



Project Coordinator Review

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HP Yadav
Project Coordinator
(Pearl Millet)



All India Coordinated Research Project on Pearl Millet

Jodhpur 342 304, Rajasthan, India

www.aicpmip.res.in

Review of Pearl Millet Research

Pearl millet is a major food, feed and fodder crop for feeding the world population. In India, pearl millet research activities were being carried out through All India Coordinated Millet Improvement Project, established in 1965 with a mandate of development of high yielding millet genotypes and refinement of production and protection technologies for betterment of millet growing farmers'. The All India Coordinated Pearl Millet Improvement Project was created in 1985 for conducting research activities exclusively on pearl millet crop. At present the project activities are being carried out at 13 All India Coordinated Project Centres. These centres are located in the states of Rajasthan, Maharashtra, Gujarat, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, Andhra Pradesh, Karnataka & Tamil Nadu. The Project Coordinator's Office is located at Mandor (Jodhpur), Rajasthan with its headquarters at New Delhi. In addition to the above centres there are 18 cooperating centres and more than 30 partners from private sectors. ICRISAT located at Hyderabad, India is also an active collaborator and it is working as resource organization for improving and providing useful genetic material to public as well as private sector.

The growing conditions of pearl millet vary from near optimum with high external inputs to highly drought prone environments. This allows for prioritization of research incognizance of production constraints and different requirement of various crop growing regions. Hence, the whole pearl millet growing area has been divided into three zones viz. A1, A & B. Zone A1 is comprised of parts of Rajasthan, Gujarat and Haryana receiving < 400 mm annual rainfall. Zone A composed of remaining parts of the states of Rajasthan, Gujarat and Haryana and entire pearl millet growing areas of Uttar Pradesh, Madhya Pradesh, Punjab and Delhi. This zone receives > 400 mm rainfall and has sandy loam soils. Zone B includes states of Maharashtra, Karnataka, Tamil Nadu & Andhra Pradesh with rainfall > 400 mm and has heavy soils and mild temperature conditions.

The concerted efforts of the scientists associated with pearl millet improvement have resulted in development of pearl millet hybrids with grain yield potential of 40-50 q/ha. However, the national average of pearl millet productivity is about 1100 kg/ha. Thus, there is a big gap in potential and realized productivity. Less adoption of

production technology, timely in availability of quality seed and illiterate farming community are the major reasons for this gap in potential and realized productivity.

Wide array of hybrids and varieties develop under auspices of AICPMIP fit into diverse cultivation and consumption requirements. At present, in addition to providing suitable genotypes for various cropping systems emphasis is also being given towards developing genotypes with high nutrition value especially Fe and Zn, development of dual-purpose genotypes to meet the demand of fodder, in animal supported suitable agriculture system of traditional pearl millet growing region. Special emphasis is being given on development of early maturing genotypes for rain fed areas and also for intercropping system.

Brief review of progress of research and salient achievements during 2012-13 are presented below:

1. Trends in pearl millet cultivation:

During the period under report pearl millet occupied an area of 7.95 mha with production of 8.9 m tonnes and productivity of 1106 kg/ha. The figures are almost in line with those of 2012-13. There is marginal an increase in area with decrease in productivity by 92 kg/ha. The decrease in productivity is mainly due to delay in the onset of monsoon and also drought period from mid August to mid September in the major pearl millet growing area of the country (Table 1).

Table 1: Area, production and yield of pearl millet in India (2004-2013).

Period	Area (mha)	Production (mt)	Productivity (Kg/ha)
2003-04	10.61	12.11	1149
2004-05	9.23	7.93	859
2005-06	9.58	7.68	802
2006-07	9.51	8.42	886
2007-08	9.57	9.97	1042
2008-09	8.75	8.81	1015
2009-10	8.9	6.51	731
2010-11	9.61	10.36	1079
2011-12	8.71	10.28	1171
2012-13	7.3	8.74	1198
2013-14*	7.95	8.79	1106

*= Advance estimate

2. Release of new hybrids

Six hybrids were released and notified in 2013-14 for different growing regions and seasons. For kharif season hybrids MPMH 17 (MH 1663), 86M89 (MH 1747) GHB-905 (MH 1655) and KBH 108 (MH 1737) were released and notified for zone A (high rainfall area of north and north-western India) comprising the states of Rajasthan, Gujarat, Uttar Pradesh, Haryana, Punjab, Madhya Pradesh and Delhi. Hybrid HHB 234 (MH 1561) was released and notified for zone A1 (low rainfall areas of north-western India) comprising states of Rajasthan, Haryana and Gujarat. Hybrid Nandi-72 (MSH 238) was released and notified for summer growing areas of Gujarat, Tamil Nadu, Rajasthan and Maharashtra.

3. Genetic enhancement

A significant progress was made during the year 2013-14 in genetic enhancement of crop. A total of 149 new experimental cultivars were evaluated in 13 trials during kharif and summer 2013 at 63 test location in four agro-climatic zones of the country. These genotypes expressed a wide range of grain and stover productivity (Table 2).

Table 2: Details of trials conducted in 2013.

Zone	Trials	No. of entries	Range	
			Grain yield	Stover yield (q/ha)
A1	IHT Early	16	1467-2421	42-51
	AHPT Early	9	1848-2415	32-40
A	IHT Medium	22	2077-3216	58-92
	IHT Late	41	2260-3813	59-104
	AHT Medium	3	2454-3005	61-80
	AHT Late	9	2776-3312	86-101
	PT	12	1850-2523	53-68
	B	IHT Medium	22	1794-3167
B	IHT Late	41	2156-3891	50-98
	AHT Medium	9	1556-3362	38-54
	AHT Late	14	2810-3249	54-66
	PT	11	1384-1993	38-54
Summer	SHT	21	3773-5799	73-121

4. 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 2013 were based on 105 A-lines (by name) and 119 R lines (by name). This is contributing significantly towards genetic diversification of parental lines and ultimately of hybrids in the country.

5. Assessment of grain quality

A total of 71 test entries were assessed for quality parameters like protein and fat. A wide range in protein content (7.90 - 12.81 %) was observed in the test material demonstrating that there exists enough opportunity to select for protein content in addition to high grain and stover yields.

Special multi-location trials comprising of released hybrids and varieties for zone A1, A and B were carried out for testing of iron and zinc content in kharif 2013 in which 13, 28 and 15 released hybrids and varieties, respectively, in zone A1, A and B were tested in these trials against check ICTP 8203. Range of iron and zinc along with superior hybrids are presented in table 3.

Table 3: Zone-wise details of superior pearl millet released hybrids and varieties containing high iron and zinc.

Zone	Range (ppm)		Superior varieties	
	Iron	Zinc	Iron	Zinc
A1	42 - 54	38 - 46	ICMH 356 (> 54 ppm)	ICMH 356 (> 45 ppm)
A	40 - 67	31 - 71	ICMV 221, JKBH 26, Nandi 65 and JKBH 676 > 58 ppm	JKBH 26, ICMV 221 and JKBH 676 > 43 ppm
B	39 - 61	40 - 53	ICMV 221 and Shradha > 60 ppm	ICMV 221, Shradha and 86M86 > 45 ppm

6. Breeder seed Production

During the current year breeder seed production of 19 parental lines (A, B & R) of hybrids and of 12 OPVs was organized. A total of 27.92 q of breeder seed was produced which was 157 % of the indented quantity of breeder seed (10.84 q) from Department of Agriculture and Cooperation, Ministry of Agriculture.

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

The DUS testing was undertaken as per approved guidelines of PPV & FRA during kharif 2013. A total of 55 candidate varieties including 19 candidate varieties for second year and 36 candidate varieties for first year along with 22 reference/example varieties were tested at AICPMIP Mandor, Jodhpur and MPKV, Rahuri. Observations on candidate and reference varieties for twenty six characters were recorded as per general and specific DUS guidelines. During the year under report eleven hybrids/parental lines of pearl millet viz; HHB 197 (MH-1302), Proagro 555 (MSH 16), (PB 727), GHB-732 (MH-1307), GHB-757 (MH-1328), KPMH-1, 86M52, MRB 204, MRB 2210, BPM 901, Nirmal-40 (NPH-40) and NB-14A were registered with PPV & FRA. So far 55 cultivars and parental lines (33 Public and 22 private) have been registered with PPV and FRA and several are in the process of registration.

The monitoring team led by Dr. O.P. Yadav at AICPMIP, Mandor on 1.10.2013 and Dr. P.A. Navle at Rahuri on 4.10.2013 visited the DUS experiments. One-day training programme for awareness on Protection of Plant Varieties and Farmers' Right and DUS testing was organized at AICPMIP, Mandor, Jodhpur on Sept. 20, 2013 in which

21 scientists/technical persons (17 public, 4 private) were practically trained for recording observation in pearl millet as per DUS guidelines given by PPV & FRA.

ICAR-ICRISAT partnership research

A range of breeding material was evaluated at 13 locations at AICPMIP centers. A total of 140 R lines and 120 B lines were assessed by AICPMIP breeders and superior entries were selected for utilization in their breeding programme. Selected 94 genetic materials from various centres were also assessed for high iron and zinc content. For salinity tolerance 12 populations were assessed at one location. Phenotyping of selected material was accomplished for mapping QTL for downy mildew and drought tolerance. High forage population lines (14) were evaluated during summer 2013 for green fodder yield, leaf stem ratio and dry matter percent. Seed parent nursery comprising of 106 designated B lines and one composite were evaluated along with 2 heat tolerant hybrid checks (Proagro 9444 and 86M64) for heat tolerance.

Resource management:

Seven different agronomy trials on the aspects of nitrogen management in advance entries (early, medium and late) during kharif season and in the newly released hybrids trial during summer season, optimization of N & P nutrition in the high yielding hybrids of respective zones under assured moisture availability, integrated weed management in pearl millet, nutrient management through major and trace elements and to see the performance of newly released hybrids during summer season and advance entries during Kharif season were conducted in different agro climatic zones (Zone A1, A and B) during summer and Kharif 2013 (Table 4).

Table 4. List of the experiment along with treatments.

S. No.	Title	Entries/treatment
1	Response of advance hybrid/ population entries to nitrogen levels Zone A1 Zone A Zone B Zone A & B	9 (cultivar 3, N level 3) 15 (cultivar 5, N level 3) 36 (cultivar12, N level 3) 9 (Hybrid 3, N levels 3)
2	Optimization of nutrients for pearl millet production under assured moisture availability situation	16 (Level of N 4, Level of P 4)
3	Suitability of hybrids under varying time of sowing during summer	9 (Sowing date 03, cultivar 3)
4	Integrated weed management in rain fed pearl millet	8
5	Nutrient management through organic and inorganic sources for major and trace elements in rain fed pearl millet	12 (Control, RDF, RDF +ZnSO ₄ , RDF + FeSO ₄ , RDF + Boron, RDF + Gypsum with and without FYM)
6	Performance of advance hybrid/ population entries under different dates of sowing Zone A1 Zone A Zone B	9 (cultivar 3, Dates of Sowing 3) 12 (cultivar 4, Dates of Sowing 3) 33(cultivar11, Dates of Sowing 3)

The salient achievements are as below;

In zone A1, the performance of advance hybrid entry MH 1771 in terms of grain yield was statistically at par with both the checks RHB 177 and HHB 67 Imp., in zone A, advance entry MH 1790 produced 10.8 per cent higher grain yield than the check GHB 744 and in Zone B, the advance hybrid entries MH 1812, MH 1790, MH 1815 and MH 1816 recorded significantly higher grain yield than the check hybrids Pratap and 86M64. There was significant increase in the grain and fodder yield up to 40 kg N/ha in Zone A1, whereas, the increase was up to 90 kg N/ha in Zone A & B.

During the summer season in Zone A & B, the grain and fodder yield of pearl millet increased statistically up to 120 Kg N/ha and performance of advance entry MSH 254 was better than the check hybrid 86M64.

Optimization of nutrient studies under assured moisture available situation revealed that the grain yield increased up to RDN and 15-30 kg P/ha in zone A , up to 125 % of RDN and 45 kg P/ha in zone A and up to 125 % of RDN and 30 kg P/ha in zone B. Three years mean data (2011, 2012 & 2013) clearly indicated that in zone A, the best sowing time for pearl millet is 15th February, whereas in zone B it is the first and second fortnight of January. The performance of hybrids Proagro 9444 and GHB 538 were better in zone A, whereas, GHB 558 was superior in the zone B.

Integrated weed management studies in pearl millet revealed that post emergence application of Atrazine @ 0.4 Kg/ha followed by one hand weeding at 35 DAS was better than the pre-emergence application of Atrazine in zone A; two hand weeding at 20 and 40 DAS, post emergence application @ 0.4 kg/ha followed by one hand weeding at 35 DAS and pre emergence application of Atrazine @ 0.4 kg/ha followed by one weeding in zone A & B effectively controlled the weeds in pearl millet.

The application of 5.0 t FYM/ha improved the grain yield between 11.4 to 13.9 % in different zones. The application of ZnSO₄ in combination with RDF produced higher grain yield compared to RDF in zone A1 and A. Application of ZnSO₄, FeSO₄, Boron and gypsum in addition to the RDF recorded 16.5, 14.5, 13.2 and 12.3 percent higher grain yield than with the application of RDF alone in zone B.

There was a decrease of 12.1 and 140.7 % in zone A1; 23.3 and 50.3 percent in zone A and 5.8 and 35.0 % in zone B in the grain yield in D2 (July 25-30) and the D3 (August 10-15) sowing compared to the D1 (July 10-15).

Technology demonstrated:

Front Line Demonstrations (FLD's) on different production aspects of pearl millet were conducted on 147 ha against the target plan of 170 ha in the states of Rajasthan, Gujarat, Haryana, U.P., Tamil Nadu, Karnataka, Maharashtra and A.P. In Kharif season, adoption of improved production technologies aspects in pearl millet recorded 6.0 to 42.5 percent higher grain yield of pearl millet compared to the grain yield recorded with the farmer's cultivation practice in zone A1 & A whereas, this increase was between 13.5 to 100.7 percent in zone B. During summer season, grain yield of 2389 Kg/ha was obtained with improved cultivation practices as against grain yield (1921 Kg/ha) recorded with farmer's practices and it was superior by 24.4 percent.

Plant Physiology

Four physiological trials (Table 5) were conducted at M.R.S. Jamnagar (JAU) Gujarat during summer and kharif and Mandor during kharif season 2013. Summary of physiological trials conducted in 2013 is given below:

Table 5: Details of physiological trials.

Trial	Location	No. of treatments	Trial
PMPHY I (summer)	Jamnagar	6	Response to terminal drought stress
PMPHY I Kharif	Mandor, Jamnagar	12	Response to terminal drought stress
PMPHY II (Summer)	Jamnagar	15	Response of R & B lines against drought
PMPHY II Kharif	Mandor, Jamnagar	15	Response of R & B lines against drought
PMPHY III	Mandor, Jamnagar	7	Effect of foliar spray on agronomic parameters
PMPHY VII	Mandor, Jamnagar	12	Screening for stay-green characters in pearl millet

It was observed that entries varied in their response to moisture stress. Hybrid HHB 67 expressed minimum reduction under terminal stress. The lowest drought susceptibility index was recorded in 20102B which showed that these B-line have better adaptation under terminal stress condition and high temperature. Hybrid MH 1796 gave maximum grain yield (3333 kg/ha) and stayed green also. Benzyle adenine applied @50ppm produced maximum grain yield.

Plant Pathology

Screening for diseases: During kharif and Summer 2013 a total of 334 entries were screened against downy mildew, smut, rust, blast and ergot (Table 6). Eight pathological trials were conducted at Mandor, Jaipur, Hisar, Gwalior, Jamnagar and Anand in zone A; and at Mysore, Aurangabad, Dhule, Coimbatore and Patancheru in

zone B. Data were generated on the disease incidence on experimental cultivars, hybrids and parental lines. Out of these, 131 entries were highly resistant showing \leq 5 % downy mildew incidence at 60 DAS at all India level (Table 6A). In addition, surveys were conducted at farmer's field to assess overall disease scenario during the crop season. The diversity in downy mildew pathogen was also characterized. The mean downy mildew incidence at 60 days after sowing (DAS) was 6.55 % in zone A and 3.27 % in zone B, indicating good resistance to downy mildew in test entries evaluated in Initial Trial. Similarly, mean downy mildew incidence in genotypes evaluated in Advance Trial was <3.0 % in zone B. During field surveys, it was observed that downy mildew and blast continued to be the main diseases of pearl millet. The range of downy mildew in the farmers' field varied according to the cultivar. In general, on farmer's field, the downy mildew disease incidence was less as compared to previous year's field survey. It was observed that blast was becoming more severe in the states like Rajasthan, Maharashtra and Gujarat. Fields in Tamil Nadu were free from blast incidence. High rust incidence was observed in Tamil Nadu, Karnataka, Gujarat and Maharashtra where up to 45 % rust was recorded during the field survey. Ergot incidence was observed in Rajasthan and some fields of Karnataka.

Table 6: Details of pathological trials conducted in 2013.

Trial	Zone	No. of entries/ treatments	Locations	Diseases
PMPT I	A & B	106	10	Downy mildew, Smut, Rust, Ergot and Blast
PMPT II	A & B	63	10	Downy mildew, Smut, Rust, Ergot and Blast
PMPT III	A & B	31	10	Downy mildew, Smut, Rust, Ergot and Blast
PMPT IVA	A & B	60	11	Downy mildew
PMPT IVC	A & B	50	9	Blast
PMPT V	A & B	6	10	Downy mildew
PMPT VI	A & B	Monitoring	Farmers' field	Downy mildew, Smut, Rust, Ergot and Blast
PMPT VII	A & B	24	2	Downy mildew and Rust
PMPT VIII	A & B	4	2	Blast

Table 6A: Details of highly resistant ($\leq 5\%$) entries at All India level at 60 DAS.

Trial	Total number of entries	Highly resistant entries (No.)	Range (%)
PMPT I	106	57	1.28 (MH 1969) – 20.5 % (MH 1935)
PMPT II	63	43	0.85 (MH 1888) – 14.58 % (B 2301)
PMPT III	31	18	1.65 (RHB 177) – 11.41 % (B 2301)
PMPT IVA	60	13	2.3 (HHB 67-2 Imp) – 83.6 % (7042 S)

Entomology

Screening for insect-pests: Trials were conducted at Jaipur, Fatehpur Shekhawati and Jamnagar in which 63 genotypes were tested against key pests of pearl millet (Table 7). There was a wide range in insect infestation in various treatments.

Table 7: Summary of entomology trials conducted in 2013

Trial	No. of entries/ treatments	Major insect-pests
PMET I	63	Shoot fly, stem borer, grey weevil, leaf roller, Helicoverpa armigera
PMET II	Monitoring on Research Station	Shoot fly, stem borer, leaf binder, grass hopper, jassid, thrips, Flea beetle, Coccinelid beetle, Chrysopa, Blister beetle, earhead beetle and Helicoverpa armigera
PMET III	Survey on Farmers' field	Shoot fly, stem borer, leaf binder, grass hopper
PMET IV	8	Shoot fly and stem borer
PMET V	4	Shoot fly, stem borer and Helicoverpa armigera
PMET VI	7	Storage grain pest of pearl millet
PMET VII	11	White grub and termite



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