Website : www.asthafoundation.in
Frontiers in Crop Improvement
Vol 9 (2) : 128-132 (July-2021) Print ISSN : 2393-8234 Online ISSN : 2454-6011
Astha Foundation, Meerut (U.P.) India

Development of High Yielding Disease Resistant Hybrid in Pearl Millet [*Pennisetum glaucum* (L.) R.Br.] for Northern Karnataka

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Abstract

Pear Millet [*Pennisetum glaucum* (L.) R. Br.] isanimportant nutri-cereal as it contains higher level of micronutrients especially Fe and Zn compared to other cereal crops like maize, wheat, rice, sorghum etcand is one of the important sources of staple food to the large masses of the people across the globe. Heterosis is the superiority of F_1 over its parents and it has been extensively studied in pearl millet. Due to its protogynous nature, it is highly cross pollinated and well amenable to exploit heterosis, further, availability of cytoplasmic-nuclear male-sterile sources in the crop gives scope for development of hybrids in turn enhance the crop productivity. Among various biotic and abiotic stresses which impact the productivity, Blast disease caused by *Pyriculariagrisea* (Cooke) Sacc., is emerging as a major disease of concern resulting into yield loss to the tune of 62 per cent.Looking into the importance of the disease, it necessitates to breed for stable and durable disease resistant hybrids. In this context, disease resistance breeding programme was initiated at All India Co-ordinated Research Project (Millets) at Regional Agricultural Research Station, Vijayapur with the aim to develop disease resistant hybrid with high productivity. After several generations of screening, evaluation and selection of parents and crosscombinations, new hybrid, VPMH-7, was identified by crossinga good combiner and an early flowering A1 cytoplasm based malesterile line ICMA 94555 with good restorer CPRT 112. The hybrid identified has recorded significantly higher mean yield of 24.50 percent over National Check, GHB 558, in Zone 3 of Karnataka. Due to its encouraging performance, the hybrid was promoted and tested underFarm Trials andLarge Scale Demonstrations, wherein, the said hybrid recorded 12.60 and 24.80 per cent superiority over GHB 558 respectively.The hybrid is promising for blast disease resistance under field condition as compared to GHB-558, and matures early (80-85 days), making it suitable for late planting and multiple cropping system. Considering all these attributes, this disease resistant hybrid, VPMH-7, having high yield potential is released (2019) and notified (2020) for commercial cultivation in Zone 3 of Karnataka.

Key words : *Pearl millet, heterosis, male sterility, hybrid and yield, disease resistant, hybrids.*

Introduction

Pearl Millet [*Pennisetum glaucum* (L.) R. Br.] also known as bajra, is an important crop of Asian and African agriculture. It is diploid, C_4, annual and highly cross pollinated crop containing chromosome number 2n=2x=14 and belongs to the family Poacae. This cereal is grown for dual purpose for both grain and fodder across seasons,*kharif* and *summer* (under irrigated condition). It is a better source of nutrition to large masses of people providing carbohydrates, fat, dietary fiber and important micronutrients such as Fe and Zn with balanced amino acid profile. It is also an important cattle fodder crop with lower hydrocyanic acid level than sorghum. It is also used as poultry feed, hay, pasture, silage and for biofuel production. Bajra can be grown in adverse agro-climatic situations like saline and alkaline soil, low precipitation, high temperature, low or high pH, poor fertile soils where it is difficult to take up other food crops like maize and sorghum. Off-late, due to increasing health awareness especially about nutri-cereals and millets, the crop is gaining importance among the consumers as preferred choice of food crop.

Pearl Millet is cultivated on about 30 mha in more than 30 countries of five continents *viz*., Asia, Africa, North America, South America and Australia. Though majority of crop area is in Asia and Africa, pearl millet cultivation is being expanded in some non-traditional areas also such as Brazil. It is being experimented as a grain and forage crop in the UAS, Canada, Mexico, the West Asia and North Africa (WANA), Central Asia (1). India is the largest producer of bajra in the world grown in area of 7.4 million hectares with production of 9.13 million tons and productivity of 1237 kg/ha. (2).

The genetic improvement programmein general has evolved beginningwith selection in local and traditional material to use of modern tools and techniques. The

Received : June-2021; Revised : June-2021; Accepted : July-2021

Table-1 : Performance of VPMH-7 in Station Trials at Vijayapur.

Entry	Seed yield (kg/ha)		Mean	% Increase of VPMH-7
	2015	2016		
VPMH-7	3241	2982	3112	
GHB-558 (NC)	1993	2471	2232	39.4
86M86 (PC)	2729	3279	3004	3.50
CD (5%)	797.2	332.9		
CV (%)	15.6	6.81		

genetic improvement of pearl millet in India started in 1930s and largely concentrated on improving the yield by mass selection and progeny testing, which led to development of some open-pollinated varieties (OPVs) (3).

Improved populations provide useful base material for developing OPVs and inbred lines for use in development of hybrid parents. Recurrent selection and population improvement, employing progeny evaluation, generally goes through single year/season of performance evaluation, with the recombination of the selected progenies for the next cycle. Develop resistance against pathogens (4). It allows for the emergence of new recombinants in each cycle of selection, of which those found promising in progeny testing are further advanced through inbreeding and selection to develop productive inbred lines for use in the development of hybrid parentsand synthetics (1).

Pearl millet is high tillering crop with protogynous flowering and highly cross pollinated in nature. Thus, exploitation of heterosis, phenotypic and functional superiority manifested in the F_1 crosses over the parents, could be achieved effectively leading to development of superior hybrids. Various classical complementation mechanisms gave way to the study of the underlying potential cellular and molecular mechanisms responsible for heterosis. In this highly cross-pollinating crop, heterosis was exploitedby the development of a commercially viable cytoplasmic male-sterility (CMS) system involving athree-lines breeding system (A, B and R-lines) (5). There are four different sources of male sterile line in pearl millet include A_1, A_2, A_3, A_4 and A_5 Systems serving as important milestones in developing hybrids for exploitingyield potentiality over open pollinated varieties but among them A_1 source is extensively been utilized for developing hybrids followed by A_4 and A_5 sources.

The first set of male-sterile lines, Tift 23A and Tift 18A, were developed in the early 1960s at Tifton,and these lines were widely used in the breeding programs at PAU and Indian Agricultural ResearchInstitute (IARI), laying the foundation of pearl millet hybrid breeding in India (5). The first hybrid, Hybrid Bajra 1 (HB 1), was released in India during 1965 (6) followed by HB 2, HB 3, HB 4 and HB 5 resulted in 75-100 percent increase in yield over the local varieties.Later, downy mildew resistant hybrids (PHB 10 and PHB 14) were released in 1975 (6). The hybrids, BJ104 and BK560 (5141A) and CJ104 (5054A) were widely cultivated during 1977-84(8). Later many high yielding hybrids were released due to intensive effortsat ICRISAT, Hyderabad and National Agricultural Research System. From 1996 onwards,more emphasis was given for genetic diversification of both seed and pollinator parents. The high productivity with niche adaptation and greater degree of tolerance to diseases are currently being targeted. As a result, rate of improvement in grain productivity has further increased, hybrids have 25–30 per cent grain yield advantage overimproved OPVs. (3). Bio-fortified hybrids *viz*., AHB 1200 Fe (ICMH 1202), HHB 299 (ICMH 1203), and Phule Maha Shakti (ICMH 1301) were released from ICRISAT, Hyderabadin collaboration with agricultural universities. These biofortified hybrids contain more than 70 mg kg^{-1} Fe and 35 mg kg^{-1} (8).

Keeping all these things in view breeding, the present research programmewas planned with the aim to develop high yielding hybrid with resistance to blast disease and suitable to Zone-3 of Karnataka state.

Materials and Methods

The present research programme, undertaken at AICRP (Millets), Regional Agricultural Research station Vijayapur, was initiated to develop high yielding blast disease resistant hybrid. Several generations of screening, evaluation and selection was carried out across seed parent, pollen parent and cross combinations. The screening and evaluation was majorly focused on morpho-phenologial traits, disease resistance and high productivity. Among several test entries, the hybrid, VPMH-7 developed in the background of good combiner and an early flowering A_1 cytoplasm based malesterile line ICMA 94555 and restorer line, CPRT 112 was found promising. Both MS and R lines were originally received from ICRISAT, Hyderabad.

Days to 50 per cent flowering (days), plant height (cm), Number of productive tillers per plant**,** Panicle length(cm), Panicle girth (cm), 1000 seed weigh (gms) and Grain yield per hectare, and dry fodder yield per hectare were the important observations recorded.

The identified hybrid was tested initially under station trials for two consecutive years, 2015 and 2016 along with National Check, GHB 558 and Private Check, 86 M 86. The test hybrid out-yielded both the checks and hence promoted for multi-location trial (MLT) in Zone-3 across

Table-2 : Performance of VPMH-7 across the locations for Three years in MLTs in Zone 3 of Karnataka.

Sl. No.	Entry	Yield (Kg/ha)								Mean	% Increase of VPMH-7
		Vijayapura			Hagari		Bagalkot				
		2016	2017	2018	2016	2017	2016	2017	2018		
1.	VPMH-7	2912	2673	3355	1661	2202	1482	1728	2799	2352	
2.	GHB-558(NC)	2392	2262	2669	1844	1523	1204	1617	1595	1888	24.5
3.	86 M 86 (PC)	3121	2964	-	1726	2152	1019	1552	-	2089	1.0
4.	K.S. Boss (PC)	-	-	3326	-	-	-	-	3293	3309	-7.5
	CD (5%)	372	555	655	334	475	267	534	548		
	CV (%)	7.9	15.2	13.9	11.3	15.9	13.6	21.0	13.7		

Table-3 : Performance of VPMH 7 with respect to ancillary data in Multilocation Trial at Vijayapur during 2018.

Entry	Seed Yield (kg/ha)	Dry Fodder Yield (kg/ha)	Days to 50% Flowering (days)	Plant Height (cm)	Productive Tillers/ Plant	Penicle Length (cm)	Penicle Girth (cm)	1000 Seed Weight (g)
VPMH 7	3355	6790	44	129	2.9	22.7	2.9	13.0
GHB-558 (NC)	2669	4599	47	115	3.0	21.2	2.9	12.2
Kaveri Super Boss (PC)	3326	7346	55	154	2.5	24.7	3.0	11.5
VPMH 08	2483	7161	41	143	2.6	21.7	3.0	11.3
VPMV-10	2117	7593	42	127	2.5	21.9	2.9	12.8
ICMV-221 (C)	2457	6543	45	133	3.0	22.8	2.8	11.6
ICMH-1301	3280	6636	53	132	2.5	21.4	3.2	12.5
BPMH 3	2413	7562	44	136	2.8	24.5	3.0	12.5
Dhanashakti	2575	5957	46	135	2.9	20.5	2.9	14.2
MBP-5	2867	6574	45	140	2.7	20.3	2.8	13.6
ICTP-8203 (C)	2376	8241	44	145	2.7	24.0	3.1	12.9
BRBH-16620	3574	6235	52	129	2.7	22.3	3.1	12.8
MBP-2	2397	6358	48	153	2.7	21.9	2.8	11.6
VPMV-9	3232	8241	46	126	2.7	22.5	2.8	13.1
CD (5%)	655.0	788.0	1.62	13	0.5	2.5	0.3	1.2
CV (%)	13.9	6.8	2.08	6.0	11.8	6.8	7.1	6.7

Vijayapur, Bagalkot and Hagari in Karnataka and evaluated from 2016 to 2018.

It was out yielded across the locations over three years in multi location trials and promoted and evaluated in Farm Trial and Large Scale Demonstrations (LSD) in 2018.

The entry was subjected to diseasescreening at Vijayapurduring 2018, to know the blast disease reaction using 0-9 scale (10). The experimental (RCBD) data was analysed using statistical tools to arrive at appropriate conclusion.

Results and Discussion

The superior hybrid, VPMH 7, recorded significantly higher mean yield of 3112 kg per ha over National Check, GHB 558 (2232 kg per ha) and found to be on par with Private Check 86 M86 (3004 kg per ha)under Station Trial (Table-1). Higher mean grain yield was also observed in earlier studies of (11,12,13,14). Higher yield in hybrid is mainly attributed to heterosisdue to diverse parental combination. Positive heterosis for grain yield per plant was recorded in other studies as well (15). Heterosis over superior parent was also reported in previous studies (16) wherein it was opined that slight increase in some of these components *viz.,* panicle length, panicle girth, seed size, *etc*. would produce high heterosis for grain yield.Looking in to its good *perse* performance, the hybrid was promoted and tested under multi-location trial (MLT) for three years, from 2017 to 2019 in Zone-3 of Karnataka. Under MLT, over three years, VPMH-7 recorded 2352 kg per ha, 24.5 per cent higher yield over National Check, GHB-558 and found to be on par with Private Check, 86M86 (Table-2). Similar results were reported in previous studies (9,13,17). The main attribute for higher yield in the hybrid, VPMH-7,as said earlier, was heterosis, and was also noticed in several other studies (18,19,20).

It matures early and takes around 80-85 days which is on par with GHB 558 while 10-12 days early as compared to 86M86 (PC). It has recorded average plant height of 129 cm with two to three productive tillers per

Table-4 : Performance of VPMH-7 in Farm trials during 2018 in Zone-3 of Karnataka.

Locations		Grain Yield kg/ha		% incr. over GHB 558
		T1=VPMH-7	T2=GHB 558	
KVK Indi (2)	1	1240	1126	10.12
	2	1254	1140	10.00
KVK Vijayapur (2)	1	1125	1010	11.38
	2	1250	1130	10.60
AEEC, Vijayapur (1)	1	825	770	7.10
JDA Vijayapur (2)	1	1200	1000	20.00
	2	1250	1100	13.63
AEEC Gadag (2)	1	1875	1625	15.40
	2	2000	1812	10.40
KVK Hulukoti (1)	1	1817	1577	15.20
Ovearall Mean		1384	1229	12.60

Table-5 : Performance of VPMH-7 in LSD during 2018 in Zone-3 of Karnataka.

Sl. No.	Locations (8)	Grain Yield q/ha	
		T1=VPMH-7	T2=GHB 558
1.	Hanumanth Kattimani Balabatti Muddebihal tq	10.5	7.5
2.	ShivappachalavadiBalabatti Muddebihaltq	11.0	9.5
3.	Dyavalappa Gantyal Balabatti Muddebihaltq	8.5	6.5
4.	Basappa HaladagiBalabatti Muddebihaltq	12.5	10.0
5.	Nigappa Daddi Balabatti Muddebihaltq	17.0	14.0
6.	Miss Yamanavva Shivappa Daddi Balabatti Muddebihaltq	12.0	10.0
7.	Vijay Purohit Sikkeri Bagalkot Tq	14.0	11.0
8.	Basavraj Pujeri Anagwadi, Bilagi Tq	15.0	12.5
	Mean seed yield (q/ha)	12.6	10.1
	% increase over GHB-558	24.8%	

plant. The panicles have recorded average length of 22 to 23 cm with girth of 2.5-3.0 cm. The seeds of the said hybrid are bold with 1000 seed weight of 13g as compared to GHB 558 (12.2g). The longer panicle coupled with bold seeds were found to be major attributes for higher productivity of 3355 kg per ha (Table-3) compared to National Check, GHB558 (2669 kg/ha).The heterosis for the above two traits was also evident in other studies(19,20,21).

Due to its encouraging performance under MLT, the hybrid was promoted to Farm Trial and tested across 8 locations. The hybrid, VPMH-7, recoded an average yield of 1384 kg per ha (Table-4) over National Check, GHB558 (1229 kg/ha). There was also Large Scale Demonstrations (LSD) in farmers field again across 8 locations to test on farm performance, where it recorded 24.80 percent superior yield over GHB558 (Table-5).

Table-6 : Disease Incidence in MLT during Kharif2018 at Vijayapur.

S. No.	Genotypes (No of entries screened were 14)	Blast Score (1-9)
1.	VPMH 7	2
2.	GHB-558	3
3.	Kaveri Super Boss (PC)	3
4.	ICMH-1301	3
5.	VPMH 08	5

Diseases reaction to blast diseases : In India, the blast disease was first reported from Kanpur, Uttar Pradesh (22). Leaf blast in pearl millet has been found to be negatively correlated with green-plot yield, dry matter yield and digestive dry matter (23) thus affecting the productivity and quality of the crop (24).Fourteen entries along with check were screened for blast resistance using scale of 0-9 under natural field condition. Among the test hybrids, VPMH-7 found to be resistant for blast with disease score of 2as compared to check GHB 558 (3) showing moderatelyresistant reaction (Table-6).

The newly identified hybrid, VPMH-7 is high yielding and resistant to blast disease, it is also coupled with earliness making itsuitable for late planting, intercropping and multiple cropping situations under changing climatic scenario. Looking in to the performance at various levels of testing and demand for the high yielding, disease resistant hybrids, VPMH-7 was released for commercial cultivation in 2019 for Zone-3 of Karnataka and notified in 2020.

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