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Effect of Different Levels of Nitrogen Application and Cutting Management on Yield, Quality and Economics of Fodder Oats (*Avena sativa* L.)

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ABSTRACT: A field experiment was performed in the *rabi* season, 2020-2021 at the agricultural fields of Lovely Professional University, Phagwara, Punjab for study the effect of different levels of nitrogen application and cutting management on yield, quality and economics of fodder oats (*Avena sativa* L.)". In factorial randomised block design, the experiment has been replicated three times, with ten treatment combinations. The treatment combinations include five nitrogen levels, i.e., 0, 60, 90, 120 and 150 kg N ha^{-1} and two cutting managements i.e., C_1 (Single cut at 50 percent flowering stage), C_2 (First cut at 60 DAS and second cut at 50 percent flowering). Forage is a widely known and inexpensive source of animal feed. Thus, improved agronomic methods such as different levels of nitrogen application and cutting management are important factors in increasing forage crop productivity. The results of research work on effect of nitrogen levels and cutting management revealed that application of nitrogen @ 150kg ha^{-1} recorded highest plant height (103.03 cm), maximum number of tillers (77.45), leaf: stem ratio (1.31), green fodder yield (584.83 q ha^{-1}), dry matter yield (95.48 q ha^{-1}), crude protein yield (13.15 q ha^{-1}) and crude fibre yield (19.10 q ha^{-1}) as when compared to the other levels of nitrogen. As regards to cutting management, highest plant height (96.31 cm), number of tillers (67.72), leaf: stem ratio (1.11) were found maximum at C_1 and green fodder yield (655.12 q ha^{-1}), dry matter yield (102.25 q ha^{-1}), crude protein yield (10.82 q ha^{-1}) and crude fibre yield (21.26 q ha^{-1}) were found maximum under C_2. Highest gross realization, net realization and benefit cost ratio were received under C_2.

Key words: Cutting management**,** levels, nitrogen, Oats and yield

INTRODUCTION

India accounts for around 2.4% of the world's cultivated area and has nearly 16% of the world's human and 15% of the world's livestock population (Anonymous, 2017). India has the world's largest cattle population, with 520 million head, or about 15 percent of the global cattle population (Neelar, 2011). However, with an overall annual forage production of 833 mt, the country only has 4.4 percent of its cultivated land under fodder crops (390 mt green and 443 mt dry forage). The yearly food demand for cattle is 1594 mt to feed the global livestock population (1025 million tonnes green and 569 million tonnes dry). The country's current feed and fodder resources can only meet 48% of the demand, with a 61.1 percent green and 21.9 percent dry fodder deficit, respectively (Anon., 2009).According to estimates, inadequate feed and fodder supply accounts for half of all livestock productivity losses. As a result, animals are short in stature, have low milk production, have poor draught power, and have a low market demand. Green fodder availability is currently insufficient, which impedes large-scale animal and milk production.

Farmers are unable to cultivate fodder crops such as Berseem or Lucerne in drought-stricken areas due to a lack of water. Oats would be a better choice for an alternative feed crop in colder climates. Furthermore, when compared to berseem, it has a lower water requirement and provides a greater amount of nutritious green fodder.

Oat (*Avena sativa* L.), also called as "Javi" or "Jayi" and it comes under the *Poaceae* family is a widely adapted cereal fodder crop in India, especially in the Western, Northern and Central states. Oats may have originated from Asia. After wheat, maize, rice, barley, and sorghum, oat ranks sixth in global cereal production. It has a fast growth rate, excellent regeneration capacity, palatability, and a high nutritive value. Oats have a high nutritional value of 6-7% protein, 66% carbohydrates, and 11% fibre. Oat regrowth provides and plays an important role in providing green fodder to cattle. Oats are a dual-purpose crop that grows in both temperate and subtropical climates. Being a high-nutritional-value cereal, it is particularly high in fat, protein, vitamin B_1, phosphorous, and iron (Tiwana *et al*., 2008). The majority of fodder oats are fed dry, with the remaining converted into the hay or silage for use at the times of shortage (Suttie and Reynolds, 2004).

On global scale, there are 13.9 million hectares of oat production, with Asia responsible for 76.2 lakh hectares (FAO, 2000). Oat crop is commonly grown in India for fodder. In India, it covers approximately 1.0 million ha of the area under oat cultivation with green fodder productivity of about 350 q ha^{-1} to 500 q ha^{-1}**(**IGFRI, 2011**).** Where irrigation is available, it is primarily grown in Haryana, Uttar Pradesh, Punjab, Jammu and Kashmir, Himachal Pradesh, Madhya Pradesh, Rajasthan, Maharashtra, West Bengal, and Gujarat. Uttar Pradesh has the most cropland (34 percent), Punjab (20 percent), Bihar (16 percent), Haryana (9 percent), and Madhya Pradesh (6 percent). Punjab has cultivated 2.03 million hectares of fodder, with a total output of 45 million tonnes, which is inadequate even to meet the maintenance needs of livestock (Anonymous, 2017).

Oat has proven to be the productive and appropriate fodder crop among various fodder crops grown for animal feed. It feeds livestock with energy-rich, nutritious, and palatable green fodder, and it is also used to make hay and silage, oats can be grown in a wide variety of climatic conditions because of its vast varietal diversity (Singh, 1973). There are many features that influence forage oat productivity and quality. Fertilization and cutting management are two important factors that impact both fodder crop productivity and quality (Mahale *et al*., 2004).

Nitrogen plays an important role, among the major plant nutrients in both quantitative and qualitative improvements in fodder production. Nitrogen is needed for the formation of proteins and chlorophyll. Nitrogen is required for fodder production as it influences cell elongation, inter-nodal expansion and cell division. It is also important for the early establishment of the crop. It improves growth parameters and dry matter growth to increase fodder yield (Kumar *et al*., 2001). Nitrogen turns plants green and promotes early vegetative development. It progresses efficiency by increasing the proximity of fodder crops and, to a large degree, regulates the utilisation of phosphorus, potassium and other nutrients. Dividing the total nitrogen application into two or more splits will assist farmers in improving nutrient efficiency, promoting optimal yields, and mitigating nutrient losses. Nitrogen splitting can aid in reducing leaching and volatilization losses while increasing nitrogen production. Forage oats are heavy nutrient feeders which remove large quantities of nutrients from the soil, in particular multi-cut oat cultivars. As a result, the effect of nitrogen splitting on oat performance must be evaluated. Cutting management also affect the crop yield. It is another important factor that determines the quality of fodder (Bhilare and Joshi, 2007) because it has a significant impact on succulency, dry matter, crude protein, and other quality parameters. Demetrio *et al.,* (2012) found that one or two cuttings in vegetative phases resulted in a greater yield of forage during the flowering phase. Sharma and Bhunia (2001) also found an interaction effect between N level and cutting management, with increasing N levels and a single cut at 85 DAS producing higher fodder yield. In view of this, efforts were made to adjust nutrient levels and cutting management so that some green fodder is accessible to livestock during the winter months.

It has been noted that oats regenerate and another good cut is possible when harvested before ear emergence. Taking more than one cut may help to extend the time of fodder availability and improve fodder quality as quality deteriorates with plant age; however, nitrogen requirements of oats may vary when raised with different cutting managements. The success of the white revolution is based on a year-round supply of balanced feed and fodder to milch animals. Overall productivity improvement cannot be achieved solely through breeding, because even improved breeds produce low yields and deteriorate quickly in the absence of an adequate supply of nutritious feed and fodders. As a result, nutritious fodder is critical to increasing livestock productivity and making this enterprise profitable.

MATERIALS AND METHODS

An experimental study was conducted at the agricultural farm of the School of Agriculture, Lovely Professional University (LPU), Jalandhar, Punjab (India) during *rabi* (2020-2021). The farm is located at 5423 m above sea level at a geographical altitude of 31.2690° N at 75.7021°E longitude. It has a tropical climate of monsoon with an average rainfall of 600 mm and a climate with severely cold winters and summers. The annual average temperature in Punjab ranges from 10°C to 46°C, with temperatures reaching 49°C in the summer and falling to 1°C in the winter. The soil of the field comes from the central alluvial plain and has a textured sandy loam and had neutral pH (7.01), 247 kg ha^{-1} total nitrogen, available phosphorous9 kg ha^{-1} and available potassium154.3 kg ha^{-1}. The experiment used a factorial randomised block design of ten treatment combinations repeated three times. The experiment included two factors: five nitrogen levels, namely 0, 60, 90, 120 and 150 kg N ha^{-1} i.e., N_0, N_1, N_2, N_3 and N_4 and two cutting managements, namely single cut at 50 percent flowering stage (C_1) and first cut at 60 DAS and second cut at 50 percent flowering stage (C_2). Drilling oat seed at a spacing of 25 cm was used. The variety, Kent seed was used in the sowing at a rate of 100 kg ha^{-1}. In C_1 treatment, at the time of sowing, half of the nitrogen dose was applied as a basal dose, and the remaining 50 percent was supplied at 30 DAS, and in C_2 treatment 25 percent N was supplied at 30 DAS and 25 percent after the first cut. Per hectare, 40 kg P_2O_5 in the single super phosphate form was applied evenly to the crop.

RESULTS AND DISCUSSION

A. Growth parameters

Different oat growth parameters, such as plant height, number of tillers per metre row length, and leaf: stem ratio, were recorded at the time of each cutting to analyse crop production and development, and are shown in Table 1.

The data revealed that different nitrogen levels and cutting management had shown major impact on all growth parameters of fodder oats, but the interaction effect between different nitrogen levels and cutting management on growth parameters was found to be non-significant.

With an increasing nitrogen levels from 0 to 150 kg N ha^{-1}, there was a linear increase in plant height, the number of tillers per metre row length, and the leaf: stem ratio. Nitrogen application greatly increased the growth parameters at each cut. Treatment N_4 (150 kg N ha^{-1}) produced substantially taller plants (106.03, 87.53, and 103.02 cm), the greatest number of tillers per metre row length (78.55, 70.63, and 77.45 cm), and the highest leaf: stem ratio (1.33, 1.22, and 1.31) at the first, second, and mean of both cuts. Significantly lower plant height (79.78, 69.66 and 78.6 cm), No. of tillers per meter row length (55.41, 51.36 and 54.67) and leaf: stem ratio (0.8, 0.72 and 0.79) was noted under the treatment N_0 (0 kg N ha^{-1}) at first, second and mean of both the cuts. A higher nitrogen supply may have resulted in maintaining a better substrate for photosynthesis operation in the leaves. It is completely obvious that sufficient nitrogen supply promotes cell elongation and multiplication. Sharma and Verma (2004), as well as Dubey *et al.,* (2013).

Table 1: Effect of different levels of nitrogen application and cutting management on growth parameters of fodder oat.

Treatments	Plant height (cm)			No. of tillers per meter row length			Leaf: Stem ratio		
	1st Cut	2nd cut	Mean	1st cut	2nd cut	Mean	1st cut	2nd cut	Mean
Nitrogen levels (kg ha^{-1}) (N)									
N_0 – 0	79.78	69.66	78.6	55.41	51.36	54.67	0.80	0.72	0.79
N_1 – 60	84.15	73.06	82.59	59.03	54.3	58.03	0.92	0.83	0.90
N_2 – 90	88.46	74.63	86.28	64.4	60.1	63.37	1.05	0.92	1.04
N_3 – 120	96.31	79.26	93.34	73.05	66.63	72.1	1.20	1.08	1.18
N_4 – 150	106.03	87.53	103.0	78.55	70.63	77.45	1.33	1.22	1.31
S. Em (±)	0.75	--	0.71	0.87	--	0.84	0.01	--	0.01
C.D. (P=0.05)	2.23	--	2.11	2.60	--	2.52	0.03	--	0.03
Cutting management (C)									
C_1	96.31	--	96.31	67.72	--	67.72	1.11	--	1.11
C_2	85.58	76.83	81.22	64.46	60.60	62.53	1.01	0.95	0.98
S. Em (±)	0.47	--	0.44	0.55	--	0.53	0.007	--	0.007
CD. (P=0.05)	1.41	--	1.33	1.64	--	1.59	0.02	--	0.02
Interaction (N×C)	NS	--	NS	NS	--	NS	NS	--	NS

When it comes to cutting management, C_1 (single cut at 50 percent flowering) had the highest plant height (96.31 cm), the most tillers per metre row length (67.72), and the highest leaf: stem ratio (1.11), when compared to C_2 (first cut at 60 DAS & second cut at 50 percent flowering). Treatment C_1 resulted in consistent crop growth with no interruptions to the plant's physiological processes. As a result, the C_2 treatment had a lower plant height, number of tillers per metre row length, and leaf: stem ratio than the C_1 treatment. Similar current findings about plant height were published previously by Singh *et al.,* (2005) and Bhilare and Joshi (2008).

B. Yield parameters

Table 2 shows information about the yield parameters of fodder oats. At the time of each cutting, yield parameters such as green fodder yield and dry matter yield were recorded. The data revealed that different nitrogen levels and cutting management had a major impact on fodder oat yield parameters, but the interaction effect between different nitrogen levels and cutting management on yield parameters was found to be non-significant. The findings revealed that raising the nitrogen dose from N_0 (0 kg N ha^{-1}) to N_4 (150 kg N ha^{-1}) resulted in a substantial increasing in green fodder yield and dry matter yield. At first cut, second cut, and sum of both cuts, the application of 150 kg N ha^{-1} (treatment N_4) resulted in significantly higher yields of green forage (416.5, 338, and 584.83 q ha^{-1}) and dry matter yield (69.29, 53.04, and 95.48 q ha^{-1}) than other nitrogen levels. Treatment N_0 (0 kg N ha^{-1}) had the lowest green fodder yield and dry matter yield as compared to all other treatments in the first, second, and average of both cuts. The related findings in terms of green forage yield and dry matter yield were verified by earlier observations made by Jehangir (2009), Singh and Dubey (2007).

In case of cutting management, treatment C_1 (single cut at 50 percent flowering) produced substantially more green fodder (379.02 q ha^{-1}) and dry matter yield (60.31 q ha^{-1}) in the first cut than treatment C_2 (first cut at 60 DAS & second cut at 50 percent flowering). Second cut provides additional green fodder yield and dry matter yield in treatment C_2. Green forage yield and dry matter yield of both cuts, i.e., treatment C_2, were significantly higher 655.12 q ha^{-1} and 102.25 q ha^{-1}, respectively. As compared to the single cut system, the double cut system yields more. Bhilare and Joshi (2008), Singh and Dubey (2007), have similar findings.

Table 2: Effect of different levels of nitrogen application and cutting management on yield parameters of fodder oat.

Treatments	Green fodder yield (q ha^{-1})			Dry matter yield (q ha^{-1})		
	1st cut	2nd cut	Total	1st cut	2nd cut	Total
Nitrogen levels (kg ha^{-1}) (N)						
N_0 – 0	308	253.63	434.81	47.16	37.44	65.88
N_1 – 60	326.03	290.46	471.26	51.52	44.51	73.78
N_2 – 90	378.96	293.73	525.83	58.58	44.73	80.95
N_3 – 120	403.96	329.26	568.63	64.52	51.56	90.31
N_4 – 150	416.5	338	584.83	69.29	53.04	95.48
S. Em (±)	1.80	--	11.05	0.64	--	1.91
C.D. (P=0.05)	5.35	--	32.84	1.90	--	5.68
Cutting management (C)						
C_1	379.02	--	379.02	60.31	--	60.31
C_2	354.09	301.02	655.12	56.12	46.26	102.25
S. Em (±)	1.13	--	6.99	0.40	--	1.21
CD. (P=0.05)	3.38	--	20.77	1.20	--	3.59
Interaction (N×C)	NS	--	NS	NS	--	NS

C. Quality parameters

Table 3 depicted the information about the quality parameters of fodder oats. At the time of each cutting, quality parameters such as crude protein yield and crude fibre yield (Fig. 2) were reported (Fig. 1). The data revealed that the different nitrogen levels and cutting management had a major impact on all quality parameters of fodder oats, but the interaction effect between nitrogen levels and cutting management on quality parameters was found to be non-significant.

The results revealed that raising the nitrogen dose from N_0 (0 kg N ha^{-1}) to N_4 (150 kg N ha^{-1}) give rise to substantial increase in crude protein yield and crude fibre yield. The application of 150 kg N ha^{-1} (treatment N_4) resulted in a significantly higher yield of crude protein (9.82, 6.66, and 13.15 q ha^{-1}) and crude fibre (13.52, 11.16, and 19.10 q ha^{-1}) than the other nitrogen levels at the first, second, and sum of both cuts. Treatment N_0 (0 kg N ha^{-1}) had the lowest crude protein yield and crude fibre yield as compared to all other treatments in the first, second, and average of both cuts. The similar results regarding quality parameters were confirmed with earlier observation recorded by Bhilare and Joshi (2007).

When it came to cutting management, treatment C_1 (single cut at 50 percent flowering) had substantially higher crude protein yield (7.70 q ha^{-1}) and crude fibre yield (12.75 q ha^{-1}) in the first cut when compared to the first cut in C_2 (first cut at 60 DAS & second cut at 50 percent flowering). In treatment C_2, the second cut yields additional crude protein and crude fibre yield. although crude protein yield and crude fibre yield of both cuts, i.e., treatment C_2, reported significantly higher crude protein yield (10.82 q ha^{-1}) and crude fibre yield (21.26 q ha^{-1}) As compared to the single cut system, the double cut system yields more. Similar findings have been published by Alipatra *et al.*, (2013) and Alipatra *et al.*, (2012).

Based on current prices of market green forage oat and various variable and non-variable inputs, the cost of output, gross realisation, net realisation, and gain cost ratio for individual components, namely different nitrogen levels and cutting management, were calculated and presented in Table 4.

D. Economics

Data revealed that the treatment N_4 (150 kg N ha^{-1}) produced higher gross realisation (58483 Rs ha^{-1}), net realisation (31448 Rs ha^{-1}) and Benefit cost ratio (2.12) than other nitrogen levels. The treatment N_0 (0 kg N ha^{-1}) yielded the lowest gross returns (43481 Rs ha^{-1}), net returns (43481 Rs ha^{-1}) and B: C ratio (1.7). Higher economic yield and lower input costs will result in higher gross returns, net returns, and B: C ratios. Similar findings have been published by Kakol *et al.*, (2003).

Table 3: Effect of different levels of nitrogen application and cutting management on quality parameters of fodder Oat.

Treatments	Crude protein yield (q ha^{-1})			Crude fibre yield (q ha^{-1})		
	1st cut	2nd cut	Total	1st cut	2nd cut	Total
Nitrogen levels (kg ha^{-1}) (N)						
N_0 – 0	4.18	2.66	5.51	10.29	8.58	14.58
N_1 – 60	5.43	3.66	7.26	11.15	9.50	15.91
N_2 – 90	7.21	4.06	9.24	12.12	9.64	16.94
N_3 – 120	8.20	5.87	11.14	13.06	10.89	18.50
N_4 – 150	9.82	6.66	13.15	13.52	11.16	19.10
S. Em (±)	0.20	--	0.33	0.15	--	0.46
C.D. (P=0.05)	0.59	--	0.98	0.46	--	1.38
Cutting management (C)						
C_1	7.70	--	7.70	12.75	--	12.75
C_2	6.23	4.58	10.82	11.30	9.95	21.26
S. Em (±)	0.12	--	0.21	0.09	--	0.29
CD. (P=0.05)	0.37	--	0.62	0.29	--	0.87
Interaction (N×C)	NS	--	NS	NS	--	NS

Table 4: Effect of different levels of nitrogen application and cutting management on economics fodder oat.

Treatment	Green forage yield (q ha^{-1})	Gross realization (Rs ha-1)	Total Cost of cultivation (Rs ha^{-1})	Net realization (Rs ha^{-1})	B : C ratio
Nitrogen levels Kg ha^{-1} (N)					
N_0 – 0	434.81	43481	25105	18376	1.7
N_1 – 60	471.26	47126	25877	21249	1.78
N_2 – 90	525.83	52583	26263	26320	1.96
N_3 – 120	568.63	56863	26649	30214	2.09
N_4 – 150	584.83	58483	27035	31448	2.12
Cutting Management (C)					
C_1	379.02	37902	23385	14516	1.61
C_2	655.126	65512	28985	36526	2.25

Fig. 1. A. Estimation of Nitrogen by Kjeldhal apparatus; B. Estimation of crude fibre by KEL Plus.

In case of cutting management, C_2 (first cut at 60 DAS & second cut at 50 percent flowering) had the highest gross returns, net returns, and B: C ratio. C_2 had the highest gross returns and net realisations, with 65512 and 36526 Rs ha^{-1}, respectively. Treatment C_1 (single cut at 50 percent flowering) yielded 37902 and 14516 Rs ha^{-1} in minimum gross returns and net realisation, respectively. In terms of B.C.R., treatment C_2 had the highest benefit cost ratio of 1.47, while treatment C_1

had the lowest benefit cost ratio of 1.61. Similarly, Jehangir *et al*. (2009) published similar findings.

CONCLUSION

The study concluded that the nitrogen application at 150 kg ha^{-1} significantly increased growth parameters, yield parameters, quality parameters, and net realisation of fodder oat as compared to other nitrogen levels. Single cut at 50 percent flowering proved to be the best in terms of growth parameters. A double cut, with the first cut at 60 DAS and the second cut at 50 percent flowering, proved to be the best method for ensuring extreme forage output with good quality and a highest net realisation of the forage oat harvest.

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