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REVIEW OF PEARL MILLET RESEARCH

In the rainfed regions of the country, pearl millet is staple food of a majority of the poor and small land holders as well as feed and fodder for livestock. About 89.5% of the cultivated area under Bajra is rainfed, i.e. without irrigation. Pearl millet excels all other cereals because it requires low input cost, mature in short duration and is considered as nutritious food, feed and fodder crop. Pearl millet is a C_4 crops having high carbon fixing properties (climate change compliant). It is the rich source of fibers and minerals especially iron, calcium, zinc and high in fats among cereals and hence can provide all the nutrients at the least cost compared to wheat and rice. Despite all these advantages, it is considered to be an inferior food crop due to lack of nutritional awareness, processing and economic incentives to farmers. Its per capita consumption is declining and production increasing that leads to high volatility in its prices and farmers' income. Its alternative uses and products are urgently needed to sustain its production.

The total area under pearl millet peaked from 9.02 million hectare in 1950-51 to 13.93 million hectares in 1973-74. After 1973-74 (the era of green revolution) the area under this crop started decreasing and has reached to the level of 7.8 million hectares in 2014-15. In spite of area shrinkage, the production of pearl millet increased almost by 4 times i.e. from 2.60 million tons in 1950-51 to 10.37 million tons in 2010-11. Highest production of pearl millet ever recorded was 12.11 million tons in 2003-04, immediately after 2002 severe drought with the corresponding highest productivity of 1.16 t/ha during 2014-15 As an average of latest data of three years (2007-08 to 2009-10) Rajasthan, Uttar Pradesh, Maharashtra, Haryana and Gujarat accounted for 92.63% of total area under Pearl millet and contributed to 92.27% of total production.

In the cultivar development greater emphasis has been given on genetic diversification of both seed and pollinator parents with the result that more than 70 hybrids were released for various niche ecologies. As a result, improvement in grain productivity has further increased to 20 kg/ha/year. Breeding programme has been fully backed-up by strong seed production and marketing of pearl millet cultivars by both public and private sectors. As a result, pearl millet has recorded 48% increase in its productivity since 1990 which is highest among all food crops during last 15 years.

Pearl millet improvement research in India is carried out through the All India Coordinated Research Project on Pearl Millet (AICRP-PM) administered by Indian Council of Agricultural Research (ICAR). The AICRP-PM has a network of 14 AICRP centers in Rajasthan, Gujarat, Maharashtra, Uttar Pradesh, Karnataka, Andhra Pradesh, Madhya Pradesh, Panjab, 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 area of germplasm utilization, improvement, production, protection, value addition etc. The growing conditions for pearl millet vary from near-optimum with high external inputs to highly drought-prone environments. This led to the prioritization of research in cognizance of production constraints and differential requirement of various crop growing regions. Hence, the whole pearl millet area has been divided into zones viz., A1, A and B. Zone A1 is comprised of parts of Rajasthan, Gujarat and Haryana receiving less than 400 mm annual rainfall.

Therefore, keeping in view the achievements and future requirements now the major emphasis for crop improvement ,crop production and protection should be on development of crop varieties and production technology to produce more yield with per drop of water with high per day productivity along with high degree of resistance to diseases like downy mildew and blast along with high concentration of Fe & Zn and low anti nutritional factors like phytate and poly phenols in grain and oxalic acid in fodder. All these desirable factors can be combined through efficient application of biotechnological tools.

Refinement of technologies for processing for grain and 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.

The results of the research conducted during 2015-16 are summarized below:

CROP IMPROVEMENT

1. Release/identification of new hybrids

Seven hybrids/varieties were identified for release for various agro-ecologies of the country viz., three hybrids, MH 1777 (MPMH 21), MH 1837 (HHB 272) and MH 1828 (JKBH 1008) for early maturity group in Zone A1 (Drier part of Rajasthan, Gujarat and Haryana); one variety MP 535 (Pusa Composite 701) for Zone A (Rajasthan, Gujarat, Haryana, UP, MP, Punjab and Delhi), two hybrids, MH 1890 (86M84) and MH 1888 (86M82) for Zone A (Rajasthan, Gujarat, Haryana, UP, MP, Punjab and Delhi) for late maturity group, and one hybrid MSH 276 (86M13) for summer cultivation in states of Rajasthan, Gujarat, UP, Maharashtra and Tamil Nadu.

2. Genetic enhancement

A significant progress was made during the year 2015-16 in genetic enhancement of crop. A total of 174 new experimental cultivars were evaluated in 14 trials during *kharif* and *summer* 2015 at 68 test locations in the four agro-climatic zones of the country. These genotypes expressed a wide range of grain and stover productivity (Table1).

Table 1: Details of trials conducted in 2015

Zone	Trials	No. of test entries	Range	
			Grain yield (kg/ha)	Stover yield (q/ha)
A1	IHT Early	22	1890-3382	39-59
	AHPT Early	5	2695-3305	51-60
A	IHT Medium	27	2532-3662	51-85
	IHT Late	39	2835-4474	67-114
	AHT Medium	6	3380-3944	89-94
	AHT Late	7	3569-3945	72-100
	PT	13	1404-2697	38-81
B	IHT Medium	27	2227-3805	42-74
	IHT Late	39	2615-4584	42-90
	AHT Medium	8	2902-3457	43-59
	AHT Late	10	3544-4259	64-86
	PT	14	1535-2854	36-67
A1, A and B	HT (Fe & Zn)	24	2838-3850	56-88
Summer	SHT	18	3310-4552	67-93

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 2015 were based on 112 A-lines (by name) and 147 R-lines (by name). This is contributing significantly towards genetic diversification of parental lines and ultimately of hybrids in the country.

4. Assessment of grain quality

- A total of 72 test entries were assessed for quality parameters like protein and fat. A wide range in protein content (9.1 – 15.9%) 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.
- A special trial for development of high iron and zinc hybrids was carried out in which hybrids MH 2185, MH 2075, MH 2172, MH 2180, MH 2178, MH 2076 and MH 2177 were identified having high iron (71-90 ppm) and zinc (42-49 ppm) content along with high grain yield.
- Iron and zinc content of hybrids tested in advance trials in zone A1, A and B during *kharif* 2015 were also estimated. Range of iron and zinc along with superior hybrids are presented in table 2.

Table 2: Zone-wise details of superior pearl millet test hybrids and varieties containing high iron and zinc

Trial	Hybrid	Iron (ppm)	Zinc (ppm)
AHT (M)-A	MH 1928	61	33
AHT (M)-B	MH 1939	55	31
AHT (L)-A	MH 1970	58	39
AHT (L)-B	MH 1962	54	32
	MH 1964	54	28

5. Breeder seed Production

During the current year breeder seed production of 21 parental lines (A, B & R) of hybrids and 10 OPVs was organized. A total of 30.19 q of breeder seed was produced which was much higher than the indented quantity of breeder seed (8.37 q) from Department of Agriculture and Cooperation, Ministry of Agriculture.

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

- The DUS testing was undertaken as per approved guidelines of PPV & FRA during *kharif* 2015. A total of 49 candidate varieties including 22 for second year and 27 for first year along with 17 reference/example varieties were tested at AICRP on Pearl Millet, 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 nineteen cultivars and parental lines namely KBMS 293, NBBH-913, 86M66, 86M33, BPM907, KBMS 231, KBR 864,

86M86, NBH-216, JKBH-550, VBBH 3115, NBH-1188 (Big B), 86M01, NBH-1134, NBH-2223, NBH-4455, NBH-216, KBR 721, NBH-1717 and RHRBH-9808 were registered with PPV and FRA and several are in the process of registration. So far 100 cultivars and parental lines (34 Public and 66 Private) have been registered with PPV and FRA.

- The monitoring team led by Dr. C.L.L. Gowda at AICRP on Pearl Millet, Mandor on 1st October, 2015 and by Dr. H.P. Yadav at Rahuri on 4th September, 2015 visited the DUS experiments.
- DUS Guideline Review Meeting of Pearl Millet were held on 29th July, 2015 at DOR, Hyderabad, 23rd September, 2015 at IIMR, Hyderabad and on 1st October, 2015 at AICRP on Pearl Millet, Mandor under the chairmanship of Dr. C.L.L. Gowda, Ex. DDG (Research) and Chairman Task Force for revision of DUS guidelines.

7. ICAR-ICRISAT partnership research

A total of 159 R lines and 154 B lines were studied at 18 locations of AICRP centers and cooperating centers and superior lines selected by breeders will be utilized by different centre's in their breeding programme. In high iron and zinc trials parental lines viz., ICTP 8203 S1-55-3-1-1, ICMB 02333, ICMB 98222, ICFe15-13, ICFe15-12, ICFe15-14 and ICFe15-15 were identified as superior to the best check Dhanshakti and recorded 95-120 ppm iron and 50-61 ppm zinc. Phenotyping of selected material was accomplished for mapping QTL for downy mildew and drought tolerance. Entry IP 6107 and IP 19586 were recorded high green forage yield. In high forage hybrid trial 12 entries out-yielded in green fodder yield (5.7-24.7%) to the best check PAC 981.

Resource management:

Six different agronomy trials on the aspects of nitrogen management in the advance hybrid entries & released hybrids (medium and late), Integrated Nutrient Management (INM) for pearl millet hybrids, Foliar application of $FeSO_4$ on pearl millet hybrids, Irrigation scheduling for summer pearl millet hybrids, Maximization in the pearl millet productivity under late sown situations and to evaluate the comparative performance of advance entries under different sowing dates during *kharif* & summer seasons of 2015 were conducted in different agro climatic zones (Zone A1, Zone A and Zone B) (Table 3).

Table 3: The list of the experiments along with treatments are as under:

S. No.	Title	Treatment
1	PMAT 1: Response of advance hybrid & population entries to nitrogen levels Zone A Zone B Zone A & B	18 (Entries 6, N level 3) 27 (Entries 9, N level 3) 12 (Hybrids 4, N levels 3)
2	PMAT 2: Integrated nutrient management (INM) for pearl millet hybrids under optimum management	12 (Hybrids 3 & INM Levels 4 *i.e.* RDF of each location, RDF + PSB + *Azospirillum,* 75% of RDF + PSB + *Azospirillum* + 5.0 t FYM/ha and 50% of RDF + PSB + *Azospirillum* + 7.5 t FYM/ha.)
3	PMAT 3: Response of pearl millet hybrids to foliar application of $FeSO_4$	12 (Hybrids 3 & 4 $FeSO_4$ foliar spray *i.e.* Control, 0.25%, 0.50% & 0.75% at tillering stage (25-30 DAS)
4	PMAT 4: Irrigation scheduling for summer pearl millet hybrids	12 (3 Hybrids *i.e.* 86M64, Pro Agro 9444 and Nandi 72 & 4 irrigation levels (At 50 mm, 75 mm, 100 mm CPE and Critical Growth Stages)
5	PMAT 5: Maximization in the pearl millet productivity under late sown situations	10 (Two Sowing Dates: July 25-30 & August 10-15; 5 nutrient management practices T_1: RDF* of respective Zones, T_2: RDF + FYM @ 5.0 t/ha, T_3: 125% of RDF (N:P:K), T_4: T_2 + NPK foliar spray (19:19:19 grade) @ 0.5% at 20-25 DAS and T_5: 75% RDF + FYM @ 5.0 t/ha.)
6	PMAT 11: Performance of advance hybrids under different dates of sowing Zone A Zone B	18 (Entries 6, Dates of Sowing 3 : July 10-15, July 25-30 & August 10-15) 27 (Entries 9, Dates of Sowing 3 : July 10-15, July 25-30 & August 10-15)

The salient achievements are as below:

- Response of advance hybrid entries to different nitrogen levels revealed that in Zone A, the entry MH 1974 (3341 Kg/ha) and MH 1984 (3275 Kg/ha) were best performer for the grain yield and former entry produced 15.2% more yield than the higher yielder check 86M86 (2900 Kg/ha). The dry fodder yield was 12.4% more in MH 1984 (82.81 q/ha) than the best check 86M86 (73.65 q/ha). Maximum grain (3249 Kg/ha) and dry fodder (80.19 q/ha) yields were recorded with the application of 90 kg N/ha and it produced 690 and 389 Kg/ha more grain yield, whereas, fodder yield was 12.55 and 6.85 q/ha higher over application of 30 kg and 60 kg N/ha, respectively.

- In Zone B, maximum grain (3368 Kg/ha) and dry fodder yield (52.50 q/ha) recorded with application of 90 kg N/ha were found to be higher by 26.0 & 8.9% in grain and 25.5 and 5.6% in dry fodder yield recorded with the application of 30 kg & 60 kg N/ha, respectively. In comparison to the hybrid checks Partap (2846 Kg/ha) and Kaveri Super Boss (3066 Kg/ha), the entries MH 1976 (3162 Kg/ha), MH 1977 (3146 Kg/ha) and MH 1979 (3230 Kg/ha) produced higher grain yield.

- During the summer season in Zone A & B, the grain and dry fodder yield of pearl millet increased with increasing level of N up to 90 kg N/ha being at statistically par with 120 kg N/ha. The entry MSH 284 produced higher grain (4095 Kg/ha) and fodder yield than check 86M64 (3706 Kg/ha).

- INM studies carried out among three different hybrids in each zone showed the superiority of treatment 75% of RDF + *PSB* + *Azospirillum* + 5.0 t FYM/ha (1628 Kg/ha) over RDF alone (1412 Kg/ha) in Zone A1. In Zone A & Zone B, seed treatment with bio inoculants *Azospirillum* and *PSB* in addition to RDF was the best one & in Zone A it improved the grain and dry fodder yield to the tune of 8.1 and 10.5%, respectively over the RDF alone. Among the hybrids, HHB 234 Improved in Zone A1, RHB173 in Zone A & 86M86 in Zone B were the best performer.

- Response of pearl millet hybrids to foliar application of $FeSO_4$ studies revealed that the grain yield was improved to the tune of 39.4, 14.9 and 39.2%, respectively by the best treatment of 0.50% $FeSO_4$ foliar spray at tillering stage (25-30 DAS) over the control in Zone A1, Zone A and Zone B.

- Irrigation scheduling for summer pearl millet hybrids study revealed that the application of irrigation at 50 mm CPE recorded maximum grain yield (3927 Kg/ha) and fodder yield (59.82 q/ha). The water use efficiency was recorded maximum in 100 mm CPE treatment (109.5 Kg/ha-cm). The mean grain yield was 12.8 and 8.7% higher in the hybrid 86M64 (3612 Kg/ha) compared to

Nandi 72 (3201 Kg/ha) and Pro Agro 9444 (3322 Kg/ha). The water use efficiency was highest in 86M64 (109.1 Kg/ha-cm) followed by Nandi 72 (100.6 Kg/ha-cm) and Pro Agro 9444 (99.8 Kg/ha-cm).

- Maximization in the pearl millet productivity under late sown situations (July 25-30 & August 10-15) study showed the superiority of the treatment RDF + FYM @ 5.0t/ha + NPK foliar spray @ 0.5% at 20-25 DAS in terms of grain (1289 Kg/ha) and fodder yield (30.83 q/ha) over RDF alone (921 Kg/ha grain; 23.37q/ha fodder) in Zone A1. Also in Zone A, this treatment with grain (2551 Kg/ha) and fodder yield (63.0 q/ha) was best and superior than RDF alone (2143 Kg/ha grain and 55.7 q/ha fodder). In Zone B, RDF + FYM @ 5.0 t/ha (2452 Kg/ha), 125% of RDF (2461 Kg/ha) and RDF + FYM @ 5.0t/ha + NPK foliar spray @ 0.5% at 20-25 DAS (2453 Kg/ha) treatments recorded 11.5, 11.9 and 11.5% higher grain yield than the RDF alone (2200 Kg/ha).
- There was a decrease of 22.3 and 45.3% in grain yield of Zone A in D2 (July 25-30) and the D3 (August 10-15) sowings compared to the D1 (July 10-15) planting. In Zone B, the D_2 sowing (3350 Kg/ha) was found higher yielder than D_1 (3205 Kg/ha) and D_3 (2360 Kg/ha). The interaction effect between dates of sowing and advance entries was found significant in Zone A, thereby, indicating differential behavior of the pearl millet entries with delayed sowing.

Technology demonstrated:

During *kharif* & Summer 2015 crop seasons, various Front Line Demonstrations (FLD's) on different production aspects [Improved hybrid/variety, weed management, use of micro nutrient $ZnSO_4$ and biofertilizer (*Azosprillum* + PSB), moisture conservation practices (opening furrows in between two rows at 30-35 DAS), sowing of pearl millet at wider row spacing of 90-120 cm, pearl millet + pigeon pea intercropping system (2:1), use of recommended dose of NPK] were conducted on 225 ha area against the target plan of 250 ha on pearl millet crop in the states of Rajasthan, Gujarat, Haryana, Tamil Nadu, Karnataka, Maharashtra and Andhra Pradesh, Adoption of improved production technologies recorded 25.5% higher grain yield compared to the yield recorded with the farmer's practice in Zone A1, 24.7% in Zone A and the increase was 31.7% in Zone B. During summer season in Gujarat state, the grain yield of 3967 kg/ha was obtained with improved cultivation practices as against 3792 kg/ha recorded with farmer's practices and improving the grain yield by 4.6%.

PLANT PATHOLOGY

Screening for diseases: During *kharif and summer* 2015 seven trials were conducted on various aspects in pathology. The trials were conducted at Mandor, Jaipur, Hisar, Gwalior, Jamnagar and Anand in zone A1 and A and at Mysore, Aurangabad, Dhule, Coimbatore and Patancheru in zone B. Total of 375 entries were screened against downy mildew, smut, rust, blast and ergot diseases. Out of these, 220 entries were highly resistant showing ≤ 5% downy mildew incidence at 60 days after sowing at all India level. In addition, surveys were conducted at farmer's field to assess overall disease scenario during the crop season. The diversity in downy mildew and blast pathogen was also characterized. The mean downy mildew incidence at 60 days after sowing in Zone A1 was 3.04%, and in Zone A it was 3.05% where as in Zone B it was 4.86%, indicating good resistance to downy mildew in test entries evaluated in Initial Trial. Similarly, mean downy mildew incidence in genotypes evaluated in Advance Trial in Zone A1 was 2.48%, and in A Zone it was 3.16% whereas, in Zone B it was 4.04% at 60 days after sowing. 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 (0-14%) according to the cultivar. It was observed that blast was becoming more severe in the states like Maharashtra and as high as 60% incidence was recorded. . Blast was recorded in traces in the fields of Tamil Nadu (0-1.3%), Madhya Pradesh (0-10%) and Karnataka (0-2%). Smut incidence was very low in the most of the surveyed states. High rust incidence (25%) was observed in Maharashtra during the field's survey. Ergot was observed in fields of Tamil Nadu and Karnataka, whereas, other states were free from ergot incidence.

Table 4: Details of highly resistant (≦ 5%) entries at All India level at 60 DAS

Trial	Total number of entries	Highly resistant entries (No.)	Range (%)
PMPT I	140	114	0.75 (MH 2151) – 30.31 (MP 569)
PMPT II	59	51	0.92 (86M86) – 16.69 (B 2301)
PMPT III	29	22	0.68 (NBH 5767) – 9.93 (MCB 2)
PMPT IVa	65	17	1.3 (DMRBL-5) – 84.6 (7042 S)
PMPT VII	22	16	0-7.73 (86M64)

ENTOMOLOGY

Four trials were conducted at Jaipur and Jamnagar. For screening insect-pests, in which 59 genotypes were tested against key pests of pearl millet. For management of foliar insect-pests application of clothianidin 50 WDG @ 7.5 g/kg as seed treatment followed by spray of fipronil 40% + imidacloprid 40% WG @ 0.04% (5 g/10 lit.) at 35 DAG found effective. Among the different IPM modules tested for their effectiveness against shoot fly, IPM module consisting, seed treatment with imidacloprid 600 FS @ 8.75 ml/kg seed + fish meal trap @ 10/ha + spraying of NSKE 5% at ear head stage found effective to manage shoot fly and application of clothianidin 50 WDG @ 7.5 g/kg as seed treatment for management of soil pests was found most effective with 0.87% plant damage, whereas, plant damage in untreated check was 14.53%.

Table 5: Summary of entomology trials conducted in 2015

Trial	No. of entries/ treatments	Major insect-pests
PMET- I	59	Shoot fly, stem borer and *Helicoverpa armigera*
PMET- II	Monitoring on Research Farm	Shoot fly, stem borer, leaf binder, grass hopper, jassid, thrips, Flea beetle, Chrysopa, Blister beetle, earhead beetle, Hairy cater pillar, *Eublema silicula, lady bird beetle,* and *Helicoverpa armigera*
PMET- III	Survey on Farmers' field	Shoot fly, stem borer, leaf binder, grass hopper, Blister beetle, *Helicoverpa armigera,* Chrysopa, jassid, thrips, Hairy cater pillar, grey weevil, leaf roller and White grub
PMET- IV	9	Shoot fly and stem borer
PMET- V	4	Shoot fly, stem borer, and *Helicoverpa armigera* and White grub
PMET -VII	11	White grub

PLANT PHYSIOLOGY

Six physiological trials were conducted at Mandor, Jaipur and Jamnagar during summer and *kharif* 2015.

PMPHY-1: (Screening of advance summer hybrids against terminal stress)

Under terminal stress condition MSH 297, MSH 299 and MSH 282 were the high yielders among advance summer hybrids at Jamnagar and MSH 284, MSH 297 and MSH 287 were high yielding at Mandor.

PMPHY-2: (Characterization for drought tolerance in pearl millet genotype)

B-lines (06555B, MIR 1272 MIR 1252 and MIR 1273) and inbred lines (J-2563, J-2558, J-2551 and J- 2480) at Jamnagar and inbred line MIR 1252, J-2510, J-2480 and J-2551 at Mandor were high yielders under terminal stress condition

PMPHY-3: (Effect of foliar spray on agronomic parameters)

Among seven treatments growth substances potassium chloride (1.50%) improved grain yield and fodder yield (1667 kg/ha and 3854 kg/ha). It was followed by the Benzyl adenine applied @ 50 ppm (1339 kg/ha and 3750 kg/ha) at Mandor and at Jamnagar 3079 kg/ha, 4052 kg/ha, respectively. Whereas, at Jaipur, benzyl adenine applied @ 50 ppm gave highest grain and stover yield (2000 kg/ha and 5413 kg/ha).

PMPHY-4: (Varietal characterization in pearl millet on the basis of root and shoot traits)

Five genotypes namely, HHB 67 Improved, RHB 177, RHB 173, GHB 538 and GHB 558 were studied for drought tolerant parameters, viz; shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight at three locations (Mandor, Jaipur and Jamnagar). The genotype RHB 173 exhibited maximum shoot length, shoot fresh weight, shoot dry weight, root dry weight, root shoot ratio, whereas, RHB 177 exhibited maximum root length. Thus, these two hybrids can perform better under water stress conditions.

PMPHY-5: (Physiological mechanism of drought tolerance in pearl millet at early seedling stage)

The drought tolerant parameters viz; shoot length, seedling dry weight, relative water content, membrane stability index, chlorophyll content were decreased significantly with application of 5% and 10% PEG by inducing water stress in all the hybrids while root length and catalase activity increased significantly under water stress. The hybrids MH1984 performed better both under non stress and water

stress conditions owing to maintain higher RWC, MSI Chlorophyll content and catalase activity at 10 and 20 days after sowing at Jaipur. Only one hybrid (MH1974) performed better under PEG induced water stress condition in 10 and 20 days old seedling at Mandor as well as Jamnagar.

PMPHY-6: (Manipulation of source sinks relationship in Pearl millet through growth retardants)

The experiment was comprised of application of three concentrations of cycocel (250, 500 & 750 ppm) and mepiquet chloride (250, 500 & 750 ppm) along control. The results revealed that both cycocel and mepiquet chloride showed significant variations on physiological growth and yield attributing characters in pearl millet. Among different concentrations cycocel 500 ppm and mepiquet chloride 500 ppm exhibited maximum number of effective tiller, ear head weight, total dry matter, biological yield and grain yield. It might be on account of maintaining higher RWC, chlorophyll content and specific leaf weight by CCC and mepiquet chloride.

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