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Growth and productivity of pearl millet (*Pennisetum glaucum*) hybrids in rainfed areas under lower hills of north-western Himalayas in Jammu and Kashmir

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ABSTRACT

The present study was aimed to assess the production potential and performance of 20 released pearl millet [*Pennisetum glaucum* (L.) R. Br.] hybrids in sandy loam soils under rainfed conditions of Jammu performed under ICAR-All India Co-Ordinated Research Project on Pearl millet (Cooperating Centre) at Advanced Centre for Rainfed Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Rakh Dhiansar, Samba, Jammu and Kashmir during rainy (*kharif*) season of 2019 and 2020. Significantly higher growth characters, viz. plant height (179.7 cm), effective tillers/plant (1.63); yield attributing parameters like panicle length (23.9 cm), panicle diameter (3.2 cm) and test-weight (12.43 g) were recorded in hybrid GHB 732. However, significantly higher grain and biological yields (3,258 and 13,971 kg/ha) was also recorded in pearl millet GHB 732; followed by statistically similar hybrids namely HHB 223, GHB 744, XMT 1497 and PB 1705. Whereas, hybrid 86M86 registered the lowest values of growth/yield parameters including grain and biological yields. The higher numerical values of economic returns, viz. gross returns (₹91,476/ha), net profit (₹67,973/ha), benefit: cost ratio (2.89) and economic efficiency (₹765.5/ha/day) were also obtained from hybrid GHB 732. The attack of various diseases and insects was also lower in hybrid GHB 732 as compared to the other hybrids.

Keywords: Diseases, Hybrids, Insects/pests, Rainfed, Soil, Yield

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is considered as a major millet crop and is a most significant and important crop after rice, wheat, maize and sorghum which are mostly grown on rainfed areas under Indian conditions (Singh *et al.* 2020). In India, pearl millet is grown in an area of 7.57 mha with a production and productivity of 10.86 mt and 14.36 q/ha, respectively (ICAR–IASRI 2022). In Jammu and Kashmir, it is grown in about 10,000 ha, with a production and productivity of about 5.95 thousand tonnes and 5.95 q/ha, respectively (Indiastat 2020). Cereal–cereal and cereal–oilseeds are the most prevailing cropping system in the study area, locally known as Kandi (Gupta *et al.* 2014) but these systems productivity is declining in its response to the added inputs and also not providing any resilience to the changing climatic conditions (Singh *et al.* 2022, Singh *et al.* 2022a). In the stressed ecosystem in this Himalayan range, pearl millet crop is the only viable option to be grown under rainfed conditions especially when the onset of monsoon is late or very late and there isn't any possibility of sowing of major crops like cereals and oilseeds and thus could be the best choice especially under the changing climatic conditions.

The crop is infested by various insect-pests and diseases (bacterial/fungal) which might cause mild to severe losses to grain and quality of crop (Prasad *et al.* 2015, Bahadur *et al.* 2021). In Jammu region, this millet crop could be well cultivated in kandi areas on marginal and neglected lands with less or no manures/fertilisers application (Singh *et al.* 2020). Selection of appropriate hybrid/variety for a particular region is the major agronomic management for a specific area (Gupta *et al.* 2020, Gupta *et al.* 2021). Thus

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seeing the importance of this millet crop, and to enhance the production and productivity in Jammu region, introduction of new hybrids for grain purpose is very necessary. Hence, the study was aimed to evaluate various pearl millet hybrids for their production potential and the suitability under low altitude plains areas of sub tropical region of north-west Himalayas.

MATERIALS AND METHODS

The experiment was conducted during rainy (*kharif*) seasons of 2019 and 2020 under AICRP on Pearl millet (Cooperating Centre) at Advanced Centre for Rainfed Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Rakh Dhiansar, Samba (32° 39" N , 74° 53" E, 332 m amsl), Jammu and Kashmir. Soil of the experimental area was sandy loam in texture and categorised as Inceptisols under Alluvial group. The soil was near to neutral, low in available nitrogen, medium phosphorus, low potassium and organic carbon. The region lies under sub-tropical and characterised as hot and dry summer with humid monsoon. The maximum and minimum temperature during the growth of pearl millet crop (*kharif* 2019 and 2020) noted in the range of 27.6–36.7 and 29.0–35.6°C and 15.3–25.0 and 14.1–25.9°C, respectively. The total rainfall recorded during the full life cycle of pearl millet crop was recorded 502 and 487 mm in *kharif* 2019 and 2020, respectively. The experiment comprised of 20 pearl millet hybrids, viz. T_1, RHB 177; T_2, HHB 197; T_3, GHB 719; T_4, GHB 538; T_5, HHB 67; T_6, HHB 299; T_7, PB 1705; T_8, XMT 1497; T_9, GHB 905; T_{10}, MPMH 17; T_{11}, RHB 173; T_{12}, HHB 223; T_{13}, GHB 744; T_{14}, GHB 732; T_{15}, KBH 108; T_{16}, 86M86; T_{17}, Kaveri Super Boss; T_{18}, MP 7792; T_{19}, Proagro 9444 and T_{20}, GHB 558, studied in randomized block design (RBD) and replicated thrice. The size of the plot was 6 m × 4 m and with a spacing of 50 cm × 20 cm. Pearl millet crop was sown on 21st July 2019 and 31st July 2020, respectively and the various hybrids were harvested as per their physiological maturity. The essential nutrients, viz. nitrogen, phosphorus and potash were applied in the form of urea, DAP and MoP, respectively as per the package and practices of SKUAST-Jammu. Two-third of nitrogen and full doses of phosphorus and potash were applied as basal dose and rest of the nitrogen applied during 30–35 days after sowing (DAS) as per the moisture availability. By considering the prevailing market rates of labour, inputs, grain and stover of the respective years, the economics of pearl millet crop was calculated for the respective years. The weather data was collected from the Agromet Observatory situated at about 150 m from the experimental area at ACRA, Rakh Dhiansar, SKUAST-Jammu (Fig. 1). Incidence of diseases on various pearl millet hybrids was studied at 55–60 DAS under natural conditions. Insect pests attacking the crop were recorded during the crop growing season mainly after 50–55 DAS under natural conditions.

RESULTS AND DISCUSSION

Growth and yield parameters: The growth characters, viz. height, tillers/plant and yield attributing parameters, viz. effective tillers/plant, panicle length, panicle diameter and test weight were significantly affected due to pearl millet hybrids (Table 1). Significantly higher plant height (179.7 cm), tillers/plant (2.79), effective tillers/plant (1.63), panicle length (23.9 cm), panicle diameter (3.2 cm) and test weight (12.43 g) were recorded with hybrid GHB 732 which was immediately followed by hybrids HHB 223, GHB 744, XMT 1497 and PB 1705. However, significantly lower values of growth parameters and yield attributes was observed in hybrid 86M86. The higher values of growth parameters and yield attributing characters in hybrid GHB 732 and other hybrids like HHB 223 and GHB 744 might be due to their suitability and adaptability to the local environmental conditions of Jammu region which might have resulted in appropriate growth and development of pearl millet crop and thus enhanced the accumulation of photosynthates from the source to sink. Environmental factors along with the genetic make-up of various pearl millet hybrids might be responsible for the variations in the various growth parametres and yield attributing characters (Nayak *et al.* 2020). Detroja *et al.* (2018) observed a significant difference among the various pearl millet hybrids with respect to growth characters and yield attributes under rainfed conditions.

Phenology: Pearl millet hybrids took significantly different number of days to 50% flowering and physiological maturity under rainfed conditions of lower Himalayas. Pearl millet hybrids took 49–57 days for accomplishment of 50% flowering phenological stage. A great variation was also observed with respect to attaining physiological maturity in the range of 82–89 days (Table 1). The significant variation for attaining these phenophases clearly indicates

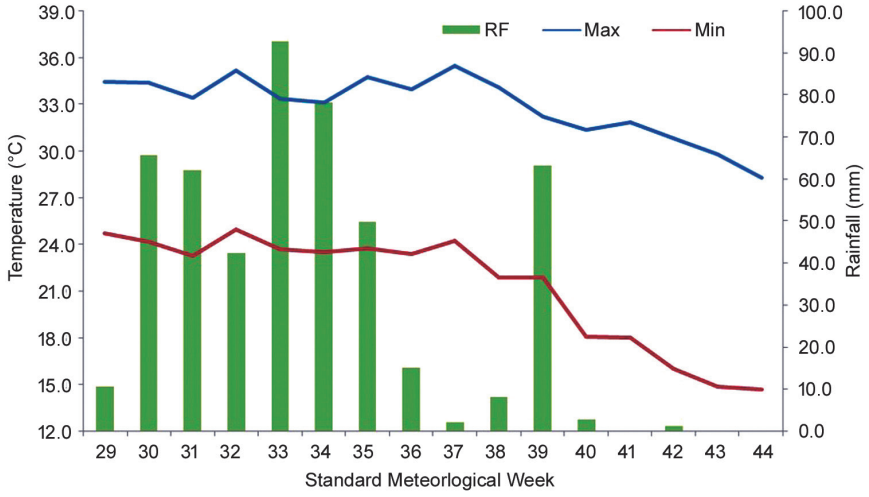

Fig. 1 Temperature (maximum and minimum) and rainfall during crop growth period of pearl millet (mean of 2 years).

Table 1 Effect of different hybrids on phenology and growth and yield attributes of pearl millet under rainfed conditions of Jammu (pooled data of 2 years)

Treatments/Hybrids	Phenology		Growth attributes		Yield attributes			
	Days to 50% flowering	Days to physiological maturity	Plant height (cm)	Total tillers/ plant	Effective tillers/ plant	Panicle length (cm)	Panicle diametre (cm)	Test-weight (g)
RHB 177	49.7	88.8	154.5	2.27	1.15	21.8	2.8	9.47
HHB 197	52.0	86.5	160.6	2.34	1.40	19.7	2.9	9.07
GHB 719	52.5	84.5	167.3	2.06	1.18	21.5	2.9	8.59
GHB 538	50.3	82.8	149.6	2.24	1.15	20.3	2.8	8.82
HHB 67 (Imp)	51.2	87.7	164.9	2.39	1.17	18.2	2.9	8.32
HHB 299	52.8	83.3	170.2	2.51	1.35	22.1	2.7	9.55
PB 1705	55.0	82.5	171.9	2.57	1.37	22.9	3.0	9.74
XMT 1497	51.8	82.8	173.8	3.30	1.38	22.9	3.0	9.88
GHB 905	53.8	86.2	150.4	2.09	1.22	22.2	2.7	9.02
MPMH 17	53.5	81.5	155.8	2.36	1.18	20.9	3.1	8.56
RHB 173	54.5	84.7	160.4	2.24	1.13	21.5	2.5	8.50
HHB 223	50.2	82.0	178.9	2.86	1.55	23.8	3.1	12.06
GHB 744	55.2	86.8	175.3	2.75	1.52	23.1	3.1	10.09
GHB 732	55.3	88.8	179.7	2.79	1.63	23.9	3.2	12.43
KBH 108	55.5	87.8	169.5	2.37	1.22	18.2	2.7	8.80
86M86	56.8	84.7	150.4	2.26	1.13	17.6	2.4	8.12
Kaveri Super Boss	53.0	85.5	170.3	2.04	1.18	21.0	2.8	8.57
MP 7792	55.2	88.5	164.5	2.11	1.17	20.6	2.9	8.59
Proagro 9444	52.0	88.3	168.6	2.42	1.30	22.1	2.7	8.80
GHB 558	51.5	88.5	161.2	2.07	1.15	22.4	2.9	9.16
CD (p=0.05)	2.5	5.6	16.10	0.25	0.17	3.57	0.30	1.47

that these phenological events have been greatly affected by environmental factors and rainfall. The sowing of pearl millet hybrids by the farmers under the rainfed conditions of Jammu region of north-western Himalayas might be beneficial especially when the onset of monsoon is late or very late which is very prevalent in this area. Similar results were also reported by Sharma (2014) and Mishra *et al.* (2015).

Yield: Among the different pearl millet hybrids tested in rainfed conditions of north-western plains of Jammu region, significantly higher grain and biological yields to the tune of 3,258 and 13,971 kg/ha, respectively were recorded in GHB 732 hybrid as compared to the other hybrids (Table 2). Whereas, hybrid 86M86 observed statistically lowest values of grain yield (1,929 kg/ha) and biological yield (10,225 kg/ha) in two years' field study. However, grain and biological yield of GHB 732 was at par with HHB 223, GHB 744, XMT 1497 and PB 1705 hybrids. An increment in grain yield to the tune of 68.9, 55.2, 54.1, 48.6 and 47.1% recorded with the hybrids GHB 732, HHB 223, GHB 744, XMT 1497 and PB 1705, respectively over the lowest yielding hybrid 86M86. The significant difference in yield might be due to potential difference in the genetic make-up of hybrids and better expression of growth attributing parametres and yield characters which might have resulted in yield enhancement of pearl millet hybrid. Nayak *et al.* (2020) and Detroja *et al.* (2018) also recorded a significant difference in the grain and biological yield of different hybrids/varieties of pearl millet under rainfed conditions whereas Maurya *et al.* (2016) and Choudhuri *et al.* (2018) also reported more or less similar findings while working on pearl millet hybrids. Thus, under the changing climatic conditions and especially during late or very late onset of monsoon, the farmers of Kandi areas of Jammu region could opt for the sowing of pearl millet.

Economics: Among the different hybrids of pearl millet, GHB 732 recorded numerically higher total (gross) returns, net profit (returns), benefit: cost (B:C) ratio and economic efficiency and was followed by HHB 223, GHB 744, XMT 1497 and PB 1705 (Table 2). The economic returns of the

Table 2 Effect of hybrids on yield and economics of pearl millet under rainfed conditions of Jammu (pooled data of 2 years)

Treatments/Hybrids	Yield		Nutrient uptake (kg/ha)			Economics			
	Grain yield (kg/ha)	Biological yield (kg/ha)	Nitrogen	Phosphorus	Potash	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio	Economic efficiency (₹/ha/day)
RHB 177	2,308	11,880	82.03	20.75	74.65	68,766	45,263	1.93	509.7
HHB 197	2,761	12,700	89.92	23.56	81.70	79,242	55,739	2.37	644.4
GHB 719	2,341	10,426	80.06	19.39	65.75	66,504	43,001	1.83	508.9
GHB 538	2,601	11,925	91.00	21.71	71.60	74,570	51,067	2.17	616.8
HHB 67 (Imp)	2,231	11,720	78.44	21.34	70.47	66,936	43,433	1.85	495.2
HHB 299	1,983	10,530	76.28	18.85	70.51	59,729	36,226	1.54	434.9
PB 1705	2,838	12,232	101.69	24.52	86.81	81,282	57,779	2.46	700.4
XMT 1497	2,866	12,976	102.54	24.86	89.94	80,342	56,839	2.42	686.5
GHB 905	2,486	13,053	88.73	23.23	79.49	74,583	51,080	2.17	592.6
MPMH 17	2,594	11,094	77.47	19.95	68.83	71,036	47,533	2.02	583.2
RHB 173	2,262	11,846	82.00	21.14	70.91	67,790	44,287	1.88	522.9
HHB 223	2,993	13,604	109.09	26.39	97.83	85,017	61,514	2.62	750.2
GHB 744	2,972	13,331	107.83	24.67	94.87	85,153	61,650	2.62	710.3
GHB 732	3,258	13,971	120.01	26.88	102.96	91,476	67,973	2.89	765.5
KBH 108	2,610	12,747	94.27	23.36	86.26	76,392	52,889	2.25	602.4
86M86	1,929	10,225	75.28	18.75	62.06	59,806	36,303	1.54	428.6
Kaveri Super Boss	2,089	11,701	82.13	21.29	71.65	64,144	40,641	1.73	475.3
MP 7792	2,216	11,128	78.34	20.09	64.94	65,465	41,962	1.79	474.1
Proagro 9444	2,306	10,773	79.42	19.10	65.29	66,504	43,001	1.83	487.0
GHB 558	2,457	11,153	81.59	20.67	68.14	70,208	46,705	1.99	527.7
CD (p=0.05)	417.8	1,598.5	13.2	3.1	10.4				

hybrid might be because of its higher productivity along with the favourable environmental conditions which could have associated with the respective pearl millet hybrids (Mishra *et al.* 2015). Socio-economic upliftment of the farmers of Kandi areas could be ensured through the incorporation of pearl millet hybrids in their cropping system.

Uptake: Pearl millet hybrids significantly affected the uptake of total nitrogen, phosphorus and potassium both in grain and stover. Hybrid GHB 732 recorded significantly higher uptake of nitrogen, phosphorus and potassium, which was followed by values of NPK uptake registered with HHB 223, GHB 744, XMT 1497 and PB 1705 hybrids (Table 2). However, the minimum value of NPK uptake was noted in hybrid 86M86. The significant difference in NPK uptake in various pearl millet hybrids might be due to the fact that different hybrids behave accordingly as per their genetic make-up and perform in different ways to the soil and environmental conditions and thus have significant variations in uptake of nitrogen, phosphorus and potassium. Singh *et al.* (2013) and Choudhary *et al.* (2016) also observed significant differences in uptake of nitrogen, phosphorus and potassium in pearl millet crop.

Relationship studies: The relationship between minimum and maximum temperature at 50% flowering and physiological maturity stages with grain yield of pearl millet hybrids was evaluated (Fig. 2–5). A negative linear relationship existed between grain yield of pearl millet hybrids and minimum temperature both at 50% flowering and physiological maturity stage, which explained about 64 and 60% variability, respectively. However, pearl millet grain yield was also affected by maximum temperature at both the respective stages, evincing a decline in pearl millet hybrids' grain yield with an accuracy of 65 and 68%, respectively under rainfed conditions of Jammu.

Plant protection: Pearl millet crop was mainly suffered by downy mildew, smut and ergot diseases during its life cycle. Significantly lower attack of these diseases were observed in hybrid GHB 732 to the tune of 10.1, 3.87 and 1.5% of downy mildew, smut and ergot, respectively, followed by HHB 223, PB1705, HHB 197 and GHB744 hybrids whereas, the disease incidence was normal to moderate and severe in other hybrids (Table 3). Green

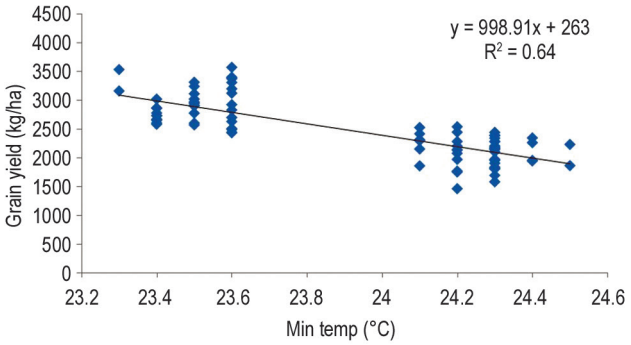

Fig. 2 Relationship between minimum temperature at 50% flowering and grain yield of pearl millet (pooled data of 2 years).

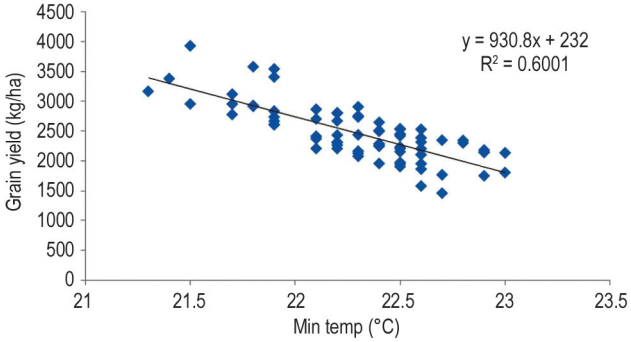

Fig. 3 Relationship between minimum temperature at physiological maturity stage and grain yield of pearl millet (pooled data of 2 years).

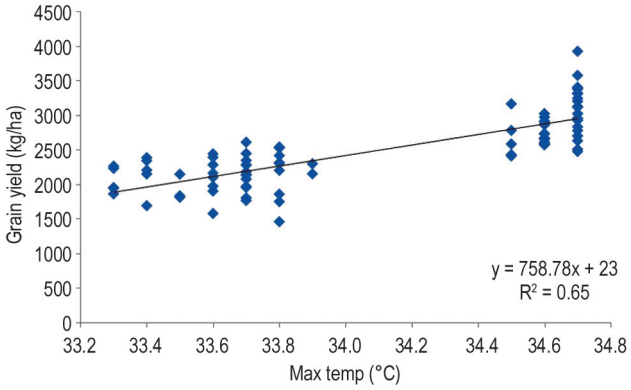

Fig. 4 Relationship between maximum temperature at 50% flowering stage and grain yield of pearl millet (pooled data of 2 years).

stink bug [*Nezara viridula* (L.) Hemiptera: Pentatomidae]; Red cotton bug [*Dysdercus koenigii* (Fabricius) Hemiptera: Pyrrhocoridae]; Flower chafer beetle [*Oxycetonia versicolor* (Fabricius) Coleoptera: Scarabaeidae]; Green June beetle [*Cotidis nitida* (L.) Coleoptera: Scarabaeidae] and stem borer [*Chilo partellus* (Swinhoe) Lepidoptera: Pyralidae] were noticed infesting the crop after 55–75 DAS. However, the incidence was too low for the varietal differences in the incidence level to be recorded.

The two year (*kharif* 2019 and 2020) study conducted under rainfed conditions in Jammu region demonstrated that

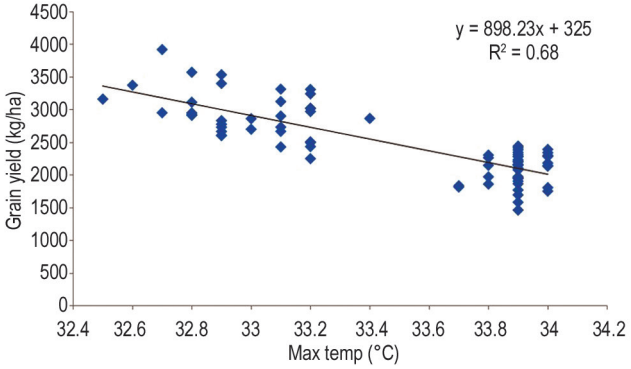

Fig. 5 Relationship between maximum temperature at physiological maturity and grain yield of pearl millet (pooled data of 2 years).

Table 3 Effect of hybrids on occurrence of various diseases in pearl millet under rainfed conditions of Jammu (pooled data of 2 years)

Treatments/Hybrids	Occurrence of diseases (%)		
	Downy mildew	Smut	Ergot
RHB 177	31.0	4.52	3.2
HHB 197	29.8	3.43	4.4
GHB 719	27.1	3.48	1.8
GHB 538	27.7	2.97	3.6
HHB 67 (Imp)	24.1	5.30	3.1
HHB 299	32.9	3.33	2.2
PB 1705	19.2	4.37	2.8
XMT 1497	27.0	3.25	1.8
GHB 905	29.0	3.90	2.1
MPMH 17	28.8	2.57	3.2
RHB 173	33.7	3.17	1.5
HHB 223	15.4	2.48	2.6
GHB 744	25.2	2.82	3.6
GHB 732	10.1	3.87	1.5
KBH 108	30.0	3.30	4.0
86M86	32.9	4.52	1.2
Kaveri Super Boss	34.0	5.18	2.6
MP 7792	32.3	4.80	2.6
Proagro 9444	31.6	5.47	2.9
GHB 558	31.6	3.53	2.5
CD (*p*=5%)	3.06	1.33	0.77

the hybrids GHB 732, HH 223, GHB 744, XMT 1497 and PB 1705 performed well under contingent crop planning for higher productivity and profitability due to relatively shorter crop duration compared to other major crops cultivated in this region. The farmers of Jammu region of Jammu and

Kashmir, could be well benefitted through the incorporation of pearl millet hybrids in their cropping systems along with their socio-economic upliftment.

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