

**Project Coordinator Review**  
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## REVIEW OF PEARL MILLET RESEARCH

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the most important cereal crop subsequent to rice, wheat, maize and sorghum. It is staple food of 90 million poor people and widely grown on 30 million ha in the arid and semi-arid tropical regions of Asia and Africa accounting for half of the global millet production. In India, pearl millet is the fourth most widely cultivated food crop after rice, wheat and maize. It is a C<sub>4</sub> plant having high photosynthetic efficiency, more dry matter productivity and survival under adverse agro-climatic conditions with lesser inputs and more economic returns. It is critically important for food and nutritional security of humans and animals in arid and semi-arid lands as it is early maturing, drought tolerant, requiring minimal purchase inputs and mostly free from biotic and abiotic stresses. Its inherent ability to endure high temperatures up to 42°C during reproductive phase makes it suitable for cultivation in adverse conditions, thus making it a climate resilient crop. During 2019-20, pearl millet was grown in 7.41 million ha with an average production of 10.3 million tonnes and 1391 kg/ha productivity (3<sup>rd</sup> advanced estimate from Directorate of Millets Development, 2020-21; Project Coordinator Review, 2021). The major pearl millet growing states are Rajasthan, Maharashtra, Uttar Pradesh, Gujrat and Haryana contributing to 90% of total production in the country. Rajasthan contributes nearly 4.283 million tonnes, followed by Uttar Pradesh (1.302), Haryana (1.079), Gujarat (0.961), Maharashtra (0.66) and Tamil Nadu (0.084). 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.

It is a highly nutritious, non-acid forming, non-glutinous food having several nutraceutical and beneficial health properties. Nutritional value of pearl millet is much superior than the most widely consumed cereals like wheat, rice, maize and sorghum. Due to its excellent nutritional properties, pearl millet is designated as *nutri-cereal* (Gazette of India, No. 133 dtd 13<sup>th</sup> April, 2018) for production, consumption, trade and was included in Public Distribution System (PDS). The minimum support price (MSP) of pearl millet increased to Rs. 2050 per quintal (raised by Rs. 50 which is 2.5 %) compared to the previous years MSP at Rs. 2000 resulting in highest returns when compared to all other crops. 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 2023 is declared as “International Year of Millets” by FAO Committee on Agriculture (COAG) forum.

Apart from the conductance of mandated coordinated multi location trials and evaluation of test entries, ICAR- AICRP on Pearl millet is committed to pearl millet improvement through research,

technology generation and transfer. Till date, a total of 185 hybrids and 62 varieties were identified and released for cultivation in different agro ecological zones of the country through AICRP on Pearl millet. 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 10<sup>th</sup> 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” etc. Under the NFSM, high iron/zinc pearl millet hybrids were demonstrated on large number of farmer's fields. Along with yield improvement, focus on the nutritional improvement was also given in Pearl millet. Pearl millet is the first crop in the world to introduce benchmark levels for Fe (42ppm) and Zn (32 ppm) in cultivar promotion and release since 2018 ensuring nutritional security in the country falling in line with the vision of nutritionally secure India. Development of micronutrient rich pearl millet hybrids and varieties with enhanced levels of Fe and Zn is taken up as a priority leading to 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. A<sub>1</sub> zone is also given priority for increasing pearl millet productivity at national level. Keeping this in view, series of meetings and interaction sessions were held for developing material and technologies for A<sub>1</sub> zone during 2019 and 2020. 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 and identified

- Pearl millet hybrids/varieties were notified and released for cultivation in various agro-ecologies of the country *viz.*
  - i) Hybrid BHB 1602 was released for cultivation in early maturity group for the states of Rajasthan, Gujarat and Haryana.
  - ii) One hybrid MP 7366 was released for cultivation in summer growing areas of Gujarat, Rajasthan, Uttar Pradesh, Maharashtra and Tamil Nadu.
  - iii) One hybrid HHB 311 was released as biofortified (high iron and zinc) dual purpose hybrids with high grain and dry fodder yield potential in A<sub>1</sub>, A and B zones.
  - iv) Hybrids VPMH 7, Proagro Marutej, Moti Shakti (GHB 1225) and Jam Shakti (GHB 1229) were released for the state of Karnataka, Rajasthan and Gujarat respectively.
- MP 7366 (MSH 346) hybrid was identified for cultivation for summer growing agro-ecology of the country during Varietal Identification Committee Meeting (Virtual) held on 23<sup>rd</sup> May, 2020.

### 2. Genetic enhancement

- A significant progress was made during the year 2020-21 in genetic enhancement of crop. A total of 77 new experimental cultivars and 39 released hybrids/varieties were evaluated in 14 trials during *kharif* and summer 2020 at 57 test locations in the four agro-climatic zones of the country. These genotypes expressed a wide range of grain and stover productivity (Table1).

### 3. 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 2020 were based on 42 A-lines (by name) and 70 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.



**Table 1: Details of coordinated trials on Pearl millet conducted during summer and *kharif*, 2020**

Zone	Trials	No. of test entries & checks	Range	
			Grain Yield (kg/ha)	Stover Yield (kg/ha)
A <sub>1</sub>	IHT Early	11	1108-2555	3554-6348
	AHPT Early	05	1501-2391	3487-5091
A	IHT Medium	15	2013-3744	4872-10451
	AHT Medium	04	2873-3683	6932-9285
	IHT Late	16	2440-3914	8228-14103
	AHT Late	09	3454-3904	9331-11911
	PT	16	1599-2527	5695-9415
A <sub>1</sub> & A	EDV	07	1337-2287	3420-6009
B	IHT Medium	15	2407-3287	5180-6701
	IHT Late	16	2713-3616	7721-12872
	PT	15	1878-3070	4209-5259
Summer	SHT	16	3500-5018	6354-9732

#### 4. Assessment of grain quality- Fe, Zn, protein and fat

- During the 52<sup>nd</sup> 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 analyzed for grain iron and zinc content across the locations. The iron and zinc content ranged from (41-97 ppm) and (22-51 ppm) respectively over different trials and locations.
- A total of 60 entries were assessed for quality parameters like protein and fat. The values ranged from 8.9–12.9 % in protein content and ranged from 4.7-6.5 % in fat content.

#### 5. Breeder seed production

- During 2020-21, breeder seed production of 31 parental lines (A, B & R) of hybrids and 05 OPVs was undertaken. A total of 12.18 q of breeder seed was produced which was higher than the indented quantity of breeder seed (7.11 q) from Department of Agriculture and Cooperation, Ministry of Agriculture and Farmer Welfare (GOI).

## 6. DUS test and registration of cultivars with PPV & FRA

- A total of 13 candidate varieties including 08 for second year and 03 for first year and 2 farmers varieties along with 56 reference/example varieties were tested at ICAR-AICRP on Pearl Millet, Jodhpur and ICAR-AICRP on Pearl Millet, BRS, Dhule. Observations on candidate and reference varieties for twenty eight characters were recorded as per general and specific DUS guidelines of pearl millet.

## 7. ICAR-ICRISAT partnership research

- A total of 62 R lines and 47 B lines were assessed by breeders in three trials at 12 locations on ICAR-AICRP centers and cooperating centers and superior entries were selected for utilization in their breeding programme. In Elite Inbred Joint Biofortification Trial, a total of 50 entries including checks were evaluated across 9 locations and analysis for grain iron and zinc content is under progress. In summer a forage trial - Promising OPV/Hybrids for forage Trial (32 entries) was conducted, along with one check PAC 981. Of these, 9 entries recorded higher green forage yield over check. Phenotypic data was generated for 345 genotypes in GWAS trials for blast resistance and heat tolerance.

## 8. CRP Biofortification (Pearl millet) parental line trial (CRPB PLT)

- The trial comprises 28 entries having high Fe and Zn contributed by different ICAR-AICRP on Pearl millet centers and cooperating centre like ICAR-IARI, New Delhi were evaluated successfully across 6 locations viz., Mandor, Jaipur, Hisar, New Delhi, Jamnagar and Dhule. The performance of experimental entries along with two checks viz; ICMB 98222 and Dhanshakti for days to flowering, plant height, panicle per plant and agronomic scores was analyzed. The days to 50% flowering ranged from 53 (Dhanshakti) to 68 (209-BCS-20). The plant height ranged from 106 cm (209-BCS-20) to 185 cm (HBL-19-126) and panicle per plant was 2.1 (162-SB-20) to 3.6 (PCMHFer 17-24). Agronomic scores ranged from 2.1 (PPMI 968) to 3.1 (211-BCS-20).
- The work on development of value added products, organoleptic evaluation of weaning food was carried out at CCSHAU, Hisar. The mean score on different aspects like colour, appearance, aroma, texture and overall acceptability for control sample and developed mixture were calculated and categorized as “liked moderately” and “liked very much”. Socio-impact studies and popularization of bio-fortified products, trainings to rural women on preparation of value added products from biofortified pearl millet like local delicacies, laddoo, sev, pasta, biscuits etc were done by many centres like Hisar, Dhule, Jamnagar etc. During kisan melas/exhibitions, various technologies of pearl millet were displayed and public was educated to increase intake of pearl millet based products due to the nutritional superiority.



## AGRONOMY

### Resource management

Five agronomical trials on the aspects of nitrogen management among advance pearl millet hybrid entries during summer and *kharif* seasons; Effect of polymers and crop residue on pearl millet productivity and water use efficiency (WUE), Performance of different weed management practices on pearl millet productivity, nutrient management through organic sources in rainfed pearl millet and Effect of tillage and nutrient management systems on pearl millet yield and soil properties were conducted during summer & *kharif* seasons of 2020 in different agro climatic zones (zone A<sub>1</sub>, zone A and zone B) (Table 2).

**Table 2 : List of agronomy experiments along with treatments**

S. No.	Title	Treatment
1	<b>PMAT1b:</b> Response of pearl millet advance hybrid entries to nitrogen levels <i>kharif</i> Season Zone A(1b) Summer Season Zone A& B(1d)	20 (Hybrid entries:5, N level:4)  12 (Hybrid entries: 4, N level: 3)
2	<b>PMAT2:</b> Moisture conservation through polymers and crop residues under rainfed conditions	10[T <sub>1</sub> : control (RDF), T <sub>2</sub> : T <sub>1</sub> +crop residue mulch @ 5.0 t/ha after 10-15 DAS, T <sub>3</sub> : T <sub>1</sub> + Pusa hydrogel dry application @ 5.0 kg/ha, T <sub>4</sub> : T <sub>1</sub> + SPG 1118 dry application @ 5.0 kg/ha, T <sub>5</sub> : T <sub>1</sub> + Pusa hydrogel slurry application @ 5.0 kg/ha, T <sub>6</sub> : T <sub>1</sub> + SPG 1118 slurry application @ 5.0 kg/ha, T <sub>7</sub> : T <sub>3</sub> + crop residue mulch @ 5.0 t/ha after 10-15 DAS and T <sub>8</sub> : T <sub>4</sub> + crop residue mulch @ 5.0 t/ha after 10-15 DAS, T <sub>9</sub> : T <sub>5</sub> + crop residue mulch @ 5.0 t/ha after 10-15 DAS and T <sub>10</sub> : T <sub>6</sub> + crop residue mulch @ 5.0 t/ha after 10-15 DAS]

3	<b>PMAT3:</b> Performance of different weed management practices on pearl millet productivity	8 [T <sub>1</sub> : weedy check, T <sub>2</sub> : weed free, T <sub>3</sub> : two hand weeding at 3 and 5 weeks after sowing, T <sub>4</sub> : pre emergence application of atrazine @ 400g a.i./ha fb one hand weeding at 3-4 week after sowing, T <sub>5</sub> : tembotrione 42% SC @ 90g a.i./ha at 3-4 leaf stage of weed, T <sub>6</sub> : tembotrione 42% SC @ 100g a.i./ha at 3-4 leaf stage of weed, T <sub>7</sub> : tembotrione 42% SC @ 110g a.i./ha at 3-4 leaf stage of weed, T <sub>8</sub> : tembotrione 42% SC @ 120g a.i./ha at 3-4 leaf stage of weed].
4	<b>PMAT4:</b> Nutrient management through organic sources in rainfed pearl millet	9 [T <sub>1</sub> : RDF, T <sub>2</sub> : RDN through FYM, T <sub>3</sub> : 75% RDN through FYM, T <sub>4</sub> : RDN through vermi-compost, T <sub>5</sub> : 75% RDN through vermicompost, T <sub>6</sub> : T <sub>2</sub> + biomix, T <sub>7</sub> : T <sub>3</sub> + biomix, T <sub>8</sub> : T <sub>4</sub> + biomix and T <sub>9</sub> : T <sub>5</sub> + biomix].
5	<b>PMAT 5:</b> Effect of tillage and nutrient management systems on pearl millet yield and soil properties	<p><b>Tillage practices (4)</b>  <b>CT<sub>1</sub>:</b> conventional tillage (two harrow + one cultivator and planking + two inter culture operations by kasola/wheel hand hoe/power weeder at 15-20 &amp; 30-35 DAS), <b>CT<sub>2</sub>:</b> conventional tillage (two harrow + one cultivator and planking + one inter culture operations by kasola/wheel hand hoe/power weeder at 21-28 DAS), <b>MT<sub>1</sub>:</b> minimum tillage (one harrow + one cultivator and planking + two inter culture operations kasola/wheel hand hoe/power weeder at 15-20 &amp; 30-35 DAS) and <b>MT<sub>2</sub>:</b> minimum tillage (one harrow + one cultivator and planking + one inter culture operations by kasola/wheel hand hoe/power weeder between 21-28 DAS)</p> <p><b>Nutrient supply sources (4)</b>  <b>F<sub>1</sub>:</b> 100% RDF of the zones, <b>F<sub>2</sub>:</b> 75 % N through RDF + 2.5 t/ha FYM, <b>F<sub>3</sub>:</b> 50 % N through RDF + 5.0 t/ha through FYM and <b>F<sub>4</sub>:</b> 100% N through FYM)</p>

### The salient achievements are given below :

- Performance of advanced medium and late maturing hybrids to nitrogen levels in Zone A revealed that the grain yield in the advance hybrid entry MH 2423 (27.26 q/ha) was lesser than the best check KBH 108 (28.47 q/ha). The dry stover yield was found superior in the advance entry MH 2423 (75.99 q/ha) but comparable to the higher yielder check KBH 108 (75.37 q/ha). Maximum grain (32.34 q/ha) and stover (86.24 q/ha) yields were recorded with the application of 90 kg N/ha and it produced



66.2, 32.2 and 11.6% more grain yield than the application of 0, 30 kg and 60 kg N/ha, respectively.

- During summer season of 2020, the study was conducted to see the response of one advance early hybrid entry (MH 3353) to three nitrogen levels (60, 90 & 120 kg N/ha) in comparison with three hybrid checks *i.e.* 86M64, Nandi 75 & Proagro 9444 in Zone A & B. The entry MSH 353 produced highest grain yield (34.33 q/ha) over the checks Proagro 9444 (32.04 q/ha) and Nandi 75 (30.95 q/ha) but comparable with the check 86M64 (34.03 q/ha). The dry fodder yield was found superior in the check Proagro 9444 (60.66 q/ha) followed by Nandi 75 (60.59 q/ha), 86M64 (59.01 q/ha) and lowest in the advance entry MSH 53 (56.14 q/ha). The grain yield at the highest level of 120 kg N/ha was found 21.3 and 9.9% superior over 60 and 90 kg N/ha.
- The field experiment aimed to study the effect of polymers and crop residues on the productivity, water use efficiency and microbial count of pearl millet exhibited the superior performance of the treatments T<sub>8</sub> (RDF + SPG 1118 dry application @ 5.0 kg/ha + crop residue mulch @ 5.0 t/ha after 10-15 DAS) in zone A<sub>1</sub>, T<sub>7</sub> (T<sub>3</sub> + crop residue mulch @ 5.0 t/ha after 10-15 DAS), T<sub>9</sub> (T<sub>5</sub> + crop residue mulch @ 5.0 t/ha after 10-15 DAS) in zone A and T<sub>9</sub> (T<sub>5</sub> + crop residue mulch @ 5.0 t/ha after 10-15 DAS) in zone B by 68.1, 36.9 and 39.0%, respectively over RDF alone. The water use efficiency was also found maximum *i.e.* 100.00, & 54.68 kg/ha-cm, respectively in these treatments in zones 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 were recorded significantly higher among all the treatments of polymers, crop residue and their combinations as compared to their population in the inorganic RDF treatment.

- The 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 also. The weed free treatment was found to be the best method for weed control in terms of grain (20.59 q/ha) and net returns (Rs 51048/ha) which was comparable to the tembotrione 42% SC @ 120 g *a.i.*/ha at 3-4 leaf stage of weed with grain yield of 20.38 q/ha and net returns (Rs. 47214/ha) in zone A<sub>1</sub>. However, in zone A & 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 A<sub>1</sub> and B, showed that the highest grain yield of 18.82 and 25.14 q/ha were obtained with the application of RDF through inorganic source (T<sub>1</sub>) treatment and it was followed by the organic treatment T<sub>6</sub> (RDN through FYM + biomix) with grain yield of 18.40 q/ha in zone A<sub>1</sub> and T<sub>8</sub> (RDN through vermicompost + biomix) with value of 25.00 q/ha in zone B.

In zone A, the maximum grain (26.42 kg/ha) and stover yield (69.35 kg/ha) were realized by T<sub>6</sub> (RDN through FYM + biomix) treatment and it was followed by RDF (26.35 and 68.32 kg/ha) treatment. The studies carried out at Hisar revealed that the soil chemical properties *i.e.* organic carbon (0.46-0.48%), available N (147.3-150.7 kg/ha) and P (19.2-21.0 kg/ha) status were either maintained or slightly higher in the organic treatments as compared to initial status before sowing (0.44%, 140 kg N/ha and 18 kg P/ha) and RDF treatment (0.39%, 135.0 kg N/ha and 16.3 kg P/ha).

- Effect of tillage and nutrient management systems on pearl millet yield and soil properties- this experiment was taken up on the resource conservation technology aspect with an objective to study the effect of different tillage manipulations and nutrient supply practices on the productivity, water use efficiency, physico-chemical and energy analysis in pearl millet crop. Maximum grain yield (26.44 q/ha), gross returns (Rs. 48310/ha) and B:C (1.43) were obtained in CT<sub>1</sub> with 2 intercultural operations whereas, the highest net return (Rs. 10663/ha) was obtained in CT<sub>2</sub> with one intercultural operation in zone A. In zone B, similar trend was obtained with values of grain yield (22.78 q/ha), gross returns (Rs. 45591/ha), net returns (Rs. 21347/ha) and WUE (63.77 kg/ha-cm) whereas, the BC ratio was realized in CT<sub>2</sub> with one intercultural operation. The energy input-output relation study of the experiment at Coimbatore showed that maximum energy input among the tillage practices was in CT<sub>1</sub> with 2 intercultural operations (9275 MJ/ha) and minimum in MT<sub>2</sub> with 1 intercultural operation (7911 MJ/ha) whereas, energy output (92769 MJ/ha), net energy (84293 MJ/ha), EUE (10.95) and energy productivity (0.34 kg/MJ/ha) were recorded in the CT<sub>2</sub> with 1 intercultural operation.

In zone A, among the nutrient supply treatments, maximum grain yield (26.98 q/ha), gross returns (Rs. 48101/ha), net returns (Rs. 14321/ha), B:C ratio (1.50) and WUE (78.46 Kg/ha-cm) were recorded in F<sub>1</sub> (00% RDF) which was followed by F<sub>2</sub> (75%RDF+2.5 t FYM/ha) with values of Rs. 45937/ha, Rs 11080/ha, 1.46 and 74.82 Kg/ha-cm, respectively. In zone B, the grain yield was almost at par among different treatments from 21.06-21.93 q/ha. The gross returns (Rs. 44,357/ha), net returns (Rs. 22785/ha) and BC ratio (2.14) were also recorded highest in F<sub>1</sub> (100% RDF) whereas, WUE was maximum in F<sub>2</sub> treatment (44.55 Kg/ha-cm). Among the nutrient supply treatments, maximum energy consumption was in the F<sub>1</sub> (RDF) treatment (8740 MJ/ha). The energy output and net energy were higher in the F<sub>4</sub> (100% N through FYM) treatment with values of 92353 and 83752 MJ/ha. EUE (10.81) and energy productivity (0.33 kg/MJ/ha) were recorded maximum in the F<sub>3</sub> (50% RDF+5 t FYM/ha) treatment.



## FRONT LINE DEMONSTRATIONS

- During *kharif* & summer, 2020 crop seasons, various Front Line Demonstrations (FLD's) on different production aspects [Improved hybrid/variety, biofortified hybrids/varieties, use of micro nutrient  $ZnSO_4$  and biofertilizer (*Azospirillum* + PSB), use of recommended dose of NP] were conducted on 324 ha area against the target plan of 350 ha on pearl millet crop in the states Rajasthan, Haryana, Gujarat, Madhya Pradesh, Punjab, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu and Nagaland. Adoption of improved production technologies recorded 15.1% to 55.0% higher grain yield compared to the yield recorded with the farmer's practice in zone A, 9.3% to 50.8% in zone B and the increase was 11.7% to 39.8% in zone B. During summer season in Rajasthan state, recorded 43.8% to 55.3% higher grain yield compared to the yield recorded with the farmer's practice. In Nagaland, during summer 2020, all the demonstrations were failed due to very poor germination. The FLD's on biofortified hybrid/variety was conducted in 60.4 ha area (18.64%) in the state of Haryana (14 ha.), Andhra Pradesh (30 ha.), Karnataka (6.4 ha.) and Maharashtra (10 ha.). In zone-wise FLD's on biofortified hybrid/variety 14 and 46.4 ha. in zone A and zone B, respectively. In biofortified hybrid/variety the yield increase was 11.3 and 11.1% in Hisar and Gurgaon (zone A), whereas, the yield increase was 22.6, 11.7, 39.8 and 22.8% in Anantapuram, Vijayapur, Vizianagaram and Aurangabad (zone B), respectively.

## PLANT PHYSIOLOGY

Five physiological trials were conducted at Mandor, Jaipur and Jamnagar during summer and *kharif*, 2020.

- During the screening of advanced summer hybrids against terminal stress for low moisture and high temperature conditions, MSH 353 was found significant superior, which reflects its better tolerance capacity towards terminal stress condition.
- Characterization for drought tolerance to identify parental lines of pearl millet suitable for summer cultivation, inbred lines JMSB - 20101 and J-2584 at Jamnagar and inbred J-2526 and JMSB 20172 at Mandor were high yielders under low moisture and high temperature conditions. Similar performance was observed for these lines in the previous year as well.
- In the experiment on photosynthate partitioning and remobilization in pearl millet under rain-fed condition, Pusa composite 612 exhibited maximum plant height (220 & 225.5 cm) and stem dry weight (48.2 & 50.3 g). MPMH 17 exhibited maximum panicle dry weight (67.5 g), grain yield (51.4 g), PNHI (75.98) and HI (45.40) at Mandor. Pusa Composite 612 (6) exhibited maximum plant height (153 & 184 cm), stem dry weight (36.0 & 61 g), leaf dry weight (18.0 g & 30.67 g) at both stages at Jamnagar whereas in Jaipur, Pusa Composite-443 had maximum plant height (215.60 &

225.37 cm) and stem dry weight (50.77 & 62.0 g) at both stages. Highest grain yield (51.36 & 81.77 g) and HI (45.40 & 39.39) were recorded in MPMH 17 at Mandor and Jaipur centres.

- In the experiment on “Identification of physiological traits for drought tolerance in pearl millet”, result showed that number of leaf, number of tillers, dry weight of stem (gm), leaf dry weight (gm), CGR, RGR increased significantly from 30, 45, and 60 DAS at all centres whereas plant height, stem dry weight and panicle weight increased significantly from 45, 60 DAS till to maturity at all centres. CGR and RGR decreased significantly from 60 DAS and maturity at Mandor and Jaipur location and same pattern was found in RGR but CGR and RGR were increased from 45, 60 DAS and maturity at Jamnagar centre
- In the experiment on “Identification of heat stress tolerance in pearl millet genotypes at seedling stage”, the parameters viz., shoot length, seedling dry weight, seedling vigor index, RWC, MSI, chlorophyll content decreased significantly under heat stress condition. The genotypes 843-22 B, J-2579 and 93333 B performed better having high shoot length, seedling dry weight, SVI and RWC at Jaipur while 843-22 B, 97111B and 93333 B performed better at Mandor.

## PLANT PATHOLOGY

**Screening for diseases:** During *kharif* and summer 2020, six trials were conducted on various aspects of pathology at Mandor, Jaipur, Hisar (zone A<sub>1</sub>), Gwalior, Jamnagar, New Delhi and Anand in zone A<sub>1</sub> & A and at Mysore, Aurangabad, Dhule, Coimbatore, Vizianagaram and Patancheru in zone B. Total of 251 entries were screened against downy mildew, blast, rust, smut and ergot diseases. Out of these, 251 entries were found resistant against downy mildew at 60 DAS however, 131 entries against blast, and all the entries found resistant to rust, smut and ergot disease at 60 DAS.

In addition, surveys were conducted to observe disease scenario during the crop season. The mean downy mildew incidence 3.49% in Zone A<sub>1</sub>, 3.25% in Zone A and 3.62% in Zone B was observed at 60 DAS in initial trial whereas in advanced trial, mean downy mildew incidence is 2.44% in Zone A<sub>1</sub>, 2.27% in Zone A and 2.30% 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 (80%) & (15%) in the states of Maharashtra and Karnataka. Blast was recorded 1-80% in majority of the farmers' fields of Maharashtra, Rajasthan, Gujarat, and Karnataka 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	65	65	53	65	65	65
PMPT II	30	30	18	30	30	30
PMPT III	39	30	37	39	39	39
PMPT IVa	51	40	-	-	-	-
PMPT VII	16	16	16	16	16	16
PMPT IVc	51	-	7	-	-	-

## ENTOMOLOGY

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

**Table 4 : Details of entomology experiments conducted during 2020-21**

<b>PMET-1A. Screening of pearl millet lines against major insect pests (initial lines/populations)</b> Locations - (Jamnagar & Jaipur); No. of test entries = 65	
Shoot fly	At vegetative stage, 4 entries (MH 2563, MH 2560, MH 2558, ICMV 221) were moderate resistant (0.1-5.0%) & 39 entries were tolerant (5.1-10.0%). At ear head stage, 15 entries were moderate resistant (0.1-5.0%) & 39 entries were tolerant (5.1-10.0%).
Stem borer	At vegetative stage, 2 entries (PB 1705 & JBV 2) were resistant (0.0%), 31 entries were moderate resistant (0.1-5.0%) and 25 entries were tolerant (5.1-10.0%). At ear head stage, 39 entries were resistant (0.0%) & 26 entries were moderate resistant (0.1-5.0%).
<i>Helicoverpa armigera</i>	28 entries were found free.
Leaf roller	HHB 272 was found free .

<b>PMET-1B. Screening of pearl millet lines against major insect pests (advance lines)</b> Locations - (Jamnagar & Jaipur); No. of test entries = 30	
Shoot fly	At vegetative stage, 12 entries (MH 2522, MH 2423, MH 2520, MH 2512, MH 2439, RAJ 171, PB 1705, MH 2480, ICMV 221, KBH 108, MH 2474 & MH 2545) were tolerant (5.1-10.0%). At ear head stage, two entries (MH 2546 & MH 2480) were moderate resistant (0.1-5.0%) & 26 entries were tolerant (5.1-10.0%).
Stem borer	At vegetative stage, JBV 2 was found free-resistant, 20 entries were moderate resistant (0.1-5.0%) and 9 entries were found tolerant (5.1-10.0%). At ear head stage, 22 entries were free-resistant & 8 entries were found moderate resistant (0.1-5.0%).
<i>Helicoverpa armigera</i>	Nine entries were found free from larval population.
Leaf roller	MH 2480 was found free. 9 entries recorded lower leaf roller damage score (0.1-1.0).
<b>PMET-2. Monitoring of major insect pests of pearl millet on research farm</b> Locations - Jamnagar, Anand, Jaipur, Aurangabad, Vijayapur, ARS Mandor	
Shoot fly	Shoot fly was observed at all the locations. However, it was higher at Jamnagar (17.73%) & Jaipur (11.05%) as compared to other locations viz., Anand (7.31%), Jodhpur (8.38) Aurangabad (10.45%) & Vijayapur (9.09%).
Stem borer	It was observed at all the locations except Jodhpur. However, the incidence was higher at Anand (15.00%) & Jamnagar (12.73%) in Gujarat.
<i>Helicoverpa armigera</i>	It was observed at Jamnagar, Anand, Aurangabad & Vijayapur. The incidence was high at Anand (3.00/20 E.H.) & Vijayapur (1.99/20 E.H.).
White grub & termite	Its damage was observed at Jaipur (6.08%) & Vijayapur (0.99%).
Fall Army Worm (FAW)	Its damage was observed only at Aurangabad (5.00%) & Vijayapur (12.10%)
Grass hopper	It was observed at Jamnagar (13.64%), Anand (9.62%), Jodhpur (5.38%) & Vijayapur (4.63%).
Leaf binder	It was observed only at Jamnagar (15.45%), Jodhpur (13.46%) & Jaipur (1.60%).
<b>PMET-3: Survey on farmer's fields</b> Locations - Jamnagar, Anand, Jaipur, Jodhpur & Aurangabad	
Jamnagar	79 farmer's fields were surveyed and the insect-pests observed were shoot fly, stem borer <i>Helicoverpa</i> , blister beetle, grass hopper, grey weevil and leaf binder. The intensity was low to medium at different locations.
Anand	20 fields were surveyed & the insect-pests observed were shoot fly, stem borer, blister beetle, termite, white grub & grey weevil.
Jaipur & Jodhpur	99 fields were surveyed & the insect-pests observed were shoot fly, white grub, termite, grass hopper, grey weevil, leaf binder & <i>Helicoverpa</i> .
Aurangabad	25 fields were surveyed. Shoot fly, stem borer & fall army worm were observed



<b>PMET-5: Testing of IPM modules against pest complex of Pearl millet</b> Locations - Jamnagar & Jaipur; Treatments - 7	
Jamnagar	10% higher seed rate + seed treatment of imidacloprid 600 FS @ 8.75 ml/kg + removal of shoot fly dead hearts + fish meal trap @ 10/ha + seed treatment of PSB @ 10 ml/kg seed + spray azadirachtin 1500 ppm (40 ml/10 litres of water) at 30 DAG and at ear head stage recorded highest grain (1599 kg/ha) & fodder (2798 kg/ha) yield, highest additional income (13460/- per hectare), net return (Rs. 10077/- per hectare) and ICBR 1:3.98.
Jaipur	Seed treatment of imidacloprid 600 FS @ 8.75 ml/kg, installation of fish meal trap @ 10/ha and spraying of NSKE 5% at ear head stage recorded lowest shoot fly per cent incidence at ear head stage, lowest white grub & termite % damage at ear head stage, highest grain and fodder yield.
<b>PMET-6 : Evaluation of different insecticides as a soil drenching for the management of soil pests (white grub and termite) in pearl millet</b> Location: Jaipur	
White grub and termite	The soil drenching of chlorantraniprole 18.5 SC @ 60 g a.i /ha recorded lowest per cent damage of white grub & termite at harvest & recorded highest grain & fodder yield. The data pooled for 4 years (2017-20) revealed that soil drenching of Imidacloprid 17.8 SL @ 60 g a.i /ha in standing crop after 21 days of sowing recorded lowest white grub & termite per cent incidence at harvest, recorded highest grain and fodder yield along with the highest ICBR.
<b>PMET-7: Survey of insect- pests of summer bajra on farmers' field.</b> Location: Jamnagar	
Jamnagar	During summer 2020, contact was made in 12 districts to the farmers, pesticide dealer, seed industry people and Agriculture Department at ear head stage of the crop during April & May 2020 (Lock down). It was observed that <i>Helicoverpa armigera</i> was the major insect-pest at ear head stage and it was observed in all the districts except Bhavnagar & Chota Udepur. The other pests were shoot fly, stem borer & grey weevil and these were found in low intensity.
<b>PMET-8: Relative susceptibility of pearl millet advanced entries to storage insect pests (new trial)</b> Locations: Jamnagar & Jaipur	
Jamnagar	<b>Test Insect:</b> <i>Tribolium castaneum</i> On the basis of per cent grain damage, adult emergence, per cent weight loss and germination percentage the entries viz., MH 2439, MH 2543, MH 2548, MH 2550, RHB 177 & MH 2423 were found to be promising against <i>Tribolium sp</i>
Jaipur	<b>Test Insect:</b> <i>Rhizopertha dominica</i> The findings could not be included because the results were not received on time.
<b>PMET-9: Monitoring of Fall Army worm (<i>Spodoptera frugiperda</i>) in kharif pearl millet</b> Locations: Jamnagar, Anand, Jaipur, Jodhpur, Aurangabad	
Monitoring at Research Farm through pheromone traps	There were no catches of Fall Army Worm (FAW) during the crop period at Jamnagar, Anand, Jaipur & Jodhpur. However, only at Aurangabad it was observed during 34-37 <sup>th</sup> SWW.

## PLANT BIOTECHNOLOGY

### **PMBT 1: Genetic diversity analysis and molecular characterization of 24 released hybrids and varieties of pearl millet**

- A total of 156 SSR primers were used for PCR amplification and study of molecular diversity among 24 pearl millet genotypes. Out of 156 SSRs, 128 primers amplified products of varying sizes ranging from 90 to 760 bp and 37 (23.7 %) were monomorphic and 91 (58.3%) were polymorphic. PIC value varied from 0.31 to 0.78.
- Cluster analysis was carried out among the genotypes using NTSYS and SSR markers discriminated well between the genotypes and gave 4 major clusters viz., I, II, III, IV and the similarity coefficient ranged between 0.59 to 0.78. 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.

### **PMBT 2: DNA fingerprinting of identified/advanced hybrid entries of third year testing**

- Analysis of MH 2423 and MH 2439 using 36 primers displayed a unique profile. Out of the 36 primers used, 17 SSR primers (47.2%) were found polymorphic for MH 2423 and 20 SSR primers (55.6%) were found polymorphic for MH 2439.

### **PMBT 3: Molecular characterization of 24 drought/heat tolerant genotypes suitable for A<sub>1</sub> zone**

- A total of 15 SSR primers specifically reported for drought were used for PCR amplification and molecular characterization among 24 pearl millet genotypes. All the 15 SSRs amplified products of varying sizes ranging between 90-550 bp with PIC value ranging from 0.34 to 0.76.

### **PMBT 4: Validation of already reported high Fe/Zn markers among pearl millet genotypes rich in Fe and Zn content**

- A total of 103 SSR primers were used for PCR amplification and validation among 18 pearl millet genotypes. Out of 103 SSRs, 84 primers amplified products of varying sizes ranging from 90 to 750 bp.

**Table 5 : Details of plant biotechnology experiments conducted during 2020-21**

S. No.	Name of experiment	No. of genotypes	No. of markers used	No. of amplified markers	No. of polymorphic markers	Polymorphism %
1.	<b>PMBT 1:</b> Genetic diversity analysis and molecular characterization of 24 released hybrids and varieties of pearl millet	24	156	128	91	58.3%
2.	<b>PMBT 2:</b> DNA fingerprinting of identified/advanced hybrid entries of third year testing	4 (2 genotypes and 2 checks)	36	36	17 (MH2423) and 20 (MH2439)	47.2% (MH2423) and 55.6% (MH2439)
3.	<b>P M B T 3 :</b> M o l e c u l a r characterization of 24 drought/heat tolerant genotypes suitable for A1 zone	24	15	15	15	100%
4.	<b>PMBT 4:</b> Validation of already reported high Fe/Zn markers among pearl millet genotypes rich in Fe and Zn content	18	103	84	74	71.8%





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बचाव के लिए  
दो गज दूरी,  
मास्क है ज़रूरी



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