to 07.12.2007. V.K. Yadav.

10. The 50th Annual Workshop on Maize held at ANGRAU, Hyderabad from April 13-16, 2007. All Scientists of DMR.

11. National Conference on "Doubling Maize Production" organised by IFFCO Foundation, ICAR, DMR & IFFCL at New Delhi on May 08-09, 2007. All Scientists of DMR.

12. BMZ Launching workshop on Abiotic Stress Tolerant Maize for increasing income and food security among the poor in eastern India and Bangaladesh during 14-15 March, 2008 at DMR, Pusa Campus, New Delhi-12.

**Awards/Honours:**

1. Dr M.L. Jat, Senior Scientist received "NAAS Associate Fellow" of the National Academy of Agricultural Sciences w.e.f 1st January 2008 for his outstanding contribution in the field of Conservation Agriculture and Precision Farming.

**Development of intellectual property right-**

**Registration of new and extant varieties/hybrids**

In the era of Intellectual Property Rights, a strong need was felt to protect the Indian germplasm from being commercially exploited by unauthorized parties. Consequently, an effective system for protection of varieties, vis-a-vis' the rights of farmers and plant breeders under *Sui generis* system has been devised. Having ratified the Agreement on Trade Related aspects of the Intellectual Property Rights (TRIPs), India had to make provision for giving effect to agreement. Resultantly, the Protection of Plant Varieties and Farmers Rights Act 2001 has been passed. Under this

Act, almost all the Application totaling 79 of extant as well as new hybrids/composites for registration have been filed at Protection of Plant Variety and Farmer Rights (PPV&FR) Authority, New Delhi through NBPGR for their protection. Of these, 15 are for new releases and 64 for extant varieties/hybrids. The centre-wise number of applications processed and filed is given below :

**CCS HAU Karnal :** HHM-1, HHMS-2, HM-4, HM-5, HQPM-1HQPM-5, HM-8, HM-9;

**ANGRAU Hyderabad :** DHM-107, DHM-109, Priya Sweet Corn;

**IARI Delhi :** Pusa Early Hybrid Makka-3, Pusa Extra-Early Hybrid Makka-5, Pusa Composite-3, Pusa Composite-4;

**VPKAS Almora :** HIM-129, Vivek Hybrid-4, Vivek Hybrid-5, Vivek Maize Hybrid-9, Vivek Maize Hybrid-15, Vivek Maize Hybrid-17, Vivek Maize Hybrid-21, Vivek Maize Hybrid-23, Vivek Maize Hybrid-25, Vivek Maize Hybrid-27, Vivek QPM-9, Vivek Sankul Makka 31, Vivek Sankul Makka-11, VL Baby Corn-1;

**PAU Ludhiana :** Parkash, Buland, PMH-1, PMH-2, PAU352;

**BHU Varanasi :** Malviya Hybrid Makka-2;

**TNAU Coimbatore :** COH-3, COH(M)-4, COH(M)-5, COBC-1;

**RAU Dholi :** Shaktiman-1, Shaktiman-2, Shaktiman-3, Shaktiman-4, Dewaki Composite Makka;

**AAU Godhra :** Gujrat Makai-6, Gujrat Makai-4, Gujrat Makkai-2,Narmada Moti;

**MPUA & T Bhanswara :** Mahi dhawal, Mahi Kanchan;

**Dharwad :** Matungha, DMH-2;

**DMR :** Shakti-1, Win Orange Sweet Corn;

**GBPAU&T Pantnagar :** D-994, Gaurav, Amar;

**BAU Ranchi :** Birsa Makai-1, Birsa Vikas Makka-2;

**CSUA &T Kanpur :** Azad Kamal;

**JNKVV Chhindwara :** JM-8, Jawahar Composite Makka-12, Jawahar Makka-216, Jawahar Vikas Maize-421, Jawahar Pop Corn-11;

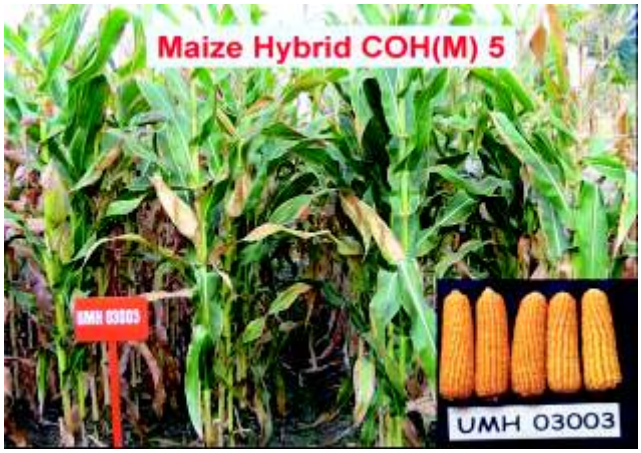
**SKUAS&T Srinagar :** C-8, C-14, Shalimar KG Maize-1 Shalimar KG Maize-2;

**UAS Nagenahalli :** NAC-6002, NAC-6004;

**MPKV Kolhapur :** Panchganga;

HM-8


HM-9


PMH-1

Plate 1 : figs Some of the newly released hybrids/varieties of maize

## Annexure-1 : List of primers evaluated

| Sl. No. | Markers | location | Sl. No. | Markers | location | Sl. No. | Markers | location |
|---|---|---|---|---|---|---|---|---|
| 1 | bnlg149 | 1.00 | 37 | mmc00231 | 2.03 | 73 | umc1136 | 3.10 |
| 2 | umc1041 | 1.00 | 38 | bnlg1018 | 2.04 | 74 | bnlg1372 | 4.00 |
| 3 | bnlg1014 | 1.01 | 39 | bnlg166 | 2.04 | 75 | umc1561 | 4.00 |
| 4 | umc1685 | 1.01 | 40 | bnlg381 | 2.04 | 76 | bnlg1241 | 4.01 |
| 5 | bnlg1429 | 1.02 | 41 | umc1259 | 2.04 | 77 | umc1276 | 4.01 |
| 6 | umc1711 | 1.02 | 42 | umc1003 | 2.05 | 78 | umc1276 | 4.01 |
| 7 | bnlg1484 | 1.03 | 43 | bnlg1138 | 2.06 | 79 | bnlg1126 | 4.03 |
| 8 | bnlg1866 | 1.03 | 44 | bnlg1831 | 2.06 | 80 | nc004 | 4.03 |
| 9 | umc1403 | 1.03 | 45 | umc1156 | 2.06 | 81 | umc1117 | 4.04 |
| 10 | bnlg1811 | 1.04 | 46 | mmc0191 | 2.07 | 82 | bnlg1217 | 4.05 |
| 11 | bnlg2238 | 1.04 | 47 | bnlg1329 | 2.08 | 83 | bnlg1265 | 4.05 |
| 12 | umc1917 | 1.04 | 48 | bnlg1662 | 2.08 | 84 | bnlg1937 | 4.05 |
| 13 | umc190 | 1.05 | 49 | bnlg1940 | 2.08 | 85 | umc1702 | 4.05 |
| 14 | bnlg1057 | 1.06 | 50 | bnlg198 | 2.08 | 86 | bnlg1137 | 4.06 |
| 15 | bnlg1273 | 1.06 | 51 | phi127 | 2.08 | 87 | bnlg252 | 4.06 |
| 16 | bnlg2086 | 1.06 | 52 | bnlg1520 | 2.09 | 88 | umc1869 | 4.06 |
| 17 | umc1664 | 1.06 | 53 | umc1551 | 2.09 | 89 | bnlg1189 | 4.07 |
| 18 | bnlg1564 | 1.07 | 54 | umc1696 | 2.10 | 90 | bnlg1784 | 4.07 |
| 19 | bnlg615 | 1.07 | 55 | umc1746 | 3.00 | 91 | umc1194 | 4.07 |
| 20 | umd1245 | 1.07 | 56 | umc1814 | 3.02 | 92 | bnlg1444 | 4.08 |
| 21 | bnlg1629 | 1.08 | 57 | bnlg1325 | 3.03 | 93 | bnlg2244 | 4.08 |
| 22 | phi002A | 1.08 | 58 | bnlg1523 | 3.03 | 94 | mmc0321 | 4.08 |
| 23 | bnlg1268 | 1.09 | 59 | bnlg1904 | 3.04 | 95 | bnlg1565 | 4.09 |
| 24 | bnlg1720 | 1.09 | 60 | bnlg2047 | 3.04 | 96 | umc1643 | 4.09 |
| 25 | umc1885 | 1.10 | 61 | umc1495 | 3.04 | 97 | bnlg1917 | 4.1 |
| 26 | phi064 | 1.11 | 62 | bnlg1456 | 3.05 | 98 | bnlg589 | 4.10 |
| 27 | phi120 | 1.11 | 63 | mmc0022 | 3.05 | 99 | umc1180 | 4.10 |
| 28 | umc1630 | 1.11 | 64 | bnlg1449 | 3.06 | 100 | bnlg1337 | 4.11 |
| 29 | umc1605 | 1.12 | 65 | umc1027 | 3.06 | 101 | bnlg1890 | 4.11 |
| 30 | mmc0063 | 2.00 | 66 | bnlg1605 | 3.07 | 102 | bnlg2186 | 4.11 |
| 31 | umc1217 | 2.01 | 67 | bnlg1108 | 3.08 | 103 | bnlg1006 | 5.00 |
| 32 | bnlg1017 | 2.02 | 68 | umc1140 | 3.08 | 104 | mmc0151 | 5.00 |
| 33 | bnlg125 | 2.02 | 69 | bnlg1182 | 3.09 | 105 | bnlg1382 | 5.01 |
| 34 | bnlg1302 | 2.02 | 70 | bnlg1257 | 3.09 | 106 | bnlg143 | 5.01 |
| 35 | umc1518 | 2.02 | 71 | umc1641 | 3.09 | 107 | umc1478 | 5.01 |
| 36 | bnlg2248 | 2.03 | 72 | bnlg1098 | 3.10 | 108 | bnlg105a | 5.02 |

| Sl. No. | Markers | location | Sl. No. | Markers | location | Sl. No. | Markers | location |
|---|---|---|---|---|---|---|---|---|
| 109 | phi396160 | 5.02 | 146 | bnlg2132 | 7.00 | | | |
| 110 | bnlg1046 | 5.03 | 147 | umc1788 | 7.00 | | | |
| 111 | bnlg1902 | 5.03 | 148 | bnlg1200 | 7.01 | | | |
| 112 | umc1355 | 5.03 | 149 | bnlg1292 | 7.01 | | | |
| 113 | bnlg1208 | 5.04 | 150 | bnlg1657 | 7.02 | | | |
| 114 | bnlg1287 | 5.04 | 151 | bnlg1657 | 7.02 | | | |
| 115 | bnlg2323 | 5.04 | 152 | bnlg1808 | 7.02 | | | |
| 116 | umc1192 | 5.04 | 153 | bnlg1904 | 7.02 | | | |
| 117 | mmc0081 | 5.05 | 154 | umc1585 | 7.02 | | | |
| 118 | bnlg1847 | 5.06 | 155 | bnlg1070 | 7.03 | | | |
| 119 | bnlg118 | 5.07 | 156 | bnlg1271 | 7.03 | | | |
| 120 | bnlg2305 | 5.07 | 157 | bnlg2259 | 7.04 | | | |
| 121 | umc1646 | 5.07 | 158 | umc1125 | 7.04 | | | |
| 122 | umc1792 | 5.08 | 159 | bnlg2328 | 7.05 | | | |
| 123 | bnlg386 | 5.09 | 160 | phi082 | 7.05 | | | |
| 124 | bnlg1043 | 6.00 | 161 | umc1406 | 7.05 | | | |
| 125 | umc1143 | 6.00 | 162 | phi116 | 7.06 | | | |
| 126 | bnlg1246 | 6.01 | 163 | umc2190 | 7.06 | | | |
| 127 | bnlg1371 | 6.01 | 164 | bnlg1252 | 8.00 | | | |
| 128 | bnlg1538 | 6.01 | 165 | umc1075 | 8.00 | | | |
| 129 | bnlg426 | 6.01 | 166 | umc1414 | 8.01 | | | |
| 130 | umc1656 | 6.01 | 167 | bnlg1194 | 8.02 | | | |
| 131 | umc1006 | 6.02 | 168 | bnlg2289 | 8.02 | | | |
| 132 | phi389203 | 6.03 | 169 | phi119 | 8.02 | | | |
| 133 | umc1795 | 6.04 | 170 | umc1304 | 8.02 | | | |
| 134 | bnlg1702 | 6.05 | 171 | bnlg1834 | 8.03 | | | |
| 135 | bnlg1732 | 6.05 | 172 | bnlg1863 | 8.03 | | | |
| 136 | bnlg1922 | 6.05 | 173 | umc1377 | 8.03 | | | |
| 137 | mmc0241 | 6.05 | 174 | phi100175 | 8.04 | | | |
| 138 | dupssr15 | 6.06 | 175 | bnlg1176 | 8.05 | | | |
| 139 | umc1414 | 6.06 | 176 | bnlg1651 | 8.05 | | | |
| 140 | bnlg1521 | 6.07 | 177 | bnlg1782 | 8.05 | | | |
| 141 | bnlg1740 | 6.07 | 178 | umc1121 | 8.05 | | | |
| 142 | phi123 | 6.0 | 179 | umc1161 | 8.06 | | | |
| 143 | phi089 | 6.08 | 180 | bnlg1065 | 8.07 | | | |
| 144 | bnlg1367 | 7.00 | 181 | bnlg1350 | 8.07 | | | |
| 145 | bnlg1642 | 7.00 | 182 | umc1268 | 8.07 | | | |

# Annexure-1

## Expression of characteristics in hybrids

| Characteristics | Vivek Hybrid 9 | Vivek Hybrid 15 | Vivek Hybrid 17 | Vivek Hybrid 23 | HM 4 | BH 1576 | BH 1620 | BH 2187 | Buland | HQPM 1 | Him 129 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Leaf: angle bet blade & stem | 7 | 3 | 7 | 7 | 7 | 3 | 3 | 7 | 7 | 7 | 3 |
| 2. Leaf: attitude of blade | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 1 | 9 |
| 3. Stem: antho col of br root | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 1 | 1 |
| 4. Tasl: Time of anthesis | 1 | 3 | 1 | 5 | 5 | 7 | 5 | 3 | 7 | 7 | 1 |
| 5. Tasl: antho col at base of glume | 9 | 1 | 9 | 1 | 1 | 1 | 9 | 1 | 1 | 1 | 1 |
| 6. Tasl: Anth col of glumes excluding base | 9 | 9 | 9 | 1 | 1 | 1 | 1 | 9 | 9 | 1 | 9 |
| 7. Tasl: antho col of anthers | 9 | 9 | 9 | 1 | 1 | 1 | 1 | 1 | 9 | 1 | 1 |
| 8. Tasl: density of spikelets | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 9 | 3 | 3 | 3 |
| 9. Tasl: angle betwn Main axis & lateral brnches | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 3 | 7 | 7 | 7 |
| 10. Tasl: attitude of lateral branches | 1 | 5 | 1 | 1 | 1 | 1 | 5 | 5 | 5 | 1 | 1 |
| 11. Ear: time of silk emergence | 3 | 1 | 1 | 5 | 5 | 1 | 5 | 3 | 5 | 5 | 1 |
| 12. Ear: antho col of silks | 9 | 9 | 9 | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 9 |
| 13. Leaf: Antho col of sheath | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 14: Tasl: Length of main axis above lowest side branch | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 15. Plant: length | 5 | 5 | 5 | 5 | 5 | 7 | 7 | 7 | 7 | 7 | 5 |
| 16. Plant: ear placement | 3 | 3 | 3 | 3 | 7 | 7 | 7 | 7 | 7 | 7 | 5 |
| 17. Leaf: width of blade | 3 | 3 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 7 | 3 |
| 18. Ear: length without husk | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 19. Ear: diameter without husk | 5 | 5 | 5 | 5 | 5 | 3 | 5 | 3 | 5 | 5 | 3 |
| 20. Ear: shape | 3 | 1 | 3 | 2 | 2 | 2 | 1 | 2 | 3 | 1 | 1 |

## Annexure Contd...

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21. | Ear: no. of rows of grain | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 22. | Ear: type of grain | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1 |
| 23. | Ear: colour of top of grain | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 5 | 5 | 3 | 3 |
| 24. | Ear: antho col of glumes of cob | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 25. | Kernel: row arrangement | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 26. | Kernel: poppiness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 27. | Kernel: Sweetness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 28. | Kernel: Waxiness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 29. | Kernel: Opaqueness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 1 |
| 30. | Kernel: Shape | 4 | 2 | 2 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 3 |
| 31. | Kernel: 1000Kernel weight | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 3 |

## Expression of characteristics in composites

| Characteristics | VS Makka -11 | VL Makka -16 | VL Makka -41 | VL Makka -88 | C-6 | C-8 | C-15 | KG-1 | KG-2 | Super Fast I |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Leaf: angle bet blade & stem | 7 | 7 | 7 | 7 | 7 | 3 | 7 | 7 | 7 | 7 |
| 2. Leaf: attitude of blade | 9 | 9 | 9 | 9 | 1 | 9 | 9 | 9 | 9 | 9 |
| 3. Stem: antho col of br root | 1 | 9 | 9 | 9 | 9 | 1 | 9 | 1 | 1 | 9 |
| 4. Tasl: Time of anthesis | 1 | 1 | 1 | 3 | 5 | 5 | 3 | 3 | - | 5 |
| 5. Tasl: antho col at base of glume | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 1 |
| 6. Tasl: Anth col of glumes excluding base | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7. Tasl: antho col of anthers | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8. Tasl: density of spikelets | 3 | 7 | 7 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 9. | Tasl: angle betwn Main axis & lateral branches | 7 | 3 | 3 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 10. | Tasl: attitude of lateral branche | 5 | 1 | 1 | 5 | 1 | 1 | 1 | 1 | 5 | 1 |
| 11. | Ear: time of silk emergence | 1 | 1 | 1 | 3 | 5 | 5 | 5 | 5 | - | 5 |
| 12. | Ear: antho col of silks | 9 | 1 | 1 | 9 | 1 | 1 | 9 | 9 | 1 | 1 |
| 13. | Leaf: Antho col of sheath | 1 | 9 | 9 | 9 | 9 | 9 | 1 | 1 | 1 | 1 |
| 14: | Tasl: Length of main axis above lowest side branch | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 3 |
| 15. | Plant: length | 7 | 5 | 3 | 5 | 5 | 3 | 5 | - | 3 | 3 |
| 16. | Plant: ear placement | 3 | 7 | 3 | 3 | 7 | 7 | 3 | 3 | - | 3 |
| 17. | Leaf: width of blade | 3 | 3 | 3 | 5 | 5 | 3 | 7 | 3 | 5 | 5 |
| 18. | Ear: length without husk | 5 | 5 | 5 | 5 | 7 | 5 | 5 | 5 | 5 | 5 |
| 19. | Ear: diameter without husk | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 3 | 3 | 3 |
| 20. | Ear: shape | 1 | 2 | 1 | 1 | 2 | 1 | - | 1 | 1 | 1 |
| 21. | Ear: no. of rows of grain | 5 | 7 | 7 | 7 | 7 | 7 | 7 | 5 | 5 | 5 |
| 22. | Ear: type of grain | 1 | 1 | 1 | 2 | 2 | 3 | 1 | 1 | 2 | 1 |
| 23. | Ear: colour of top of grain | 5 | 3 | 3 | 3 | 5 | 1 | 3 | 3 | 3 | 3 |
| 24. | Ear: antho col of glumes of cob | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 25. | Kernel: row arrangement | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| 26. | Kernel: poppiness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 27. | Kernel: Sweetness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 28. | Kernel: Waxiness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 29. | Kernel: Opaqueness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 30. | Kernel: Shape | 2 | 3 | 2 | 2 | 4 | 3 | 3 | 2 | 4 | 3 |
| 31. | Kernel: 1000Kernel weight | 2 | 5 | 3 | 3 | 3 | 5 | 3 | 5 | 5 | 5 |

**Annexure Contd...**

| Characteristics | Azad Uttam | Shrada mani | Azad Kamal | Girja Co-mposite | African Tall | GM 12 | Gujrat Makka 2 | Gujrat Makka 3 | Gujrat Makka 4 | Gujrat Makka 6 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Leaf: angle bet blade & stem | 7 | 7 | 7 | 7 | 7 | 3 | 7 | - | 7 | 7 |
| 2. Leaf: attitude of blade | 9 | 9 | 9 | 9 | 1 | 9 | 9 | 9 | 9 | 1 |
| 3. Stem: antho col of br root | 9 | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 4. Tasl: Time of anthesis | 5 | 3 | 3 | 5 | 7 | 5 | - | 7 | 5 | 5 |
| 5. Tasl: antho col at base of glume | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6. Tasl: Anth col of glumes excluding base | 1 | 1 | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7. Tasl: antho col of anthers | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8. Tasl: density of spikelets | 3 | 3 | 9 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 9. Tasl: angle betwn Main axis & lateral brnches | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 10. Tasl: attitude of lateral branches | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 1 |
| 11. Ear: time of silk emergence | 5 | 5 | 5 | - | - | 5 | 5 | - | 5 | 5 |
| 12. Ear: antho col of silks | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 13. Leaf: Antho col of sheath | 1 | 1 | 1 | 9 | 1 | 9 | 1 | 1 | 1 | 9 |
| 14. Tasl: Length of main axis above lowest side branch | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 15. Plant: length | 5 | 5 | 5 | 5 | 7 | - | - | 5 | 5 | 5 |
| 16. Plant: ear placement | 3 | 3 | 7 | 3 | 7 | 7 | 3 | 3 | 7 | 7 |
| 17. Leaf: width of blade | - | 5 | 5 | 5 | - | 5 | 5 | 5 | 5 | 3 |
| 18. Ear: length without husk | 7 | 7 | 7 | 7 | 5 | 7 | 7 | 7 | 7 | 7 |
| 19. Ear: diameter without husk | 3 | 3 | 3 | 3 | 3 | * | 5 | 3 | 3 | - |
| 20. Ear: shape | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 21. Ear: no. of rows of grain | 7 | 7 | 7 | 7 | 5 | 7 | 7 | 7 | 7 | 7 |
| 22. Ear: type of grain | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| 23. Ear: colour of top of grain | 3 | 3 | 5 | 3 | 1 | 1 | 3 | 1 | 1 | 1 |
| 24. Ear: antho col of glumes of cob | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 25. Kernel: row arrangement | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 26. Kernel: poppiness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 27. Kernel: Sweetness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 28. Kernel: Waxiness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 29. Kernel: Opaqueness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 30. Kernel: Shape | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 2 |
| 31. Kernel: 1000Kernel weight | 5 | 5 | 5 | 5 | 3 | 5 | 5 | 5 | 5 | 3 |



## Annexure Contd...

| Characteristics | Narmada Moti | Ashwini | Harsha | Varun | Amber Pop Corn | Madhuri | Priya Sweet Corn | PH Shakti Corn | Gaurav | Pragati |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Leaf: angle bet blade & stem | 7 | 7 | 7 | 7 | * | 7 | 7 | 7 | 7 | 7 |
| 2. Leaf: attitude of blade | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 3. Stem: antho col of br root | 9 | 9 | 9 | 9 | 1 | 1 | 1 | 1 | 9 | 9 |
| 4. Tasl: Time of anthesis | * | * | 3 | 3 | 7 | 5 | * | 1 | 3 | 3 |
| 5. Tasl: antho col at base of glume | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6. Tasl: Anth col of glumes excluding base | 1 | 1 | 9 | 9 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7. Tasl: antho col of anthers | 1 | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8. Tasl: density of spikelets | 3 | 3 | 3 | 3 | 9 | 7 | 3 | 3 | 3 | 3 |

**Annexure Contd...**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 9. | Tasl: angle betwn Main axis & lateral brnches | 7 | 7 | 7 | 7 | 7 | 3 | 3 | 3 | 7 | 7 |
| 10. | Tasl: attitude of lateral branches | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 1 |
| 11. | Ear: time of silk emergence | 5 | 5 | 5 | 5 | - | 5 | 5 | 1 | - | - |
| 12. | Ear: antho col of silks | 1 | 1 | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 9 |
| 13. | Leaf: Antho col of sheath | 1 | 1 | 1 | 9 | 1 | 1 | 1 | 9 | 1 | 9 |
| 14. | Tasl: Length of main axis above lowest side branch | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 15. | Plant: length | 5 | 5 | 5 | 5 | - | 3 | 5 | 3 | - | 3 |
| 16. | Plant: ear placement | 3 | 7 | 3 | * | * | 7 | * | 7 | 7 | 7 |
| 17. | Leaf: width of blade | 5 | - | 5 | 5 | 3 | 5 | 3 | 3 | 5 | 3 |
| 18. | Ear: length without husk | 5 | 5 | 7 | 7 | - | 5 | 7 | - | 5 | 5 |
| 19. | Ear: diameter without husk | 3 | 3 | 5 | 3 | 3 | 3 | 5 | 3 | 3 | 3 |
| 20. | Ear: shape | 1 | - | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| 21. | Ear: no. of rows of grain | 7 | 7 | 7 | 7 | 7 | 5 | 7 | 7 | 7 | 7 |
| 22. | Ear: type of grain | 2 | 1 | 1 | 1 | 1 | 3 | 3 | 1 | 2 | 1 |
| 23. | Ear: colour of top of grain | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 24. | Ear: antho col of glumes of cob | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 25. | Kernel: row arrangement | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 |
| 26. | Kernel: poppiness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 27. | Kernel: Sweetness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 28. | Kernel: Waxiness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 29. | Kernel: Opaqueness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 30. | Kernel: Shape | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 4 | 2 |
| 31. | Kernel: 1000Kernel weight | 5 | 5 | 5 | 5 | 3 | 3 | 3 | 3 | 3 | 3 |

## Annexure Contd...

| Characteristics | Aravati Makka | Pratap Makka 3 | Pratap Makka 4 | Pratap Makka 5 | Win Orange Sweet Corn |
|---|---|---|---|---|---|
| 1. Leaf: angle bet blade & stem | 7 | 7 | 7 | 7 | 7 |
| 2. Leaf: attitude of blade | 9 | 9 | 9 | 9 | 9 |
| 3. Stem: antho col of br root | 9 | 9 | 9 | 9 | 1 |
| 4. Tasl: Time of anthesis | - | - | 5 | 5 | - |
| 5. Tasl: antho col at base of glume | 1 | 1 | 1 | 1 | 1 |
| 6. Tasl: Anth col of glumes excluding base | 9 | 1 | 1 | 1 | 1 |
| 7. Tasl: antho col of anthers | 1 | 1 | 1 | 1 | 1 |
| 8. Tasl: density of spikelets | 3 | 3 | 3 | 3 | 3 |
| 9. Tasl: angle betwn Main axis & lateral brnches | 7 | 7 | 7 | 7 | 7 |
| 10. Tasl: attitude of lateral branches | 1 | 1 | 1 | 1 | 5 |
| 11. Ear: time of silk emergence | 5 | 5 | 5 | 5 | 5 |
| 12. Ear: antho col of silks | 1 | 9 | 1 | 1 | 1 |
| 13. Leaf: Antho col of sheath | 9 | 1 | 1 | 1 | 1 |
| 14. Tasl: Length of main axis above lowest side branch | 7 | 7 | * | 7 | 7 |
| 15. Plant: length | 5 | 5 | * | - | 5 |
| 16. Plant: ear placement | - | 7 | 3 | 3 | 3 |
| 17. Leaf: width of blade | 5 | 5 | * | - | 5 |
| 18. Ear: length without husk | 5 | 7 | 7 | 7 | 5 |
| 19. Ear: diameter without husk | 3 | 3 | 5 | - | 3 |
| 20. Ear: shape | 1 | 2 | 2 | 2 | 2 |

## Annexure Contd...

| | | | | | |
|---|---|---|---|---|---|
| 21. Ear: no. of rows of grain | 7 | 7 | 7 | 7 | 5 |
| 22. Ear: type of grain | 1 | 1 | 1 | 1 | 3 |
| 23. Ear: colour of top of grain | 1 | 1 | 1 | 1 | 3 |
| 24. Ear: antho col of glumes of cob | 1 | 1 | 1 | 1 | 1 |
| 25. Kernel: row arrangement | 1 | 1 | 1 | 1 | 1 |
| 26. Kernel: poppiness | 1 | 1 | 1 | 1 | 1 |
| 27. Kernel: Sweetness | 1 | 1 | 1 | 1 | 9 |
| 28. Kernel: Waxiness | 1 | 1 | 1 | 1 | 1 |
| 29. Kernel: Opaqueness | 1 | 1 | 1 | 1 | 1 |
| 30. Kernel: Shape | 4 | 4 | 4 | 4 | 1 |
| 31. Kernel: 1000Kernel weight | 5 | * | 5 | 5 | 3 |



## Expression of characteristics in inbred lines

| Characteristics | BML 10 | BML 11 | BML 13 | BML 14 | BML 15 | BML 2 | BML 20 | BML 22 | BML 23 | BML 3 | BML 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Leaf: angle bet blade & stem | 3 | 3 | 7 | 7 | 3 | 3 | 7 | 3 | 3 | 7 | 7 |
| 2. Leaf: attitude of blade | 9 | 9 | 9 | 9 | 1 | 1 | 9 | 9 | 1 | 9 | 9 |
| 3. Stem: antho col of br root | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 1 | 9 |
| 4. Tasl: Time of anthesis | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 5. Tasl: antho col at base of glume | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6. Tasl: Anth col of glumes excluding base | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 9 | 9 | 1 | 1 |
| 7. Tasl: antho col of anthers | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8. Tasl: density of spikelets | 7 | 7 | 3 | 3 | 7 | 7 | 7 | 3 | 3 | 7 | 3 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9. | Tasl: angle betwn Main axis & lateral brnches | 3 | 3 | 7 | 7 | 3 | 3 | 3 | 7 | 7 | 3 | 7 |
| 10. | Tasl: attitude of lateral branches | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11. | Ear: time of silk emergence | 5 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 12. | Ear: antho col of silks | 1 | 1 | 1 | 1 | 9 | 9 | 1 | 1 | 1 | 1 | 1 |
| 13. | Leaf: Antho col of sheath | 1 | 9 | 1 | 1 | 1 | 9 | 1 | 9 | 9 | 1 | 9 |
| 14: | Tasl: Length of main axis above lowest side branch | 5 | 5 | 7 | 5 | 5 | 5 | 5 | 7 | 5 | 5 | 5 |
| 15. | Plant: length | 3 | 3 | 3 | 3 | 5 | 5 | 5 | 5 | 3 | 3 | 3 |
| 16. | Plant: ear placement | 5 | 7 | 5 | 3 | 7 | 3 | 3 | 7 | 5 | 3 | 7 |
| 17. | Leaf: width of blade | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 5 |
| 18. | Ear: length without husk | 5 | 5 | - | - | 5 | 5 | 5 | 5 | 5 | 5 | - |
| 19. | Ear: diameter without husk | 3 | 3 | - | - | 3 | 3 | 3 | 3 | 3 | 3 | - |
| 20. | Ear: shape | 2 | 2 | - | - | 1 | 1 | 2 | 1 | 1 | 1 | - |
| 21. | Ear: no. of rows of grain | 5 | 5 | - | - | 5 | - | 5 | - | 5 | 5 | - |
| 22. | Ear: type of grain | 2 | 1 | - | - | 1 | 1 | 1 | 1 | 1 | 2 | - |
| 23. | Ear: colour of top of grain | 3 | 3 | - | - | 3 | 3 | 3 | 3 | 3 | 3 | - |
| 24. | Ear: antho col of glumes of cob | 2 | 1 | - | - | 1 | 1 | 1 | 1 | 3 | 1 | - |
| 25. | Kernel: row arrangement | 3 | 1 | - | - | 3 | 1 | 3 | 3 | 1 | 3 | - |
| 26. | Kernel: poppiness | 1 | 1 | - | - | 1 | 1 | 1 | 1 | 1 | 1 | - |
| 27. | Kernel: Sweetness | 1 | 1 | - | - | 1 | 1 | 1 | 1 | 1 | 1 | - |
| 28. | Kernel: Waxiness | 1 | 1 | - | - | 1 | 1 | 1 | 1 | 1 | 1 | - |
| 29. | Kernel: Opaqueness | 1 | 1 | - | - | 1 | 1 | 1 | 1 | 1 | 1 | - |
| 30. | Kernel: Shape | 2 | 2 | - | - | 2 | 2 | 2 | 2 | 4 | 2 | - |
| 31. | Kernel: 1000Kernel weight | 3 | 3 | - | - | 5 | 5 | 3 | 3 | 5 | 3 | - |

## Annexure Contd...

| Characteristics | BML 6 | BML 7 | BML 8 | CM 104 | CM 105 | CM 114 | CM 115 | CM 118 | CM 119 | CM 120 | CM 121 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Leaf: angle bet blade & stem | 3 | 3 | 3 | 7 | 7 | 3 | 3 | 7 | 7 | 3 | 3 |
| 2. Leaf: attitude of blade | 9 | 9 | 1 | 9 | 9 | 1 | 9 | 9 | 9 | 9 | 9 |
| 3. Stem: antho col of br root | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 1 | 9 | 9 | 9 |
| 4. Tasl: Time of anthesis | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 5. Tasl: antho col at base of glume | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6. Tasl: Anth col of glumes excluding base | 1 | 1 | 9 | 9 | 1 | 1 | 1 | 1 | 1 | 9 | 9 |
| 7. Tasl: antho col of anthers | 1 | 1 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 |
| 8. Tasl: density of spikelets | 3 | 3 | 3 | 7 | 3 | 3 | 7 | 7 | 3 | 3 | 3 |
| 9. Tasl: angle betwn Main axis & lateral brnches | 7 | 3 | 7 | 3 | 7 | 7 | 3 | 3 | 7 | 7 | 7 |
| 10. Tasl: attitude of lateral branches | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 |
| 11. Ear: time of silk emergence | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 12. Ear: antho col of silks | 1 | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 1 |
| 13. Leaf: Antho col of sheath | 9 | 1 | 1 | 9 | 1 | 1 | 9 | 1 | 9 | 9 | 1 |
| 14: Tasl: Length of main axis above lowest side branch | 5 | 5 | 7 | 7 | 5 | 5 | 5 | 5 | 5 | 7 | 5 |
| 15. Plant: length | 3 | 5 | 5 | 3 | 3 | 3 | 3 | 3 |  | 3 | 3 |
| 16. Plant: ear placement | 7 | 7 | 3 | 7 | 7 | 3 | 7 | 7 | 3 | 3 | 3 |
| 17. Leaf: width of blade | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 18. Ear: length without husk | - | - | - | - | - | - | - | - | 5 | - | - |
| 19. Ear: diameter without husk | - | - | - | - | - | - | - | - | 3 | - | - |
| 20. Ear: shape | - | - | - | - | - | - | - | - | 1 | - | - |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21. Ear: no. of rows of grain | - | - | - | - | - | - | - | - | 7 | - | - |
| 22. Ear: type of grain | - | - | - | - | - | - | - | - | 1 | - | - |
| 23. Ear: colour of top of grain | - | - | - | - | - | - | - | - | 3 | - | - |
| 24. Ear: antho col of glumes of cob | - | - | - | - | - | - | - | - | 3 | - | - |
| 25. Kernel: row arrangement | - | - | - | - | - | - | - | - | 3 | - | - |
| 26. Kernel: poppiness | - | - | - | - | - | - | - | - | 1 | - | - |
| 27. Kernel: Sweetness | - | - | - | - | - | - | - | - | 1 | - | - |
| 28. Kernel: Waxiness | - | - | - | - | - | - | - | - | 1 | - | - |
| 29. Kernel: Opaqueness | - | - | - | - | - | - | - | - | 1 | - | - |
| 30. Kernel: Shape | - | - | - | - | - | - | - | - | 2 | - | - |
| 31. Kernel: 1000Kernel weight | - | - | - | - | - | - | - | - | 3 | - | - |



**Annexure Contd...**

| Characteristic | CM 128 | CM 129 | CM 153 | CM 130 | CM 131 | CM 132 | CM 133 | CM 139 | CM 140 | CM 143 | CM 145 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Leaf: angle bet blade & stem | 3 | 7 | 7 | 3 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 2. Leaf: attitude of blade | 9 | 9 | 9 | 9 | 9 | 1 | 9 | 9 | 9 | 9 | 9 |
| 3. Stem: antho col of br root | 9 | 9 | 1 | 1 | 9 | 9 | 9 | 1 | 9 | 9 | 9 |
| 4. Tasl: Time of anthesis | 5 | 7 | 3 | 7 | 7 | 7 | 7 | 5 | 5 | 7 | 7 |
| 5. Tasl: antho col at base of glume | 1 | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| 6. Tasl: Anth col of glumes excluding base | 1 | 9 | 9 | 1 | 9 | 1 | 9 | 9 | 1 | 1 | 9 |
| 7. Tasl: antho col of anthers | 1 | 9 | 9 | 1 | 9 | 1 | 9 | 9 | 1 | 1 | 9 |
| 8. Tasl: density of spikelets | 7 | 7 | 3 | 7 | 3 | 7 | 3 | 7 | 7 | 3 | 7 |

**Annexure Contd...**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9. | Tasl: angle betwn Main axis & lateral brnches | 3 | 3 | 7 | 3 | 7 | 3 | 7 | 3 | 3 | 7 | 3 |
| 10. | Tasl: attitude of lateral branches | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11. | Ear: time of silk emergence | 5 | 5 | 3 | 5 | 7 | 7 | 7 | 5 | 7 | 7 | 5 |
| 12. | Ear: antho col of silks | 9 | 9 | 9 | 1 | 1 | 1 | 1 | 1 | 9 | 1 | 9 |
| 13. | Leaf: Antho col of sheath | 9 | 9 | 9 | 1 | 1 | 1 | 9 | 1 | 1 | 1 | 9 |
| 14: | Tasl: Length of main axis above lowest side branch | 7 | 5 | 7 | 7 | 5 | 5 | 7 | 7 | 7 | 5 | 5 |
| 15. | Plant: length | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 5 | 3 | 3 | 3 |
| 16. | Plant: ear placement | 7 | 3 | 3 | 3 | 7 | 7 | 7 | 3 | 7 | 7 | 3 |
| 17. | Leaf: width of blade | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 3 |
| 18. | Ear: length without husk | 3 | - | 5 | 3 | 5 | - | 5 | 5 | 5 | 3 | 5 |
| 19. | Ear: diameter without husk | 3 | - | 3 | 3 | 3 | - | 3 | 3 | 3 | 3 | 3 |
| 20. | Ear: shape | 1 | - | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 |
| 21. | Ear: no. of rows of grain | 5 | - | 7 | 5 | * | - | 5 | 5 | 5 | 5 | 5 |
| 22. | Ear: type of grain | 1 | - | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 |
| 23. | Ear: colour of top of grain | 3 | - | 3 | 3 | 3 | - | 3 | 3 | 3 | 3 | 3 |
| 24. | Ear: antho col of glumes of cob | 1 | - | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 |
| 25. | Kernel: row arrangement | 3 | - | 1 | 1 | 3 | - | 3 | 1 | 2 | 1 | 1 |
| 26. | Kernel: poppiness | 1 | - | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 |
| 27. | Kernel: Sweetness | 1 | - | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 |
| 28. | Kernel: Waxiness | 1 | - | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 |
| 29. | Kernel: Opaqueness | 1 | - | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 |
| 30. | Kernel: Shape | 2 | - | 2 | 2 | 2 | - | 2 | 2 | 2 | 2 | 4 |
| 31. | Kernel: 1000Kernel weight | 3 | - | 3 | 3 | 3 | - | 3 | 3 | 3 | 3 | 3 |

## Annexure Contd...

| Characteristics | CM 150 | CM 151 | CM 152 | CM 201 | CM 202 | CM 206 | CM 208 | CM 209 | CM 210 | CM 211 | CM 212 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Leaf: angle bet blade & stem | 3 | 7 | 7 | 3 | 3 | 3 | 7 | 7 | 7 | 3 | 3 |
| 2. Leaf: attitude of blade | 9 | 9 | 9 | 9 | 1 | 9 | 9 | 9 | 9 | 9 | 9 |
| 3. Stem: antho col of br root | 9 | 1 | 9 | 9 | 9 | 1 | 9 | 9 | 9 | 9 | 1 |
| 4. Tasl: Time of anthesis | 5 | 7 | 3 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 5 |
| 5. Tasl: antho col at base of glume | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 1 | 9 | 1 |
| 6. Tasl: Anth col of glumes excluding base | 9 | 1 | 1 | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 9 |
| 7. Tasl: antho col of anthers | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 9 | 1 | 9 |
| 8. Tasl: density of spikelets | 3 | 3 | 3 | 3 | 3 | 3 | 7 | 3 | 3 | 7 | 3 |
| 9. Tasl: angle betwn Main axis & lateral brnches | 7 | 7 | 7 | 7 | 7 | 3 | 3 | 7 | 7 | 3 | 7 |
| 10. Tasl: attitude of lateral branches | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 1 | 1 | 1 |
| 11. Ear: time of silk emergence | 3 | 5 | 3 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 5 |
| 12. Ear: antho col of silks | 1 | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 13. Leaf: Antho col of sheath | 9 | 1 | 9 | 1 | 1 | 9 | 1 | 9 | 9 | 9 | 9 |
| 14: Tasl: Length of main axis above lowest side branch | 7 | 7 | 7 | 7 | 7 | 5 | 7 | 5 | 5 | 7 | 5 |
| 15. Plant: length | 5 | 7 | 3 | 5 | 3 | 3 | 3 | 3 | 3 | 5 | 3 |
| 16. Plant: ear placement | 7 | 7 | 3 | 3 | 7 | 7 | 7 | 7 | 3 | 7 | 3 |
| 17. Leaf: width of blade | 3 | 5 | * | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 18. Ear: length without husk | 5 | 7 | 5 | 5 | 7 | - | - | 5 | - | * | - |
| 19. Ear: diameter without husk | 3 | 3 | 3 | 3 | 3 | - | - | 3 | - | 3 | - |
| 20. Ear: shape | 1 | 1 | 1 | 2 | 2 | - | - | 2 | - | 1 | - |

## Annexure Contd...

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21. | Ear: no. of rows of grain | 7 | 7 | 5 | 5 | 7 | - | - | 5 | - | 5 | - |
| 22. | Ear: type of grain | 2 | 1 | 1 | 3 | 2 | - | - | 2 | - | 1 | - |
| 23. | Ear: colour of top of grain | 3 | 3 | 3 | 4 | 3 | - | - | 3 | - | 4 | - |
| 24. | Ear: antho col of glumes of cob | 1 | 1 | 1 | 2 | 1 | - | - | 1 | - | 1 | - |
| 25. | Kernel: row arrangement | 1 | 1 | 1 | 3 | 1 | - | - | 3 | - | | - |
| 26. | Kernel: poppiness | 1 | 1 | 1 | 1 | 1 | - | - | 1 | - | 1 | - |
| 27. | Kernel: Sweetness | 1 | 1 | 1 | 1 | 1 | - | - | 1 | - | 1 | - |
| 28. | Kernel: Waxiness | 1 | 1 | 1 | 1 | 1 | - | - | 1 | - | 1 | - |
| 29. | Kernel: Opaqueness | 1 | 1 | 1 | 1 | 1 | - | - | 1 | - | 1 | - |
| 30. | Kernel: Shape | 2 | 4 | 2 | 3 | 2 | - | - | 2 | - | 2 | - |
| 31. | Kernel: 1000Kernel weight | 3 | 5 | 3 | 3 | 3 | - | - | 5 | - | 3 | - |



## Annexure Contd...

| Characteristics | CM 502 | CM 135 | EI 116 | EI 364 | LM 5 | LM 6 | LM 9 | LM 10 | LM 11 | LM 12 | LM 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Leaf: angle bet blade & stem | 7 | 7 | 7 | 7 | 3 | 3 | 3 | 7 | 3 | 3 | 3 |
| 2. Leaf: attitude of blade | 9 | 9 | 9 | 9 | 9 | 1 | 9 | 9 | 1 | 9 | 1 |
| 3. Stem: antho col of br root | 9 | 9 | 9 | 9 | 9 | 9 | 1 | 1 | 9 | 9 | 9 |
| 4. Tasl: Time of anthesis | 3 | 3 | 5 | 5 | | 7 | 5 | 7 | 7 | 7 | 7 |
| 5. Tasl: antho col at base of glume | 1 | 9 | 1 | 1 | 1 | 9 | 1 | 1 | 1 | 9 | 1 |
| 6. Tasl: Anth col of glumes excluding base | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 1 | 1 |
| 7. Tasl: antho col of anthers | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| 8. Tasl: density of spikelets | 3 | 3 | 3 | 3 | 3 | 3 | 7 | 7 | 3 | 7 | 7 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9. | Tasl: angle betwn Main axis & lateral brnches | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 3 | 3 | 3 | 3 |
| 10. | Tasl: attitude of lateral branches | 1 | 5 | 5 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11. | Ear: time of silk emergence | 1 | 5 | 5 | 5 | 5 | 7 | 7 | 7 | 7 | 5 | 7 |
| 12. | Ear: antho col of silks | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| 13. | Leaf: Antho col of sheath | 9 | 9 | 1 | 9 | 9 | 9 | 1 | 1 | 1 | 1 | 9 |
| 14: | Tasl: Length of main axis above lowest side branch | 7 | 7 | 7 | 7 | 7 | 7 | 5 | 7 | 7 | 5 | 5 |
| 15. | Plant: length | 3 | 7 | 5 | 5 | 5 | 7 | 5 | 5 | 5 | 3 | 5 |
| 16. | Plant: ear placement | 7 | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 3 | 7 | 7 |
| 17. | Leaf: width of blade | 3 | 5 | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 3 | 3 |
| 18. | Ear: length without husk | | | 5 | 5 | 7 | 5 | 5 | 5 | 5 | 5 | |
| 19. | Ear: diameter without husk | 3 | 3 | 3 | 3 | 5 | 3 | 3 | 3 | 3 | 3 | 3 |
| 20. | Ear: shape | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 |
| 21. | Ear: no. of rows of grain | 7 | 5 | 5 | 5 | 5 | 5 | 7 | 7 | 5 | 7 | 5 |
| 22. | Ear: type of grain | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 23. | Ear: colour of top of grain | 3 | 3 | 2 | 4 | 2 | 3 | 4 | 3 | 5 | 5 | 3 |
| 24. | Ear: antho col of glumes of cob | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 25. | Kernel: row arrangement | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 |
| 26. | Kernel: poppiness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 27. | Kernel: Sweetness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 28. | Kernel: Waxiness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 29. | Kernel: Opaqueness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 30. | Kernel: Shape | 4 | 2 | 3 | 4 | 4 | 2 | 2 | 2 | 2 | 2 | 4 |
| 31. | Kernel: 1000Kernel weight | 5 | 3 | 5 | 5 | 5 | 3 | 3 | 3 | 5 | 5 | 7 |

**Annexure Contd...**

| Characteristics | LM 14 | LM 15 | LM 16 | V 341 | V 351 | CML 142 | CML 150 | CML 161 | CML 163 | CML 176 | CML 186 | CML 169 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Leaf: angle bet blade & stem | 3 | 3 | 3 | 7 | 7 | 5 | 7 | 3 | 7 | 3 | 3 | 7 |
| 2. Leaf: attitude of blade | 9 | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 1 | 9 | 9 |
| 3. Stem: antho col of br root | 9 | 9 | 9 | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 4. Tasl: Time of anthesis | 7 | 5 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 5. Tasl: antho col at base of glume | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6. Tasl: Anth col of glumes excluding base | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 1 | 1 |
| 7. Tasl: antho col of anthers | 9 | 9 | 1 | 1 | 1 | 9 | 1 | 1 | 1 | 9 | 1 | 1 |
| 8. Tasl: density of spikelets | 3 | 7 | 7 | 3 | 3 | 3 | 7 | 3 | 3 | 3 | 7 | 7 |
| 9. Tasl: angle betwn Main axis & lateral brnches | 3 | 3 | 3 | 7 | 7 | 7 | 3 | 7 | 7 | * | 7 | * |
| 10. Tasl: attitude of lateral branches | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11. Ear: time of silk emergence | 7 | 5 | 7 | 5 | 7 | 7 | 7 |  | 7 | 7 | 7 | 7 |
| 12. Ear: antho col of silks | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 9 | 3 | 9 | 9 | 1 |
| 13. Leaf: Antho col of sheath | 9 | 9 | 1 | 1 | 1 | 9 | 9 | 9 | 1 | 1 | 1 | 1 |
| 14: Tasl: Length of main axis above lowest side branch | 7 | 5 | 5 | 7 | 7 | 7 | 5 | 7 | 5 | 5 | 7 | 5 |
| 15. Plant: length | 5 | 5 | 3 | 3 | 3 | 7 | 3 | 3 | 3 | 5 | 5 | 3 |
| 16. Plant: ear placement | 7 | 3 | 3 | 3 | 3 | 7 | 3 | 3 | * | 3 | 3 | * |
| 17. Leaf: width of blade | 5 | 3 | 3 | 3 | 3 | 3 | 3 | 5 | * | 3 | 3 | 3 |
| 18. Ear: length without husk | 5 | 5 | 5 | 5 | - | 7 | - | 5 | - | 5 | - | - |
| 19. Ear: diameter without husk | 3 | 3 | 3 | 3 | - | 3 | - | 3 | - | 3 | - | - |
| 20. Ear: shape | 1 | 1 | 1 | 1 | - | 1 | - | 1 | - | 1 | - | - |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21. Ear: no. of rows of grain | 5 | 5 | 5 | 5 | - | 5 | - | 5 | - | 5 | - | - |
| 22. Ear: type of grain | 1 | 1 | 1 | 1 | - | 1 | - | 1 | - | 1 | - | - |
| 23. Ear: colour of top of grain | 3 | 3 | 3 | * | - | 1 | - | 3 | - | 1 | - | - |
| 24. Ear: antho col of glumes of cob | 1 | 1 | 1 | 1 | - | 1 | - | 1 | - | 1 | - | - |
| 25. Kernel: row arrangement | 3 | 1 | 1 | 3 | - | 1 | - | 1 | - | 1 | - | - |
| 26. Kernel: poppiness | 1 | 1 | 1 | 1 | - | 1 | - | 1 | - | 1 | - | - |
| 27. Kernel: Sweetness | 1 | 1 | 1 | 1 | - | 1 | - | 1 | - | 1 | - | - |
| 28. Kernel: Waxiness | 1 | 1 | 1 | 1 | - | 1 | - | 1 | - | 1 | - | - |
| 29. Kernel: Opaqueness | 1 | 1 | 1 | 1 | - | 1 | - | 1 | - | 1 | - | - |
| 30. Kernel: Shape | 2 | 2 | 2 | 2 | - | 2 | - | 4 | - | 2 | - | - |
| 31. Kernel: 1000Kernel weight | 5 | 5 | 3 | 3 | - | 3 | - | 3 | - | 3 | - | - |

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