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Research Paper

Economic Analysis of Seed Rate and Nitrogen Management for Forage Production in *Makkhan* Grass (*Lolium multiflorum* Lam)

ANKIT TIWARI[1], JAGANNATH PATHAK[2], MUKESH KUMAR[3], SHIVAM SINGH[4] AND HIMANSHU PANDEY[5]

Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh

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ABSTRACT

A field experiment was conducted during *rabi* 2021–22 and 2022–23 at research farm of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, (Uttar Pradesh) to study the effect of seed rate and nitrogen levels on forage yield and quality of *Makkhan* grass in Western Uttar Pradesh with the objective to study the economic feasibility of different treatments. The treatments are composed three levels of seed rate (10, 15 & 20 kg/ha) and five levels of Nitrogen (N) (0, 50, 75, 100 & 125 kg/ha).The design used in the experiment factorial randomized block design with four replications. Result revealed that sowing of *makkhan* grass with 20 kg/ha seed rate was better over the 10 and 15 kg/ha seed rate in respect gross returns, net returns and B: C ratio during both the years. Among the treatments, combined application of 20 kg/ha seed rate and 125 kg N per hectare recorded higher profit during both years of experiment. The interaction between N levels and seed rate was also found significant and positive in all the parameters concerned.

Key words: Cost of cultivation, Economic, *Makkhan* grass, Seed and N levels

Makkhan grass, scientifically known as *Lolium multiflorum* Lam is an annual forage crop that holds significant importance in forage production and livestock feeding due to its rapid regrowth after cutting, high biomass production, nutritional value, and adaptability to poor soil fertility and different climatic conditions (Kumar *et al.,* 2024). One of the notable attributes of *Makkhan* grass is its high protein content, good palatability and digestibility, which contributes to its nutritional value as an animals feed source (Tiwari *et al.,* 2023). This grass offers additional environmental benefits such as soil erosion control, carbon sequestration, and biodiversity enhancement (Ghale *et al.,* 2022). Its deep root system helps stabilize soil structure, reduce nutrient runoff, and improve water infiltration, making it an eco-friendly option for sustainable land management practices.

[1]Corresponding author's Email: ankit.tiwari12130@gmail.com

[1]Assistant Professor-cum-Junior Scientist-Department of Agronomy, Tilka Majhi Agriculture College, (BAU, Ranchi) Jharkhand 834 006; [2]Professor, Department of Soil Science and Agricultural Chemistry Banda University of Agriculture and Technology, Banda 210 001; [3]Professor Department of Agronomy- Sardar Vallabhbhai Patel University of Agriculture and Technology 250 110; [4]Subject Matter Specialist (Soil Science and Agricultural Chemistry), KVK Sultanpur, Acharya Narendra Deva University of Agriculture and Technology 224 229; [5]Young Profession-II -Indian Institute of Sugarcane Research, Lucknow 226 002, India

The economic analysis of seed rate and N management in quality and economical viable forage production a critical aspect for decision-making to optimizing seed rate and nitrogen levels this can profoundly influence both the economic viability and sustainability of forage production systems particularly in regions where forage plays a significant role in livestock feeding and quality fodder production management (Tiemann *et al.,* 2023). Seed rate plays a pivotal role in establishing optimum stand density, forage yield potential, and overall productivity, profitability of forage production (Hazra *et al.,* 2014). Levels of seed rate can significantly impact on crop establishment, seedling vigour, competition with weeds, and subsequent forage yield. Understanding the economic implications of varying seed rates is essential for minimise input costs while maximizing quality forage production and profitability.

Similarly, Nitrogen management represents a key determinant of quality forage production and profitability. N is an essential primary nutrient for plant growth, protein synthesis, and biomass accumulation (Shah *et al*., 2024). Adequate N fertilization can enhance profitable forage yield, nutritional content, and digestibility, thereby improving animal performance and feed efficiency (Lal *et al.,* 2024). However, excessive N application may lead to environmental pollution, nutrient imbalances, and economic inefficiencies. Balancing Nitrogen inputs with forage production goals and economic considerations is crucial for

achieving sustainable and profitable forage systems.

The economic analysis of seed rate and nitrogen management for forage production in *Makkhan* grass represents a fundamental aspect of agricultural decision-making, with implications for both farm profitability and environmental sustainability. By integrating economic principles with agronomic knowledge and livestock management practices, farmers can optimize resource use, enhance productivity, and foster resilience in forage-based livestock systems (Alvarez-Rodriguez *et al.,* 2024). The economic analysis of seed rate and N management in forage production including various components like, input costs, yield potential, market prices, and financial returns. It involves assessing the cost-effectiveness of different application rates of seed rate and Nitrogen in relation to forage production, quality, and market value. By quantifying the costs and benefits associated with alternative management practices, farmers can make informed decisions to optimize resource allocation, mitigate risks, and enhance profitability. Furthermore, the economic analysis provides valuable insights into the trade-offs between input expenditures and output revenues, considering factors of production input such as agriculture labour, farm machinery, fertilizer prices, and forage market dynamics (Duan *et al*., 2023). It enables farmers to identify the most economically viable strategies for forage production, taking into account local agro climatic conditions, soil fertility, and livestock feeding requirements.

The objective of the present study was to evaluate the effect of different seed rates and N levels on the total green forage yield and economic feasibility of *Makkhan* grass in Western Uttar Pradesh. It was hypothesized that higher seed rates and increased N application would significantly improve the total green forage yield, and economic returns of *Makkhan* grass.

MATERIALS AND METHODS

Experiments were conducted at crop research farm of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut during the *rabi* season 2021–22 and 2022–23. Initially, the soil was sandy clay loam in textured and slight alkaline in reaction, with low in available nitrogen (197.8 kg/ha), available phosphorus (19.15 kg/ha), organic carbon (0.48%) and medium in available potassium (135.6 kg/ha). The site is situated on Delhi- Dehradun high way and lies between 29.04' North latitude and 77^0.42 East longitude at an elevation of 237 meters above sea level. This region falls under agro climatic zone VIII (Sub tropical climate) of Uttar Pradesh. Most of the facilities are available on this farm.

The experiment in each year was arranged in a factorial randomize block design with five N levels (0, 50, 75, 100 and 125 kg/ha) and three seed rate levels (10, 15 and 20 kg/ha) assigned on the four replications. Application of N and maintenance of seed rate was done as per treatment in all plots (0 to 125 kg/ha N and 10, 15 and 20 kg/ha). One fourth of nitrogen use at basal dose, and rest of Nitrogen was top dressed in three splits does after each cutting of green forage. Economic analysis of *Makkhan* grass was performed to determine the efficiency of different treatments. In the economic analysis, only Nitrogen and seed rate levels costs, which were variable, were considered (Variable cost). Other management costs, which were the same for all treatments also included (Fixed cost). The amount of Nitrogen fertilizer and seed rate required for one hectare was calculated, and the cost was estimated based on their current market price. The number of labourers for fertilizer application, seed sowing, and crop cuttings were counted and labour wages was based on an 8- hour workday. The market price of green forage was determined during the year of experiment and used for calculation of the gross income. The net profit per hectare for each treatment was calculated after deducting the total cost (N fertilizer cost, seed cost plus common cost) from the gross income. The data were analysed by using analysis of variance technique for Factorial Randomized Block Design (FRBD) to evaluate differences between treatments, and the means were separated using least significant differences (LSD) at the 5% level of significance as suggested by Panse and Sukhatme (1967).

RESULTS AND DESCUSSION

Total green forage yield

Total green fodder yield of *Makkhan* grass significantly influenced by varying levels of seed rates and nitrogen (Table 1). The highest total green forage yield was recorded when crop was sown at the 20 kg/ha seed rate followed by 15 kg/ha seed rate. The increase in total forage yield with increased seed rate might be due to higher plant density m^2, plant height, leaf area index and leaf shoot ratio. Similar findings were also recorded by Meena *et al.,* (2017), Satpal *et al.,* (2018), Todorovi *et al.,* (2020) and Shital *et al.,* (2022). Similarly, increasing levels of nitrogen from 0 to 125 kg/ha caused significant increase in total green forage yield of *Makkhan* grass. The highest total green forage yield was recorded with the application of 125 kg/ha N followed by 100 kg/ha N at all the cuttings during both years. The minimum green fodder yield was recorded at no application of N. The increased supply of N to the plant is necessary to promote meristemetic activity in plants, and improved growth parameters as well as forage yield (Sidhu *et al.,* 2021 and Shital *et al.,* 2022). Interactive effects between seed rate and N levels on green forage yield at all cuttings and in total yield were found significant, as mentioned in Table 1.a, 1.b and 1.c. Increasing levels of N and

Table 1. Effect of seed rate and nitrogen levels on green forage yield (q/ha) of makkhan grass during 2021–22 and 2022–23

Treatment	Green forage yield (q/ha)										
	1st cut		2nd cut		3rd cut		4th cut		Total		
	2021–22	2022–23	2021–22	2022–23	2021–22	2022–23	2021–22	2022–23	2021–22	2022–23	Pooled
Seed Rate											
S_1 (10)	79.8	82.7	97.1	89.1	98.7	103.4	82.8	84.8	358.5	360.1	359.3
S_2 (15)	103.0	107.0	114.5	122.6	115.6	126.4	111.1	115.3	444.3	471.5	457.9
S_3 (20)	142.2	148.3	152.1	162.0	160.1	173.3	153.2	154.1	607.8	637.9	622.9
SEm±	1.01	1.1	0.96	1.2	2.9	1.1	1.8	1.2	3.5	2.4	2.07
CD (P=0.05)	2.8	3.2	2.75	3.4	8.4	3.3	5.1	3.4	10.1	7.1	5.92
Nitrogen levels											
N_0 (0)	77.69	84.6	100.7	98.5	104.8	110.4	83.8	84.3	367.1	378.0	372.6
N_1 (50)	104.7	109.1	118.1	126.0	121.6	131.4	114.1	116.7	458.6	483.4	471.0
N_2 (75)	113.8	115.9	125.9	127.5	129.2	141.6	121.6	124.5	490.7	509.7	500.2
N_3 (100)	119.0	124.8	126.2	131.0	131.1	139.8	126.8	129.7	503.3	525.4	514.3
N_4 (125)	126.6	128.9	135.3	139.9	137.2	148.6	132.3	135.3	531.4	552.9	542.2
SEm±	1.3	1.4	1.24	1.5	2.9	1.5	2.3	1.5	4.59	3.2	2.6
CD (P=0.05)	3.7	4.1	3.5	4.4	8.4	4.3	6.6	4.4	13.1	9.1	7.64
Interaction (S × N)											
SEm±	2.2	2.5	2.1	2.6	2.9	2.6	4.0	2.7	7 .9	5.5	4.6
CD (P=0.05)	6.4	7.1	6.1	7.7	8.4	7.5	11.5	7.7	22.7	15.91	13.2

Table 1(a). Effect of seed rate x nitrogen levels on total green forage yield (q/ha) of makkhan grass during 2021–22

Seed rate (kg/ha)	Nitrogen levels (kg/ha)				
	N_0 (0)	N_1 (50)	N_2 (75)	N_3 (100)	N_4 (125)
S_1 (10)	324.57	313.18	367.94	379.37	407.91
S_2 (15)	370.48	445.10	466.46	474.50	465.30
S_3 (20)	406.46	617.68	637.78	656.22	721.27
SEm±			7.95		
CD (P=0.05)			22.70		

Table 1(b). Effect of seed rate x nitrogen levels on Total green forage yield (q/ha) of makkhan grass 2022–23

Seed rate (kg/ha)	Nitrogen levels (kg/ha)				
	N_0 (0)	**N_1** (50)	**N_2** (75)	**N_3** (100)	**N_4** (125)
S_1 (10)	324.61	312.22	371.86	383.95	408.18
S_2 (15)	372.81	483.05	485.29	496.60	520.22
S_3 (20)	436.82	654.94	672.02	695.71	730.34
SEm±			5.57		
CD (P=0.05)			15.91		

Table 1(c). Effect of seed rate x nitrogen levels on pooled Total green forage yield (q/ha) of makkhan grass 2021–22 and 2022–23

Seed rate (kg/ha)	Nitrogen levels (kg/ha)				
	N_0 (0)	N_1 (50)	N_2 (75)	N_3 (100)	N_4 (125)
S_1 (10)	324.59	312.70	369.90	381.66	408.04
S_2 (15)	371.65	464.08	475.87	485.55	492.77
S_3 (20)	421.64	636.31	654.90	675.97	725.81
SEm±			4.63		
CD (P=0.05)			13.24		

higher seed rate caused increase in green forage yield synergistically. The maximum total green forage yield 721.27 and 730.34 q/ha during 2021-22 and 2022-23, respectively was recorded with combined application of 20 kg seed rate and 125 kg N/ha. The lowest green forage yield 313.18 and 312.22 q/ha was recorded with the application of 10 kg seed rate and 0 kg N/ha during 2021–22 and 2022–23, respectively.

Economic Studies

The effects of Nitrogen levels and seed rates on economic performance are presented in Table 2. The economic analysis was calculated based on the prevailing general market prices during the experimental cropping seasons for various commodities, as well as the wages of labourers and the costs of machinery during those years. The analysis included the cost of cultivation, gross return, net return, and benefit-cost (B:C) ratio under different treatment combinations of seed rate and nitrogen levels for forage *Makkhan* grass.

Cost of Cultivation

The cost of cultivation (Rs/ha) for different seed rates and nitrogen levels was determined by considering all operations performed under various treatments. Among the seed rates of *Makkhan* grass, the highest cost of cultivation, Rs/ha 50,543 and 51,943, was observed for sowing at a seed rate of 20 kg/ha, while the lowest cost of cultivation, Rs/ha 46,643 and 47,543, was recorded for sowing at a rate of 10 kg seed/ha during 2021–22 and 2022–23, respectively. Regarding N levels, the highest cost of cultivation, Rs/ha 45,012 and 45,412, was found with the application of 125 kg N/ha, followed by 100 kg N/ha during 2021–22 and 2022–23. The minimum cost of cultivation, Rs/ha 42,743 and 43,143, was recorded under the control treatment during 2021–22 and 2022–23, respectively.

Gross Returns

The data related to gross returns are presented in Table 2. The gross returns were calculated based on the total value of green forage yield of *Makkhan* grass. Crops sown at a seed rate of 20 kg/ha resulted in the highest gross returns, amounting to Rs/ha 164,129 and 175,441 whereas the lowest gross returns, Rs/ha 96,821 and 99,046 , were recorded for crops sown at a seed rate of 10 kg per hectare during 2021–22 and 2022–23, respectively. This increase in gross returns may be attributed to the higher green forage yield observed at the 20 kg seed rate /ha. Similar results were also reported by Singh (2018), Bora (2018), and Ningoji *et al*. (2020). Among nitrogen levels, the highest gross returns, Rs/ha 143,503 and 152,052, were recorded with the application of 125 kg N/ha, followed by 100 kg N/ha. The lowest gross returns, Rs/ha 99,136 and 103,973, were observed under the control treatment during 2021–22 and 2022–23, respectively. This increase in gross returns may be attributed to the higher forage yield resulting from the higher Nitrogen application rate. These findings are in close agreement with those of Sheoram *et al*. (2017), Bora

Table 2. Cost of cultivation, gross return, net return and B:C ratio of makkhan grass influenced by levels of seed rate and nitrogen during 2021–2022 and 2022

Treatment	Cost of Treatment (₹/ha)		Cost of cultivation (₹/ha)		Gross return (₹/ha)		Net return (₹/ha)		Benefit: cost ratio	
	2021–22	2022–23	2021–22	2022–23	2021–22	2022–23	2021–22	2022–23	2021–22	2022–23
Seed Rate (S) (kg/ha)										
S_1 (10)	3,900	4,400	46,643	47,543	96,821	99,046	48,930	50,255	2.01	2.02
S_2 (15)	5,850	6,600	48,593	49,743	119,980	129,689	70,159	78,718	2.40	2.54
S_3 (20)	7,800	8,800	50,543	51,943	164,129	175,441	112,358	122,831	3.16	3.33
SEm(±)					960	685	960	685	0.019	0.01
CD (P=0.05)					2,741	1,957	2,741	1,957	0.05	0.03
Nitrogen levels (N) (kg/ha)										
N_0 (0)	-	-	42,743	43,143	99,136	103,973	50,543	54,230	2.03	2.08
N_1 (50)	1,226	1,226	43,969	44,369	123,836	132,937	74,366	82,317	2.48	2.60
N_2 (75)	1,617	1,617	44,360	44,760	132,497	140,174	82,636	89,163	2.64	2.72
N_3 (100)	1,943	1,943	44,686	45,086	135,909	144,491	85,432	92,864	2.67	2.77
N_4(125)	2,269	2,269	45,012	45,412	143,503	152,052	92,767	101,099	2.81	2.97
SEm±	-	-	-	-	1,239	885	1,239	885	0.02	0.01
CD (P=0.05)	-	-	-	-	3,538	2,526	3,538	2,526	0.07	0.04
Interaction										
S.Em±	-	-	-	-	2,147	1,533	2,147	1,533	0.04	0.03
CD (P=0.05)	-	-	-	-	6,129	4,376	6,129	4,376	0.18	0.12

and Singh *et al.* (2018), Sidhu *et al*. (2020), and Shital *et al.* (2022).

Net Returns

The net return data (Rs/ha presented in Table 2 indicate that the highest net returns, 112,358 and 122,831 Rs/ha, were obtained for crops sown at a seed rate of 20 kg/ha during 2021–22 and 2022–23, respectively. The lowest net returns, Rs/ha 48,930 and 50,255, were recorded for crops sown at a seed rate of 10 kg /ha during 2021–22 and 2022–23, respectively. Among the Nitrogen levels, the highest net returns, Rs/ha 92,767 and 101,099, were observed with the application of 125 kg N/ha, while the lowest net returns, Rs/ ha 50,543 and 54,230, were recorded under the control treatment during 2021–22 and 2022–23, respectively.

Benefit: Cost Ratio

The data presented in Table 2 show that the highest benefit-cost (B: C) ratio, 3.16 and 3.33, was recorded for crops sown at a seed rate of 20 kg per hectare, while the lowest B:C ratio, 2.01 and 2.02, was observed for crops sown at a seed rate of 10 kg/ha during 2021–22 and 2022–23, re-

Table 2(a). Effect of seed rate x nitrogen levels on Gross return (₹/ha) of *makkhan* grass 2021–22

Seed rate (kg/ha)	Nitrogen levels (kg/ha)				
	N_0 (0)	N_1 (50)	N_2 (75)	N_3 (100)	N_4 (125)
S_1 (10)	87,634	845,58	99,345	102,431	110,135
S_2 (15)	100,030	120,177	125,944	128,117	125,632
S_3 (20)	109,744	166,774	172,202	177,181	194,742
SEm±			2147		
CD (P=0.05)			6129		

Table 2(b). Effect of seed rate x nitrogen levels on Gross return (₹/ha) of *makkhan* 2022–23

Seed rate (kg/ha)	Nitrogen levels (kg/ha)				
	N_0 (0)	N_1 (50)	N_2 (75)	N_3 (100)	N_4 (125)
S_1 (10)	89,269	85,862	102,262	105,587	112,249
S_2 (15)	102,524	132,840	133,454	136,565	143,061
S_3 (20)	120,127	180,109	184,805	191,321	200,844
SEm±			1,533		
CD (P=0.05)			4,376		

Table 2(c). Effect of seed rate x nitrogen levels on Net return (₹/ha) of *makkhan* grass 2021-22

Seed rate (kg/ha)	Nitrogen levels (kg/ha)				
	N_0 (0)	N_1 (50)	N_2 (75)	N_3 (100)	N_4 (125)
S_1 (10)	40,991	36,689	51,085	53,845	61,223
S_2 (15)	51,437	71,358	75,734.2	77,581	75,096
S_3 (20)	59,201	115,005	120,042	124,695	141,930
SEm±			2147		
CD (P=0.05)			6129		

Table 2(d). Effect of seed rate x nitrogen levels on Net return (₹/ha) of *makkhan* grass 2022–23

Seed rate (kg/ha)	Nitrogen levels (kg/ha)				
	N_0 (0)	N_1 (50)	N_2 (75)	N_3 (100)	N_4 (125)
S_1 (10)	41726	37093	53102	56101	62437
S_2 (15)	52781	81871	82094	84879	91049
S_3 (20)	68184	126940	131245	137435	146632
SEm±			1533		
CD (P=0.05)			4376		

Table 2(e). Effect of seed rate x nitrogen levels on B:C ratio of *makkhan* grass 2021–22

Seed rate (kg/ha)	Nitrogen levels (kg/ha)				
	N_0 (0)	N_1 (50)	N_2 (75)	N_3 (100)	N_4 (125)
S_1 (10)	1.87	1.76	2.05	2.10	2.25
S_2 (15)	2.05	2.46	2.50	2.53	2.48
S_3 (20)	2.17	3.22	3.30	3.37	3.68
SEm±			0.04		
CD (P=0.05)			0.18		

Table 2(f). Effect of seed rate x nitrogen levels on B:C ratio of *makkhan* grass 2022–23

Seed rate (kg/ha)	Nitrogen levels (kg/ha)				
	N_0 (0)	N_1 (50)	N_2 (75)	N_3 (100)	N_4 (125)
S_1 (10)	1.87	1.76	2.08	2.13	2.25
S_2 (15)	2.06	2.60	2.59	2.64	2.75
S_3 (20)	2.31	3.38	3.45	3.55	3.70
SEm±			0.03		
CD (P=0.05)			0.12		

spectively. Among N levels, the highest B:C ratio, 2.81 and 2.97, was obtained with the application of 125 kg N/ha, followed by 100 kg N/ha. The lowest B:C ratio, 2.03 and 2.08, was observed under the control treatment (0 kg N/ha) during 2021–22 and 2022–23, respectively. The interactive effect between seed rate and N levels in relation to gross returns, net returns and B:C ratio as mentioned in Table 2.a, 2.b, 2.c, 2.d, 2.e, and 2.f, were found significant and positive effect during both years. The maximum gross returns, net returns and B:C was recorded maximum with combined use of 20 kg seed rate with 125 kg N/ha during the both years of the experiment.

Based on the results, it can be concluded that the highest significant total green forage yield, gross returns, net returns, and B:C ratio were recorded with the application of 20 kg seed/ha, followed by 15 kg seed/ha during 2021–22 and 2022–23. Among N levels, the highest significant total green forage yield gross returns, net returns, and B:C ratio were recorded with the application of 125 kg N/ha, followed by 100 kg N/ha during both years of the experiment in Western Uttar Pradesh.

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