

PROGRESS REPORT 2019-20

ALL INDIA COORDINATED RESEARCH PROJECT ON MAIZE



DIRECTOR'S REPORT
ICAR-INDIAN INSTITUTE OF MAIZE RESEARCH
PAU CAMPUS, LUDHIANA 141004

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Introduction

Maize (*Zea mays* L.) is the third most important cereal crop after rice and wheat. It is cultivated in tropics, subtropics to temperate climate and has several types like field corn, sweet corn, popcorn and baby corn. Within field corn, it has several other types like quality protein maize (QPM), waxy maize, high-oil maize etc. Maize is used as the raw material for several food, feed and non-food-based industries including as a source of bio-fuel. The consumption pattern of maize (feed-64%, food-16%, industry-19%, and seed and other miscellaneous 1%) in India largely matches with the global pattern (feed-61%, food-17% and industry-22%). It has attained a position of industrial crop globally as 83% of its production in the world and 76% in India is used in feed, starch and bio fuel industries. Further, it is an important industrial raw material where more than 3000 products are being made using maize directly or indirectly providing wide opportunity for value addition.

Currently, 1147.62 million MT of maize is being produced together by over 169 countries from an area of 193.73 million ha with an average productivity of 5.92 t/ha (FAO, 2017). In India, the total maize produced during 1950-51 was around 1.73 million MT, which has increased to 27.23 million MT by 2018-19 which is close to 16 times higher. The average productivity during the period has increased by 5.4 times to 2965 kg/ha from 547 kg/ha, while area increased by 3 times. During 2018-19, based on the calculated value, the maize area has reached to 9.18 million ha.

All India Coordinated Research Project on Maize (AICRP-Maize), the first co-ordinated agricultural research programme in India, has completed six decades of its service to the nation in 2017. Since its inception, the maize community continues to generate technologies for sustained maize production in the country as witnessed by the boom in maize production in recent years. Even though maize area, production and productivity have increased continuously since 1950s, the substantial increase was recorded in the last decade mainly due to adoption of hybrid technology. The increase maize production has become a driving force for maize based industrial growth like livestock, poultry feed, beverages/alcohol, starch etc.

The merit of AICRP-Maize lies with their ability to address the requirement of maize for the entire nation through various centres distributed across the country. The entire maize growing area in India has been divided in five major zones, viz., northern hill zone (NHZ), north western plain zone (NWPZ), north eastern plain zone (NEPZ), peninsular zone (PZ) and central western zone (CWZ) for effective evaluation of the maize breeding materials and experimental cultivars. Total of 58 locations (32 regulars and 26 volunteer) were identified for evaluation of seventeen different breeding trials.

Major Accomplishments

MAIZE BREEDING

During *Kharif* 2019, 290 maize entries were evaluated in all India coordinated trials. Of 290 entries, 162 entries were evaluated in national initial varietal trial (NIVT), 46 in advance varietal trial-I (AVT-I), 21 in advance varietal trial-II (AVT-II), 16 entries in quality protein maize (QPM), and 27 in specialty corns trials (13 in baby corn, 11 in sweet corn, and 3 in popcorn), 10 in rainfed trials (late-2, Medium-4, and early-4) and 8 in OPV trial. Of total entries received, 193 were contributed from public and 97 by the private sector. Thirty-six breeding trials, including separate trials for NHZ were constituted in *Kharif* 2019. These comprised of NIVT (6), AVT (15), QPM (2) and specialty corns (5), rainfed (6) one each of OPV, quality trial were constituted for evaluation at 58 locations (32 regular and 26 volunteer) across country. Data received from was reviewed and analysed critically for yield and related traits. The performance of each variety was compared with 27 relevant checks varieties of different types and maturity. The test entries were promoted from first year (NIVT) to second year (AVT-I) and second year to third year on the bases of criteria given below:

- i) Promotion criteria (Yield): Entries must be numerically superior over the best check and should have non-significant differences in yield from the best entry (rank 1st) of the trial at CD ($P=0.05$)
- ii) In early and medium trials, besides yield, the test entry should not exceed the relevant best check by 2.0 days in
- iii) The disease reaction of test entries to the diseases of zonal/regional importance was considered while promotion
- iv) In specialty corn, besides yield, the quality parameters were also considered while promotion e.g. (QPM: % Trp ≥ 0.6 ; SC: TSS $\geq 15\%$; PC: Popping % age $\geq 80\%$), (Note: all quality parameters were analyze in self (TSS, Popping %) and chain crossed (Lys, Trp) kernels

- v) In QPM, all entries were compared with the best check except for NHZ (Zone1) where the test entries found to be early based on criteria was compared with VIVEK QPM 9.

If CV value found more than 20% for a trial at any of location of NWPZ, NEPZ, PZ and more than 30% for location of NHZ and CWZ, then the data of those trials were rejected from the final analysis. Similarly, if trial mean is falling below state average yield of the year then the same location has been rejected from the analysis.

The different breeding trials were organized at 10 test locations in NHZ, 9 in NWPZ, 9 in NEPZ, 18 in PZ and 12 test locations in CWZ. All entries were tested under three maturity group viz., late, medium, and early (extra early clubbed with early). The success rate of NHZ for reporting of trials is low. The details of success rate in reporting the data from each zone is given in Table 1 below:

Table 1 : Details of Zone wise trials allotted and conducted during Rabi 2018-19.

Zone(s)	Centers	Trials allotted	Trials reported	Percent Success
NHZ	Srinagar, Almora, Bajaura, Barapani, Kangra, Gossaingaon, Imphal, Poonch, Rajouri, Dhaulakuam,	62	57	92.0
NWPZ	Ludhiana, Karnal, Delhi, Pantnagar, Aligarh, Kapurthala, Gurdaspur, Jhansi, Banda	57	54	95.0
NEPZ	Dholi, Ranchi, Bhubaneswar, Varanasi, Bahraich, Sabour, Kalyani, Koraput, Medinapur,	74	71	96.0
PZ	Arabhavi, Buldana, Mandya, Karimnagar, Hyderabad, Coimbatore, Vagarai, Kolhapur, Peddapuram, Dharwad, VRDCKSSC, Shimoga, Devihosur, Dhule, Parbhani, Nasik, Rahuri, Raichur	103	94	91.0
CWZ (12)	Udaipur, Banswara, Chindwara, Ambikapur, Godhra, Bhiloda, Dahod, Jagadapur, Ujjain, , Kota, Chitrakoot, Indore	77	69	90.0
Overall		373	345	93.0

In Early maturity trial, a total of 40 new test entries were received for NIVT trial in which 24 entries were received for being tested in NHZ and 28 entries (12 common entry of NHZ) were tested in rest of the four zones. Out of 24 entries tested in NHZ, two entries have been promoted to AVT I while out of 28 entries tested in rest of the zones, two entries in zone II, three entries in zone III & one entry in zone five have been promoted to AVT I. DKC 7204 has been promoted in both zone II & III. In AVT early trial, a total of 10 entries were received out of which, only one entry KMH 17-89 has been promoted to AVT II.

In medium maturity, a total of 80 test entries were received for being tested in NIVT. Eighteen entries were for NHZ & 78 entries (16 common of NHZ entries) for rest of the four zones. Out of the eighteen entries tested in NHZ, five entries have been promoted for AVT I. For rest of the four zones, NIVT medium trial was conducted in two sets of 39 test entries each due to large number of entries. Out of the 78 entries, nine entries in zone II, 15 entries in zone III, 14 entries in zone IV & five entries in zone V have been promoted for AVT I. In AVT I trial, a total of 27 entries were received for testing, out of which, two entries in zone I, three entries in zone II, three entries in zone IV & one entry in zone five have been promoted for AVT II.

In late maturity trial, fifty-five new test entries were tested in NIVT in four zones except NHZ. Out of 55 entries, seven entries in zone II, eight entries in zone III, seven entries in zone IV & five entries in zone V have been promoted to AVT I. Under AVT late trial, a total of 15 entries were tested, in which four entries got promoted for AVT II in zone II, one entry PM 18106L got promoted in both zone IV & V for AVT II trial.

Quality Protein Maize (QPM I-II-III)

There were two quality trials namely QPM I-II-III (Trial no 586 for NHZ) and QPM I-II-III (Trial no 688 for NWPZ, NEPZ, PZ and WZ) were conducted during Kharif, 2019. The data was recorded for grain yield, plant height, ear height, 50 % anthesis, 50% silking , no of cobs, plant stand, 75 % dry husk, moisture and shelling percentage. The percent superiority over the check entries was also calculated for each entry. The details of each of the trial are given below:

Trial no 586 (QPM-I-II-III) for NHZ

In this trial 8 QPM and two Pro-vit A entries were evaluated against four QPM checks (HQPM 1, HQPM 5, HQPM 7 and Vivek QPM 9) and Pro-Vit. A check (APQH 9) at six locations namely Srinagar, Bajaura, Almora, Barapani, Gossaingaon and Imphal. The average grain yield of QPM entries ranged from 5904 kg/ha to 8432 kg/ha. FQH 160 was observed as the best performing entry with grain yield of 8432 kg/ha whereas SQPMH 2 gave least yield of 5904 kg/ha. Both Pro-Vit. A entries performed better than the check APQH 9. In this zone Vivek QPM 9 was the best check, therefore for promotion the entries found superior over Vivek QPM 9 were considered for promotion.

Trial no 688 (QPM-I-II-III) for NWPZ, NEPZ, PZ and WZ

Trial no 688 was conducted in NWPZ, NEPZ, PZ and CZ. In this trial 11 QPM entries were tested against five checks (HQPM 1, HQPM 5, HQPM 7, Partap QPM 1 and Vivek QPM 9). Out of 11 test entries three entries namely IIMRQPMH 1705, IIMRQPMH 1708 and VEHQ 16-1 wherein AVT II, four entries namely IQPMH 18-2, IQPMH 18-4, QPMMH 51 and FQH 148 were in AVT I and four entries namely IQPMH-19-1, IQPMH-19-2, IQPMH-19-3 and IQPMH-19-4 were in NIVT. Among Pro-Vit. A five entries namely APH1, APH 2, APH 3, APHQ 1 and APHQ 8 were tested against APQH 9. In NWPZ the trial was conducted at IARI New Delhi, Karnal, Ludhiana and Pantnagar. IIMRQPMH 1705 was observed as the best entry with grain yield of 7895 kg/ha. Among Pro-Vit. A five entries were tested against check APHQ 9. APHQ 1 was observed as the best performing entry with grain yield of 7257 kg/ha and APQH 9 was the least performing entry with a grain yield of 6522 kg/ha. HQPM 5 was the best performing QPM check, therefore, the entries found superior than HQPM 5 were considered for promotion in this zone. In Zone the entry VEHQ 16-1 was adjudged as best entry with grain yield of 6702 kg/ha. Among Pro-vit. A group APH 3 was observed as best performing entry with grain yield of 6651 kg/ha. The grain yield of QPM entries in peninsular zone ranged from 6823 kg/ha to 8790 kg/ha. HQPM 7 was adjudged as the best performing entry with grain yield of 8790 kg/ha. Among Pro-vit. A entries the grain yield ranged from 6765 kg/ha to 8577 kg/ha. APQH 1 was observed as best performing entry with 8577 kg/ha and APQH 9 was the least yielding entry with grain yield of 6765 kg/ha. In QPM group HQPM 7 was the best performing check and ranked no 1 in the trial, hence no QPM entry was promoted in this zone. The grain yield of QPM entries in CWZ ranged from 4557 kg/ha to 6929 kg/ha. IIMRQPMH 1708 was adjudged the best performing QPM entry with grain yield of 6929 kg/ha whereas, Among Pro-vit. A, APH 3 was observed as best performing entry with grain yield of 6372 kg/ha.

The specialty corn trial comprises of three types of trials namely baby corn, sweet corn and popcorn. During Kharif-2019 five trials were conducted two each of baby corn and sweet corn and one of popcorn. The baby corn (BC), sweet corn (SC) and popcorn (PC) trials were conducted at 30, 27 and 7 locations respectively. The numbers of entries evaluated in BC, SC and PC trials were 18, 16 and 3 entries respectively.

Baby corn

The number of entries in NIVT, AVT-I and AVT-II in baby corn trial were 10 (3 entries in NHZ, 7 entries in rest of the zones), three (all zones except NHZ), and five (two entries in NHZ and three entries in rest of the zone) entries respectively. Out of 10 NIVT entries one entry, LBCH-119 (1894 Kg/ha) in NHZ was found superior over the best check (CMVLBC-2 with 1893 Kg/ha), whereas two entries namely ABHS4-1 (2070 Kg/ha) and ABHS4-2 (2010 Kg/ha), Essentially Derived Hybrids/Varieties (EDH/Vs), a male sterile version of HM-4 (2081 Kg/ha) showed comparable performance with initial variety. Out of three entries under AVT-I, one test entry, AH-7204 (2196 Kg/ha) was found superior performance over the best check in NEPZ. In rest of the zones all the entries would be re-tested as number of locations for which the zonal mean calculated was less than the optimum number three.

Sweet Corn

The number of sweet corn entries in NIVT, AVT-I and AVT-II were 11 (four in NHZ, seven in rest of the zone), two (rest of the zones except NHZ) and three (one in NHZ and two in rest of the zones). Out of four entries in NHZ, two entries namely FSCH-128 (15018 Kg/ha) of NIVT and Nuzi-205 (14724 Kg/ha) of AVT-II have shown superiority over the best check (Misthi with 14594 Kg/ha) by 3.22 and 7.99 per cent respectively. Whereas in rest of the zones out of seven NIVT entries three entries namely CP Sweet-2 (11289 Kg/ha and 14794 Kg/ha), CPSC-301 (11545 Kg/ha and 14245 Kg/ha) in NWPZ and NEPZ and ISCH-1901 (10756 Kg/ha) in NWPZ were found superior over best check in NWPZ (Misthi with 9776 Kg/ha), NEPZ (CMVLSC-1 with 12165 Kg/ha). Similarly AVT-I entries namely Super Sweet in NWPZ (11453 Kg/ha), NEPZ (15740 Kg/ha) and CWZ (9206 Kg/ha) and Top Sweet in NWPZ (11181 Kg/ha) and NEPZ (15873 Kg/ha) have shown yield superiority over the best check in their respective zone. Two AVT-II entries namely NUZI-205 and NUZI-260

have shown superiority over best check in all the four zones namely NWPZ (12073 Kg/ha and 11463 Kg/ha), NEPZ (14849 Kg/ha and 16250 Kg/ha), PZ (15293 Kg/ha and 15351 Kg/ha) and CWZ (9787 Kg/ha and 10039 Kg/ha) respectively.

Popcorn

The trial comprised of three entries of NIVT namely APCH-3, LPCH-119 and LPCH-219 along with two check entries namely Shalimar Popcorn KDPC-2, and VL Amber Popcorn (VLAPC). The entry LPCH-219 was found superior with respect to popping percentage (82), popping volume (24) along with higher yield (5122 Kg/ha) over the best check Shalimar Popcorn/ KDPC-2 (73, 11 and 4468 Kg/ha).

RABI 2018-19

During Rabi 2018-19, total 94 entries were received for multi-location evaluation in AICRP late, medium maturity and popcorn trials. Of 94 test entries, total 58 entries were tested in NIVT, 11 in AVT-I, 19 in AVT-II and 6 in popcorn trials. Further in NIVT, out of total 58, the 20 entries were tested in late and 38 in medium maturity. Among 11 entries of AVT-I, 6 were tested in late and 5 in medium maturity. In AVT-II, out of 19 entries, 18 were tested in late and only one in medium maturity. The six entries were received in popcorn which were used to constitute a common trial for it. Total six different trials were constituted and put for evaluation at 20 testing locations across the four zones. However, popcorn trials were evaluated only at NWPZ and CWZ. The details of the trial along with entries and locations is given in Table 2 below:

Table 2 : Details of breeding trial conducted during Rabi 2018-19.

Sl. No.	Trial Name	No. of Entries	No. of locations	Success percent
1	NIVT (Late)	23	20	100
2	NIVT (Medium)	42	20	100
3	Popcorn	8	20	100
4	AVT-I (Late)	9	23	100
5	AVT-II (Late)	22	23	100
6	AVT-I and AVT-II (Medium)	10	23	100

During Rabi 2018-19, all trials were successfully conducted and 100 % data was received. Out of 94 test entries, 32 were promoted for testing for next stage. The details of promotion in different trials is given in table 3 below:

Table 3 : Numbers of entries tested and promoted different breeding trials during rabi 2018-19

Sl. No.	Trials	Entries tested including checks	Entries promoted
1.	NIVT-Late Maturity	23	11
2.	NIVT-Medium Maturity	42	6
3.	AVT-I-Late Maturity	9	6
4.	AVT-II-Late Maturity	22	6
5.	AVT-I-II-Medium Maturity	10	3
6.	Popcorn I	8	6
Total		114	32

CROP PRODUCTION

The maize agronomy programme focused on development of agronomy of pre-release genotypes of various maize types, nutrient and tillage management in maize systems, ecological intensification for climate resilient maize system, sensor guided N management validation in maize, integrated nutrient management in maize system and weed management in maize system.

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

- **50 pre-release cultivars (12 in rabi and 38 in kharif) of different maturity groups and types under AVT-II were evaluated with 20 national checks in 60 experiments** under two planting densities (Normal and High) and two nutrient levels [N:P:K @ RDF (Recommended Dose of fertilizer) and 150% RDF]. The late maturing hybrids responded to both high planting density and high nutrient dose (250:80:100) at NWPZ during rabi season. Late maturity genotypes significantly responded to high density at NWPZ and NEPZ, while they responded positively to 150% RDF at NWPZ and CWZ.

- In the late maturity genotypes tested, the genotype CP-858, Bio-218 and KMH-463 and ADV-1390064 recorded significantly higher yield over best checks. Medium maturity genotypes, INDAM-1122, BLH-118 and RCRMH-2 gave significantly higher yield over best checks in various zones. Among the QPM and EDV genotypes tested, APQH-1(QPM+PRO-A) and EQH-16-1 gave higher yield over best checks. The sweet corn genotype NUZI-260 recorded significantly higher yield over best check. The tested babycorn genotypes, viz., PAC-321 and AH-521 significantly outperformed the best check. The OPV genotype, RCM-1-61 and RCM-1-76 recorded significantly higher yield over best check in NHZ.

Nutrient and tillage management in maize systems

- The experiments on tillage and nutrient management were conducted on eight different locations. Zero tillage (ZT) gave significantly higher grain yield and net returns over permanent bed (PB) at Pantnagar and was at par to conventional tillage (CT) in maize. PB gave significantly higher yield over CT at Dholi while ZT and PB gave significantly higher yield and net returns of maize system over CT at Udaipur. At Srinagar, tillage and nutrient management showed a significant interaction effect and ZT with RDF produced best results for yield and net returns from maize over other treatment combinations. At Banswara and Chhindwara, ZT followed by CT gave significantly higher net returns over CT in maize.
- For rice-maize cropping system, significantly higher grain yield was obtained in permanent beds for *rabi* maize at Dholi, however at Kalyani, significantly higher yield was obtained for CT over ZT. Amongst different nutrient management, GS based nutrient application resulted in significantly higher yield over RDF and FFP at Dholi, while at Kalyani, significantly higher yield was obtained with SSNM over RDF and FFP. *It shows location specific responses of maize systems to the various tillage and nutrient management practices in maize-wheat-mungbean cropping system.*

Long-term trial on integrated nutrient management in maize system

- The experiments were conducted at seven locations to explore the integrated nutrient management options for various maize systems in different locations representing four different agro-ecologies. Application of 100% RDF + 5 t/ha farmyard manure (FYM) gave significantly higher yield at five locations which shows importance of the organic manure in maize systems along with RDF. Significantly highest equivalent yield was obtained with 100% RDF + 5 t/ha FYM, which was at par with 75% RDF + 5 t/ha FYM and 100% RDF + 5 kg/ha Zinc at Pantnagar.

Ecological intensification for climate resilient maize based cropping systems

- The experiment was conducted at 18 locations all over country to know the effect of best management practices in maize under climate change scenario and conducted throughout the five zones. The treatment "ecological intensification(EI)" with best management practices gave significantly higher yield and net returns over farmers' practices at all locations, except at Karimnagar. The yield and net returns enhancement due to EI was very high in NHZ, NEPZ and CWZ compared to NWPZ and PZ. The maximum yield reduction and lowest net returns in maize due to omission of best nutrient management, planting density and weed management practices were recorded at four, three and eight locations, respectively. *Thus, the different ecological conditions responded positively to certain management practices, which can be targeted effectively to ensure more yield gains at farmer's field.*

Weed management in maize systems

- To design and develop effective pre- and post-emergence weed management practices in maize, experiments were conducted during *kharif* 2019 at 15 locations in all zones. *Overall, the weed infestation caused 48.8% losses in maize yield during kharif 2019.* However, the losses in maize grain yield varied at various locations [NHZ (45.4 to 56.3%), NWPZ (49.2 to 80.4%), NEPZ(29.2 to 45.3%), PZ(30.9 to 49.6%) and CWZ (46.8 to 51.3%)]. All the pre- and post-emergence weed management treatments gave significantly higher yield and net return with reduction of weed density over recommended Atrazine followed by hand weeding treatment. The best treatment for yield and net returns was Tembotrione (120 g/ha) + Atrazine (750 g/ha) at 15 days after sowing (DAS) at Karnal, Ludhiana and Peddapuram; Topramezone (25.2 g/ha) + Atrazine (750 g/ha) at 15 DAS at Bajaura, Imphal and Vagarai; Atrazine (1000 g/ha) followed by Tembotrione (120 g/ha) at 25 DAS at Chitrakoot; (Atrazine 1000 g/ha) fbTopramezone (25.2 g/ha) at 25 DAS at Srinagar, Pantnagar, Ranchi, Coimbatore and Ambikapur, and Atrazine (750 g/ha) fbTopramezone (25.2 g/ha) at 25 DAS at Dholi.

ENTOMOLOGY

During *Kharif* 2019, a total of 152 entries belonging to eleven AICRP trials of early, medium, late maturity group, QPM, baby corn, sweet corn and rain-fed entries were evaluated against *Chilo partellus* (Swinhoe) under artificial infestation. AICRP locations- Northern Hill Zone (NHZ) represented by Imphal, North West Plain Zone (NWPZ) represented by Karnal and Ludhiana, North East Plain Zone (NEPZ) by Dholi, Peninsular Zone (PZ) by Kolhapur, Coimbatore, Hyderabad and Central Western Zone (CWZ) represented by Udaipur.

The entries were evaluated by pinning 10-12 black-headed eggs of *C. partellus* laid on butter paper in the whorl of the plant. The plants were observed 35 days after infestation recording the leaf injury rating on 1-9 scale.

LIR	Plant Symptoms
1	Plants showing no infestation
2	1-2 leaves with pinholes
3	3-4 leaves with holes
4	1/3 leaves showing infestation
5	Half the number of the leaves with infestation
6	2/3 leaves with infestation symptoms and the holes becoming windows
7	Leaves with long window and plant growth is stunted
8	Almost all leaves displaying heavy infestation and plant growth is stunted
9	Dead heart formed

The resistant, moderately resistant and susceptible entries are defined by LIR 1-3, >3.1-6 and >6.1-9 respectively.

Different maturity groups: The following entries registered resistant reaction against *C. partellus*.

- *Early Maturity group:* Out of 12 entries of early maturity group screened under artificial infestation against *C. partellus*, none of the entries were found to be resistant and all the twelve entries were moderately resistant across the zones.
- *Medium Maturity group:* Out of 36 entries of medium maturity group screened under artificial infestation against *C. partellus*, none of the entries were found to be resistant and the entry PM 18107 M (6.08) was susceptible.
- *Late Maturity group:* Out of 31 entries of late maturity group screened under artificial infestation against *C. partellus*, none of the entries were resistant, thirty entries were moderately resistant and one entry JKMH 150375(6.04) was susceptible.
- *QPM:* Out of 23 QPM entries evaluated, none of the entries were found to be resistant and all the entries recorded LIR between 4.79 -5.74 across the zones.
- *Baby Corn:* Out of 15 baby corn entries evaluated, none of the entries were found to be resistant and all the fifteen entries were moderately resistant with LIR ranging from 4.07(DBCH 326) to 5.11 (AH 7043) respectively.
- *Sweet Corn:* Out of 15 sweet corn entries evaluated against *C. partellus*, none of the entries were found to be resistant and all the fifteen entries were moderately resistant with LIR ranging from 4.29(NUZI 260) to 5.64 in ISCH 1901 respectively.
- *Rainfed:* Out of 20 entries evaluated under rain-fed category of early (7), medium (8) and late(5) against *C. partellus* under artificial infestation all the entries were moderately resistant. The lowest LIR was observed in CMH 12 -686 (4.16) and the highest LIR was observed in OMH14-27(5.83).

ET2. Evaluation of maize AICRP entries against fall armyworm under natural infestation for during Kharif, 2019

- *Early Maturity group:* Out of 12 entries of early maturity group screened under artificial infestation against *C. partellus*, none of the entries were found to be resistant and all the twelve entries were moderately resistant across the zones.
- *Medium Maturity group:* Out of 36 entries of medium maturity group screened under artificial infestation against *C. partellus*, none of the entries were found to be resistant and the entry PM 18107 M (6.08) was susceptible.
- *Late Maturity group:* Out of 31 entries of late maturity group screened under artificial infestation against *C. partellus*, none of the entries were resistant, thirty entries were moderately resistant and one entry JKMH 150375(6.04) was susceptible.
- *QPM:* Out of 23 QPM entries evaluated, none of the entries were found to be resistant and all the entries recorded LIR between 4.79-5.74 across the zones.

- *Baby Corn*: Out of 15 baby corn entries evaluated, none of the entries were found to be resistant and all the fifteen entries were moderately resistant with LIR ranging from 4.07(DBCH 326) to 5.11 in (AH 7043) respectively.
- *Sweet Corn*: Out of 15 sweet corn entries evaluated against *C. partellus*, none of the entries were found to be resistant and all the fifteen entries were moderately resistant with LIR ranging from 4.29(NUZI 260) to 5.64 (ISCH 1901) respectively.
- *Rainfed*: Out of 20 entries evaluated under rain-fed category of early(7), medium(8) and late(5) against *C. partellus* under artificial infestation all the entries were moderately resistant. The lowest LIR was observed in CMH 12 -686 (4.16) and the highest LIR was observed in OMH14-27(5.83).

ET3. Evaluation of maize inbred lines against fall armyworm *Spodoptera frugiperda* under natural infestation during Kharif, 2019

A total of one hundred twelve accessions were evaluated against fall army worm during *kharif* 2019 at Imphal, Hyderabad and Coimbatore locations under natural infestation. The Davis score on 1-9 scale for whorl feeding injury ranged from 1.8 to 5.0 and eleven accessions recorded Davis score between 1.8 to 2.0. These lines need further evaluation under artificial infestation.

ET 4: Evaluation of inbred lines against spotted stem borer *Chilo partellus* (Swinhoe) under artificial infestation- during Kharif 2019

A total of one hundred fifteen accessions were evaluated against spotted stem borer during *kharif* 2019 at four locations Karnal, Ludhiana, Hyderabad and Udaipur locations under artificial infestation. Leaf injury rating ranged from 3.6 to 6.4; only seven accessions recorded LIR between 3.6 to 4.0; and fifty one accessions recorded LIR between 4.1 to 5.0. and nine accessions recorded LIR more than 6.0

ET 5. Monitoring of fall armyworm by pheromone traps during Kharif 2019 at different locations

Fall armyworm was monitored in 10 locations *viz.*, Ambikapur, Coimbatore, Delhi, Dholi, Hyderabad, Imphal, Kolhapur, Pantnagar, Rahuri and Udaipur using FAW pheromone traps at two places in each location. At Ambikapur, trap data was recorded from 27-2 SMW with peak moth catch during 2 SMW (0.73). At Coimbatore, trap data was recorded from 22-36 SMW with peak moth catch during 31 SMW (4.04). At Delhi, trap data was recorded from 26-52 SMW with peak moth catch during 44 SMW (23.12). At Dholi, trap data was recorded from 32-46 SMW with peak moth catch during 38 SMW (1.07).

At Hyderabad, trap data was recorded from 30-45 SMW with peak moth catch during 41 SMW (4.63). At Imphal trap data was recorded from 31-41 SMW with peak moth catch during 38 SMW (0.38). At Kolhapur trap data was recorded from 30-46 SMW with peak moth catch during 40 (0.61). At Pantnagar trap data was recorded from 31-52 SMW with peak moth catch during 36 SMW (18.13). At Rahuri trap data was recorded from 31-52 SMW with peak moth catch during 49 SMW (2.14). At Udaipur, trap data was recorded from 32-39 SMW with peak moth catch during 36 SMW (3.5).

ET 6. Monitoring of corn ear borer, *Helicoverpa armigera* (Hubner) by pheromone traps at different AICRP locations during spring and Kharif 2019

To monitor *H. armigera* in *Kharif* maize, pheromone traps were installed at two locations each at Karnal and Delhi on 8th and 27th August, 2019 respectively. Trap data was recorded from 33 - 41 SMW at Karnal and 36 - 44 SMW at Delhi. At Karnal, moths were trapped from 36- 39 SMW with peak trap catch during 38 SMW (3.13 moths/trap/location). At Delhi, moths were trapped from 37 - 44 SMW with peak activity during 41 SMW (10 moths/trap/location). At Ludhiana, *H. armigera* pheromone traps were installed on 15th March 2019 in spring maize and trap data was recorded from 12 - 24 SMW. Moths were trapped in every week starting from 12 till 24 SMW with the peak trap catch during 18 SMW (19.29 moths/trap/location). However, in *kharif*-sown crop no *H. armigera* moths were found in the traps at this location.

ET 7 Evaluation of insecticides as seed treatment against fall armyworm (FAW) (1st year) during Kharif 2019

Field experiments were conducted at Hyderabad (WNC), Godhra and Rahurito to evaluate effect of the seed treatment insecticides at varying doses under natural infestation for the management of fall armyworm during *Kharif* 2019. The experiment was completely randomized with three replicates of twelve treatments including untreated control. At Hyderabad centre, lowest per cent plant infestation of 29.44 to 42.78 and 38.33 to 52.22 was observed in Cyantraniliprole 19.8% + Thiamethoxam 19.8% at 7 and 14 DAG, respectively compared to untreated control (65.56 to 87.22). In terms of whorl feeding injury as per Davis scale, all the treatments showed whorl injury rating <5.0 upto 14 DAG and thereafter, the leaf damage increased. Maximum grain yield was obtained in seed treated with Cyantraniliprole 19.8% + Thiamethoxam 19.8% @ 6ml/kg seed (74.00 q/ha)

compared to untreated control (49.80 q/ha). It can be concluded that seed treatment is a viable alternative for controlling fall armyworm in maize up to 14 DAG.

At Godhra centre, lowest per cent plant infestation of 0.00 and 28.33 to 43.33 was observed in Cyantraniliprole 19.8% + Thiamethoxam 19.8% at 7 and 14 DAG, respectively compared to untreated control (61.67 to 100). Among all the treatments, whorl feeding injury rating was observed in the range of 1.0 to 5.35 upto 14 DAG and thereafter the leaf damage increased. Maximum grain yield was obtained in seed treated with Cyantraniliprole 19.8% + Thiamethoxam 19.8% @ 6ml/kg seed (79.83 q/ha) compared to untreated control (63.00 q/ha).

At Rahuri centre, among the treatments tested, Thiamethoxam 30 FS recorded significant lowest per cent plant infestation of 11.67 to 12.50 and 15.00 to 16.25 respectively at 7 and 14 DAG compared to untreated control (39.17 to 45.00). Thereafter, the efficacy of seed treatment with insecticides decreased. In terms of whorl feeding injury based on Davis scale, all the treatments showed leaf injury rating <4.0 upto 14 DAG. There after, this damage increased in the range of 4.42 to 5.37 among all the treatments at 28 DAG. Thiamethoxam 30 FS @ 8 ml/kg seed recorded maximum grain yield of 55.30 q/ha compared to untreated control (42.03 q/ha).

ET 8. Evaluation of Bio-pesticides against fall armyworm during Kharif 2019 (1st Year)

The efficacy of different bio-pesticides were evaluated at three AICRP centres, Hyderabad, Kolhapur and Coimbatore against fall armyworm during Kharif 2019. At Hyderabad, EPN *Heterorhabdus indica* NBAIR Hi101@ 4 kg/acre (21.20) followed by *Beauveria bassiana* 2 x 10⁸ spores/ml (21.60) and *Pseudomonas flourescens* (PfDWD 1%) (22.40) were found to be the most effective based on percent plant infestation. The maximum number of dead larvae were observed in EPN *Heterorhabdus indica* NBAIR Hi101@ 20g/l of water (0.13) followed by *Pseudomonas flourescens* (PfDWD 1%) (0.10) when compared to untreated control (0.02). However, minimum Davis score (1-9 scale) was observed among all the bio-pesticides tested (2.50 to 3.63) compared to untreated control (5.17). EPN *Heterorhabdus indica* NBAIR Hi101 (50.04 q/ha) followed by *Beauveria bassiana* (48.15 q/ha) recorded maximum yield return as compared to untreated control (31.74 q/ha). Maximum number of ear wigs (5.33) were observed in NBAIR Bt 2%, Coccinellids (5.0) in *Metarhizium anisopliae* NBAIR- Ma 35 and spiders in *Pseudomonas flourescens*, PfDWD 1% (1.33) compared to untreated control (3.67, 2.33 and 0.33) respectively. The ear damage rating (Davis 1-9 scale) was less than 3.0 among all the treatments including control.

At Coimbatore, *Metarhizium anisopliae* NBAIR- Ma 35 (53.33) followed by *Metarhizium anisopliae* NBAIR- Ma 45 (66.67) were found to be the most effective based on percent plant infestation at ten days after first spray. However, the Davis score was less than 5 among all the treatments at seven days after first spray. *Bacillus thuringiensis var kurstaki* (63.32 q/ha) followed by EPN *Heterorhabdus indica* NBAIR Hi101 (63.25 q/ha) and *Metarhizium anisopliae* NBAIR- Ma 35 (62.95 q/ha) resulted in maximum yield return as compared to control (56 q/ha). The ear damage rating was less than 4.0 among all the treatments including control.

At Kolhapur, minimum percent plant infestation was recorded in EPN *Heterorhabdus indica* NBAIR Hi101 (20.18) followed by *Pseudomonas flourescens* (PfDWD 1%) (20.53) and NBAIR Bt 2% (24.73) compared to control (84.51). NBAIR Bt 2% (104.76 q/ha) followed by *Metarhizium anisopliae* NBAIR- Ma 35 (103.44 q/ha) resulted in maximum yield return as compared to control (85.78 q/ha).

ET 9A. Study on incidence of spotted stem borer, *Chilo partellus* in Kharif sown maize in relation to plant age and meteorological factors (3rd year)

The population dynamics of *C. partellus* was monitored in two genotypes during kharif 2018 at five different locations. The infested plants were recorded at weekly interval and then dissected to observe the number of larvae present. Therefore crop age wise observation was based on the existing number of plants in each week, whereas the total infestation and total number of larvae was based on the initial plant population.

In Ludhiana, highest infestation observed in PMH1 in crop established during third week of June (21.74 %), whereas maximum number of larvae (2.65/per plant) was recorded in JC 4 established during fourth week of June. In Karnal, highest infestation was recorded in HQPM 1 established in third week of July (66.67%) and maximum number of larvae in HM 10 established during first week July (5.84/plant). In Udaipur, highest infestation was recorded in Pratap Hybrid Maize 3 established during fourth week of June (52.56%) and the number of larvae recovered per plant ranged from 1.08 to 1.18 across the sowings. In Hyderabad, 100% infestation was recorded in CM 400 in the crop established during third week of June to first week of July and in fourth week of July. Maximum number of larvae (0.45/plant) was recorded in CM 400 established during

second week of July. In Imphal, highest infestation was recorded in crop established during third week of July (52%) and maximum number of larvae in crop established during fourth week of July (1.92/plant) in Hybrid Vijay. Generally, no infestation was noticed after 50 days of crop growth except in Hyderabad, where the crop damage was recorded at later stage due to fall armyworm infestation.

ET 9B. Study on incidence of fall armyworm, *Spodoptera frugiperda* in Kharif sown maize in relation to plant age and meteorological factors (1st year)

The incidence of fall armyworm (FAW) was monitored in maize genotypes during *Kharif* 2019 at Udaipur location. In Udaipur, highest infestation was recorded in Pratap Hybrid Maize 3 established during fourth week of June (53.75%) and the number of larvae recovered per plant ranged from 1.1 to 1.28 across the sowings.

ET 10. Study of insect pest succession on maize during kharif 2019 at different locations

The study on insect pest succession was conducted in Imphal, Hyderabad, Ludhiana and Udaipur locations during *Kharif* 2019.

Imphal: The incidence of Aphid, spotted stem borer, fall armyworm and corn ear borer were observed on maize at this location. Aphid infestation started in the last week of July and the peak aphid activity was observed in the third week of August and continued till third week of October. Spotted stem borer incidence was observed from first week of August and continued till third week of October. Peak incidence of *Chilo* was noticed in the fourth week of August. Fall armyworm incidence started from first week of August and continued till last week of October. Peak incidence of FAW was observed in the fourth week of August. Corn ear borer incidence was observed in the second week of August and continued till last week of October. Peak corn ear borer incidence was observed in the last week of August.

Hyderabad: Incidence of Spotted stem borer and fall army worm were observed during *kharif* maize at this location and incidence of these insects were observed in the last week of July and continued till the fourth week of August.

Ludhiana: In *kharif* sown maize, Spotted stem borer, fall army worm, chaffer beetle and aphid incidence was observed at Ludhiana. Spotted stem borer incidence started in the first week of July and the peak incidence was observed in the third week of July. Army worm incidence was noticed in the third week of September and observed till last week of September. *Chiloloba acuta* incidence was observed in the last week of August to first week of September only. Aphid incidence was noticed in the first week of September till second week of September only.

Udaipur: The incidence of following insects spotted stem borer, fall army worm, aphids, chaffer beetle and termite were noticed on maize at this location. Spotted stem borer incidence started from the last week of July and continued till first week of October. Peak spotted stem borer incidence was observed in the first week of September. Fall army worm incidence also started from from the last week of July and continued till first week of October. Peak FAW incidence was observed in the second week of September. Aphid and chaffer beetle incidences started from the first week of September till first week of October. Stray termite incidence was noticed in the last week of August and continued till last week of September.

ET11. Assessment of yield loss due to fall armyworm in maize during Kharif 2019

Assessment of grain loss due to fall armyworm infestation was studied at Kolhapur centre during *Kharif* 2019 on maize using the cultivar Rajashri with two treatments *viz.*, Protected and un protected. Mean grain yield/ear was 128g at Davis score of 1 as against Davis core of 9(51 g). The loss in grain yield due to fall army worm infestation was 38.06 q/ha and the percent loss in grain yield due to this pest was 47.26. The grain yield was 118.6 q/ha when the crop was fully protected from FAW with three sprays of insecticides as against untreated control (80.54q/ha)

ET 12. Evaluation of different ITK's for management fall army worm during Kharif 2019

To evaluate the ITK's for the management fall armyworm during *kharif* 2019 on maize, field experiments were conducted at Coimbatore (18 treatments) and Kolhapur(17 treatments) in a replicated trial. Results indicated that mild phytotoxicity was observed on maize treated with lime + caustic soda, Washing powder + jaggery +lime and washing powder alone (0.7 to 3.5 %) at Coimbatore location. However the dry sand + lime/ash application did not cause any phytotoxicity in maize. Dry sand + lime (8:2) recorded mean Davis score of 2.95 over other ITK's. Mean percent plants infested were lowest in Washing powder* 4 g+ Jaggery 4 g+ Lime 4 g in 1 liter of water (61.25) as against other ITK's. However, mean percent plant infestation and mean Davis score was significantly lowest in Chlorantraniliprole @ 0.4 ml/l followed by Spinetoram @ 0.5 ml/l sprayed plots.

At Kolhapur, none of the ITK's were found effective in managing the FAW damage. However the insecticide sprays Spinetoram @ 0.5 ml/l followed by Chlorantraniliprole @ 0.4 ml/l recorded significantly lowest mean percent plant infestation (8.08, 9.59), Davis score (1.91, 2.15) and significantly higher grain yield (104.8, 97.4 q/ha) respectively.

PATHOLOGY

During *Kharif* 2019, following maize entries were evaluated in different zones of AICRP on Maize across the country:

Trial	NHZ			NWPZ			NEPZ			PZ			CWZ		
	Late	Medium	Early	Late	Medium	Early	Late	Medium	Early	Late	Medium	Early	Late	Medium	Early
NIVT	-	18	24	55	78	28	55	78	28	55	78	28	55	78	28
AVT I II	-	4	2	27	33	9	27	33	9	27	33	9	27	33	9
QPM I II III	10				16		16			16			16		
SC I II III	5				11		11			11			11		
PC I II III	4			-			-			-			-		
BC I II III	5			13			13			13			13		
Rainfed I II III	-			2	3	3	2	4	2	2	4	3	2	4	2
OPV	8			-			-			-			-		
Total	80			278			278			279			278		

Details of the coordinated trials conducted under AICRP on maize during Kharif 2019 are given below.

Sl. No.	Centre	University	Total Trials allotted
1	Almora	ICAR-VPKAS, Almora	11
2	Larnoo	SKUAST, Kashmir	10
3	Bajaura	CSKHPKV, Palampur	13
4	Barapani	NEH, Barapani	07
5	Imphal	CAU), Iroisembla, Imphal	07
6	Dhaulakuan	CSKHPKV, Palampur	18
7	Delhi	ICAR-IARI, Delhi	27
8	Ludhiana	PAU, Ludhiana	28
9	Karnal	CCSHAU, Hisar	28
10	Pantnagar	GBPUAT, Pantnagar	15
11	Dholi	RAU, Samastipur	14
12	Sabour	BAU, Sabour	14
13	Kalyani	BCKV, Kalyani	03
14	Hyderabad	PJTSAU, Hyderabad	15
15	Dharwad	UAS, Dharwad	15
16	Mandya	UAS, Bengaluru	29
17	Coimbatore	TNAU, Coimbatore	14
18	Rahuri	MPKV, Rahuri	14
19	Peddapuram	ANGRAU, Guntur	15
20	Udaipur	MPUAT, Udaipur	53
21	Godhra	AAU, Anand	04

Criteria for disease reaction:

S.No.	Disease	Scale	Disease Reaction			
			R	MR	MS	S
1	MLB	1-9	≤3.0	3.1-5.0	5.1-7.0	>7.0
2	TLB	1-9	≤3.0	3.1-5.0	5.1-7.0	>7.0
3	BLSB	1-9	≤3.0	3.1-5.0	5.1-7.0	>7.0
4	C. Rot	1-9	≤3.0	3.1-5.0	5.1-7.0	>7.0
5	FSR	1-9	≤3.0	3.1-5.0	5.1-7.0	>7.0
6	CLS	1-9	≤3.0	3.1-5.0	5.1-7.0	>7.0
7	BSR	0-100 %	≤10 %	10.1-25.0%	25.1-50.0%	>50.0%
8	RDM	0-100 %	≤10 %	10.1-25.0%	25.1-50.0%	>50.0%
9	SDM	0-100 %	≤10 %	10.1-25.0%	25.1-50.0%	>50.0%

Criteria of rusts reaction:

S.No.	Disease	Scale	Disease Reaction					
			Immune/HR	R	MR	MS	S	HS
1.	P. Rust	1-9	≤1.0	1.1-2.0	2.1-4.0	4.1-6.0	6.1-7.0	>7.0
2.	C. Rust	1-9	≤1.0	1.1-2.0	2.1-4.0	4.1-6.0	6.1-7.0	>7.0

Criteria for non-insect pest cyst nematode:

S.No.	Disease/Non insect pest	Scale(cyst/plant)	Reaction		
			R	MR	S
1.	CN	Number of cyst/plant	0-4.0	5.0-9.0	>9.0

The hybrids having disease resistance (DR) in advance trials are:

- Northern Hill Zone (NHZ):** Three hybrids which were resistant against turicum leaf blight (TLB) are DKC9190, DKC 8191, LMH1417 in medium maturity group. One hybrid FH3875 resistant against TLB in early maturity
- North West Plain Zone (NWPZ):** Four hybrids showing resistance against maydis leaf blight (MLB) were CP 858, JH 16041, PM 18106 L, SYN816514 in late maturity whereas eight hybrids viz.; AH 7067R, CAH 1511, DKC 8181, IMHBG-17 K-17, INDAM 1118, JKMH1518, KMH 004 and LMH 1016 were resistant against MLB in medium maturity group. Three hybrids viz.; JH 31947, JH 32057, JH 32094 were resistant against MLB in early maturity group.
- North East Plain Zone (NEPZ):** Only one hybrid JH 31947 was resistant against MLB in early maturity group.
- Peninsular Zone (PZ):** Three hybrids viz.; SYN816514, ADV 1390164 and ADV 7132 were resistant against SDM in late maturity group and four hybrids viz.; DKC 9190, INDAM 1122, LMH 1016 and LMH 3417 exhibited resistance to TLB in medium maturity group. Only one hybrid AH 8181 was resistant to TLB in early maturity group.
- Central Western Zone (CWZ):** Three hybrids viz.; B57, JH 16041 and Rasi 3499 were resistant against Curvularia leaf spot (CLS) whereas eight hybrids viz.; BLH 137, CP 858, JH 17026, KMH 463, PM 18101 L, RCM 1-61, Rasi 4992, SYN816514 were resistant against Rajasthan downy mildew (RDM) in late maturity group. Five hybrids viz.; BH416215, JH 16045, JKMH 15303, NMH 4053 and RCRMH 7 were resistant against CLS whereas four hybrids viz.; DKC 9194, DKC 9198, JH 16045 and NMH 4053 were resistant against Rajasthan downy mildew (RDM) in medium maturity group. Only one hybrid JH 32094 was resistant against and one hybrid JH 32057 was resistant against RDM in early maturity group

Disease management in maize

- Seed treatment and foliar application of Azoxystrobin 18.2 w/w +Difenoconazole 11.4% w/w SC@ 0.10% at 35 and 45 DAS found significantly superior with respect to TLB control (49.4%) and increase in yield (31.8%) at Imphal.
- Soil application of Vermicompost enriched with *Trichoderma viride* (2x10⁹cfu/g) @ 250 kg/ha was found to be the best treatment in terms of disease reduction and increased grain yield against charcoal rot at Hyderabad.

- The maximum disease control 69.9% and 61.73 % for the treatment of Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE @ 0.15% at 3 days and 18 days after inoculation against MLB at Karnal and Ludhiana respectively.
- Two sprays of Panchgavya @ 8% 80 ml/l was found most effective to manage the TLB with 38.3 per cent of disease control over water control check at Bajaura.
- IDM approach soil amendment with Trichoderma formulation [@ 6t/acre FYM], metalaxyl 35% WS [3g/kg of seed], foliar spray with Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC @ 0.1% using 500 l water/ha at 30DAS was found most promising to manage the sorghum downy mildew (SDM) with control of 98.5% at Mandya.
- IDM approach soil amendment with Trichoderma formulation [@ 6t/acre FYM], metalaxyl 35% WS [3g/kg of seed], foliar spray with Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC @ 0.1% using 500 l water/ha at 30DAS was found most promising to manage the Rajasthan downy mildew (RDM) with control of 42.2% at Udaipur.
- The cow products Panchgavya@20% w/v found most effective to reduce Females /5 g root (31.43%), Cyst/ 100 cc soil (29.76%) and Final larvae/100 cc soil (34.49%) at Udaipur.
- IDM module (Seed treatment with *T. viride* @ 10g/kg seed and Thiram 75 WP @ 3g/kg seed; One foliar application of Nimbecidine 5ml/litre of water @ 35 DAS and one foliar application Azoxystrobin 18.2% + Difenoconazole 11.4% (29.6 SC) @ 1 ml/litre of water @ 50 DAS) was observed best in checking Curvularia leaf spot (CLS) disease severity (26.72%) resulted in highest grain (53.64 q/ha) with 36.38% yield increase over unprotected organic check.

BIOCHEMISTRY

The biochemistry laboratory facilitates the analysis of samples received under AICRP quality trial. The laboratory is well equipped with modern equipment's including Ultra Performance liquid Chromatography, Automatic Nitrogen Analyzer, Automatic Solvent Extraction System, NIRT, Double Beam Spectrophotometers, Vacuum Concentrator and Lyfolyzer etc. The laboratory also helps the AICRP centres in identifying superior germplasm for protein quality, oil content, carotenoids composition and starch profile. During the period of 2018–2019 samples received under AICRP quality programme were analysed for protein quality and provitamin A components as required. For protein quality analysis a total of 14 genotypes consisting of seven newly developed QPM hybrids and seven checks were grown at two locations, viz., Ludhiana and Delhi. The selfed maize ears collected from respective entries from each centre was analysed separately at the above mentioned two locations for protein quality parameters viz: protein, tryptophan and lysine. For this purpose, the kernels were screened on the basis of opaqueness to select the representative sample. The endosperm was separated, defatted and processed for protein quality i.e. tryptophan and lysine content in the endosperm protein. The data for protein, tryptophan and lysine are presented in Table 1, 2 and 3, respectively. For any samples to be categorized as QPM, the threshold concentration of lysine and tryptophan is to be ≥ 2.50 per cent and ≥ 0.6 per cent of endosperm protein, respectively. The entries namely APQH 1, APH 1, APH 2, VEQH 16-1, IIMRQPMH 1705, IIMRQPMH 1708 and APQH-8 possessed the threshold concentration of protein quality to be considered as QPM.

EXTENSION AND OUTREACH

AICRP on maize has a strong outreach component in maize value chain with the Scheduled Tribe Component (STC), North Eastern Hill (NEH) component, Scheduled Caste Sub Plan (SCSP) are also implemented by the institute for capacity building, technology demonstration and critical input distribution in maize growing areas. The project has a Frontline Demonstrations programme sponsored by Department of Agriculture and Cooperation, Government of India under National Food Security Mission (NFSM) for demonstration of the improved maize hybrids and production technology. All these activities focus the inspirational districts identified by Government of India, areas under newer production ecologies of maize and traditional low productivity areas in the country.

Front Line Demonstrations

- The Frontline Demonstrations (FLDs) under NFSM were conducted on 287.9 hectares (ha) acreage involving 890 farmers during three seasons (*kharif*, *rabi* and spring) in 15 states/Union Territories (UTs), out of which 5.8 ha FLDs failed due to heavy rainfall/flood. The FLDs focused on demonstration of newly released single cross hybrids, post-emergence weed management, integrated pest management,

intercropping etc. In *rabi* 2018-19, spring 2019 and *kharif* 2019 yield gains % under FLDs over farmers practices were 21.2(10.3-78.2), 49.9 (24.4-68.5) and 33.2(3.9 to 127.7) , respectively.

- Across the seasons, highest yield of 90 q/ha under FLDs was reported during *rabi* 2018-19 at West Bengal. The seasonal averages of the FLDs were 20.0 and 25.0 q/ha higher than national average yield of maize during *rabi* and *kharif* season, respectively which shows the potential of enhancing maize productivity in both the seasons with available technology targeting in niche areas. The FLDs on biofortified maize cultivars of quality protein maize (Shaktiman-5 and HQPM-5) were conducted on 20.0 ha area in Meghalaya and Bihar, where yield gap of 28.0 and 6.0% were recorded, respectively.

Scheduled Tribe Component (STC)

- Scheduled Tribe Component (STC) funded by ICAR aims to enhance income and profitability of tribal farmers. The programme was implemented in the tribal dominated aspirational districts in 12 states, viz., Chhattisgarh, Himachal Pradesh, Maharashtra, Odisha, Madhya Pradesh, Jammu and Kashmir, Jharkhand, Uttar Pradesh, Gujarat, Rajasthan, Bihar and West Bengal. During 2019, 36 farmers' training programmes were conducted in different parts of the country, benefiting 1565 tribal farmers on various aspects of scientific maize cultivation. Under STC, seeds were distributed for demonstrations on the scientific maize cultivation over 693 ha area, benefitting 879 farmers.

Maize Promotion in North Eastern Hill Region

- ICAR-Indian Institute of Maize Research, Ludhiana in collaboration with ICAR-Research Complex for North Eastern Hill Region (ICAR-RC NEH), Barapani implemented a major component of NEH programme. A collaborative programme on “*Maize production in NEH region for sustainable livestock production*” was also initiated with ICAR-National Research Centre on Pig, Guwahati (Assam), ICAR-National Research Centre on Yak, Dirang (Arunachal Pradesh) and ICAR-National Research Centre on Mithun, Dimapur (Nagaland). Emphasis were laid on the fodder and feed from maize for the livestock sustainability in the NEH region.
- Participatory demonstrations were conducted over 515 ha area with 1050 farmer beneficiaries. The FLDs emphasized on quality protein maize production, crop diversification with sweet corn and intercropping along with best scientific management practices. The yield gap varied from 27.7% (at Sikkim) to as high as 303.4% (at Tripura), with an average yield gap of 57.4% in the NEH region. The results indicate substantial possibility for maize production enhancement with available crop production technologies across the North East Indian hills.
- Under NEH, 32 training programmes were organized and 1675 beneficiaries were benefited in collaboration with stakeholder in NEH region.

Collaborative efforts for conducting awareness and management of fall armyworm (FAW) in maize during 2019

- The sudden and first-time attack of fall armyworm (FAW) created panic among the maize growers in North East India, particularly at Mizoram and Manipur. Real-time support from the collaborative efforts of scientists working at ICAR Research Complex for NEH Region and ICAR-IIMR, Ludhiana was provided to the respective state Governments for extensive sensitization and awareness development on FAW infestation in maize over the seven North East Indian Hill States. 3 National-level and 5 State-level workshops/brainstorming sessions for awareness/officials’ trainings and farmer-scientist interactions on FAW management organized. Along these workshop 16 trainings also organized and altogether 1897 officers/progressive farmers were trained on FAW management across the NEH states.

SCSP programme

- The SCSP (Scheduled Caste Sub Plan) has been started by Government of India to benefit the farmers of scheduled caste (SC) communities of the country. The institute implemented SCSP plan in maize to benefit the maize growing farmers of SC community. 16 training and agricultural inputs distributions were conducted and 1135 famers benefited by different AICRP centres under the SCSP plan during the year 2019. Inputs distributed for ~250 ha demonstrations along with farm implements and storage bins under SCSP programme.

Training and awareness programmes conducted on Fall armyworm and its management by ICAR-IIMR, AICRP on Maize

- A number of programmes were organized by ICAR-Indian Institute of Maize Research and All India Coordinated Research Project (AICRP) on Maize. As mentioned above, ICAR-IIMR organized 24 programmes related to fall armyworm in North East Hill region, benefitting 1782 participants. Apart from this, ICAR-IIMR and/or its AICRP centers have organized 82 training programmes throughout the country, benefitting 7988 participants.

ICAR-CIMMYT COLLABORATION

- Major emphasis of collaborative program is on stress-resilient maize technologies, suitable for rainfed/kharif season, including high yielding maize with tolerance to drought, heat and/or waterlogging and suitable agronomics for system resilience.
- Program implemented through various collaborative projects, including ICAR-fund project on *kharif* maize, bi-lateral projects and CRP-Maize work-packages.
- Under ICAR-funded project, precision phenotyping sites were established at Kolhapur, Godhra and Varanasi centres. Pilot trial involving pipe-line/released hybrids from ICAR-IIMR, AICRP centres and CIMMYT were constituted. Managed drought trials taken-up during rabi 2019-20 and heat stress trials planted in spring 2020. For genetic diversity analysis panel of 752 lines from various AICRP center and 658 lines from CIMMYT were constituted. DNA extracted from panel lines and validation of the DArTAGplat form is in progress
- Using genomics selection (GS) and double haploid technologies new maize germplasm developed with combined drought and waterlogging tolerance, and drought and heat tolerance. Selected line by partners were shared for developing new hybrid combinations, apart from ready hybrids from collaborative trials.
- A number of hybrids combination from bilateral project entered in state as well as AICRP evaluation, reached to different stage to testing.
- International maize improvement consortium (IMIC-India chapter) field day organized on 12 March at ICRISAT campus where a total 1565 diverse line were demonstrated. Partners made their selection, and seed of selected line will be made available for planting in Kharif-2020.
- With support from CRP-MAIZE three screen-houses for FAW is proposed, each of 1.0-acre size at Winter Nursery Centre-IIMR, Bapatla and ICRISAT campus.
- DH facility being established at Kunigal in collaboration with UAS-Bangalore, ICAR is key stallholder in this. The facility will be functional by Feb, 2021 and provide DH service to NARS and SMEs.
- During 2019 a total 761 lines, including 661 from CIMMYT Hyderabad and 100 from CIMMYT Mexico were shared with various AICRP centres.
- Under capacity development program training course were organized on seed system, gender and CA were participants from SAUs and IIMR trained. A total 13 students were trained through joint studentship program between SAUs and CIMMYT.
- A total 14 joint publications were brought out during 2019 and one policy paper of maize in NEH region.