

Project Coordinator Review

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REVIEW OF PEARL MILLET RESEARCH

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the most widely grown staple food of majority of poor and small land holders in Asia and Africa. It is also consumed as feed and fodder for livestock. It accounts for almost half of global millet production. It is the sixth most important cereal crop in the world next to maize, rice, wheat, barley and sorghum. In India, pearl millet is the fourth most widely cultivated food crop after rice, wheat and maize. It occupies an area of 6.93 million ha with an average production of 8.61 million tonnes and productivity of 1243 kg/ha (Directorate of Millets Development, 2020). The major pearl millet growing states are Rajasthan, Maharashtra, Uttar Pradesh, Gujarat and Haryana contributing 90% of total national production.

The growing conditions for pearl millet vary from near-optimum with high external inputs to highly drought-prone environments, prioritization of research in cognizance of production constraints and differential requirement of various crop growing regions led to formation of different zones viz., A₁, A, B zones and summer segment. The areas under different zones during 2017-18 is as follows - A₁ - 3.5 m.ha; A zone - 2.45 m.ha; zone B - 1.14 m.ha and summer segment - 0.40 m.ha. Zone A₁ is comprised of parts of Rajasthan, Gujarat and Haryana receiving less than 400 mm annual rainfall. Zone A is comprised of Rajasthan, Gujarat, Haryana, plains of Uttar Pradesh, New Delhi, Madhya Pradesh (Bhind, Morena, Gwalior and adjoining areas) Punjab, Jharkhand and Jammu & Kashmir. Zone B comprises states of Maharashtra, Andhra Pradesh, Telangana, Karnataka, Tamil Nadu and Odisha. Most of Pearl millet in India is grown in rainy (*kharif*) season (June/July–September/October). It is also cultivated during summer season (February–May) in parts of Gujarat, Rajasthan and Uttar Pradesh; and during the post-rainy (*rabi*) season (November–February) at a small scale in Maharashtra and Gujarat. Pearl millet excels all other cereals due to its unique features - C₄ plant with high photosynthetic efficiency, high dry matter production capacity and is grown under the most adverse agro-climatic conditions where other crops like sorghum and maize fail to produce economic yields. It is critically important for food and nutritional security as it possess several advantages such as early maturing, drought tolerance, require minimal purchase inputs and mostly free from biotic and abiotic stresses.

Pearl millet is also called as the “*Powerhouse of Nutrition*” as it consists of most of the important nutrients in good quantity and quality which is required for maintaining healthy life. It has higher contents of macronutrients and micronutrients such as iron, zinc, calcium, magnesium, copper, manganese, phosphorous, folic acid and riboflavin. It is rich source of unsaturated fatty acids (75%). Nutritional value of pearl millet is better in comparison to wheat, rice, maize and sorghum. It is a good source of energy, carbohydrate, fat (5-7%), ash, dietary fibre (1.2g/100g), α -amylase activity, quality protein (9-13%), vitamin A and B, minerals (2.3mg/100g), antioxidants such as ferulic acid and coumaric acids with better fat digestibility (Poshan, 2019). Pearl millet has special health benefiting properties for people suffering from life style diseases like diabetes, obesity etc. as it has high proportions of slowly digestible starch (SDS) and resistant starch (RS) that contribute to low glycemic index (GI). Pearl millet is gluten free and retains its alkaline properties even after being cooked which is ideal for people suffering from gluten allergy and acidity. Due to the excellent nutritional properties and resilience to climate change, pearl millet along with other millets is renamed as *nutri-cereals* (Gazette of India, No. 133 dtd 13th April, 2018) for production, consumption, trade and was included in Public distribution system. The MSP of pearl millet is increased to Rs. 2000 per quintal (raised by Rs. 50 which is 2.6 %). To bring millets into mainstream for exploiting the nutritional rich properties and promoting their cultivation, Govt. of India

has declared Year 2018 as the “Year of Millets” and the Year 2021 was declared as “International Year of Millets” by FAO Committee on Agriculture (COAG) forum.

Research on Pearl millet improvement in India is carried through the All India Coordinated Research Project on Pearl Millet (AICRP-PM) administered by Indian Council of Agricultural Research (ICAR) through a network of 13 AICRP centers in Rajasthan, Gujarat, Maharashtra, Uttar Pradesh, Karnataka, Andhra Pradesh, Madhya Pradesh, Punjab, Haryana and Tamil Nadu. The AICRP-PM centers located in 12 State Agricultural Universities (SAU's) and University of Mysore pursue mandated activities and strategic research on pearl millet in the areas of germplasm utilization, improvement, production, protection and value addition etc.

Through ICAR- All India Coordinated Research Project on Pearl millet, a total of **175 hybrids (public 101 and private sectors 74) and 62 varieties** were identified and released for cultivation in different agro-ecological zones of the country. Pearl millet is the **first crop where MAS strategies and tools** have been applied to develop **"Improved HHB 67"**. Pearl millet is the **first crop to establish first global minimum standards for micronutrient content in promotion criteria in the cultivar release policy**. A number of production and protection technologies specific to different agro-ecological regions which will prove useful in enhancing the productivity of improved cultivars to commercial farming scales and increase the profitability of pearl millet growers were developed through this system. Website and Information System of ICAR-AICRP on Pearl millet was developed and launched through Krishi Portal with support of IASRI, New Delhi by Dr. Trilochan Mohapatra, Secretary (DARE) and DG, ICAR, New Delhi on 10th December, 2019.

ICAR-AICRP on Pearl millet is actively collaborating as technology and knowledge partner in several new research initiatives like UNEP-GEF project on “Mainstreaming agricultural biodiversity conservation and utilization in agricultural sectors to ensure ecosystem services and reduce vulnerability”, “Millet mission” by NFSM, Niche area of excellence (NAE) programme from ICAR on “Development of biochemical and physical processing technology to arrest oxidation of lipids/flavones to enhance the shelf-life of pearl millet flour”, ICAR-BMGF project on “Application of next-generation breeding, genotyping, and digitalization approaches for improving the genetic gain in Indian staple crops”. Under the NFSM, high iron/zinc pearl millet hybrids were demonstrated on farmer's fields (56.40 ha out of total 306.40 ha in FLDs) which accounts to 18.4% of total FLD area in pearl millet. Along with yield improvement, focus on the nutritional improvement was also given in Pearl millet. Biofortified varieties/hybrids with Fe and Zn were taken up as a priority area due to which mainstreaming of biofortification happened in pearl millet and now is a routine affair.

Development of high yielding, dual purpose disease resistant cultivars for low rainfall areas i.e. A₁ zone is of utmost priority for increasing pearl millet productivity at national level. Refinement of technologies for processing of grain, development of value added products along with development of sound extension support for popularization of these technologies and products, spread of pearl millet cultivation in nontraditional areas and pearl millet hybrid seed production in North - Western part of the country is the need of the hour. These changes will certainly add to the national efforts of doubling the farmer's income.

CROP IMPROVEMENT

1. Hybrids/ varieties notified

Pearl millet hybrids/varieties were notified and released for cultivation in various agro-ecologies of the country viz.,

- i). Hybrid PB 1852, JKBH 1326 and DHBH 1397 were released for cultivation in medium maturity group for the states of Rajasthan, Gujarat, Haryana, Punjab, Delhi, Uttar Pradesh and Madhya Pradesh.
- ii). Three hybrids RHB 234, RHB 233 and AHB 1269 were released as biofortified (high iron and zinc) dual purpose hybrids with high grain and dry fodder yield potential in A₁, A and B zones.
- iii). Hybrid Phule Mahashakti and PROAGRO 9450 were released for the state of Maharashtra and Uttar Pradesh, respectively.

The following hybrids and varieties were identified for cultivation for various agro-ecologies of the country during 54th Annual Group Meeting at ICAR-IARI, New Delhi - viz., BHB 1602, PB 1852 and JKBH 1326.

Genetic enhancement

A significant progress was made during the year 2019-20 in genetic enhancement of the crop. A total of 130 new experimental cultivars and 37 released hybrids/varieties were evaluated in 13 trials during *kharif* and *summer* 2019 at 62 test locations in the four agro-climatic zones of the country. These genotypes expressed a wide range of grain and stover productivity (Table 1).

Table 1: Details of coordinated trials on Pearl millet conducted during 2019

Zone	Trials	No. of test entries & Checks	Range	
			Grain Yield (kg/ha)	Stover Yield (kg/ha)
A ₁	IHT Early	26	1278-2188	3226-5360
	AHPT Early	07	1630-2077	3854-4655
A	IHT Medium	36	2294-3744	6402-11358
	IHT Late	34	2952-4145	9336-14408
	AHT Late	05	3411-3886	10630-12939
	PT	13	1671-2647	6609-10086
	EDV	12	1595-2143	4837-5580
B	IHT Medium	36	1971-4305	4285-8706
	IHT Late	34	2723-4242	6421-10396
	AHT Late	04	3301-3734	5965-7457
	PT	12	1863-2606	4232-6120
	SHT	19	4110-5363	6789-9530
Summer				

1. Utilization of male-sterile (A) and restorers (R) lines

A wide range of A and R lines were used in order to develop new experimental hybrids for evaluation. The hybrids evaluated during 2019 were based on 76 A-lines (by name) and 108 R-lines (by name). This is contributing significantly towards genetic diversification of parental lines and ultimately pearl millet hybrids for different agro ecologies in the country.

2. Assessment of grain quality- Fe, Zn, Protein and Fat

During the 52nd AGM of ICAR-AICRP on Pearl millet at PAU, Ludhiana a landmark decision of including minimum Fe (42 ppm) & Zn (32 ppm) in promotion criteria was taken.

In Coordinated experimental trials, those entries with high grain yield along with the checks were analysed for grain iron and zinc content across the locations. The iron and zinc content ranged from (36-74 ppm) and (23-44 ppm), respectively over different trials and locations.

A total of 25 test entries were assessed for quality parameters like protein and fat. The values ranged from 7.6–12.5% in protein content. (This demonstrates that there exists enough opportunity to select for protein content in addition to high grain and stover yields).

3. Breeder seed Production

During 2019-20, breeder seed production of 25 parental lines (A, B & R) of hybrids and 05 OPVs was undertaken. A total of 67.01 q of breeder seed was produced which was much higher than the indented quantity of breeder seed (6.107 q) from Department of Agriculture and Cooperation, Ministry of Agriculture and Farmer Welfare (GOI).

4. DUS test and registration of cultivars with PPV & FRA

A total of 18 candidate varieties including 08 for second year and 06 for first year and 4 farmers varieties along with 14 reference/example varieties were tested at ICAR-AICRP on Pearl Millet, Jodhpur and MPKV, Rahuri. Observations on candidate and reference varieties for twenty eight characters were recorded as per general and specific DUS guidelines of pearl millet. Monitoring of the DUS trials was done under the chairmanship of Dr. B. S Rajpurohit, Professor & Director PME, AU, Jodhpur on 19th October, 2019 at Mandor.

5. ICAR-ICRISAT partnership research

A total of 174 R lines, 98 B lines and 19 OPVs were assessed by breeders in five trials at 14 locations of AICRP centers and cooperating centers. Superior entries were selected for utilization by respective breeders. Phenotypic data was generated for genomic selection trials.

6. CRP Biofortification (Pearl millet) Parental Line Trial (CRPB PLT)

The trial comprises 22 entries including two checks (PCMhFeB-05 and Dhanshakti) having high Fe

and Zn contributed by different ICAR-AICRP on Pearl millet centers. The trial was successfully conducted across 6 locations viz., Mandor, Jaipur, Hisar, New Delhi, Jamnagar and Dhule. The data were generated for grain iron and zinc content and agronomic performance. Days to 50% flowering ranged from 47 (Dhanshakti) to 60 (PPMI 961, PPMI 962 and J-2615). The plant height ranged from 95 cm (H 19/0002) to 150 cm (PPMI 965) and panicles per plant ranged from 2.0 (PCMhFeR17-7) to 2.6 (PPMI 964 and PPMI 965). Agronomic scores ranged from 1.8 (J-104) to 3.0 (PPMI 965). Fe content range from 44-136 ppm and were recorded high in entry no. 12, 13, 2, 21, 20, 18, 19 and high Zn content range from 22-63 ppm and were recorded high in entry no. 13, 2, 21, 20, 18 and 19 in comparison to the check Dhanshakti (Fe 83 & Zn 44 ppm). Entry no. 19, 18 and 20 recorded higher or at par in iron and zinc content over best check PCMhFeB-05. The dry fodder nutritional analysis for bio-fortified pearl millet hybrids/varieties is under progress.

The work on development of value added products, ready to cook and multigrain mixtures suitable for mid day meal schemes, weaning flour mixes were prepared from malted HHB 299 and were found to be organoleptically acceptable. Socio-impact studies and popularization of bio-fortified products, trainings imparted to rural women on preparation of value added products from pearl millet like laddoo and sev. During kisan melas/exhibitions, various technologies of pearl millet were displayed and public was educated to increase intake of pearl millet based products.

RESOURCE MANAGEMENT

Four agronomy trials on the aspects of- 1. Nitrogen management among advance pearl millet hybrid entries during summer season; 2. Effect of mulching and hydrogel on pearl millet productivity, 3. Performance of different weed management practices on pearl millet productivity and 4. Nutrient management through organic sources in rainfed pearl millet were conducted during *summer & kharif* season of 2019 in different agro climatic zones (Zone A₁, Zone A & Zone B) (Table 2).

Table 2: The list of the experiments along with treatments are as under:

S. N.	Title	Treatment
1	PMAT 1: Response of pearl millet advance hybrid entries to nitrogen levels Summer Season Zone A & B (1d)	9 (Hybrid Entries: 3, Nitrogen levels: 3)
2	PMAT 2: Effect of mulching and hydrogel on the productivity of pearl millet under rainfed conditions	8 [T ₁ : Control (RDF), T ₂ : Crop residue mulch @ 5.0 t/ha, T ₃ : Hydrogel @ 2.5 kg/ha, T ₄ : Hydrogel @ 5.0 kg/ha, T ₅ : Hydrogel @ 7.5 kg/ha, T ₆ : Crop residue mulch @ 5.0 t/ha + Hydrogel @ 2.5 kg/ha, T ₇ : Crop residue mulch @ 5.0 t/ha + Hydrogel @ 5.0 kg/ha and T ₈ :Crop residue mulch @ 5.0 t/ha + Hydrogel @ 7.5 kg/ha]

3	PMAT 3: Performance of different weed management practices on pearl millet productivity	T ₁ :Weedy check, T ₂ :Weed free, T ₃ :Two hand weeding at 3 and 5 weeks after sowing, T ₄ :Pre emergence application of Atrazine @ 400g <i>a.i./ha</i> <i>fb</i> one hand weeding at 3-4 week after sowing, T ₅ :Tembotrione 42% SC @ 90 g <i>a.i./ha</i> at 3-4 leaf stage of weed, T ₆ :Tembotrione 42% SC @ 100 g <i>a.i./ha</i> at 3-4 leaf stage of weed, T ₇ : Tembotrione 42% SC @ 110 g <i>a.i./ha</i> at 3-4 leaf stage of weed, T ₈ : Tembotrione 42% SC @ 120 g <i>a.i./ha</i> at 3-4 leaf stage of weed.
4	PMAT 4: Nutrient management through organic sources in rainfed pearl millet	T ₁ : RDF, T ₂ : RDN through FYM, T ₃ : 75% RDN through FYM, T ₄ : RDN through Vermi-compost, T ₅ : 75% RDN through vermicompost, T ₆ : T ₂ + Biomix, T ₇ : T ₃ + Biomix, T ₈ : T ₄ + Biomix and T ₉ : T ₅ + Biomix.

The salient achievements are as follows:

- The response of advance early hybrid entry (MH 346) was tested to three nitrogen levels (60, 90 & 120 kg N/ha) in comparison with two hybrid checks *i.e.* 86M64 & Proagro 9444, the grain yield was found statistically at par with different nitrogen levels at three locations except Dhule where, the yield was found significantly superior at 120 kg/ha as compared to 60 kg N/ha. The entry MSH 346 produced more grain yield (46.72 q/ha) than the checks 86M64 (45.91 q/ha) and Proagro 9444 (44.31 q/ha) whereas, stover yield was found superior in the check Proagro 9444 (71.67 q/ha) than the advance entry MSH 346 (67.94 q/ha) and the check 86M64 (66.44 q/ha).
- The field experiment aimed to study the effect of mulching and hydrogel on the productivity, water use efficiency and microbial activity of pearl millet exhibited the superior performance of the treatment RDF + crop residue mulch @ 5.0 t/ha+ hydrogel @ 7.5 kg/ha by 49.8, 40.2 and 43.7%, respectively over RDF alone in zone A₁, zone A and zone B, respectively. The water use efficiency was found to be 70.24, 78.78, & 79.98 kg/ha-cm, respectively in Zones A₁, A & B. The soil microbial studies revealed that the microbial population was found better in the Delhi soils as compared to Mandor Centre. The dehydrogenase activity, MBC, alkaline phosphatase, acid phosphatases and urease populations recorded significantly higher among all the treatments of hydrogel, mulching and their combinations as compared to their population in the inorganic RDF treatment.
- Weed control studies were conducted with an objective to improve/ fine tune the existing recommendations of weed management in pearl millet with eight different treatments including new herbicide Tembotrione 42 SC treatments. The treatment Tembotrione 42% SC @ 120 g *a.i./ha* at 3-4 leaf stage of weed was found to be the best method for weed control in terms of grain yield (Rs. 22.87 q/ha) and it was followed by weed free treatment (22.78 q/ha) in Zone A₁. Pre emergence

application of Atrazine @400 g a.i./ha fb 1 HW at 3-4 weeks after sowing (Rs. 39,937/ha) followed by two hand weedings at 3 & 5 weeks after sowing (Rs.35,011/ha) in Zone A recorded better economic yields whereas, in Zone B, application of tembotrione from 90 to 120 g a.i./ha could not produce the grain and stover yield to the tune of weed free and recommended practices of weed control for the pearl millet crop.

- To enhance the productivity and improve quality of pearl millet the trial Nutrient management through organic sources in rainfed pearl millet was planned with nine treatments of inorganic & organic sources. The mean data of the Zone A₁, A & B showed that the highest grain yield of 18.64 q/ha, 24.24 q/ha & 25.14 q/ha, respectively was obtained by the application of RDF through inorganic source (T₁) treatment and it was followed by the organic treatment T₆ (RDN through FYM + Biomix) with grain yield of 17.61 q/ha in Zone A₁ & 23.84 q/ha in Zone A whereas, it was T₈ treatment (RDN through vermicompost + biomix) with grain yield of 24.57 q/ha in Zone B.
- The protein content also recorded maximum in T₆ (9.8%) treatment followed by T₁ (9.7%) treatment. The physico-chemical studies carried out at Hisar revealed that the soil chemical properties *i.e.* EC (dS/m) was lower between 0.20-0.25 dS/m among different treatments after harvesting of the crop in comparison to initial status (0.23-0.27 dS/m). The OC (%), available N and P status were either maintained or slightly higher in the organic treatments as compared to initial status before sowing and RDF treatments.

FRONT LINE DEMONSTRATIONS

- During kharif & summer 2019 crop seasons, various Front Line Demonstrations (FLD's) on different production aspects [improved hybrid/variety, biofortified hybrids/varieties, use of micro nutrient ZnSO₄ and biofertilizer (Azospirillum + PSB), use of recommended dose of NP] were conducted on 306.4 ha area (**56.4 ha area under Biofortified hybrids/variety which is 18.4% of total FLD area**) against the target plan of 350 ha on pearl millet crop in the states of Rajasthan, Gujarat, Haryana, Madhya Pradesh, Punjab, Tamil Nadu, Karnataka, Maharashtra and Andhra Pradesh. The KVK Sirohi, KVK Jalore and ICAR Dimapur (North East) did not conduct the allotted FLD's. Adoption of improved production technologies recorded 20.4% to 39.9% higher grain yield compared to the yield recorded with the farmer's practice in zone A₁, 5.9% to 38.6% in zone A and the increase was 16.9% to 132.2% in zone B. During summer season in Gujarat state, the grain yield of 4739 kg/ha was obtained with improved cultivation practices as against 4494 kg/ha recorded with farmer's practices thereby improving the grain yield by 5.4%.

PLANT PHYSIOLOGY

Five physiological trials were conducted at Mandor, Jaipur and Jamnagar during *summer* and *kharif* 2019.

- During the screening of advanced summer hybrids against terminal stress low moisture and high temperature conditions, MSH 346 was found significant superior, which reflects its better tolerance capacity towards terminal stress condition.
- Characterization for drought tolerance in pearl millet genotype, inbred lines (J-2592) at Jamnagar and B-lines (JMSB 20101 and JMSB 20172) at Mandor were high yielders under low moisture and high temperature conditions.
- The photosynthate partitioning and remobilization in pearl millet under rain-fed condition, MPMH 17 exhibited maximum panicle dry weight (97.56 g) grain yield (76.53 g), panicle harvest index (79.52) and harvest index (65.41).
- Varietal characterization in pearl millet on the basis of root and shoot traits, the genotype RHB 173 exhibited maximum shoot length, root length, shoot fresh weight, shoot dry weight, root dry weight, whereas, GHB 558 exhibited maximum shoot fresh weight at par with RBH 177 under field condition.
- Identification of heat stress tolerance in pearl millet genotype at seedling stage, parameters viz., shoot length, seedling dry weight, seedling vigor index, RWC, MSI, chlorophyll content decreased significantly under heat stress condition. The genotypes 843-22B, 97111B and 04999B performed better having high shoot length, seedling dry weight, seedling vigour index and high root shoot ratio.

PLANT PATHOLOGY

Screening for diseases: During *kharif* and *summer* 2019, six trials were conducted on various aspects of pathology at Mandor, Jaipur, Hisar (zone A₁), Gwalior, Jamnagar, New Delhi and Anand in zone A₁ & A and at Mysore, Aurangabad, Dhule, Coimbatore, Vizianagaram and Patancheru in zone B. Total of 333 entries were screened against downy mildew, blast, rust, smut and ergot diseases. Out of these, 169 entries were found resistant against downy mildew at 60 DAS whereas, 71 entries against blast, 204 entries against rust, 203 entries against smut and 204 entries against ergot were found resistant.

In addition, surveys were conducted to observe disease scenario during the crop season. The mean downy mildew incidence was 5.77% in zone A₁, 3.48% in zone A and 1.84% in zone B at 60 DAS in initial trial whereas in advanced trial, 8.36% downy mildew incidence in zone A₁, 5.94% in zone A and 4.46% in zone B was observed at 60 DAS. It was observed that rust and blast continued to be the main diseases of pearl millet. The range of downy mildew in the farmer's field varied from 0 to 10% according to the cultivars/varieties. It was observed that blast and rust were becoming more severe (90%) & (12%) in the states of Rajasthan and Karnataka. Blast was recorded 5-90% in all the fields of Rajasthan while high rust incidence (15%) was observed in Maharashtra. However, smut and ergot incidence was very low in the most of the surveyed states.

Table 3: Details of highly resistant entries against downy mildew, blast, rust, smut and ergot.

Trial	Total number of entries	Highly resistant entries (No.)				
		Downy Mildew	Blast	Rust	Smut	Ergot
PMPT I	115	105	32	115	114	115
PMPT II	31	18	5	31	31	31
PMPT III	38	24	7	38	38	38
PMPT Iva (DM)	64	3	-	-	-	-
PMPT IVc (Blast)	65	-	7	-	-	-
PMPT VII	20	19	20	20	20	20

ENTOMOLOGY

Eight trials in kharif and one in summer (total 9) were allotted to entomology discipline. All the experiments were conducted successfully.

Trial	No. of entries/ treatments	Major insect-pests	Reactions/ comments
PMET-1A (Jamnagar & Jaipur)	115 Initial lines/ populations	Shoot fly	At vegetative stage, 2 entries were moderate resistant & 17 entries were tolerant. At ear head stage, 15 entries were moderately resistant & 64 entries were tolerant.
		Stem borer	At vegetative stage, 20 entries were moderate resistant & 34 entries were tolerant. At ear head stage, 15 entries were resistant & 64 entries were moderately resistant
		<i>Helicoverpa armigera</i>	None of the entry was found free
		Leaf roller	8 entries were found free
PMET-1B (Jamnagar & Jaipur)	31 Advance lines	Shoot fly	At vegetative stage, 3 entries were tolerant. At ear head stage, one entry was moderately resistant & 20 entries were moderate tolerant.

		Stem borer	At vegetative stage, 9 entries were moderately resistant & 13 entries were tolerant. At ear head stage, 30 entries were moderately resistant.
		<i>Helicoverpa armigera</i>	16 entries recorded lower larval population.
		Leaf roller	Only one entry was found free. 17 entries recorded lower leaf roller damage score.
PMET-2 (Jamnagar, Anand, Jaipur, Aurangabad & Vijayapur)	Monitoring on research farm	Shoot fly	Shoot fly was observed at all the locations. However, it was higher at Jamnagar (16.0%) & Jaipur (10.54%) as compared to other locations viz., Anand (7.69%), Aurangabad (8.89%) & Vijayapur (6.93%).
		Stem borer	It was observed at all the locations except Vijayapur. However, the incidence was higher at Jamnagar (12.0%) & Anand (10.38%) in Gujarat.
		<i>Helicoverpa armigera</i>	It was observed at Jamnagar, Anand, Aurangabad & Vijayapur. The incidence was high at Jamnagar (10.40/20 E.H.) & Vijayapur (14.25/20 E.H.).
		White grub	Its damage was observed at Jamnagar (7.0%), Jaipur (6.13%) & Vijayapur (4.88%).
		Fall Army Worm (FAW)	Its damage was observed only at Aurangabad (7.22%).
		Grass hopper	It was observed at Jamnagar (6.20/20 pl.), Anand (2.92/20 pl.) & Vijayapur (5.17/20 pl.).
PMET-3 (Jamnagar, Anand, Jaipur, Aurangabad & Vijayapur)	Survey on farmer's fields	Jamnagar	64 farmer's fields were surveyed and the major were shoot fly, stem borer <i>Helicoverpa</i> , Blister beetle, grass hopper, grey weevil and leaf binder. Its intensity was low to high.
		Anand	15 fields were surveyed. The major were shoot fly, stem borer, blister beetle, grass hopper, grey weevil & leaf binder.
		Jaipur	67 fields were surveyed. The major were shoot fly, stem borer, white grub & termite, grass hopper, grey weevil, leaf binder, <i>Helicoverpa</i> & chaffer beetle.
		Aurangabad	25 fields were surveyed. shoot fly, stem borer, <i>Helicoverpa</i> & fall army worm were observed
		Vijayapur	5 fields were surveyed and shoot fly, stem borer, <i>Helicoverpa</i> , blister beetles & grass hopper were observed.

PMET-5 (Jamnagar & Jaipur)	Testing of IPM modules with farmer's practice against pest complex of pearl millet	Shoot fly & <i>Helicoverpa</i>	Seed treatment of imidacloprid 600 FS @ 8.75 ml/kg + removal of shoot fly dead hearts + fish meal trap @ 10/ha impregnated with DDVP + Spray Dimethoate 30 EC 0.03 % (10 ml/10 litres of water) at 30 DAG + Fipronil 5 SC @ 150 g a.i. /ha (broadcast after mixing in sand) at 30 DAG + Azadirachtin @ 1500 ppm (40 ml/10 lit water) at ear head stage) recorded lowest shoot fly & <i>Helicoverpa</i> incidence.
		Stem borer, white grub, termite & grass hopper	Seed treatment of imidacloprid 600 FS @ 8.75 ml/kg + removal of shoot fly dead hearts + fish meal trap @ 10/ha impregnated with DDVP + spray Novaluron 10 EC 0.01% (10 ml/10 litres of water) at 30 DAG + Fipronil 5 SC @ 150 g a.i./ha (broadcast after mixing in sand) at 30 DAG + Azadirachtin @ 1500 ppm (40 ml/10 lit water) at ear head stage recorded lowest incidence of stem borer, white grub, termite & grass hopper.
PMET-6 (Jaipur)	Evaluation of different insecticides as a soil drenching for the management of soil pests (white grub and termite) in pearl millet	White grub and termite	The soil drenching of Imidacloprid 17.8 SL @ 60 g a.i. /ha recorded lowest damage at harvest & recorded highest grain & fodder yield.
PMET-7 (Jamnagar)	Survey of insect- pests of summer bajra on farmers' field.	Jamnagar	Total 135 fields covering 31 talukas of eleven districts were observed at ear head stage during summer 2019. Shoot fly, stem borer, <i>Helicoverpa</i> & grey weevil were observed at farmer's fields.
PMET-8 (Jamnagar & Jaipur)	Relative susceptibility of pearl	Jamnagar test insect: <i>Tribolium</i>	On the basis of adult population, grain damage & per cent weight loss, the entries viz., MH 2455, MH 2224, MH 2456, MH 2228, MH 2354, MH 2192,

	millet advanced entries to storage insect pests (New trial).	<i>castaneum</i> Jaipur test insect: <i>Rhizopertha dominica</i>	Pusa Composite 383, JBV 2, 86M01 & ICMV 221 were found tolerant against <i>Tribolium castaneum</i> On the basis of adult emergence, grain damage & per cent weight loss, MH 2228, MH 2192, MH 2455 & 86M01 was found tolerant
PMET-9 (Jamnagar, Anand & Jaipur)	Monitoring of fall army worm (<i>Spodoptera frugiperda</i>) in Kharif pearl millet	Monitoring at research farm	There were no catches of Fall Army Worm (FAW) during the crop period at any of the stations.

PLANT BIOTECHNOLOGY

A lab was established at PC unit with minimal facilities and experiment was initiated.

Experiment 1: Genetic diversity analysis and molecular characterization studies in pearl millet

- Good quality genomic DNA having sharp band was successfully isolated from fresh and young leaves of 48 pearl millet hybrids and varieties using CTAB method and it was also observed that good quality DNA was extracted even without using liquid nitrogen for grinding of hard leaf tissues like pearl millet which can reduce cost of isolation.
- A total of 125 SSR primers were used for molecular characterization among 48 pearl millet genotypes. Out of the 125 SSRs, 93 primers amplified products of varying sizes and 32 (25.6 %) were monomorphic and 61 (48.8%) were polymorphic and the PIC value ranged from 0.33 to 0.75.
- Cluster analysis was carried out among the genotypes using NTSYS and SSRs markers discriminated well between the genotypes and gave 4 major clusters viz., I, II, III, IV and the similarity coefficient ranged between 0.58 to 0.73. The genetic relationships among the genotypes were consistent and the information revealed through this study is very useful and can be further used in breeding programmes.



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