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YIELD, NITROGEN USE EFFICIENCY AND ECONOMICS OF FORAGE PEARL MILLET AS AFFECTED BY GENOTYPES AND NITROGEN LEVELS

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SUMMARY

A field investigation was undertaken at AICRP on Forage crops and utilization, Dr. Rajendra Prasad Central Agricultural University, Pusa during *Kharif* season, 2021 to study the response of pearl millet genotypes to different N levels. The experiment was conducted in factorial randomized block design with seven genotypes and four nitrogen levels (0, 30, 60 and 90 kg N/ha) with three replications. The results revealed that genotype Dev-1 recorded 53.4, 58.8, 63.4% higher green forage yield (GFY), dry matter yield (DMY) and crude protein yield (CPY), respectively than national check and 17.2, 22.1 and 22.3% higher GFY, DMY and CPY, respectively than zonal check. Similarly, application of 90 kg N/ha recorded 5.8, 9.9 and 12.4% higher GFY, DMY and CPY, respectively than application of 60 kg N/ha. Among genotypes, JPM-18-1 had the highest agronomic efficiency of N (AEN) in term of GFY (334.96 kg GFY/kg N applied) and DMY (103.08 kg DM/kg N applied) while application of lower dose of N (30 kg/ha) recorded the highest respective AEN (292.27 kg GFY/kg N applied and 89.47 kg DM/kg N applied). Among genotypes, significantly higher net return (Rs. 63708/ha) and B:C ratio (3.44) was achieved with genotype Dev-1. Among N levels, application of the highest dose (90 kg/ha) registered the highest net return (Rs. 55007/ha) and B:C ratio (3.07).

Key words : Pearl millet, green fodder yield, nitrogen use efficiency, quality, economics

Pearl millet (*Pennisetum glaucum* L.) is popular among farmers for food and fodder and is the sixth most important cereal crop of the world on the basis of area under cultivation (Pujarula *et al.*, 2021). It is a highly palatable cereal fodder with good nutritional profiles and is rich in tryptophan and cysteine (Shekara *et al.*, 2021). It is becoming popular among farmers of Northern Bihar due to its short duration, quick regeneration capacity and ability to provide superior and palatable green fodder. As a feedstuff, it is grown mainly to produce green-chops, pasture and stand over feed grazed directly or hay and silage (Sheoran *et al.,* 2016).

Nitrogen is one of the most vital nutrients for crop production (Shapiro *et al.*, 2003; Maman *et al.*, 2006). Pearl millet is generally grown in low N management (Gascho *et al.*, 1995). However, several studies indicated that increasing N application enhance the yield and quality of pearl millet (Shekara *et al.*, 2021; Shekara *et al.*, 2019; Rostamza *et al.,* 2011) but decreases nitrogen use efficiency (Shekara *et al.*, 2021; Shekara *et al.*, 2019; Rostamza *et al.*, 2011; Maman *et al.*, 2006). Application of N improves vegetative growth and herbage quality (Bramhaiah *et al.*, 2018) which is desirable for forage production. Further, it influences dry matter production and its partitioning among different plant parts (Meena *et al.*, 2019). Due to rising population of livestock in the state of Bihar, there is a need to enhance forage production which is already facing several constraints with respect to increase in area of forages due to competition from food crops. Putting efforts for enhancing the production and productivity of fodder crops will enhance the availability of green fodder thereby reducing the cost of feeding and ultimately improving the profit margins of dairy farmers (Nanda *et al.*, 2021). So, intervention in terms of new genotypes and N management may help to bridge the gap between demand and supply of green fodder for profitable livestock production. Also evaluating the response of forage pearl millet genotypes to nitrogen doses for green fodder would help manage the resource better (Rostamza *et al.*, 2011) and for achieving acceptable forage both in quantity and quality aspects. With this background the present investigation was undertaken to assess the optimum N level for enhancing the yield and quality of forage pearl millet genotypes.

MATERIALS AND METHODS

The present experiment was carried out at Forage Research Block (Plot no. 12) of Cattle Farm, Animal Production Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar under AICRP on Forage Crops and Utilization during *Kharif* season, 2021. The experiment was carried out in a factorial randomised complete block design involving two factors *i.e.* genotypes and N management with three replications. There were seven genotypes (JPM-18-7, Dev-1, 16ADV0055, BAIF Bajra-7, RBB-1, Giant Bajra and APFB-9-1) and four N levels (0, 30, 60 and 90 kg/ha) with a total treatment combination of 28 taken in the experiment. The crop was sown on 15th July, 2021 at a row spacing of 30 cm using a seed rate of 12 kg/ha. Recommended dose of 40 kg each of P and K was applied at the time of sowing. Application of N was done as per the treatments. The sources for nitrogen, phosphorus and potassium were urea, DAP and MOP, respectively. All other cultural operations were done as per recommended package of practices. Harvesting of green fodder was done on the day of 50% flowering and the green forage yield (GFY) of the plot was recorded and converted to q/ha. 500g of green fodder samples were taken from each plot and placed in hot air oven at 70 ± 2°C temperature till constant weight was achieved to determine the dry matter content for determination of dry matter yield (DMY) when multiplied with GFY. Total N of the dry matter was determined and it was multiplied by the DMY to get nitrogen uptake. The nitrogen 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). Total digestible crude protein yield (TDCPY) was worked out as per Iqbal *et al.* (2013) and Shekara *et al.* (2021) as follows

TDCPY (q/ha) = [0.97 × Crude protein yield (q/ha)] – 0.67

The agronomic efficiency of nitrogen was calculated as per Singh *et al.* (2021) in terms of GFY and DMY as follows

AEN (kg GFY or DMY/kg N applied) = (Yf-Yc)/AFNA

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

Yc is the GFY/DMY in control plot (kg/ha)

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

The nitrogen utilization efficiency (NutE) was worked out as per Rostamza *et al.* (2011) as follows

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 subjected to Analysis of Variance for factorial experiment in randomized block design (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth, yield and productivity

Different genotypes significantly affected plant height, leaf:stem ratio (LSR), green fodder and dry matter yield and their per day productivity (Table 1). The highest plant height (247.1 cm), GFY (598.2 q/ha), DMY (128.8 q/ha), per day productivity of GFY (9.50 q/ha) and per day productivity of DMY (2.04 q/ha) was registered with Dev-1 which significantly higher than rest of the genotypes except for plant height for which Zonal check APFB-9-1 was at par with it. However, the maximum LSR was recorded with BAIF Bajra-7 which was significantly higher than rest of the genotypes. Dev-1 registered 17.2 and 22.1% higher GFY and DMY than zonal check (APFB-9-1) and 53.4 and 58.8% higher GFY and DMY than national check (Giant Bajra). Higher GFY with Dev-1 is attributed to higher plant height. Similarly, higher DMY is due to higher GFY and dry matter percentage than national and zonal check. Genotypic variation in plant height, LSR, GFY and DMY in forage pearl millet has been reported (Shekara *et al.*, 2019 and Shekara *et al.*, 2021). Among the different N levels, application of 90 kg N/ha produced the highest plant height, LSR, green fodder and dry matter yield and their per day productivity. However, application of 60 kg N/ha produced statistically similar plant height, LSR, GFY and per day productivity of GFY. The highest value of above parameters with application of 90 kg N/ha might be due to higher nitrogen availability in soil which would have led to better absorption and utilization in plant which augmented vegetative growth and resulted in higher growth attributes like plant height and LSR. Higher DMY under 90 kg N/ha is due to significantly higher DM content (%) and higher GFY. Improvement in plant height, LSR, GFY and DMY due to N application has also been reported (Shekara *et al.*, 2019; Shekara *et al.*, 2021; Aboelgoud and Ragab, 2021).

TABLE 1
Growth, yield and productivity of forage pearl millet as affected by genotypes and N levels

Treatments	Plant height (cm)	Leaf : stem ratio	GFY (q/ha)	DMY (q/ha)	Per day productivity (q/ha/day)	
					GFY	DMY
Genotypes						
Giant bajra	216.9	0.30	390.0	81.1	6.50	1.35
JPM-18-1	230.1	0.31	496.1	111.4	7.89	1.77
BAIF Bajra-7	222.1	0.41	447.1	89.8	8.10	1.63
RBB-1	213.9	0.22	379.1	77.6	7.15	1.46
APFB-9-1	237.0	0.26	510.6	105.5	8.58	1.77
Dev-1	247.1	0.36	598.2	128.8	9.50	2.04
16ADV0055	234.6	0.33	488.9	98.1	7.56	1.52
SEm±	4.0	0.00	14.2	3.0	0.25	0.05
CD (P=0.05)	11.3	0.01	40.4	8.6	0.71	0.15
N levels (kg/ha)						
0	210.3	0.24	372.9	66.4	6.34	1.13
30	225.9	0.32	460.6	93.2	7.76	1.57
60	236.4	0.34	514.1	112.4	8.57	1.87
90	242.6	0.35	543.8	123.5	8.92	2.02
SEm±	3.0	0.00	10.8	2.3	0.19	0.04
CD (P=0.05)	8.5	0.01	30.5	6.5	0.53	0.11

*GFY- Green forage yield; DMY- Dry matter yield.

Fodder quality

Different genotypes significantly affected dry matter percent, crude protein percent, crude protein yield and total digestible CPY (Table 2). Genotype JPM-18-1 had the maximum dry matter content (22.1%) which was superior to rest of the genotypes. Crude protein (CP) content was the highest in 16ADV0055 (8.57%) which was comparable with the CP content of genotypes Giant bajra, JPM-18-1, BAIF bajra-7, APFB-9-1 and Dev-1. The highest CPY and TDCPY was recorded with Dev-1 which was significantly

TABLE 2
Dry matter percentage and quality parameter of forage pearl millet as affected by genotypes and N levels

Treatments	Dry matter (%)	Crude protein (%)	CPY (q/ha)	Total digestible CPY (q/ha)
Genotypes				
Giant bajra	20.6	8.29	6.77	5.90
JPM-18-1	22.1	8.56	9.59	8.63
BAIF Bajra-7	19.8	8.46	7.59	6.70
RBB-1	20.2	8.04	6.29	5.43
APFB-9-1	20.3	8.48	9.04	8.10
Dev-1	21.3	8.54	11.06	10.06
16ADV0055	19.8	8.57	8.48	7.56
SEm±	0.2	0.13	0.27	0.26
CD (P=0.05)	0.5	0.36	0.76	0.74
N levels (kg/ha)				
0	17.8	7.95	5.27	4.44
30	20.2	8.36	7.80	6.90
60	21.8	8.60	9.67	8.71
90	22.7	8.77	10.87	9.87
SEm±	0.1	0.10	0.20	0.20
CD (P=0.05)	0.4	0.27	0.58	0.56

*CPY- crude protein yield.

higher than rest of the genotypes. Higher CPY was due to significantly higher DMY with Dev-1. Genotypic variation in dry matter (%), CP (%), CPY (Shekara *et al.*, 2019 and Shekara *et al.*, 2021) and TDCPY (Shekara *et al.*, 2021) of forage pearl millet variety have been reported. Among N levels, application of 90 kg N/ha gave the highest DM content (22.7%), CP content (8.77%), CPY (10.87 q/ha) and TDCPY (9.87 q/ha) which was comparable with application of 60 kg N/ha for CP content. Higher CPY with 90 kg N/ha was due to higher CP (%) and DMY. Similarly, Rostamza *et al.* (2011) reported significant increment in CP (%) when N level was increased from 0 to 225 kg N/ha in forage pearl millet cv. Nutrifeed. Similar findings on DM content, CP content and yield (Shekara *et al.*, 2019; Shekara *et al.*, 2021) and TDCPY (Shekara *et al.*, 2021) has been reported.

Nitrogen uptake and use efficiency and economics

Different genotypes significantly affected nitrogen uptake, nitrogen use efficiency, gross and net return and B:C ratio (Table 3). The highest nitrogen uptake was recorded with Dev-1 (177.0 kg/ha) which was markedly higher than rest of the genotypes tested. The highest AEN was recorded with JPM-18-1 (334.96 kg GFY/kg N applied and 103.08 kg DMY/kg N applied) followed by APFB-9-1 (307.33 kg GFY/kg N applied and 91.24 DMY/kg N applied) followed by 16ADV0055 (248.15 kg GFY/kg N applied) which were comparable with each other. Genotypic variation in terms of AEN of forage pearl millet genotypes have been evaluated by Shekara *et al.* (2019) and Shekara *et al.* (2021). The highest gross (Rs. 89728/ha) and net return (Rs. 63708/ha) and B:C ratio (3.44) was obtained with Dev-1 which is primarily due to higher green fodder yield of the genotype. Among the N levels, the highest AEN was found with the lowest N level (30 kg N/ha) and AEN decreased with increase in N levels from 30 to 90 kg N/ha. This confirms the findings of Shekara *et al.* (2019) and Shekara *et al.* (2021). The maximum NutE of 78.85 kg DM/kg N uptake was achieved with control which reached to 71.43 kg DM/kg N uptake at 90 kg N/ha. Similar findings have been reported by Rostamza *et al.* (2011) who found NutE of 42.85, 39.17, 36.23 and 34.04 kg DM/kg N uptake with control, 75, 150 and 225 kg N/ha. Lower AEN with increasing N levels was due to lesser rate of increase in GFY and DMY per incremental dose of Nitrogen. Application of 90 kg N/ha resulted in the highest gross (Rs. 81567/ha) as well as net return (Rs.55007/ha) and B:C ratio (3.07). Greater GFY with application of 90 kg N/ha resulted in higher gross and net return and B:C ratio. Shekara *et al.* (2019) and Shekara *et al.* (2021) also noticed increase in gross and net return and B:C ratio with increase in N fertilization. Similarly, Rostamza *et al.* (2011) reported significant increment in gross return and net

TABLE 3

Nitrogen uptake and use efficiency and economics of forage pearl millet as affected by genotypes and N levels

Treatments	N uptake (kg/ha)	AEN (kg GFY/kg N applied)	AEN (kg DMY/kg N applied)	NutE (kg DM/kg N uptake)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
Genotypes							
Giant bajra	108.3	166.83	53.91	75.62	58498	32478	2.25
JPM-18-1	153.4	334.96	103.08	73.33	74411	48391	2.85
BAIF Bajra-7	121.5	199.55	61.69	74.22	67070	41050	2.57
RBB-1	100.6	193.67	58.76	78.01	56871	30851	2.18
APFB-9-1	144.6	307.33	91.24	73.92	76593	50573	2.94
Dev-1	177.0	223.46	88.63	73.38	89728	63708	3.44
16ADV0055	135.7	248.15	78.29	73.08	73339	47319	2.81
SEm±	4.3	46.32	7.37	1.15	2135	2135	0.08
CD (P=0.05)	12.2	93.97	21.14	3.25	6054	6054	0.23
N levels (kg/ha)							
0	84.4	-	-	78.85	55941	30461	2.20
30	124.9	292.27	89.47	74.93	69093	43253	2.67
60	154.7	235.32	76.61	72.82	77120	50920	2.94
90	173.9	189.82	63.46	71.43	81567	55007	3.07
SEm±	3.3	30.33	4.82	0.87	1614	1614	0.06
CD (P=0.05)	9.2	61.52	13.84	2.46	4576	4576	0.18

GFY- Green forage yield; DMY- Dry matter yield; AEN- Agronomic efficiency of nitrogen; NutE- Nitrogen utilization efficiency.

TABLE 4
Pearson correlation coefficient (r) between important parameters

Variable	PH	LSR	DMP	PGFY	PDMY	CP%	CPY	TDCPY	GFY	DMY
PH	-									
LSR	0.607***	-								
DMP	0.736***	0.515**	-							
PGFY	0.892***	0.613***	0.721***	-						
PDMY	0.895***	0.608***	0.870***	0.966***	-					
CP%	0.883***	0.756***	0.835***	0.800***	0.859***	-				
CPY	0.938***	0.622***	0.862***	0.927***	0.972***	0.904***	-			
TDCPY	0.938***	0.622***	0.862***	0.927***	0.972***	0.904***	1.000***	-		
GFY	0.948***	0.614***	0.725***	0.952***	0.937***	0.848***	0.969***	0.969***	-	
DMY	0.934***	0.609***	0.857***	0.935***	0.976***	0.886***	0.999***	0.999***	0.973***	-

* p < .05, ** p < .01, *** p < .001; PH-plant height, LSR- leaf: stem ratio, DMP- dry matter(%), PGFY- per day productivity in terms of green forage yield (GFY); PDMY- per day productivity in terms of dry matter yield (DMY); CP%- crude protein (%), CPY- Crude protein yield; TDCPY- total digestible CPY; GFY- Green forage yield; DMY- Dry matter yield.

return when N level was increased from 0 to 225 kg N/ha in forage pearl millet cv. Nutrifeed. However, application of 60 kg N/ha also produced comparable gross and net return and B:C ratio.

Correlation among important parameters

The correlation between important parameters showed that green forage yield was positively and significantly correlated with plant height (r = 0.948) and leaf:stem ratio (r = 0.614) (Table 4). Similary, dry matter yield was positively and significantly correlated with green forage yield (0.973), plant height (r = 0.934), dry matter content (r = 0.857) and leaf:stem ratio (r = 0.609). Similary, crude protein yield was positively and significantly correlated with dry matter yield (r = 0.999) and plant height (r = 0.938), and crude protein content (r = 0.904).

CONCLUSION

Based on the present investigation, it can be concluded that genotype Dev-1 with application of 90 kg N/ha was found to produce higher yield and quality with profitability parameter of forage pearl millet under North Bihar condition.

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REFERENCES

Aboelgoud, S.A. and M. N. Ragab, 2021 : Performance of Two Fodder Pearl Millet Varieties under Different Seeding and Nitrogen Fertilizer Rates. *Journal of Plant Production 12*(10): 1069-1076. doi:10.21608/jpp.2021.205709.

Bramhaiah, U., V. Chandrika, A. V. Nagavani, and P. Latha, 2018 : Performance of fodder pearl millet (*Pennisetum glaucum* L.) varieties under different nitrogen levels in southern agro-climatic zone of Andhra Pradesh. Journal of Pharmacognosy and Phytochemistry 7(2): 825-827.

Gascho, G. J., R. S. C. Menezes, W. W. Hanna, R. K. Hubbard, and J. P. Wilson, 1995 : Nutrient requirements of pearl millet. In: National Grain Pearl Millet Symposium ,. Rural Industries Research and Development Corporation, Barton, ACT, Australia, pp. 92-97.

Gomez, K. A. and A. A. Gomez, 1984 : Wiley 2nd edition, paperback, Statistical Procedures in Agricultural Research New York.

Iqbal M., Z. Iqbal., M. Farooq., L. Ali., and M. Fiaz., 2013 : Impact of nitrogenous fertilizer on yield and quality of oat. *Pak. J. Sci.,* **65**(1): 1-4.

Maman, N., S. C. Mason, and D. J. Lyon, 2006 : Nitrogen rate influence on pearl millet yield, nitrogen uptake, and nitrogen use efficiency in Nebraska. *Commun. Soil Sci. Plant Anal.* **37** : 127-141.

Meena, A. K., D. K. Singh, P. C. Pandey, and G. Nanda, 2019 : Dynamics of dry matter and nitrogen distribution in transplanted rice on mollisols. *J. Pl. Nutr.* **42**(7): 749-758.

Nanda, G., M. Kumar, and B. Prajapati, 2021 : Polybag maize silage as mitigation strategy for green

fodder shortage during recurring flood events in Bihar. Just Agriculture 2(3). Available at https://justagriculture.in/files/newsletter/2021/november/8.%20Polybag%20maize%20silage.pdf (Last accessed on 27.04.2022).

Pujarula, V., M. Pusuluri, S. Bollam, R. R. Das, R. Ratnala, G. Adapala, V. Thuraga, A. Rathore, R. K. Srivastava, and R. Gupta, 2021 : Genetic Variation for Nitrogen Use Efficiency Traits in Global Diversity Panel and Parents of Mapping Populations in Pearl Millet. *Front. Plant Sci.* **12** : 625915. doi: 10.3389/fpls.2021.625915.

Rostamza, M., M. R. Chaichi, M. R. Jahansouz, and A. Alimadadi, 2011. Forage quality, water use and nitrogen utilization efficiencies of pearl millet *(Pennisetum americanum* L.) grown under different soil moisture and nitrogen levels. *Agricultural Water Management*, **98**(10): 1607-1614.

Shapiro, C. A., R. B. Ferguson, G. W. Hergert, A. R. Doberman, and C. S. Wortman, 2003 : Fertilizer suggestions for corn. NebGuide G74-174-A. Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska–Lincoln, Lincoln, NE (2001). Ext. Publ. G74-174-A. Nebraska Coop. Ext., Univ. of Nebraska, Lincoln.

Shekara, B. G., P. Mahadevu, N. M. Chikkarugi, and N. Manasa, 2019 : Response of pearl millet (*Pennisetum glaucum* L.) varieties to nitrogen levels for higher green forage yield and quality in southern dry zone of Karnataka. *Forage Res.,* **45**(3): 232-234.

Shekara, B., P. Mahadevu, N. M. Chikkarugi, and Manasa, N. 2021. Performance of forage pearl millet genotypes to different levels of Nitrogen. *Forage Res.,* **47**(2): 193-196.

Sheoran, R. S., Satpal, U. N. Joshi, B. S. Duhan and S. Arya, 2016 : Response of forage pearl millet (*Pennisetum glaucum* L.) genotypes to different nitrogen levels. *Forage Res.,* **42**(2) : 115-118.

Singh, V. K., P. Gautam, G. Nanda, S. S. Dhaliwal, B. Pramanick, S. S. Meena, W. F. Alsanie, A. Gaber, S. Sayed, and A. Hossain, 2021 : Soil Test Based Fertilizer Application Improves Productivity, Profitability and Nutrient Use Efficiency of Rice (*Oryza sativa* L.) under Direct Seeded Condition. *Agronomy* **11**(9): 1756.