Project Coordinator Review

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Project Coordinator

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Review of Pearl Millet Research

Pearl millet research activities were initially taken care of by "All India Coordinated Millet Improvement Project (AICMIP)", established in 1965 with a mandate of improving millet crops. Later, AICPMIP was created in 1985 for conducting and coordinating research activities exclusively on pearl millet improvement. Presently, AICPMIP project has 13 centers that are located in pearl millet growing regions of the country viz. Rajasthan, Maharashtra, Gujarat, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu. The AICPMIP Project Coordinator's office is located at Mandor, near Jodhpur, Rajasthan. In addition, there are 18 cooperating centers and more than 30 partners from private sector. ICRISAT, an international institute with its headquarters at Hyderabad, India is also an active collaborator and has been instrumental in improving and providing useful genetic resources to both private and public sector.

Pearl millet remains the most widely cultivated cereal in India after rice and wheat. The major pearl millet growing state is Rajasthan which account for more than 50% (57.6% in current year) of pearl millet acreage in country with Maharashtra, Gujarat, Uttar Pradesh and Haryana together sharing another 40%. However, exceptionally delay in rains, less or unprofitable cultivation caused a tremendous reduction (22%) in area under this crop during current year 2012-13 (68.43 lakh ha) as against last year's (87.54 lakh ha). In order to address late rains short duration hybrids like HHB 67 (imp) and GHB 538 produced reasonable yields under late sown conditions at Mandor are promising. The HHB 67 (imp) yielded higher (4904 kg/ha) under late sown (10.08.2012) condition than normal (04.07.2012) sown crop (4509 kg/ha). The yields of GHB 538 though lesser in late sown condition (4397 kg/ha) compared to timely sowing (4786 kg/ha) it is better than HHB 67 (imp) for timely sowing.

Pearl millet used to be the staple food in arid and semi-arid regions of country particularly Rajasthan, but has been replaced by wheat and rice in last three decades. The extension of irrigation facilities and increased production of wheat and rice has been major reason for this shift. With the enhanced agricultural inputs, preference of farmers also shifted towards more economic pulses and oilseed crops. Hence, a reducing trend for area under pearl millet cultivation has been experienced in past few decades with substantial reduction in last five years (8.57 mha) as against earlier trend enduring above 9.2 mha. However, scientists working on this crop have been able to sustain production by improving performance and productivity of new hybrids with better resistance to biotic and abiotic stresses suiting diverse agro-ecological zones and cultivation conditions.

Pearl millet can provide economical grain yield (600–700 kg/ ha) under marginal and low management conditions. Hybrids with a grain yield potential of 4-5 t/ha maturing in 80-85 days in summer under irrigated and high management conditions is possible. Yields as high as 5.5 t/ha have been realized in summer cultivation in Gujarat while a potential of 7-8 t/ha was recorded in demonstration fields at Mandor during *kharif* 2011 and 2012. This not only succeeded in maintaining the sustainability of the traditional marginal environments of bajra, but in providing alternative crop for better endowed environments with high input agriculture during *kharif* as well as summer.

Wide array of hybrids and varieties developed under the auspices of AICPMIP fit into diverse cultivation and consumption requirements. In addition to providing suitable genotypes for various cropping systems, lately emphasis has also been towards developing genotypes with high nutritional value especially Fe and Zn. However, trait and usage specific breeding could not yet get preference in this crop as has been emphasized in maize (for e.g. bear making, popping, sweet grain etc). Dual purpose varieties have been developed to meet the demand of fodder, in animal supported sustainable agriculture system of traditional pearl millet growing region, time has come to explore possibilities to improve nutritional quality of the fodder, this need was felt in last Regional Committee meeting also and appears in its recommendations.

Complacent of tremendous achievements experienced in this crop during last 25 years we should take up more focused basic research while maintaining the upward trend of productivity through applied research resulting in better varieties with enhanced resistance to both biotic and abiotic stresses. Pearl millet research group has been successful in shouldering dual responsibility of addressing traditional marginal areas while providing alternative to better endowed regions.

The brief review of the progress of research and salient achievements during 2012-13 are presented here.

Fig1. Late sown HHB 67 (imp) date of sowing 10-08-2012

Fig2. Late sown GHB 538 sowing date 10-08-2012

1. Trends in pearl millet cultivation (Table 1)

All time high production (12.57 mt) and productivity (1431 kg/ha) of pearl millet was achieved during last year 2011-12, with general productivity trend remaining above 1000 kg/ha during last five years. The trends in area, production and productivity of pearl millet suggest that in general area has decreased during last five years (8.57 mha) however, larger area (9.6 mha) was sown during 2010-11 after 2003-04. A substantial decrease in area (22%) and production (42%) was recorded in current year compared to last year (2011-12), due to delayed onset of monsoon. Productivity was also low compared to 2011-12 but was comparable with general trend of 5 years.

Table 1: Area, production and yield estimates of Pearl millet during 2008-09 to 2012-13

Unit: Area in Lakh ha; Production in Lakh tonnes

S. No.	State	Season	2008-09		2009-10		2010-11		2011-12 (Advance)		2012-13 (Advance)	
			Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
1	Andhra Pradesh	*Kharif*	0.500	0.510	0.330	0.430	0.510	0.840	0.430	0.610	0.480	0.620
		Rabi	0.090	0.090	0.120	0.100	0.160	0.170				
		Total	**0.590**	**0.600**	**0.450**	**0.530**	**0.670**	**1.010**	**0.430**	**0.610**	**0.480**	**0.620**
2	Bihar	*Kharif*	0.030	0.036	0.030	0.033	0.049	0.054	0.046	0.052	0.045	0.051
3	Gujarat	*Kharif*	5.290	5.350	4.980	4.320	4.900	4.064	4.340	5.180	3.000	3.150
		Summer	1.750	4.260	1.740	3.960	3.830	6.848	4.330	10.950	2.150	4.483
		Total	**7.040**	**9.610**	**6.720**	**8.280**	**8.730**	**10.912**	**8.670**	**16.130**	**5.150**	**7.633**
4	Haryana	*Kharif*	6.100	10.790	5.850	9.320	6.610	11.850	5.770	11.770	2.900	5.080
5	Himachal Pradesh	*Kharif*	0.002	0.001	0.001	0.001	0.002	0.001	0.002	0.001	0.002	0.001
6	J & K	*Kharif*	0.179	0.106	0.174	0.109	0.166	0.099	0.190	0.112	0.176	0.105
7	Jharkhand	*Kharif*	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.009	0.002
8	Karnataka	*Kharif*	2.650	1.850	3.040	1.520	3.080	3.330	2.810	2.750	2.500	1.900
		Summer	0.010	0.020	0.010	0.010	0.010	0.010	0.060	0.060		
		Total	**2.660**	**1.870**	**3.050**	**1.530**	**3.090**	**3.340**	**2.870**	**2.810**	**2.500**	**1.900**
9	M.P.	*Kharif*	1.753	2.406	1.655	2.475	1.623	3.080	1.790	3.444	1.935	2.957
10	Maharashtra	*Kharif*	8.650	6.620	10.340	7.660	10.350	11.230	8.370	8.370	6.240	4.360
11	Orissa	*Kharif*	0.030	0.018	0.028	0.017	0.033	0.021	0.031	0.019	0.028	0.017
12	Punjab	*Kharif*	0.050	0.050	0.030	0.040	0.030	0.030	0.030	0.030	0.040	0.040
13	Rajasthan	*Kharif*	51.746	42.834	51.685	20.349	54.887	45.666	49.868	64.349	39.437	32.465
14	Tamilnadu	*Kharif*	0.567	0.841	0.544	0.823	0.495	0.774	0.553	1.188	0.309	0.470
15	Uttar	*Kharif*	8.090	13.020	8.480	13.890	9.350	15.570	8.880	16.330	9.150	16.820

	Pradesh											
16	West Bengal	*Kharif*	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000
17	Others	*Kharif*	0.036	0.068	0.004	0.006	0.037	0.061	0.036	0.061	0.025	0.037
ALL INDIA		***Kharif***	**85.675**	**84.501**	**87.173**	**60.994**	**92.124**	**96.671**	**83.149**	**114.267**	**66.277**	**68.075**
		Rabi	**0.090**	**0.090**	**0.120**	**0.100**	**0.160**	**0.170**	**0.000**	**0.000**	**0.000**	**0.000**
		Summer	**1.760**	**4.280**	**1.750**	**3.970**	**3.840**	**6.858**	**4.390**	**11.010**	**2.150**	**4.483**
		Total	**87.525**	**88.871**	**89.043**	**65.064**	**96.124**	**103.699**	**87.539**	**125.277**	**68.427**	**72.558**

Source: Directorate of Millets Development, Jaipur

2. Release of new hybrids

Thirteen hybrids and two populations were released and notified in 2012-13 for different growing regions and seasons. For *kharif* season cultivation, hybrids 86M86 (MH 1684) and Kaveri Super Boss (MH 1553) were released across both the zones viz., zone A (high rainfall area of north and north-western India) and zone B (high rainfall area of South - Central India) entailing states of Rajasthan, Gujarat, Uttar Pradesh, Haryana, Punjab, Delhi, Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka and Andhra Pradesh.

Certain hybrids were released for single zone; hybrids, 86M66 (MH 1617), MP-7792 (MH 1609), MP-7872 (MH 1610) and Bio 448 (MH 1671) were released for zone A. Hybrids, PAC 909 (MH 1435), VBBH 3040 (MH 1578) and Pratap (MH 1642) were released for zone B. Whereas, Hybrid Bio 70 (MH 1632) and variety MBC 2 (MP 489) were released for zone A1 (low rainfall areas of north–western India, including states of Rajasthan, Haryana and Gujarat). Hybrid Nandi-70 (MSH 224) was released for summer growing areas of Gujarat, Tamil Nadu, Rajasthan and Maharashtra. Hybrids were also released at state level; Co 9 was released for state of Tamil Nadu and PKV-Raj (BBH 3) and variety ABPC-4-3 (MP 484) for Maharashtra.

3. Genetic enhancement

A significant progress was made during the year 2012-13 in genetic enhancement of crop. Number of experimental new cultivars (145) was evaluated in 13 trials during *kharif* and summer 2012 at 66 location combinations in four agro-climatic zones of pearl millet (Table 2). A wide range in their grain and stover productivity was observed.

Table 2: Details of pearl millet experimental cultivar evaluated in 2012 and range in their grain and stover yields

Zone	Trials	No. of entries	Grain yield (kg/ha)	Stover yield (q/ha)
A_1	IHT Early	19	1601-2543	41-56
	AHPT Early	6	2033-2679	43-55
A	IHT Medium	31	1811-3759	58-107
	IHT Late	32	2923-4230	82-132
	AHT Medium	4	2704-3312	70-85
	AHT Late	5	3348-3878	84-99
	PT	17	1493-2492	56-80
B	IHT Medium	31	2151-4385	44-82
	IHT Late	32	2603-4754	49-95
	AHT Medium	10	2895-3832	46-63
	AHT Late	6	3768-4391	71-81
	PT	15	1648-2759	40-60
Summer	SHT	17	3950-5755	64-105

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 2012 were based on 90 A-lines (by name) and 106 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 32 genotypes were assessed for quality parameters like protein. A wide range in protein content (8.16 - 13.21%) 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.

6. Breeder seed Production

During the current year breeder seed production of 20 parental lines (A, B & R) of hybrids and of 13 OPVs was organized. A total of 36.83 q of breeder seed was produced which is 117% higher over indented quantity of 16.95 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* 2012. Two candidate varieties DGB-013 and KBR 780 for second year and thirty five candidate varieties 86M33, 86M40, 86M76, 86M11, 86M66, 86M86, BPM 907, BPM 906 (Dual 69), BPM 904 (XL 51), BPM 905 (Tejas), SINDHU (NPH-2475), VBBH 3115, NBBH-913, Noble (VBBH 3041), JKBH 1105, JKBH 550, Sujlam 810, Nirmal-40 (NPH-40), AKASH (VBBH 350), KBR 870 KBR 721, KBR 864, NB-86R, NB-10R, NB-151R, NB-152R, NB-20R, NB-153R, KBMS 293, KBMS 231, NB-60A, NB-61A, NB-14A, NB-101A, NB-102A, for first year along with seventeen 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 guide lines. Four extant varieties HHB-146(MH-960), Pusa 605 (MH 564), Pusa Composite 334 (MP-334) and Pusa-415 (MP-739) of pearl millet were registered with PPV & FRA.

The monitoring team chaired by Dr. S. Dass visited the DUS experiments AICPMIP, Mandor on 1.10.2012 and at Rahuri on 6.09.2012. One day training on awareness on PPV & FR was organized at AICPMIP, Jodhpur in which 15 researchers from public and private sectors participated.

ICAR-ICRISAT partnership research

A range of breeding material was evaluated at 13 AICPMIP centres in order to select adapted lines to various zones. A total of 209 R-lines and 231 B-lines were assessed by AICPMIP breeders and many of them were selected for utilization in their breeding programme. In addition, 2 populations were grown over 11 locations for selection and further inbreeding to derive new parental lines of hybrids. Selected genetic materials were also assessed for high iron contents and salinity tolerance. Phenotyping of selected material was accomplished for mapping QTLs for downy mildew and drought tolerance. High Forage Population lines (22) were evaluated during summer 2012 for green fodder yield, leaf stem ratio and dry matter per cent. Seed parent nursery comprising of 153 designated B-lines was evaluated along with 2 heat tolerant hybrid checks (Proagro 9444 and 86M64) for heat tolerance during Summer 2012.

Crop management

Six agronomy trials were conducted in different agro climatic zones (Zone A1, A and B) during summer and *Kharif* 2012 (Table 3).

Table 3: Details of agronomic trails

S. No.	Title	Entries/treatment
1	Response of advance hybrid/ population entries to nitrogen levels Zone A1 Zone A Zone B	 09 (cultivar 3, N level 3) 39 (cultivar 13, N level 3) 30 (cultivar 10, N level 3)
2	Organic cultivation of pearl millet chick pea cropping sequence	08
3	Optimization of nutrients for pearl millet production under assured moisture availability situation	16 (Level of N-4, Level of P-4)
4	Suitability of hybrids under varying time of sowing during summer	09 (Sowing date 03, cultivar 3)
5	Integrated weed management in rain fed pearl millet	08
6	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)

During the year, thirteen advance hybrid and three population entries were evaluated for their response to three levels of nitrogen viz. 20, 40 and 60 Kg N/ha for zone A1 30, 60 and 90 Kg N/ha for zone A and B and 60, 90 and 120 Kg N/ha for summer season in zone A and B. The entries were compared with the check (hybrid/ population) recommended for specific zone to generate data for varietal release.

In studies on organic cultivation of pearl millet chick pea cropping sequence, application of 7.5 Ton FYM gave maximum pearl millet yield equivalent, net return along with the higher B:C ratio.

Other trials conducted to fine tune the existing technology includes:

- Optimization of nutrients under assured moisture available situation
- Suitability of hybrids under varying time of sowing during summer
- Integrated weed management in rainfed pearl millet
- Nutrient management through organic and inorganic sources for major and trace elements in rainfed pearl millet

Plant Physiology

Four physiological trials (table 4) were conducted at M.R.S. Jamnagar (JAU) Gujarat during summer and *kharif* season 2012. Summary of physiological trials conducted in 2012 is given below:

Table 4: Details of physiological trials

Trial	No. of treatments	Trial
PMPHY I	12	Agronomic performance under drought and normal conditions
PMPHY II	13	Agronomic performance under drought and normal conditions
PMPHY III	7	Effect of foliar spray on agronomic parameters
PMPHY VII	110	Screening for stay-green characters in pearl millet

It was observed that entries varied in their response to moisture stress. Hybrid MH-1719 produced maximum grain yield (5085 kg/ha) under irrigated situation while entry MP-508 produced maximum grain yield (2490 kg/ha) under terminal stress situation.

Plant Pathology

Screening for diseases: During *kharif* 2012, 294 entries were screened against downy mildew, smut, rust, blast and ergot (Table 5). Six pathological trials were conducted at Mandor, Jaipur, Fatehpur Shekhawati, 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. 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 3.92% in Zone A and 3.07% in Zone B, indicating good resistance to downy mildew in test entries evaluated in Initial Trials. Similarly, mean downy mildew incidence in genotypes evaluated in Advance Trials was <4% 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 Maharashtra, Gujarat, Rajasthan and Madhya Pradesh. Fields in Tamil Nadu were free from blast incidence. High rust incidence was observed in Maharashtra, Tamil Nadu and Karnataka where up to 60% rust was recorded during the field survey. Ergot incidence was observed in Rajasthan, Karnataka and Maharashtra.

Table 5: Details of pathological trials conducted in 2012

Trial	**Zone**	**No. of entries/ treatments**	**Locations**	**Diseases**
PMPT I	A & B	113	11	Downy mildew, Smut, Rust, Ergot and Blast
PMPT II	A & B	54	11	Downy mildew, Smut, Rust, Ergot and Blast
PMPT III	A & B	27	11	Downy mildew, Smut, Rust, Ergot and Blast
PMPT IVA	A & B	50	12	Downy mildew
PMPT IVC	A & B	30	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	20	2	Downy mildew and rust

Fourteen host differentials have been identified to distinguish pathotypes of *Sclerospora graminicola*. A downey mildew pathotype distribution map was developed by Mysore centre that would help in developing screening strategies.

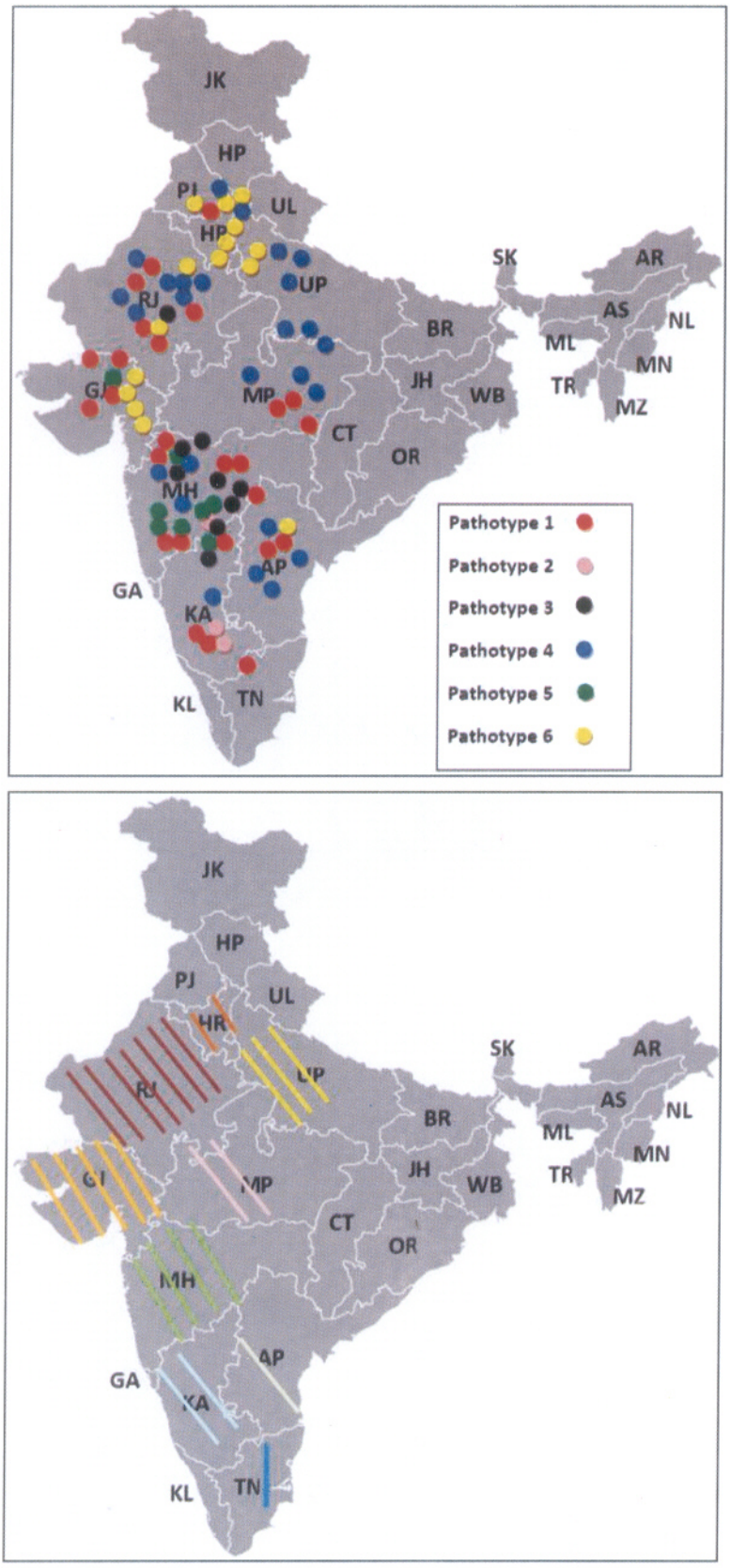

Fig3. Distribution of different pathotypes of downy mildew pathogen in different pearl millet growing regions of India

Entomology

Screening for insect-pests: Trials were conducted at Jaipur, Fatehpur Shekhawati and Jamnagar in which 54 genotypes were tested against key pests of pearl millet (Table 6). There was a wide range in insect infestation in various treatments.

Table 6: Summary of entomology trials conducted in 2012

Trial	No. of entries/ treatments	Major insect-pests
PMET I	54	Shoot fly, stem borer, grey weevil, chaffer beetle, Blister beetle
PMET II	Monitoring, Res. Station and Farmers field	Shoot fly, stem borer, leaf binder, grass hopper, aphid, jassid, thrips, Flea beetle, Coccinelid beetle and Chrysopa
PMET III	8	Shoot fly and stem borer
PMET IV	4	Shoot fly, stem borer, white grub, chaffer beetle, grey weevil
PMET V	7	Storage grain pest of pearl millet
PMET VI	11	White grub and termite

Technology demonstrated

Frontline Demonstrations (FLD's) on different production aspects of pearl millet were conducted on 279 ha against the target plan of 300 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 recorded 21.4 per cent higher grain yield of pearl millet as compared to the grain yield (1490 Kg/ha) recorded with the farmer's cultivation practice. In summer season grain yield of 3358 Kg/ha was obtained with improved cultivation practices as against grain yield of 3120 Kg/ha recorded with farmer's practices.

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