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Impact of Seed Rate and Nitrogen Levels on Yield and Major Nutrients Uptake by Forage Oat Crop (*Avena sativa* L.)

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ABSTRACT
A field experiment was conducted during two consecutive winter (rabi) seasons of 2014-15 and 2015-16 to study the "Productivity and quality of forage oat (Avena sativa L.) under varying seed rate and nitrogen levels in irrigated conditions of western plain zone of Uttar Pradesh. The treatment consist of two factors seed rate and nitrogen levels. The factor seed rate has three rates viz. 60, 90, 120 kg per hectare while factor nitrogen has six levels i.e. 0, 40, 80, 120, 160 and 200 kg nitrogen per hectare. Pooled results revealed that sowing of oat with 90 kg per hectare seed rate increased total dry matter yield (86.10 q/ha) and uptake of nitrogen (168.6 kg/ha), whereas phosphorus (17.35 kg/ha) and potassium uptake (211.11 kg/ha) recorded significantly higher with seed rate 120 kg per hectare .Also with successive increase in level of nitrogen increased dry matter yield (108.99 q/ha) and uptake of nitrogen (255.15 kg/ha) , phosphorus (24.28 kg/ha) and potassium (274.13 kg/ha) was observed and was highest with application of 200 kg N/ha.
Keywords: Seed Rate, Nitrogen Level, Avena sativa

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INTRODUCTION

India secures first position in livestock population globally, being 512.05 million heads with Madhya Pradesh as highest population (10.27%) followed by Uttar Pradesh (10.24%) . Livestock production is the backbone of Indian agriculture contributing nearly 25.6% and 4.11% in agriculture and total GDP, respectively and proved to be source of employment and ultimate livelihood for most part of population [1]. Indian agriculture is oriented towards mixed farming in which livestock rearing forms an integral part of rural living. Livestock productivity directly depends upon the nutritious, balanced and adequate feeding. Some of major feed resources are the herbages from cultivated forages, grazing materials from grasslands and crop residues/by products i.e., straw, stover etc.

In India the area under fodder cultivation is estimated to be about 4% of the gross cropped area which has remained static for the last four decades because of preferential need of human food accounting 8.6 m ha. At present, the demand is about 222 million tonnes green and 416 million tonnes of dry fodder but availability is only about 143 and 253 million tonnes, respectively [2]. To meet the fodder shortage the growing area should ideally be around 20 m ha by 2020 A.D. which appears to be rather difficult to achieve [4]. Since area under cultivated forages cannot be increased much however, the possibilities exist for improved land productivity through appropriate management practices.

Among cultivated forage crops, oat (*Avena sativa* L.), due to its quick growing, high forage yielding ability and energy rich nutritional forage, is a valuable winter forage crop of India. Moreover, it produces very high green fodder per unit area and per unit time with minimum irrigation. Its fodder and grains are highly nutritious, rich in fat, protein, vitamin-B, phosphorus, iron, etc. Due to high forage yield, palatability and nutritive value, it has become a very popular *rabi* forage crops in areas having limited irrigation facilities in the country.

The production of oat is not being fully exploited because of the lack of proper information on its optimum fertilizer requirements. It has been recognized that the careful use of fertilizer can improve yield of crops [11]. Nitrogen element is major plant nutrient that most frequently limits yield and plays an important role in quality of forage crops [15].The importance of nitrogen fertilization to maintain higher production potential of oat is well recognized. Among the major nutrient elements, nitrogen has special significance in increasing green biomass yield and its quality. Nitrogen fertilization has been reported to improve not only the yield but also the crude protein content of multicut forage oat. It is thus, the basic constituent of plant life. It tends to encourage vegetative growth and governs to considerable degree of the utilization of other nutrients. The increase in nitrogen doses with increase in growth resulted in plant height, number of shoot and leaves [11], increasing leaf area per plant. All growth attributes that directly or indirectly affected forage yield and quality are affected by cultural practices as well as agricultural inputs.

The selection of optimum seed rate is another important cultural practice and is mainly controlled by seed size, vigor, germination percentage, sowing methods and required plant population of the crop. Seed rate is defined as the amount of seed sown per unit area. It is an important factor for forage production, since it affect plant density and consequently affect the yield of forage. Higher seed rates usually results in higher plant density, which increases forage yield. Therefore the optimum seed rate for forage production is higher than that for grain production [9]. Nutritive value of fodder maize was reported to vary with plant population. Nitrogen , phosphorus and potassium uptake in forage decreased with increasing seed rate of maize [10] as well as in sorghum [3].

MATERIALS AND METHODS

The field experiment was conducted during rabi season 2014-15 and 2015-16 at Sardar Vallabhbhai Patel University of Agriculture and Technology Meerut (Uttar Pradesh) situated 29^0 04, N latitude and 77^0 42 'E longitude at an altitude of 237 meters above the mean sea level. The soil was sandy loam in texture (60.20 % sand, 18.63 % silt and 21.18% clay having 7.95pH,0.47 % organic carbon , low in available nitrogen (238.94 kg/ha) and medium in phosphorus(15.35 kg/ha) and potassium(222.07 kg/ha).The treatments comprised three seed rates of oat [S_{60}-60 kg/ha ; S_{90}-90 kg/ha; S_{120}-120 kg/ha] and six N levels (0, 40, 80, 120, 160 and 200 kg/ha).The experiment was laid out in factorial randomized block design with four replications. The crop was fertilized with 60 kg P/ha, 40 kg K/ha as common dose and N as per treatments. Oat 'Kent' variety was sown in rows 30 cm apart on 14/11/2014 and 28/11/2015. Half the quantity of nitrogen and full dose of P were applied as basal dressing in each plot. The remaining half dose of N was top dressed just after first cut (55 DAS). The first irrigation was given 20 DAS , second 55 DAS and last at 95 DAS. Thus, a total of three irrigations were given to meet the water requirement of crops. To keep the experimental plots weed free, two hand weeding was done at 28 and 60 DAS. Rainfall during the crop period was 160.10 and 21.20 mm in 2014-15 and 2015-16 respectively. The two cuttings were taken with first cutting at 55 DAS and second at 115 DAS. Fresh sample (500g) at each cut from each plot was taken and dried in oven at 70 °C for 48 hours to determine the dry matter content and estimation of NPK uptake. Nitrogen was determined by the method of micro Kjeldahl [5], phosphorus by Olsen's method and potassium by flame photometric method. The nutrient uptake (kg ha^{-1}) was calculated by using respective nitrogen, phosphorus, potassium content values and dry matter of crop plant on hectare basis.

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%)} \times \text{Dry matter yield (kg ha}^{-1})}{100}$$

RESULTS AND DISCUSSION

Effect on dry matter yield

The dry matter yield was in general higher during 2015-16 as compared to 2014-15. The dry matter yield at first and second cut was significantly affected by seed rate during both the years. At first cut seed rate 120 kg per hectare (S_{120}) recorded significantly higher dry matter yield (18.15 and 20.54 q ha^{-1}) except being at par with 90 kg per hectare seed rate (S_{90}) during both season whereas at second cut stage 90 kg per hectare seed rate (S_{90}) recorded significantly higher (66.93 and 68.57 q ha^{-1}) and further increase in seed rate reduce yield during both years. The non significant difference due to seed rate for total dry matter was recorded during both year. However, maximum total dry matter yield obtained with 90 kg per hectare seed rate (S_{90}) during both years. The minimum dry matter yield for first, second cut and total were recorded with 60 kg per hectare seed rate (S_{60}).

In general, increasing level of nitrogen increased total dry matter yield as well as dry matter yield at each cut. At first and second cut increasing the levels of nitrogen increased dry matter yield significantly and highest yield (21.82 and 84.47 q ha^{-1}) and (24.46 and 87.23 q ha^{-1}) was recorded at the level of 200 kg nitrogen per hectare, which was higher (161.94 and 116.65) and (97.74 and 142.64) percent than control during 2014-15 and 2015-16, respectively. Minimum dry matter yield (8.33 and 38.99 q ha^{-1}) and (12.37

and 35.95) during 2014-15 and 2015-16, respectively was obtained under no nitrogen application. Similarly increasing the doses of nitrogen increased total dry forage yield significantly which reached from (47.32 and 48.35 q ha^{-1}) at control to 106.29 and 111.69 q ha^{-1} at 200 kg nitrogen per hectare (N_{200}). The increase in nitrogen rates from 40 -160 kg per hectare also increased significantly dry matter yield at both cuts and total dry matter yield. The increase in total dry matter yield were 26.71, 72.19, 102.58, 117.84, 124.62 and 28.65, 84.14, 106.74, 123.66, 131.00 percent at 40, 80, 120, 160 and 200 kg nitrogen per hectare, respectively compare to control.

The interaction effect between seed rate and nitrogen levels in relation to dry matter yield at second cut were found to be significant [Table 1 (a) and 1 (b)] during both the years. At second cut, maximum dry matter yield (88.68 and 89.80 q ha^{-1}) at 200 kg nitrogen per hectare was recorded under seed rate 90 kg per hectare which was found to be superior over rest of the treatments except being statistically at par with combination of 60 kg per hectare seed rate along with application of 200 kg nitrogen per hectare (S_{60} N_{200}), 90kg per hectare seed rate along with 160 kg nitrogen per hectare (S_{90} N_{160}) and 60 kg per hectare seed rate with 160 kg nitrogen per hectare ($S_{60}N_{160}$), 60 kg per hectare seed rate with application of 200 kg nitrogen per hectare ($S_{60}N_{200}$), 90 kg per hectare seed rate along with 160 kg nitrogen per hectare ($S_{90}N_{160}$) during 2014-15 and 2015-16, respectively. Whereas lowest dry matter yield was recorded in 60 kg per hectare seed rate (S_{60}) (36.49 and 34.76 q ha^{-1}) with application of 0 kg nitrogen per hectare. The increased biomass production with 120 and 90 kg seed rate per hectare could be attributed to the higher number of shoot per metre linear row length and taller plant at first and second cut which might have increased the photosynthetic area leading to higher biomass production. These findings are in line with [13, 14, 16, 7, 8].

Effect on NPK uptake

Data presented in Table 2 indicated that in general, nitrogen, phosphorus and potassium uptake increased with crop age. Among seed rate the significant difference for nitrogen phosphorus and potassium uptake was found at each cut except for nitrogen and potassium uptake at second cut and also non significant difference for total N uptake due to seed rate was recorded during both the years. At first cut nitrogen and phosphorus uptake was maximum with 120 kg per hectare seed rate followed by 90 (S_{90}) and 60 (S_{60}) kg seed rate per hectare during both years. However, phosphorus uptake was maximum with 90 kg per hectare (S_{90}) seed rate followed by 120 (S_{120}) and 60 (S_{60}) kg per hectare seed rate. At second cut maximum phosphorus and potassium uptake recorded with 120 kg per hectare seed rate (S_{120}) whereas maximum values for nitrogen uptake recorded with 90 kg per hectare (S_{90}) seed rate. The total phosphorus and potassium uptake was maximum with 120 kg per hectare seed rate (S_{120}) and for nitrogen uptake, it was maximum with 90 kg per hectare seed rate (S_{90}) during both the years.

Table 1: Effect of seed rate and nitrogen levels on dry matter yield (q/ha) during 2014-15 and 2015-16

Treatments	2014-15			2015-16		
	First cut	Second cut	Total	First cut	Second cut	Total
Seed Rate (kg ha^{-1})						
S_{60}	15.70	64.48	80.18	17.87	65.58	83.45
S_{90}	17.32	66.93	84.25	19.49	68.57	87.95
S_{120}	18.15	64.42	82.57	20.54	65.58	86.14
S.Em.±	0.31	0.66	1.17	0.52	0.60	1.29
C.D. at 5%	0.88	1.88	N.S.	1.48	1.69	N.S.
N levels (kg ha^{-1})						
N_0	8.33	38.99	47.32	12.37	35.95	48.35
N_{40}	13.78	46.19	59.96	16.03	46.17	62.20
N_{80}	18.38	63.09	81.48	18.53	66.20	84.74
N_{120}	18.95	76.91	95.86	21.20	78.98	99.96
N_{160}	21.08	82.00	103.08	23.20	84.94	108.14
N_{200}	21.82	84.47	106.29	24.46	87.23	111.69
S.Em.±	0.44	0.94	1.65	0.74	0.84	1.82
C.D. at 5%	1.24	2.66	4.69	2.10	2.39	5.16

Table 1(a): Effect of seed rate × nitrogen levels on dry matter yield (q/ha) at second cut during 2014-15

Seed rate (kg ha^{-1})	N levels (kg ha^{-1})					
	N_0	N_{40}	N_{80}	N_{120}	N_{160}	N_{200}
S_{60}	36.49	44.79	63.01	76.35	81.50	84.74
S_{90}	37.91	45.91	62.09	80.50	86.48	88.68
S_{120}	42.57	47.86	64.18	73.87	78.03	80.00
S.Em.±			1.62			
C.D. at 5%			4.61			

Table 1(b): Effect of seed rate × nitrogen levels on dry matter yield (q/ha) at second cut during 2015-16

Seed rate (kg ha^{-1})	N levels (kg ha^{-1})					
	N_0	N_{40}	N_{80}	N_{120}	N_{160}	N_{200}
S_{60}	34.76	43.16	64.78	77.00	86.03	87.77
S_{90}	35.91	47.50	66.59	83.79	87.82	89.80
S_{120}	37.18	47.85	67.24	76.14	80.97	84.12
S.Em.±			1.46			
C.D. at 5%			4.15			

The effect of nitrogen application on uptake of nitrogen, phosphorus and potassium by crop varied significantly. At first cut with increase in nitrogen level increased the nitrogen, phosphorus and potassium uptake significantly. At first cut the minimum uptake of nitrogen, phosphorus and potassium by crop were recorded with no nitrogen application i.e (14.79, 1.41, 31.10 and 23.81, 2.51 and 48.50 kg per hectare during 2014-15 and 2015-16, respectively, while maximum uptake of nitrogen, phosphorus and potassium 68.16, 7.28, 86.98 and 82.49, 8.47, 101.51 kg per hectare with application of 200 kg nitrogen per hectare during 2014-15 and 2015-16, respectively. At second cut minimum uptake of nitrogen, phosphorus and potassium were recorded with no nitrogen application i.e 48.79, 4.18, 69.86 and 45.13, 4.44, 68.67 kg per hectare whereas maximum 182.61, 15.99, 173.27 and 177.04, 16.81, 186.49 kg per hectare during 2014-15 and 2015-16 respectively with application of 200 kg nitrogen per hectare. The total uptake of nitrogen by crop in both cut were also varied significantly. The minimum total uptake of nitrogen, phosphorus and potassium by crop 63.58, 5.60, 100.97 and 68.95, 6.95, 117.17 kg per hectare during 2014-15 and 2015-16, respectively were recorded with application of 0 kg nitrogen per hectare while maximum total uptake crop 250.77,23.27, 260.25. and 259.53, 25.28, 288.0 kg per hectare, respectively with application of 200 kg nitrogen per hectare. The uptake of nitrogen at both cut and all levels were observed statistically significant with each other. The cause for increased uptake could be due to more availability of nutrients and higher herbage production with higher levels of nitrogen. The results are in conformity of those by Singh *et al.* [13] also reported that the beneficial effect of nitrogen on nutrient uptake in oat. These similar result was observed by Kakol *et al.* [7] who reported that higher nitrogen uptake results increased synthesis of structural protein required for body buildings as well as functional protein (enzymes) which help in the further synthesis of amino acid, protein and carbohydrate and therefore, results in increased productivity. This means that with increased nitrogen uptake at higher nitrogen levels, the rate of dry matter production per unit absorbed nitrogen also increased.

CONCLUSION

The sowing of oat with 90 kg per hectare seed rate along with application of 160 kg per hectare nitrogen found to be better for getting higher dry matter yield and increased uptake of nutrients.

Table 4.2: Effect of seed rate and nitrogen levels on NPK uptake by plant (kgha^{-1}) during 2014-15 and 2015-16

Treatments	NPK uptake by plant (kg ha^{-1})																	
	2014-15									2015-16								
	N			P			K			N			P			K		
	I cut	II cut	Total	I cut	II cut	Total	I cut	II cut	Total	I cut	II cut	Total	I cut	II cut	Total	I cut	II cut	Total
Seed Rate (kg ha^{-1})																		
S_{60}	42.83	117.14	159.97	4.36	9.87	14.24	61.01	125.92	186.93	51.59	112.69	164.28	5.30	10.73	16.03	72.39	135.28	207.67
S_{90}	47.13	118.95	166.08	5.44	9.52	14.96	68.93	128.24	197.17	55.75	115.38	171.12	6.36	9.83	16.19	79.91	136.74	216.66
S_{120}	47.58	117.17	164.75	4.45	11.61	16.06	69.67	130.25	199.88	57.57	113.19	170.77	5.76	12.87	18.63	82.53	139.81	222.34
S.Em.±	*0.81*	*2.04*	*2.64*	*0.10*	*0.16*	*0.19*	*0.91*	*1.78*	*2.04*	*1.13*	*2.27*	*3.04*	*0.12*	*0.16*	*0.21*	*1.49*	*1.75*	*2.15*
C.D. at 5%	2.30	N.S.	N.S.	0.30	0.44	0.55	2.59	N.S.	5.79	3.21	N.S.	N.S.	0.33	0.46	0.60	4.22	N.S.	6.10
N levels (kg ha^{-1})																		
N_0	14.79	48.79	63.58	1.41	4.18	5.60	31.10	69.86	100.97	23.81	45.13	68.95	2.51	4.44	6.95	48.50	68.67	117.17
N_{40}	30.44	70.09	100.53	2.97	5.87	8.83	52.43	85.95	138.38	38.08	67.16	105.24	4.04	6.62	10.66	63.66	90.64	154.30
N_{80}	45.97	108.34	154.31	4.68	9.27	13.95	70.92	120.97	191.90	49.40	101.39	150.78	5.37	10.38	15.75	74.61	134.17	208.78
N_{120}	51.81	138.19	190.01	5.49	12.25	17.75	74.29	152.17	226.46	61.23	136.32	197.55	6.64	13.09	19.73	85.74	164.09	249.83

N_{160}	N_{200}	S.Em.±	C.D. at 5%
63.91	68.16	*1.14*	3.25
158.49	182.61	*2.88*	8.18
222.40	250.77	*3.74*	10.61
6.67	7.28	*0.15*	0.42
14.44	15.99	*0.22*	0.62
21.11	23.27	*0.28*	0.78
83.49	86.98	*1.29*	3.66
166.59	173.27	*2.52*	7.14
250.0	260.25	*2.88*	8.18
74.80	82.49	*1.60*	4.54
155.49	177.04	*3.21*	9.13
230.29	259.53	*4.30*	12.20
7.80	8.47	*0.16*	0.46
15.51	16.81	*0.23*	0.66
23.31	25.28	*0.30*	0.84
95.65	101.51	*2.10*	5.96
179.60	186.49	*2.47*	7.02
275.25	288.0	*3.04*	8.63

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