Ann. Agric. Res. New Series Vol. 46 (4) : 391-397 (2025)

Response of pearlmillet (*Pennisetum glaucum* L.) hybrids to different doses of fertilizer on yield and economics under irrigated condition in Western Rajasthan

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Received: May 2025; Revised Accepted: August 2025

Abstract

A field experiment was conducted during *Kharif*, 2022 at the Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner to study the response of pearlmillet (*Pennsisetum glaucum* L.) hybrids to different doses of fertilizer under irrigated condition in western Rajasthan. The treatments comprising four fertility levels (control, 60:40:20, 80:50:30 and 100:60:40 N:P:K kg ha^{-1}) in main plots and five hybrids (RHB-177, HHB-299, MPMH-17, 86M90 and KPH-6277) in sub plots making 20 treatment combinations was laid out in split plot design with three replications. The results showed that in fertility level of 80:50:30 N:P:K kg ha^{-1} significantly higher yield attributes, grain and stover yield as well as net return and B: C ratio over rest of the fertility levels but it was remained statistically at par with fertility level of 100:60:40 N:P:K kg ha^{-1} in this regard. Further data showed that highest fertilizer use efficiency of fertility level recorded with 80:50:30 N:P:K kg ha^{-1} followed with increased the fertility level decreased the fertilizer use efficiency. Among pearl millet hybrids KPH-6277 recorded significantly higher grain and stover yield, net returns and B:C ratio over rest of the hybrids but 86M90 hybrid was found significantly at par in this regard. Interaction effect of fertility levels and pearl millet hybrids also found significant on grain and stover yield, gross and net returns and B:C ratio which were significantly higher under application of 80:50:30 N:P:K kg ha^{-1} along with KPH-6277 hybrid as compared to all other treatment combinations and it was at par with 100:60:40 N:P:K kg ha^{-1} along with KPH-6277 hybrid. Based on a one-year finding, it is determined that under irrigated condition in western Rajasthan, pearl millet hybrid KPH-6277 when fertilized with 80:50:30 N:P:K kg ha^{-1} proved its advantage by registering a higher B:C ratio and yielding grain and stover at a level consistent with fertility level of 100:60:40 N:P:K kg ha^{-1}.

Key words: Pearl millet, hybrids, fertility levels, grain yield, stover yield, economics

Introduction

Pearl millet (*Pennisetum glaucum* L.) popularly known as "Bajra", belongs to the grass family known as poaceae. After rice, wheat, and maize, pearl millet is the fourth most extensively grown food crop in India. It is the most drought tolerant crop among cereals and millets and generally grown as rainfed on marginal lands under low input management conditions. Nonetheless, responds favorably to improved management and increased fertility rates. It is often grown in regions with 150–600 mm of rainfall per year, and it can also be grown in areas, which receive less than 350 mm of annual rainfall. Prolonged spells of warm, rainless weather may be deterimental and may lead to reduce crop yield. India is the largest producer of pearl millets with an annual production of 10.28 million tonnes from 7.52 million hectares area exhibiting productivity of 1368 kg ha^{-1}. The major pearl millet growing states in India are Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, Haryana, Tamil Nadu, Karnataka and Andhra Pradesh (Anonymous, 2021).

Rajasthan is the largest producer of Pearl millet, with an annual production of 5.77 million tonnes from 4.31 million hectares area, exhibiting a productivity of 1337 kg ha^{-1}. (Anonymous (2018-2019). The major pearl millet producing districts in Rajasthan are Alwar, Sikar, Jaipur, Dausa, Sawai Madhopur, Jhunjhunu, Barmer, Nagaur, Bikaner, Jaisalmer and Churu. In Bikaner district, it occupy 11.5 Million hectare cultivated area with 4.8 Million tones production and productivity around 418 kg ha^{-1} (Anonymous, 2020-2021).

Pennisetum glaucum can grow in a broad range of environmental conditions and can produce still good yield even under unfavourable conditions like drought stress and high temperatures. It is generally grown between 40^{o} north to 40^{o} south of the equator, in warm and hot countries characterstics of the semi arid environment. Pearl millet is a hot and warm weather crop and grows between 28^{o}C and 37^{o}C. Pearl millet has a greater ability to stand at high temperature compare to any other cultivated cereal. These useful characterstics mean that it is finding a new niches in some unanticipated places. The favourable temperature for the emergence of pearl millet seed is 23^{o}C to 32^{o}C. Pearl millet seed does not germinate and grow under cool and temperate soil conditions, because it is susceptible to cold. Bad emergence and seedling growth may occur if planted before soil temperature reaches 23^{o}C.

At harvesting time, dry warm weather is most suitable. Pearl millet is also susceptible for water logging, so for its cultivation well drained loamy soils are required. Pearl millet is predominantly gaining importance in the world due to increasing population and climate uncertainities[2].

The nutrient content of pearl millet compares very well with other food grain crops. It has 11.6% protein (with a slightly superior amino acid profile), about 12.4% moisture, 5% fat, 67% carbohydrates and 2.7% minerals (Gill, 1991). It also contains higher amount of carotene, riboflavin (Vit-B2) and niacin (Vit-B4).

The first pearl millet hybrid HB1 was released in 1965, making India the first country in the world to develop a grain hybrid utilizing the cytoplasmic- genetic male- sterile line (Tift 23 A) and a restorer line (BIL 3B). A large number of disease- resistant pearl millet hybrids have been developed with specific combination of traits and ecological adaptations. There are several hybrids recommended for cultivation in Rajasthan *viz*., Nandi-75 (NMH82), HHB-272, 86M84, MPMH 21, Proagro Tejas, Nandi-72 (NMH-75), 86M89, MPMH-17, Kaveri Super Boss, HHB226, RHB-177, HHB 299, HHB-67, Pusa 23 (MH169) etc.

Pearl millet is grown mostly on soils with poor inorganic matter, low in available nitrogen and phosphorus. Poor soil fertility and erratic rains are the most important constraints to crop production in arid and semi arid region. Soil fertility management, *i.e.,* nutrient management particularly nitrogen (N) and phosphorus (P), plays a major role in increasing production and productivity of pearl millet.

Nitrogen is an essential nutrient and key limiting factor in crop production across different agro ecosystems.It is considered as one of the most important plant nutrients for the growth and development of crop plant. It also plays an important role in synthesis of chlorophyll and amino acids, which contribute to the building unit of protein and thus, growth of plants. Nitrogen is a component of nucleic acid that forms DNA, a genetic material significant in transfer of certain crop traits and characterstics that aid plant survival. Nitrogen to some extent enhances the utilization of phosphorus and potassium. The soil of Western Rajasthan is very poor in its physical and chemical properties. Therefore, fertilizer use efficiency is very low. Nitrogen is the most commonly deficient nutrient in Indian soil and gives a considerable response in pearl millet crop.

Phosphorus is the key element in the process of conversion of solar energy into chemical energy. It influences the plant vigour, root growth, and improves quality of the produce. It is backbone of balanced fertilizer use and occupies a key place in intensive agriculture.

Potassium is an essential macronutrient required for proper development of plants. In addition to the activation of numerous enzymes, K plays an important role in the maintenance of electrolyte potential gradients across cell membranes and the generation of turgor. It is also essential for photosynthesis, protein synthesis, and regulation of stomatal movement, and is the major cation in the maintenance of cation-anion balances.

Usually, pearl millet has been known for growing under low nitrogen management. The enhancement of yield attributes with continuous increase in nitrogen levels deficient plants are generally stunted, develop late and produce less flowers as well as shriveled grains. Judicious and suitable use of fertilizer not only increases yield but also improves quality of forage, especially protein contents (Narolia and Poonia, 2021). A well-balanced nutrition is crucial in increasing pearl millet yield (Ayub *et al.,* 2009).

Materials and Methods

The experiment was conducted at the Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner, during *Kharif* 2022-23. The soil of the experimental site was loamy sand, with bulk density of 1.55 g cc^{-1}. It had 0.15% organic carbon, 92.26 $KMNO_4$ oxidizable N ha^{-1}, 14.68 kg 0.5 N $NaHCO_3$ extractable P ha^{-1}, 207.06 kg 1.0 N NH4OAC-exchangeable K ha^{-1}, pH 8.3 and electerical conductivity 0.13 dSm^{-1} at the start of the experiment. The experiment was conducted in a split plot design with three replications. The treatments consisted of four fertility levels in the main plot *viz.*, F_1- control, F_2- 60:40:20 N:P:K kg ha^{-1}, F_3- 80:50:30 N:P:K kg ha^{-1} and F_4- 100:60:40 N:P:K kg ha^{-1}. The five pearl millet hybrids were: H_1- RHB-177, H_2-HHB-299, H_3-MPMH-17, H_4-86M90 and H_5-KPH-6277. Sowing of the crop was done on July 15 and harvested on October 2 (short duration hybrids *viz.*, RHB-177, HHB-299 and MPMH-17), October 12 (long duration hybrid *viz.*, 86M90) and October 16 (long duration hybrid *viz.*, KPH-6277. Half of the N and full dose of P and K through urea, diammonium phosphate and muriate of potash, respectively were applied at the time of sowing and the remaining N was applied in two split doses at the time of 1st and 2nd irrigation.

Five plants were selected randomly from each plot for the measurement of the earhead length, grains $earhead^{-1}$, weight of grains $earhead^{-1}$, earhead girth, and test weight. After harvesting, the grain yield was recorded per plot and then converted into kg ha^{-1}. Net returns of the crop was computed on the basis of grain and stover yield, their prevailing market prices and cost of cultivation. In order to test the significance of variance in experiments, the data obtained for various treatment effects were statistically analysed using the F-test as per the procedure described by (Panse and Sukhatme, 1985). The results are presented at 5% level of significance (P=0.05).

Results and Discussion

Effect of fertility levels on yield and econom-

Table 1. Effect of fertility levels and pearl millet hybrids on yield attributes and yield

Treatments	Yield attributes					Yield (kg ha^{-1})		
Fertility levels (N:P:K kg ha^{-1})	Grains $earhead^{-1}$	Weight of grains $earhead^{-1}$(g)	Length of earhead (cm)	Earhead girth (cm)	Test weight (g)	Grain yield	Stover yield	Biological yield
Control	1322	12.91	24.56	11.39	9.45	2695	6889	9584
60:40:20	1698	17.10	26.57	14.10	9.81	3491	7873	11364
80:50:30	1815	19.02	28.74	14.61	10.29	4344	8948	13292
100:60:40	1899	20.37	29.11	15.29	10.54	4553	9327	13880
SEm+/-	44	0.67	0.50	0.44	0.16	107	205	285
CD at 0.05 %	153	2.32	1.72	1.51	0.55	371	709	987
Hybrids								
RHB-177	1547	13.86	24.76	12.84	8.93	3176	7636	10712
HHB-299	1640	15.75	28.39	13.86	9.58	3513	8012	11525
MPMH-17	1318	11.10	22.34	10.42	8.21	2850	6942	9791
86M90	1940	21.77	29.86	15.45	11.18	4506	9119	13625
KPH-6277	1973	24.26	30.87	16.67	12.21	4810	9688	14498
SEm±	41	0.57	0.43	0.37	0.16	88	241	284
CD (P=0.05)	118	1.63	1.23	1.06	0.47	254	693	818

ics: A reference of data revealed that maximum grains earhead^{-1} (1815), weight of grains earhead^{-1} (19.02 g), length of earhead (28.74 cm), earhead girth (14.61 cm), test weight (10.29 g) and grain yield (4344 kg ha^{-1}) was observed with the application of 80:50:30 N:P:K kg ha^{-1} over rest of the fertility levels but was at par with the 100:60:40 N:P:K kg ha^{-1}. Similar to the maximum stover yield, the 80:50:30 N:P:K kg ha^{-1} provided a yield of 8948 kg ha^{-1}, which was statistically equivalent to the 100:60:40 N:P:K kg ha^{-1} but much greater than the rest of the fertility levels. Fertility levels upto 80:50:30 N:P:K kg ha^{-1} improved the crop's improved nutritional quality in previously N, K, and P, difficient soil, leading to noticeably higher grain and stover output. Their adoption in the plant served as evidence of this. The availability of nutrients was enhanced, and plants absorbed them more readily, which may have accelerated a number of physiological processes in the crop. The positive impact of NPK on yield attributes may be attributable to improved nutrient availability, which may have led to more photosynthate being synthesized and subsequences portioning to sink; Increased NPK fertilization, levels which improve leaf area and the photosynthetic process in growth attributes, demonstrate high dry matter production and distribution in fruiting parts, yielding a very high attribut. The increase in stover yield with application of N:P:K fertilizers could be partly attributed to its direct influnce on dry matter production of each vegetative part and indirectly through increased morphological parameters of growth (Plant height, leaf area and number of effective tillers). Since biological yield is a function of grain and stover yield from vegetative and reproductive growth, the profound influence of N:P:K fertilizers on these components of crop growth led to realization of higher biological yield. The current study's findings with fertilizer application are consistent with those of Malik *et al.*, (1990); Kumar *et al.*, (2008); Girase *et al.*, (2009); Amanullah *et al*., (2014); Mona E. El-Azab, (2015); Rundla and Bairwa, (2018); Nirere *et al*. (2019) and Prakrati Malakar *et al.* (2022).

Application of 80:50:30 N:P:K kg ha^{-1} fetched maximum gross returns of (₹147090) *i.e* proved 48.16% and 20.26 % higher over control and 60:40:20 N:P:K kg ha^{-1} but it was at par with application of 100:60:40 N:P:K kg ha^{-1}. The fertility level 80:50:30 N:P:K kg ha^{-1} earned net returns of (115611 ha^{-1}) which was significantly higher than control and 60:40:20 N:P:K kg ha^{-1} but remained at par with 100:60:40 N:P:K kg ha^{-1}. Among fertility levels, fertility level of 80:50:30 N:P:K kg ha^{-1} showed the maximum B:C ratio (3.66), which was more than the other fertility levels but equal to fertility level of 100:60:40 N:P:K kg ha^{-1}. The lowest B:C ratio (2.71) was recorded in control plot. Fertility levels showed significant variation in gross returns, net returns and B:C ratio. The results showed that increasing fertility levels upto 80:50:30 N:P:K kg ha^{-1} increased the gross returns,

Table 2. Effect of fertility levels and pearl millet hybrids on economics

Treatments	Economics		
Fertility levels (N:P:K kg ha^{-1})	Gross returns (₹ha^{-1})	Net returns (₹ha^{-1})	B:C ratio
Control	99272	72573	2.71
60:40:20	122302	91825	3.00
80:50:30	147090	115611	3.66
100:60:40	153855	120872	3.65
S.Em.±	3229	3229	0.10
C.D	11173	11173	0.36
Hybrids			
RHB-177	113497	83452	2.76
HHB-299	123608	93562	3.09
MPMH-17	102914	73182	2.42
86M90	151593	120615	3.89
KPH-6277	161536	130290	4.12
SEm±	2758	2758	0.09
CD (P=0.05)	7944	7944	0.25

net returns and B:C ratio due to higher grain and stover yields of pearl millet. Similar observation was also recorded by Bhanuprakash (2016) in pady, Ganapati and Guggari, (2018) and Sadhna R Babar *et al*. (2021) in pearl millet.

Effect of hybrids on yield and economics: Data from the current investigation showed that hybrid KPH-6277 recorded higher grains earhead^{-1} (1973), length of earhead (30.87 cm) and test weight (12.21 g) over the rest of all the hybrids, but 86M90 hybrid remained at par in this regard. Data in table 1 further elucidate that hybrid KPH-6277 showed its superiority over RHB-177, HHB-299, MPMH-17 and 86M90 hybrid by recording grain yield of 4810 kg ha^{-1}. It was also excelled from data that hybrid KPH-6277 registered 51.44, 36.92, 68.77 and 6.74 per cent higher grain yield over RHB-177, HHB-299, MPMH-17 and 86M90 hybrid, respectively. The reason for higher yields of KPH-6277 hybrid is the internodal distance and also their stem diameter. More is the internodal distance and thicker is the stem results in more yield and vice-versa. Due to various hybrids, the stover yield also displayed notable variance (Table 1). The highest reported stover production was in KPH-6277 hybrid (9688 kg ha^{-1}). Hybrid KPH-6277 yielded a much increased output of grain and stover. The total of all agronomically and genetically manipulated growth-contributing elements results in the grain and stover yield. The higher grain and stover yield in KPH-6277 hybrid seems to be an account of overall improvement in growth as evidenced from higher leaf area index, effective tillers plant^{-1} and dry matter accumulation which ascribes to be because higher growth inputs were available, which matched the development of the grain and stover yield component. The variance in these parameters might be due to differential capacity of hybrids in utilizing available resources. The results confirmed the earlier findings of Prasad *et al*. (2014) and Kaur and Goyal (2019).

Data given in Table 2 revealed that the hybrid KPH-6277 had the highest B:C ratio (4.12), followed by 86M90, HHB-299, RHB-177 and MPMH-17 hybrid. Hybrid KPH-6277 fetched higher gross returns (₹161536 ha^{-1}) over rest of the hybrids. The percentage increase in gross returns by KPH-6277 hybrid to the tune of 42.32, 30.68, 56.96 and 6.55 per cent over RHB-177, HHB-299, MPMH-17 and 86M90 hybrids respectively. Table 2 data made it evident that hybrids had a substantial impact on net return and recorded the highest net return. with hybrid KPH-6277 (₹130290 ha^{-1}) as compared to rest of all the hybrids and significant difference was also found in between each hybrids. The percentage increase in net returns by KPH-6277 hybrid to the tune of 56.12, 39.25, 78.03 and 8.02 per cent over RHB-177, HHB-299, MPMH-17 and 86M90 hybrid, respectively. Different hybrids have their potential to produced different crop yield, resulting in different gross returns, net returns and B:C ratio. Similar findings were reported by Sheoran *et al* (2016).

Interaction effect of fertility levels and pearl millet hybrids on grain yield

Data presented in Table 3 indicate that grain yield was significantly influenced by interaction effect of fertility levels and pearl millet hybrids during experimentation. Results revealed that

Table 3. Interaction effect of fertility levels and pearl millet hybrids on grain yield

Hybrids	Grain yield (kg ha^{-1})			
	Fertility levels (N:P:K kg ha^{-1})			
	Control	60:40:20	80:50:30	100:60:40
RHB-177	2287	3166	3862	3655
HHB-299	2621	3412	3922	3862
MPMH-17	1761	2402	2435	2340
86M90	3632	4431	4922	5039
KPH-6277	3172	4045	5802	6219
			SEm±	CD (P=0.05)
Fertility levels at same hybrid			194.14	559.25
Hybrid at same level of fertility			176.22	507.62

highest grain yield was recorded with the treatment combination of application of 80:50:30 N:P:K kg ha^{-1} along with KPH-6277 hybrid but it was at par with fertility level of 100:60:40 N:P:K kg ha^{-1}.

Conclusion

From the studies mentioned above, it can be concluded that under irrigated condition in western Rajasthan, pearl millet hybrid KPH-6277 when fertilized with 80:50:30 N:P:K kg ha^{-1} highlighted its superiority by registering a higher B:C ratio in addition to generating yield characterstics as well as grain and stover yield at par with fertility level of 100:60:40 N:P:K kg ha^{-1}.

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