Indian Journal of Ecology (2024) 51(3): 537-541
DOI: https://doi.org/10.55362/IJE/2024/4269

Manuscript Number: 4269
NAAS Rating: 5.38

Production Potential, Profitability and Nitrogen use Efficiency of Forage Pearl Millet Varieties

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***Abstract*:** Field experiment was conducted to study the production potential, profitability and nitrogen use efficiency of forage pearl millet varieties with nitrogen doses. The experiment comprised of four forage pearl millet varieties (TSFB 15-4, TSFB 15-8, Moti bajra and BAIF bajra-1) at two N levels (80 and 120 kg N/ha) and the eight treatment combinations were tested.BAIF bajra-1 with 120 kg N/ha recorded the maximum green forage yield, dry matter and crude protein yield, gross and net return and B:C ratio. This treatment also exhibited markedly higher nitrogen uptake but markedly higher partial factor productivity of nitrogen fertilizer was recorded in BAIF bajra-1 with 80 kg N/ha. Hence, BAIF bajra-1 with application of 120 kg N/ha was the most promising treatment for achieving higher nitrogen uptake, dry matter yield and crude protein yield.

***Keywords*:** Production potential, Profitability, Nitrogen use efficiency, Forage pearl millet, N levels

Due to ever increasing livestock population in India, there is a tremendous pressure on feed and fodder resources. Parmar and Misra (2020) indicate there was a deficit of 26%green fodder in the country during 2015 which is expected to increase up to 40% by 2025. As forage crops are already facing severe competition from other cash crops for occupying arable land (Choudhary and Prabhu 2014), efforts for enhancement of production and productivity of forage crops is of outmost importance for sustaining the livestock production and profit margins of dairy farmers (Nanda et al 2021).Pearl millet (*Pennisetum glaucum* L.) ranks sixth among the cereal crops of the world on the basis of area under cultivation and is popular among farmers for providing food and fodder (Pujarula et al 2021). It can be grown successfully in both rainfed and irrigated condition (Ayubet al 2009) and is becoming popular among farming community of Bihar due to its short duration, quick regeneration capacity and ability to provide superior and palatable green fodder in summer and rainy season. Nitrogen one of the key nutrients for crop production (Nanda and Nilanjaya 2022) which influences vegetative growth and herbage quality (Bramhaiah et al 2018). Previous reports indicated that enhancing N application improves yield and quality of pearl millet (Shekara et al 2019,Shekaraet al2021 and Nanda and Nilanjaya 2022) but decreases nitrogen use efficiency (Rostamza et al 2011,Shekara et al 2019, Shekara et al 2021 and Nanda and Nilanjaya 2022). Recently, two varieties such as TSFB 15-4 and TSFB 15-8 with higher production potential have been released. Hence, nitrogen management in these forage pearl millet varieties could further improve the productivity and quality, profitability and nitrogen use efficiency for sustaining livestock production. Current investigation was carried out to assess the production potential, profitability and nitrogen use efficiency of forage pearl millet varieties with nitrogen doses.

MATERIAL AND METHODS

Experimental site: The present experiment was conducted at RPCAU, Pusa, Samastipur, Bihar during *Kharif* season, 2020.Geographically, the site falls under the sub-tropical zone of Indo-Gangetic plains and is situated at the bank of river *Budhi Gandak*. It is located on $25^0 98^{'}$N latitude, $85^0 68^{'}$E longitude and at an elevation of 63.9 meters above MSL. Pusa, Samastipur experiences subtropical humid weather and receives an annual average rainfall of 1200 mm of which 941 mm (about 70 percent rainfall) is received during July and September. Usually monsoon arrives in the third week of June which remains till end of September or sometimes till first week of October. The winter months are very cool whereas the summer months are hot, dry and humid. Total rain fall during crop growing period was 1026.5 mm. The soil was silty clay loamin nature with pH of 8.52. The soil was low in organic carbon (0.46%), available nitrogen (199.1 kg/ha) high in available P (35.6 kg/ha)and low in available K (86.2 kg/ha).

Experimental design: Four forage pearl millet varieties were evaluated in the experiment (TSFB 15-4, TSFB 15-8, Moti bajra and BAIF bajra-1) at two N levels (80 and 120 kg

N/ha) and these eight treatment combinations representing eight treatments (Table 1) were evaluated in randomized block design using three replications with individual plot size of 12 m^2 (4m × 3m) plot.The crop was sown on July 2, 2020 at a row spacing of 30 cm using a seed rate of 10 kg/ha. Recommended dose of 30 kg each of P and K was applied at the time of sowing. Application of N was done as per the treatments *i.e.* 80 or 120 kg N/ha. Of the total quantity of fertilizer N, 40% was applied as basal, 30% was applied after 1st cut and rest 30% was applied after 2st cut. Regarding harvest of green fodder, first cut was taken at 50 days after sowing (DAS), second cut was taken at 30 days after 1st cut and the 3rd cut was taken at 50% flowering. Other cultural operations were done as per recommended package of practices. The sources for nitrogen, phosphorus and potassium were urea, SSP and MOP, respectively.

Observations and method of analysis: At each harvest, observation on plant height (cm), number of tillers/m row length (TMRL) and leaf: stem ratio (LSR) (dry weight basis) was taken. Green forage yield (GFY) of the plot was recorded and converted to t/ha. A representative sample of 500g of green fodder was taken from each plot and dry matter (DM) content was determined by placing a hot air oven at 70 ± 2°C temperature till constant weight was achieved. Dry matter yield (DMY) was calculated by multiplying GFY with DM content. Nitrogen (N) content of the dry matter was determined using modified Kjeldahl method (AOAC 1955) and it was multiplied by the DMY to get N uptake. The N content in dry matter was multiplied by a factor 6.25 to get crude protein (CP) content. CP content (%) was multiplied by DMY to get crude protein yield (CPY).The partial factor productivity of N fertilizer (PFPN) was calculated as per Singh et al (2021) in terms of GFY and DMY as follows

PFPN (kg DMY/kg N applied) = DMY/AFNA

Where DMY is DMY in fertilized plot (kg/ha)

AFNA is the amount of fertilizer nitrogen applied (kg/ha)

N fertilizer use efficiency (NFUE) was calculated as per Hou et al (2021) as follows

NFUE (kg CPY/kg N applied) = CPY (kg/ha)/AFNA (kg/ha).

Nitrogen utilization efficiency (NutE) was worked out as per Rostamza et al (2011)

NutE (kg DM/kg N uptake) = DMY/NU

Where DMY is the dry matter yield (kg/ha) of the plot and NU is the nitrogen uptake (kg/ha) of that plot.

The economics of forage pearl millet was calculated with prevailing market price of the inputs and the output.Data were analyzed as per Analysis of Variance for randomized block design using online statistical package OPSTAT (Sheoran et al 1998).

RESULTS AND DISCUSSION

Yield attributes: Different treatments caused significant variation in plant height for first cut (Table 1). The highest plant height was in BAIF bajra-1 with 120 kg N/ha (184.0 cm) which was comparable with other treatments except TSFB 15-4 at 80 and 120 kg N/ha (Table 1). For second and third cut, the highest plant height was with TSFB 15-4 with 120 kg N/ha (166.9 cm) and TSFB 15-4 with 120 kg N/ha (141.9 cm), respectively. Different treatments had significant effect on number of tillers per meter row length (TMRL) for first and third cut (Table 1). Significantly higher TMRL was recorded in BAIF bajra-1 with 120 kg N/ha at first cut (47.0) which was significantly superior to rest of the treatments. The TMRLat second cut was withBAIF bajra-1 with 120 kg N/ha (45.0). Application of 120 kg N/ha recorded the highest number TMRL (39.2) which was comparable with rest of the treatments except TSFB 15-4 at 80 and 120 kg N/ha. LSR showed significant variation at each cut and Moti bajra with 120 kg N/ha recorded the highest value of LSR at each cut

Table 1. Plant height, number of tillers and leaf: stem ratio of forage pearl millet varieties with varied nitrogen doses

Treatments	Plant height (cm)			Number of tillers/m row length			Leaf: stem ratio		
	First cut	Second cut	Third cut	First cut	Second cut	Third cut	First cut	Second cut	Third cut
T_1-TSFB 15-4 with 80 kg N/ha	151.3	164.5	128.6	29.0	34.1	27.2	0.40	0.46	0.39
T_2-TSFB 15-4 with 120 kg N/ha	153.6	166.9	130.8	33.0	36.1	28.3	0.43	0.48	0.39
T_3-TSFB 15-8 with 80 kg N/ha	176.6	156.2	140.9	36.0	37.8	35.3	0.42	0.38	0.37
T_4-TSFB 15-8 with 120 kg N/ha	178.5	158.3	141.9	42.0	39.6	36.2	0.45	0.41	0.38
T_5-Moti bajra with 80 kg N/ha	171.4	151.1	136.4	33.0	36.4	34.2	0.54	0.51	0.49
T_6-Moti bajra with 120 kg N/ha	174.6	153.8	137.8	38.0	37.0	34.8	0.57	0.54	0.50
T_7-BAIF bajra-1 with 80 kg N/ha	181.3	159.8	133.7	40.0	42.0	38.6	0.46	0.44	0.45
T_8-BAIF bajra-1 with 120 kg N/ha	184.0	162.4	132.7	47.0	45.0	39.2	0.48	0.47	0.49
CD ($p<0.05$)	14.8	NS	NS	3.4	NS	6.5	0.09	0.03	0.05

(0.57, 0.54 and 0.50, respectively) which was statistically similar with Moti bajra with 80 kg N/ha at each cut and BAIF bajra-1 with 120 kg N/ha at first and third cut and BAIF bajra-1 with 80 kg N/ha at third cut (0.45).Nitrogen plays important role in cell division and elongation than might have resulted in higher plant height, TMRL and LSR. Ayub et al (2009) also reported that plant height increased significantly up to application of 180 kg N/ha. Similarly, significant effect of N on plant height and LSR of pearl millet varieties for first, second and third cut has been reported by Aboelgoud and Ragab (2021).

Yield: Different treatments caused significant variation in GFY and DMY for first and second cut and total GFY and DMY (Table 2). BAIF bajra-1 with 120 kg N/ha gave the highest GFY at first cut (28.6 t/ha) which was at par with BAIF bajra-1 with 80 kg N/ha. For second cut, TSFB 15-4 with 120 kg N/ha recorded the highest GFY (21.2 t/ha) which was comparable with BAIF bajra-1 with 120 kg N/ha and TSFB 15-4 with 80 kg N/ha. However, Moti bajra with 120 kg N/ha produced the highest GFY at third cut. Total GFY was the highest with BAIF bajra-1 with 120 kg N/ha (59.0 t/ha) which was comparable with BAIF bajra-1 with 80 kg N/ha. BAIF bajra-1 with 120 kg N/ha produced significantly higher DMY for first and second cut which was at par with TSFB 15-4 with 120 kg N/ha for DMY of second cut. For third cut both TSFB 15-8 and Moti bajra with 120 kg N/ha produced the highest DMY (2.1 t/ha). However, total DMY was significantly higher with BAIF bajra-1 with 120 kg N/ha (12.0 t/ha). Shekara et al (2020) also observed that multi-cut forage pearl millet genotypes responded significantly up to 120 kg N/ha for GFY and DMY. Higher DMY with 120 kg N/ha was due to increase in DM content (Shekara et al 2020). Our results are in line with the findings of Ayubet al (2009) that GFY and DMYof pearl millet markedly increased up to application of 180 kg N/ha. Increase in N dose (from 80 to 120 kg N/ha) was reflected in on growth attributes *i.e.* plant heightand TMRL and resulted in higher green forage and dry matter yield of pearl millet varieties. Similar trend was observed by Ibrahim et al (2014) and Aboelgoud and Ragab (2021).

Fodder quality: Different treatments caused marked variation in crude protein (CP) content and its yield except CP content of third cut (Table 3). CP content for first cut was highest withTSFB 15-8 with 120 kg N/ha (8.73%) which was comparable with BAIF bajra-1 with 120 kg N/haand TSFB 15-8 with 80 kg N/ha. BAIF bajra-1 with 120 kg N/ha produced the highest CP content at second cut (7.45%) which was at par with BAIF bajra-1 with 80 kg N/ha, TSFB 15-8 with 120 kg N/ha and TSFB 15-8 with 80 kg N/ha. TSFB 15-8 with 120 kg N/ha resulted in the highest CP content of third cut). Ayubet al (2009) observed that CP content of pearl millet increased significantly up to application of 180 kg N/ha. Similarly, Aboelgoud and Ragab (2021) observed that increasing N levels brought significant increase in CP contents of first, second and third cut of forage pearl millet varieties. CPY of first and second cut was the highest with BAIF bajra-1 with 120 kg N/ha which was comparable with TSFB 15-8 with 120 kg N/ha for first cut and BAIF bajra-1 with 80 kg N/ha (0.27 t/ha) and TSFB 15-4 with 120 kg N/ha (0.26 t/ha) for second cut. Regarding CPY of third cut, TSFB 15-8 with 80 and 120 kg N/ha recorded the highest value (0.18 t/ha) and were comparable with all other treatments except for TSFB 15-4 with 80 kg N/ha and 120 kg N/ha. However, total CPY was significantly higher with BAIF bajra-1 with 120 kg N/ha (0.97 t/ha). Higher CPY with 120 kg N/ha than application of 80 kg N/ha with multi-cut genotypes of forage pearl millet was noted by Shekara et al (2020) which was due to higher CP content and dry matter yield.

Nitrogen uptake: Different treatments caused significant variation in nitrogen uptake for first, second and third cut as well as total nitrogen uptake (Table 4). The highest N uptake

Table 2. Green forage and dry matter yield of forage pearl millet varieties with varied nitrogen doses

Treatments	Green forage yield (t/ha)				Dry matter yield (t/ha)			
	First cut	Second cut	Third cut	Total	First cut	Second cut	Third cut	Total
T_1	17.9	20.1	9.0	46.9	3.3	3.6	1.7	8.5
T_2	19.8	21.2	9.3	50.2	3.8	4.0	1.7	9.5
T_3	23.6	16.2	10.5	50.2	4.5	3.1	2.1	9.7
T_4	25.8	16.9	10.7	53.3	5.2	3.4	2.1	10.7
T_5	23.5	15.1	10.5	49.1	4.5	2.8	2.0	9.3
T_6	25.6	16.3	10.8	52.7	5.1	3.2	2.1	10.5
T_7	27.1	19.1	9.9	56.1	5.2	3.6	2.0	10.8
T_8	28.6	20.2	10.2	59.0	5.8	4.1	2.1	12.0
LSD (p=0.05)	2.8	1.7	NS	3.2	0.6	0.3	NS	0.9

See Table 1 for treatment details

for first and second was observed with TSFB 15-8 with 120 kg N/ha (79.7 and 48.4 kg/ha, respectively) which was comparable with TSFB 15-8 with 120 kg N/ha for first cut and BAIF bajra-1 with 80 kg N/ha for second cut. TSFB 15-8 with 120 kg N/ha recorded the highest N uptake for third cut (29.0 kg/ha) which was comparable with rest of the treatments except TSFB 15-4 with 80 kg N/ha and 120 kg N/ha. However, total N uptake was significantly higher with BAIF bajra-1 with 120 kg N/ha (155.9 kg/ha). Higher N uptake of forage pearl millet varieties with 120 kg N/ha might be due to higher availability in soil coupled with better absorption and utilization in crop.

Nitrogen use efficiency: Different treatments caused significant variation in nitrogen use efficiency (NUE) indices (PFPN, NFUE and NutE) (Table 5). NUE indices decreased with increase in N application from 80 to 120 kg N/ha. PFPN, NFUE and NutE varied from 79.0 to 135.1kg DMY/kg N applied, 5.8 to 10.7 kg CPY/kg N applied, 76.0 to 89.3 kg DMY/kg N uptake, respectively among the treatments. The highest PFPN and NFUE was with BAIF bajra-1 with 80 kg N/ha which was statistically similar with TSFB 15-8 with 80 kg N/ha (9.7kg CPY/kg N applied) for NFUE. However, the

Table 4. Nitrogen uptake by forage pearl millet varieties with varied nitrogen doses

Treatments	N uptake (kg/ha)			
	First cut	Second cut	Third cut	Total
T_1	39.0	38.2	20.4	97.6
T_2	47.7	42.1	21.5	111.3
T_3	60.5	35.1	28.5	124.1
T_4	73.5	39.5	29.0	142.0
T_5	53.7	30.3	25.3	109.3
T_6	65.6	35.2	26.6	127.4
T_7	67.6	43.2	26.2	136.9
T_8	79.7	48.4	27.8	155.9
CD (p<0.05)	8.5	5.7	5.0	11.9

See Table 1 for treatment details

Table 3. Crude protein content and yield of forage pearl millet varieties with varied nitrogen doses

Treatments	Crude protein (%)				Crude protein yield (t/ha)			
	First cut	Second cut	Third cut	Total	First cut	Second cut	Third cut	Total
T_1	7.40	6.52	7.74	0.24	0.24	0.13	0.61	
T_2	7.81	6.60	7.80	0.30	0.26	0.13	0.70	
T_3	8.30	7.13	8.54	0.38	0.22	0.18	0.78	
T_4	8.73	7.29	8.61	0.46	0.25	0.18	0.89	
T_5	7.53	6.70	7.81	0.34	0.19	0.16	0.68	
T_6	7.91	6.82	7.86	0.41	0.22	0.17	0.80	
T_7	8.02	7.40	8.30	0.42	0.27	0.16	0.86	
T_8	8.46	7.45	8.37	0.50	0.30	0.17	0.97	
CD (p<0.05)	0.44	0.62	NS	0.05	0.04	0.03	0.07	

See Table 1 for treatment details

Table 5. Nitrogen use efficiency and production economics of forage pearl millet varieties with varied nitrogen doses

Treatments	Nitrogen use efficiency			Economics		
	PFPN (kg/kg)	NFUE (kg/kg)	NutE (kg/kg)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
T_1	106.4	7.6	89.3	70382	37284	2.13
T_2	79.0	5.8	86.2	75347	41769	2.24
T_3	121.0	9.7	78.8	75332	42234	2.28
T_4	89.3	7.4	76.0	79935	46357	2.38
T_5	116.3	8.5	85.5	73608	40510	2.22
T_6	87.2	6.6	82.9	79026	45448	2.35
T_7	135.1	10.7	79.9	84149	51051	2.54
T_8	99.7	8.1	77.2	88490	54912	2.64
CD (p<0.05)	10.6	1.0	4.1	4764	4764	0.14

See Table 1 for treatment details

highest NutE was recorded with TSFB 15-4 with 80 kg N/ha (89.3kg DMY/kg N uptake) which was comparable with TSFB 15-4 with 120 kg N/ha (86.2 kg DMY/kg N uptake) and Moti bajra with 80 kg N/ha (85.5 kg DMY/kg N uptake). Variation in nitrogen use efficiency exists in forage pearl millet genotypes (Shekara et al 2019, 2021) and multi-cut forage genotypes exhibited lower NUE with 120 kg N/ha than 80 kg N/ha (Shekara et al 2020).

Production economics: Different treatments caused significant variation in profitability indices like gross and net return and B:C ratio (Table 5). The highest gross and net return and B:C ratio was with BAIF bajra-1 with 120 kg N/ha (Rs. 88490/ha, Rs. 54912/ha and 2.64, respectively) which was at par with BAIF bajra-1 with 80 kg N/ha. Higher gross and net return and B:C ratio with BAIF bajra-1 with 120 kg N/ha was mainly due to higher GFY recorded in this treatment. Shekara et al (2020) also reported that applying 120 kg N/ha registered higher gross and net return and B:C ratio compared to 80 kg N/ha in multi-cut fodder pearl millet genotypes.

CONCLUSION

BAIF bajra-1 with application 120 kg N/ha resulted in higher green forage yield, dry matter yield, crude protein yield and nitrogen uptake and profitability indices such as net return and B:C ratio.

ACKNOWLEDGEMENT

The authors are thankful to AICRP on Forage Crops and Utilization, IGFRI, Jhansi and Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar for financial support.

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Received 11 November, 2023; Accepted 30 April, 2024