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Evaluation the effect of pearl millet varieties and nitrogen levels on growth, green fodder yield and economics

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Abstract
A field experiment entitled "Evaluation the effect of pearl millet varieties and nitrogen levels on growth, green fodder yield and economics" was conducted in *kharif* season 2022 at the School of Agriculture Research Farm, ITM University, in Gwalior. The experiment followed a factorial randomized block design, contains twelve treatment combinations with four nitrogen levels (0, 40, 80, and 120 kg ha^{-1}) and three fodder pearl millet varieties (Jumbo Plus, Diamond 20^{+} Plus, and Rijka). Each treatment was replicated thrice, the results of the experiment demonstrated that, both nitrogen levels and the varieties shown significant affect on the growth of plant height, yield attributes, quality parameters and economics of the crop at both harvest stages. During first and second harvest stages, when nitrogen levels were increased up to 120 kg ha^{-1}, there was a considerably significant impact on total green fodder yield (38.02 t ha^{-1}) as well as on total dry fodder yield (9.38 t ha^{-1}) over 0, 40, and 80 N kg ha^{-1}. Moreover, the quality parameters were also influenced significantly by different levels of nitrogen application at both harvest stages. Maximum dry matter content recorded under the application of nitrogen at 120 kg ha^{-1} similarly, crude protein content, ash content, ether extract content were observed maximum, when nitrogen was applied at 120 kg ha^{-1}, surpassing the values obtained from lower nitrogen levels, however highest crude fibre content recorded under 0 N kg ha^{-1}. In the evaluation of the three varieties at both harvest stages, it was observed that Rijka variety outperformed and excelled in producing the total green (34.87 t ha^{-1}) and dry fodder yield. (8.25 t ha^{-1}) as compared to the Jumbo Plus and Diamond 20^{+} plus varieties. Regarding with quality aspect, once again Rijka variety exhibited superior results, by showing a significant outcome in terms of maximum dry matter content, higher crude protein content, ether extract content, ash content, as compared to other two varieties, yet Jumbo Plus variety recorded maximum crude fibre content. From an economic perspective, it was found that the application of the nitrogen at 120 kg ha^{-1} in combination with the Rijka variety was contributed in getting the highest gross returns (57,029.76 ₹ ha^{-1} and 52,316.12 ₹ ha^{-1}), maximum net returns (33,654.03 ₹ ha^{-1} and 29,727.56 ₹ ha^{-1}) higher benefit-cost ratio (1.45 and 1.32) and higher returns per rupee invested, (2.45 and 2.33) as well as better economic efficiency (570.30 and 523.16).

Keywords: Nitrogen levels, varieties, green fodder yield, dry fodder yield and crude protein

Introduction
Pearl millet (*Pennisetum glaucum* L.) holds immense significance as a crop for both food and fodder production, making it a crucial component of agriculture and animal husbandry. Its remarkable features, such as profuse tillering capacity multiple cutting ability, drought tolerance, pest and disease resistance, non-toxicity, wider adaptability and more productivity per unit area, makes as highly encouraged crop for fodder cultivation. Notably, in dry land areas, pearl millet serves as a valuable green fodder crop during the *Kharif* season, providing 2-3 cuttings to fulfill the green fodder requirements for milch animals. Its ability to thrive with less water and endure extreme pH levels, high temperature, biotic and abiotic stress, further led to its cultivation as the best fodder crop. The advantages of cultivating pearl millet are numerous, including rapid growth, a short time for high yield potential, enhanced palatability, superior nutritional value, and adaptability to diversified climatic and soil conditions. Moreover, its multi-cut nature ensures a continuous and extended supply of fodder. The current estimate has India's livestock population at 535.78 million, with 192.49 million cattle, 109.85 million buffaloes, 74.26 million sheep, and 148.88 million goats (20th livestock census).

Therefore, to meet the demand for increasing livestock population, fodder cultivation is required on a large scale but there was a deficit of 64.21% in green fodder and 24.81% in dry fodder (Rathod *et al.*, 2019) [9] in our country, and also there is a need to explore new and improved genotypes of fodder pearl millet which helps in enhancing the yield potential and improving the nutritional content of fodder for livestock feed. Nitrogen is an important plant nutrient that significantly influences vegetative growth and herbage quality. It plays a pivotal role in enriching the overall quality aspects of crops, thereby contributing to sustainable crop production. The utilization of nitrogen varies among different pearl millet varieties, influencing their functions and benefits. It is essential to determine the optimum nitrogen dosage level for fodder pearl millet cultivation and to study the new varieties with various characteristics associated with it. With these considerations in view, this investigation aimed to identify suitable pearl millet varieties with optimum nitrogen level to obtain higher green and dry fodder yield, by improving nutritional quality, and to get maximum profit revenue.

Materials and Methods

During the *kharif season* of 2022, a field study entitled "Evaluation the effect of pearl millet varieties and nitrogen levels on growth, green fodder yield and economics" was conducted at the Agronomy Research CRC Farm – 1, School of Agriculture, ITM University in Gwalior (M.P.). The research farm is situated at latitude of 26.1378º N and a longitude of 78.2082º E, with an elevation of 197 meters above the mean sea level. The region experiences an annual rainfall ranging up to 764.4 mm. Gwalior receives maximum rainfall during south west monsoon period i.e. June to September. The experiment was laid out as a Factorial Randomized Block Design (FRBD) with the following factors: nitrogen levels (N) at 0, 40, 80, and 120 kg ha^{-1}, and three varieties namely (Jumbo Plus, Diamond 20^{+} Plus, and Rijka), with 12 treatment combinations which were replicated thrice. At the time of seed sowing, half dose of nitrogen (50%) and the full doses of phosphorus (30 kg ha^{-1}) and potassium (30 kg ha^{-1}) were applied according to the recommended dosage of fertilizers (only P and K). The remaining half-dose of nitrogen (25%) was applied at 30 days after sowing (DAS), followed by the other half-dose of nitrogen (25%) applied immediately after the first harvest (60 DAS). Growth parameter (Plant height) data was measured at 20 DAS, 40 DAS and at First harvest (60 DAS) followed by 20 and 40 Days after first harvest (DAFH) i.e., at Second harvest. Yield attributes and Quality parameters were recorded at the first harvest (60 DAS) and followed by the second harvest (40 DAFH) stage. All the data pertaining to plant height and green fodder yield were collected from the net plot area, which was later converted into a hectare basis. The known quantity of sample was taken and oven dried till it attains constant weight in thermo statistically controlled oven at 70 + 2º for the estimation of the dry matter content. The nitrogen content of the fodder sample was determined using the Kjeldahl method, and the resulting value was then multiplied by 6.25 to calculate the crude protein content of the sample. Fodder nutritive value were analyzed in terms of crude fibre, ether extract and ash content using the methods outlined in the (A.O.A.C. 1995) [2] guidelines. The cost of cultivation for each treatment was calculated by summing up all the expenses incurred from land preparation to crop harvesting. To determine the gross realization, the prevailing market price of fodder at the time of harvest was considered. Net returns were obtained by subtracting the total cost of cultivation from the gross returns. The benefit-cost ratio was computed using the following formula".

$$\text{B: C Ratio} = \frac{\text{"Net Return (₹ ha}^{-1}\text{)"}}{\text{"Total Cost of Cultivation (₹ ha}^{-1}\text{)"}}$$

"The Returns per rupee invested (RPRI) were worked out by using formula"

$$\text{RPRP(₹ ha}^{-1}\text{)} = \frac{\text{"Gross returns (₹ ha}^{-1}\text{)"}}{\text{"Total Cost of Cultivation (₹ ha}^{-1}\text{)"}}$$

"The economic efficiency (EE) were worked out by using formula"

$$\text{Economic efficiency(₹ ha}^{-1}\text{/day)} = \frac{\text{Gross returns (₹ ha}^{-1}\text{)}}{\text{Crop duration (days)}}$$

Analysis of variance (ANOVA) was performed using a Factorial Randomized Block Design on data pertaining to pearl millet used for animal feed, following the procedures outlined by Snedecor and Cochran (1994) [12]. To determine the significance of differences between treatment means, a critical difference at the 5% level of probability was employed for comparisons.

Results and Discussion

Effect of nitrogen levels on fodder pearl millet varieties had significantly influenced on the plant height growth, yield attributes, quality parameters and economics, whereas the interaction effect between nitrogen levels and varieties was found to be non- significant at all stages of the crop growth period. Growth (Plant height) and Yield attributing analysis at first and second harvest stages (table 1), shows that, the among the three varieties evaluated, the highest plant height was recorded with Rijka variety up to (157.12 cm, 234.25 cm, and 133.85 cm) which was significantly superior as compare to other two varieties during at 40 DAS as well as at first and at second harvest stages, whereas there was no significant difference in terms of plant height at 20 DAS and at 20 DAFH, the differences in the plant height was mainly because of the genetic makeup of the individual variety, similar results were reported by Shah *et al.* (2022) [10]. Again, Rijka variety exhibited significantly maximum total green fodder yield (34.87 t ha^{-1}) and the total dry fodder yield (8.25 t ha^{-1}) over Jumbo Plus and Diamond 20^{+} Plus varieties. This might be linked to the genetic potentiality of each variety which were in conformity with Bramhaiah *et al.* (2017) [3]. Apart from that, the application of nitrogen at 120 kg ha^{-1} were recorded maximum plant height up to (167.6 cm 241.98 cm and 141.62 cm) which was displayed a significant result over the other nitrogen levels 0, 40, 80, kg ha^{-1}, during at 40 DAS as well as at first and at second harvest stages, at 20 DAS and at 20 DAFH there was no significant difference in plant height. The increase in the plant height due to the increase in the length of internodes at higher dose of nitrogen levels, similar findings have been confirmed by Shekara *et al.* (2021) [11]. Likewise, higher yield attributes with a significant difference, was noted under the application of nitrogen at 120 kg ha^{-1} with total green (38.02 t ha^{-1}) and dry fodder yield (9.38 t ha^{-1}) as compared to lower nitrogen levels, (0, 40, and 80 kg ha^{-1}).

This might be due to the overall cumulative effects on growth characteristics under elevated nitrogen levels which often led to increase in the yield attributes, these findings align with similar results reported by Meena *et al.* (2012) [6]."

"Quality parameters analysis during at both harvest stages (table 2) revealed that, highest dry matter content was produced by Rijka variety up to (24.45% and 20.98%) which was significantly superior over the other two varieties, these findings were in conformity with Govind *et al.* (2018) [5]. Nutritional value of fodder crops is mainly determined by the amount of crude protein they contain. The Rijka variety exhibited highest crude protein content, when treated with nitrogen at 120 kg ha^{-1} surpassing the results which were obtained from other two varieties and lower nitrogen levels. The increase in crude protein content was attained due to higher nitrogen levels, which in turn stimulate the synthesis of more amino acids, similar results were reported by Midha *et al.* (2015) [7]. Furthermore, the differences in crude protein content among the varieties was due to their inherent genetic traits, consistent with the findings of Damame *et al.* (2012) [4]. Once again, Rijka variety proved to be significant in producing the highest ether extract content and ash content, over the Jumbo Plus and Diamond 20^{+} Plus varieties however, the highest crude fibre content with significant difference was recorded with Jumbo Plus variety. This might be due different genetic makeup of individual variety, these findings are collaborate with Sundar *et al.* (2022) [13]. Besides that application of nitrogen at 120 kg ha^{-1} recorded highest dry matter content up to (25.50% and 22.30%) as compare to lower nitrogen levels, Ayub *et al.* (2009) [8] also reported alike results. Similarly, increase in ether extract content and ash content, which was found to be significant under the application of nitrogen at 120 kg ha^{-1} over lower nitrogen levels 0, 40, 80, kg ha^{-1}, at both harvest stages, however under the 0 N kg ha^{-1} crude fibre content was recorded maximum, this might be because of higher dose of nitrogen levels decreases pectin, cellulose, and hemi cellulose content, which are major constitutes of crude fibre. These results are in conformity with shah *et al.* (2022) [10]."

Economic analysis (Table 3), depict that economic plays an important role in determining the feasibility of new research in the public domain. The application of nitrogen at 120 kg ha^{-1} along with the Rijka variety combination were demonstrated with maximum gross returns, (57,029.76 ₹ ha^{-1} and 52,316.12 ₹ ha^{-1}) higher net returns, (33,654.03 ₹ ha^{-1} and 29,727.56 ₹ ha^{-1}) profitable B:C ratio (1.45 and 1.32) higher returns per rupee invested, (2.45 and 2.33) and better economic efficiency (570.30 and 523.16) as compared to the Jumbo Plus and Diamond 20^{+} Plus varieties as well as with lower nitrogen levels (0, 40, and 80 kg ha^{-1}).

Table 1: Effect of nitrogen levels on Plant height growth and Yield attributes of fodder pearl millet varieties

Treatment	"Plant Height (cm)"					"Green fodder yield (t ha^{-1}) "		Total	"Dry fodder yield (t ha^{-1}) "		Total
	"20 DAS"	"40 DAS"	"60 DAS At first harvest"	20 DAFH	40 DAFH At second harvest	60 DAS At first harvest	40 DAFH At second harvest		60 DAS at first harvest	40 DAFH At second harvest	
Nitrogen (kg ha^{-1})											
0	40.83	118.4	185.58	40.42	106.39	17.37	7.22	24.59	3.43	1.17	4.60
40	41.78	137.2	207.10	41.12	117.63	21.07	9.24	30.31	4.57	1.67	6.24
80	43.78	152.7	221.99	43.21	130.72	23.98	9.70	33.68	5.72	2.00	7.72
120	45.55	167.6	241.98	43.97	141.62	26.97	11.05	38.02	6.91	2.47	9.38
SE(m)±	1.62	4.62	6.69	1.21	3.55	0.88	0.34		0.21	0.08	
C.D. at 5%	NS	13.56	19.63	NS	10.41	2.59	1.00		0.61	0.23	
Varieties											
Jumbo Plus	41.59	131.07	191.52	40.59	113.80	20.08	8.36	28.44	4.30	1.50	5.80
Diamond 20^{+} Plus	42.95	143.66	216.72	42.34	124.61	22.34	9.29	31.63	5.10	1.82	6.92
Rijka	44.41	157.12	234.25	43.61	133.85	24.62	10.25	34.87	6.08	2.17	8.25
SE(m)±	1.40	4.00	5.80	1.05	3.07	0.76	0.30		0.18	0.07	
C.D. at 5%	NS	11.74	17.00	NS	9.02	2.24	0.87		0.52	0.20	
N×S interaction											
SE(m)±	2.81	8.01	11.59	2.10	6.15	1.53	0.59		0.36	0.14	
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS		NS	NS	

"*DAS: Days after sowing, DAFH: Days after first harvest

Table 2: Effect of nitrogen levels on Quality parameters of fodder pearl millet varieties

Treatment	"Dry matter (%)"		"Crude protein (%) "		"Ether extract (%)"		"Total Ash (%)"		"Crude fibre (%)"	
	60 DAS At first harvest	40 DAFH At second harvest	60 DAS At first harvest	40 DAFH At second harvest	60 DAS at first harvest	40 DAFH At second harvest	60 DAS at first harvest	40 DAFH At second harvest	60 DAS at first harvest	40 DAFH At second harvest
Nitrogen (kg ha^{-1})										
0	19.64	16.00	7.94	6.56	2.23	2.02	9.32	8.78	32.71	34.03
40	21.58	18.09	8.99	8.18	2.57	2.24	9.79	9.06	31.44	32.29
80	23.55	20.52	9.84	8.82	2.96	2.50	10.86	10.00	30.84	31.59
120	25.50	22.30	11.03	9.54	3.18	2.70	11.68	10.78	30.00	31.19
S.E(m)±	0.58	0.47	0.35	0.21	0.07	0.06	0.28	0.26	0.41	0.55
C.D. at 5%	1.71	1.38	1.04	0.61	0.20	0.19	0.82	0.76	1.21	1.60
Varieties										
Jumbo Plus	20.95	17.64	8.47	7.62	2.54	2.19	9.69	8.98	32.42	33.75
Diamond 20^{+}	22.50	19.06	9.47	8.31	2.73	2.36	10.41	9.65	31.19	32.25

Plus										
Rijka	24.45	20.98	10.41	8.90	2.92	2.53	11.14	10.33	30.12	30.83
S.E(m)±	0.51	0.41	0.31	0.18	0.06	0.05	0.24	0.22	0.36	0.47
C.D. at 5%	1.48	1.20	0.90	0.53	0.18	0.16	0.71	0.66	1.05	1.38
N×S interaction										
S.E(m)±	1.01	0.82	0.61	0.36	0.12	0.11	0.48	0.45	0.72	0.94
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Effect nitrogen levels on Economics of fodder pearl millet varieties

Treatment	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B: C ratio	RPRI (₹ ha^{-1})	EE (₹ ha^{-1}/day)
Nitrogen (kg ha^{-1})					
0	36882.67	15263.38	0.71	1.71	368.83
40	45464.76	23179.80	1.05	2.06	454.65
80	50522.35	27590.68	1.22	2.23	505.22
120	57029.76	33654.03	1.45	2.45	570.30
S.E(m)±	1534.03	1038.41	0.05	0.07	15.34
C.D. at 5%	4499.15	3045.57	0.14	0.20	44.99
Varieties					
Jumbo Plus	42665.37	19938.82	0.88	1.88	426.65
Diamond 20^{+} Plus	47443.17	25099.53	1.12	2.12	474.43
Rijka	52316.12	29727.56	1.32	2.33	523.16
S.E(m)±	1328.51	899.29	0.04	0.06	13.29
C.D. at 5%	3896.38	2637.54	0.12	0.17	38.96
N×S interaction					
S.E(m)±	2657.02	1798.59	0.08	0.12	26.57
C.D. at 5%	NS	NS	NS	NS	NS

Conclusion

Based on the present experimental findings it can be presumed that, the optimum level of nitrogen application at 120 kg ha^{-1} resulted in superior outcome concerning with plant growth (height) yield attributes, quality parameters, and economic value as compared to lower nitrogen levels (0, 40, and 80 kg ha^{-1}). Crude fiber content significantly decreased with enhancing the levels of nitrogen up to 120 kg ha^{-1} and recorded maximum under 0 N kg ha^{-1}. Among the different varieties tested, the Rijka variety displayed favorable responses and proved to be well-suited for enhancing the all parameters of the crop, omitting the crude fibre content which was recorded maximum with Jumbo Plus variety. However, the combination of Rijka variety along with nitrogen application at 120 kg ha^{-1} emerged as the most suitable treatment combination for significantly improving the crop production and to maximize the profitability.

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Conflict of Interest

The study was conducted without the authors having any conflicts of interest, as stated by the authors.

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