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Lalita H Saini
Assistant Research Scientist, Agroforestry Research Station, SDAU, S. K. Nagar, Gujarat, India

Dr. Laxmi Rani Dubey
Assistant Professor, College of Agribusiness Management, SDAU, Sardarkrushinagar, Gujarat, India

AK Saini
Centre for Natural Resources Management, SDAU, S. K. Nagar, Gujarat, India

JJ Makwana
Centre for Natural Resources Management, SDAU, S. K. Nagar, Gujarat, India

Muniya Sapana S
Department of Agronomy, C. P. College of Agriculture, SDAU, S. K. Nagar, Gujarat, India

Corresponding Author:
Lalita H Saini
Assistant Research Scientist, Agroforestry Research Station, SDAU, S. K. Nagar, Gujarat, India

Response of forage oat (*Avena sativa* L.) to nutrient management practices under North Gujarat conditions

Lalita H Saini, Dr. Laxmi Rani Dubey, AK Saini, JJ Makwana and Muniya Sapana S

Abstract
A field experiment was conducted during *rabi* season of 2019-20 on loamy sand soils of Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat to assess the impact of nitrogen, phosphorous and FYM on growth, yield, quality and economics of forage oat. The soil of experimental plot was low in organic carbon and available nitrogen, medium in available phosphorus and high in potassium. The experiment was laid out in RBD (factorial concept) and replicated thrice. Twelve treatment combinations consisting three levels of nitrogen, two levels of phosphorus and two levels of farm yard manure were embedded. The results indicated that significantly highest growth and yield parameters *viz*., plant height, number of tillers per meter row length, leaf area index, leaf: stem ratio and thereby highest total green forage yield (401.2, 367.1, 369.4 q/ha), dry matter yield (94.3, 88.1, 88.0 q/ha) and crude protein yield (8.01, 7.05, 6.93 q/ha) with application of 120 kg N/ha, 60 kg P_2O_5/ha and 10 t FYM/ha, respectively. Total N and P uptake as well as available N and P_2O_5 were found highest with higher level of inputs *i.e*., N, P and FYM. The higher net returns (63095, 54231 ₹/ha) and B:C ratio (1.72, 1.45) were obtained with 120 kg N and 60 kg P_2O_5/ha while without FYM application treatment secured higher monetary returns from forage oat, respectively. Thus, it is concluded that for securing higher forage production and monetary returns with good quality forage, oat crop should be fertilized with 120 kg nitrogen and 60 kg phosphorus per ha.

Keywords: Forage oat, (*Avena sativa* L.), nutrient management practices

Introduction
Oat (*Avena sativa* L.) is annual grass plant belonging to the family Gramineae which is commonly cultivated as an important winter season forage crop and sown in the month of November under irrigated conditions.It is important winter forage in many parts of the world and is grown as multipurpose crop for grain, pasture, forage or as a rotation crop.It requires cool and moist climate for its normal growth. Oat requires cool temperature during germination, tillering, booting and heading stages. It is medium height shrub growing up to 155-165 cm just higher than wheat and its leaves are long and succulent. It has comparatively high palatability and has cooling effect on animal body; thereby it fits in the dairy production program (Handbook of Agriculture, 2007) [19]. It became popular among the dairy farmers due to its excellent quick regrowth habit, highest biomass with better nutritive value and ratooning ability which offer it an opportunity for green forage or seed with high yield in short span of time.It is a palatable, succulent and nutritious crop. The protein quality of oat is excellent. Out of the three major plants nutrients, nitrogen ranks first and it plays an important role in plant metabolism by virtue of essential constituent of structure component. Moreover, nitrogen helps in cell division and cell elongation which virtually increase the plant growth. An optimum level of improves leaf to stem ratio, succulency and palatability of fodder crops. It improves the quality by increasing the protein content of fodder crops and governs to a considerable degree, the utilization of potassium, phosphorus and other elements (Patel *et al.*, 2007). It increases the crude protein and also metabolizable energy. It also plays an important role in plant metabolism because it is an essential constituent of different type of metabolically active compounds like amino acids. It imparts dark green colour to the plants and promotes plant growth rapidly.

Material and Methods
The field experiment was laid out during *rabi* season of the 2019-20 at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture,

Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District: Banaskantha (Gujarat) is situated at 24^{o} 19' North latitude and 72^{o} 19' East longitude with an elevation of 154.52 meters above the mean sea level and situated in the North Gujarat Agro-climatic Region. The soil of the experimental plot was loamy sand in texture low in organic carbon, available nitrogen, medium in available phosphorus and high potassium status. Experiment carried out with total twelve treatment combinations consisting three levels of nitrogen *viz*. N_1: 80 kg/ha, N_2: 100 kg/ha, N_3: 120 kg/ha and two levels of phosphorus *viz*. P_1: 40 kg/ha, P_2: 60 kg/ha and Farm Yard Manure (FYM) *viz*. F_0: No FYM, F_1: 10 t/ha. The experiment was laid out in factorial randomized block design with three replications. Dates of all operations were noted; data collected including growth parameters *viz.* plant height, Number of tillers per meter row length, Leaf Area Index, Leaf: stem ratio and yield and yield attributes *viz.* Green forage yield (q/ha) and dry matter yield (q/ha). For the height of main shoot, random selection of six representative plants from each net plot was done and their height measured from ground level to the tip of plant, the mean was recorded. The plants from the net plot were harvested keeping 2-3 cm height from ground level and fresh weight of harvested produce was recorded for each treatment separately and converted into hectare basis by multiplying with multiple factor. For estimation of dry matter content (%) the fresh sample of 1000 g green fodder taken from each net plot was chopped into small pieces and was sun dried for three to four days. These sun dried samples were then dried in the oven at 70 ^{0}C till constant weight was attained. The statistical analysis of data was done using analysis of variance (ANOVA) technique for split plot design at 0.05 probability level.

Results and Discussion

Plant population at 20 DAS and at second cut (per meter row length)

The plant population of forage oat was counted per meter row length at 20 DAS and at second cut (final cut) are revealed that various levels of nitrogen, phosphorus and FYM and interaction effect did not exert significant influence on plant population per metre row length.

Effect of Nitrogen

Plant height (cm)

Giving nitrogen dose of 120 kg N/ha showed significantly the higher plant height *viz*. 35.0, 61.7 and 49.1 cm at 30 DAS, first and second cut, respectively. The increase in plant height with increase in successive levels of nitrogen might be due to more supply of nitrogen to crop resulting in rapid synthesis of carbohydrates and consequently converted into protoplasm and thereby smaller portion available for cell wall formation. This has served consequences of increase in size of cell which is expressed morphologically through increase in plant height.

Number of tillers per meter row length

The highest number of tillers per meter row length 70.52 and 71.13were recorded with nitrogen level 120 kg N/ha (N_3) at first and second cut, respectively. The higher number of tillers per plant may be due to higher and sufficient availability of available nitrogen to the root of the crop. It might be due to higher availability of nitrogen may have increase the nutrition to active growing part of plant which have the ability to multi shooting with favorable condition and that is why ultimately leads to higher shooting of the tillers to the base of the plant.

Leaf Area Index

Leaf area index of forage oat increased significantly with increased level of nitrogen 120 kg N/ha (N_3) which recorded significantly the highest leaf area index during first and second cut (1.51 and 1.36), respectively. Higher leaf area index with increasing level of nitrogen might be due to more supply of nitrogen, leading to more protein synthesis. The extra protein might have allowed the leaves to grow larger and ultimately larger surface area.

Leaf: stem ratio

Significantly higher leaf: stem ratio was noticed with application of 120 kg N/ha (0.311 and 0.299) at first and second cut than that of 80 kg N/ha, respectively. The increase in leaf: stem ratio with increasing levels of nitrogen was mainly due to rapid expansion of dark green foliage which could intercept and utilize the incident solar radiation in the production of photosynthates and eventually resulting in higher meristematic activity and increased leaf: stem ratio of forage oat. This might be also due to favourable influence of nitrogen on cell division and cell elongation, which could have produced more functional leaves for a longer period of time.

Green forage yield (q/ha)

At first cut, second cut and in total of both the cuts green forage yield of oat progressively and significantly increased with each increase in level of nitrogen from 80 kg/ha (N_1) to 120 kg N/ ha (N_3). Significantly the highest green forage yield of 277.1, 174.1and 401.2 q/ha was obtained with application of 120 kg N/ha (N_3) at first, second and total of both the cuts. The percent increase in green forage yield by the application of 100 and 120 kg N/ha over application of 80 kg N/ha was to the tune of 20.66 and 9.60% at first cut, 37.08 and 17.16% at second cut, serially. This may be mainly attributed to improved growth and yield parameters *viz*., plant height, number of tillers/m row, leaf: stem ratio and the beneficial effects of nitrogen on cell division and elongation, formation of nucleotides and co-enzymes which resulted in increased meristematic activity and photosynthetic area and hence more production and accumulation of photosynthates, yielding higher green forage.

Dry matter yield (q/ha)

The nitrogen level 120 kg N/ha (N_3) produced significantly the highest dry matter yield of 52.9, 41.4 and 94.3q/ha at first, second and total of both cut. The percent increase in dry matter yield by the application of 120 kg N/ha over application of 80 kg N/ha was to the tune of 19.4% at first and 23.95% at second cut, respectively. Pronounced effect of applied nitrogen on the dry matter yield of forage oat might be due to higher vegetative growth and yield at higher level of nitrogen turning in higher dry matter. Nitrogen is used largely in synthesis of protein, but structurally it is a constituent of chlorophyll molecule combined with carbohydrates and fatty acids. It helps in formation of protoplasm, which is the physical base of a life of the plant.

Effect of Phosphorus

Plant height (cm)

Application of 60 kg P_2O_5/ha (treatment P_2) recorded significantly the highest plant height (33.8 cm) at 30 DAS, first (57.3 cm) and second cut (48.5 cm). The maximum plant height observed under higher dose of phosphorus may be attributed to involvement of P in better root development and subsequent absorption of more nutrients (N) from soil which ultimately resulted in taller plants.

Number of tillers per meter row length

At first and second cut significantly higher number of tillers per meter row length (67.90 and 68.80) was noticed with application of P_2O_5 @ 60 kg/ha. This might be owing to adequate phosphorus supply to forage oat which fulfils the requirement of newly sprouted tillers. The increase in number of tillers at higher level of phosphorus could be attributed to the better development of roots and crop canopy due to enhancement of phosphorus availability and its efficient utilization by the crop.

Leaf Area Index

Higher level of phosphorus fails to exert significant effect on leaf area index at first cut while it influenced significantly during second cut. At second cut significantly the highest leaf area index *i.e.* 1.31 was recorded with the application of 60 kg P_2O_5/ha (P_2). Higher leaf area index is due to more tillering and increased height of crop with higher level of phosphorus.

Green forage yield (q/ha)

Application of 60 kg P_2O_5 /ha (treatment P_2) recorded significantly the highest green forage yield of 211.4, 155.7 and 367.1q/ha at first, second and total of both the cut respectively. The percent increase in green forage yield by application of 60 kgP_2O_5/ha (P_2) over its lower level was to the tune of 4.08, 7.90 and 5.67% at first, second cut and total of both the cuts, respectively. Phosphorus is known to play beneficial role in growth by promoting extensive root development. The enhanced root development improve the supply of nutrients and water from the deeper soil layers for higher photosynthetic activity and translocation of photosynthates to the sink of the site of their requirement consequently increased all the parameters studied and green forage yield ultimately.

Dry matter yield (q/ha)

Application of P_2O_5 @60 kg/ha (treatment P_2) produced significantly the highest dry matter yield 49.7 q/ha, 38.4 q/ha and 88.1 q/ha at first, second and total of both cut. There was 4.41 and 5.20% and 4.75% enhancement in dry matter yield of forage oat over its lower level *i.e.* P_2O_5 @40 kg/ha at first, second cut and total of both cut, respectively. Positive effect of applied phosphorus on the dry matter yield of forage oat might be due to higher vegetative growth and yield at higher level of phosphorus turning in higher dry matter.

Effect of Farm yard manure

Plant height (cm)

Plant height measured at 30 DAS was found non-significant. While, plant height observed at first and second cut were significantly affected by FYM application recording highest plant height with treatment F_1 (FYM @ 10 t/ha). This might be due to adequate and continuous supply of nutrients at different stages due to release of sufficient amount of nutrients by easy mineralization of FYM at a constant level that resulted in higher plant growth and height of oat at different stages.

Number of tillers per meter row length

Treatment FYM @ 10 t/ha (F_1) produced significantly higher number of tillers (67.79 and 69.65) per meter row length during first and second cut, respectively. This might be due to more vegetative growth and growth attributes obtained through the availability of nutrients from deeper layers as roots penetrate into deeper layers in plots treated with FYM application.

Leaf: stem ratio

The higher leaf: stem ratio (0.294 and 0.282) was noted at first and second cut under treatment FYM @ 10 t/ha, respectively. Treatment F_0 (No FYM) recorded lowest leaf: stem ratio (0.266 and 0.254) at first and second cut, respectively. This might be due to addition of FYM improved physical, chemical and biological properties of soil and this leads to improve the root growth and development of fresh leaves.

Green forage yield (q/ha)

Application of FYM @ 10 t/ha (F_1) recorded the maximum green forage yield *i.e*., 211.8,157.6 and 369.4 q/ha at first and second as well as total of both the cuts the percentage was tune 4.54, 10.67 and 7.07% respectively. From these result it may be inferred that the beneficial effect of FYM is due to its contribution in supplying additional plant nutrients, improvement of soil physical, chemical and biological process in soil due to favourable influence on soil physical properties leading to increased root growth and ultimately green forage yield of forage oat.

Dry matter yield (q/ha)

The dry matter yield of forage oat was not affected by various levels of FYM but numerically higher dry matter yield (49.2 q/ha) was obtained under treatment F_1 (FYM @ 10 t/ha) during first cut of forage oat. Reversely, statistically higher dry matter yield was under treatment F_1 (FYM @ 10 t/ha) during second cut.

Table 1: Effect of nitrogen, phosphorus and FYM on plant population at 20 DAS and at second cut of forage oat and plant height at 30 DAS, first and second cut of forage oat

Treatments				Plant population per meter row length		Plant height (cm)		
				20 DAS	At 2nd cut	30 DAS	1st cut	2nd cut
A.	**Nitrogen levels**							
	N_1	:	80 kg/ha	28.38	27.68	28.3	49.5	42.8
	N_2	:	100 kg/ha	30.58	28.30	32.3	53.2	47.6
	N_3	:	120 kg/ha	31.20	28.83	35.0	61.7	49.1
	S.Em. ±			1.08	1.18	1.30	1.71	1.40
	C.D. at 5%			NS	NS	3.81	5.02	4.10
B.	**Phosphorus levels**							
	P_1	:	40 kg/ha	30.72	29.22	30.0	52.3	44.5
	P_2	:	60 kg/ha	29.38	27.32	33.8	57.3	48.5
	S.Em. ±			0.88	0.96	1.06	1.40	1.14
	C.D. at 5%			NS	NS	3.11	4.10	3.34
C.	**FYM levels**							
	F_0	:	No FYM	29.42	27.97	31.8	52.4	44.6
	F_1	:	10 t/ha	30.68	28.58	32.0	57.2	48.4
	S.Em. ±			0.88	0.95	1.06	1.40	1.14
	C.D. at 5%			NS	NS	NS	4.10	3.34
Interactions								
N x P				NS	NS	NS	NS	NS
N x F				NS	NS	NS	S	S
P x F				NS	NS	NS	NS	NS
N x P x F				NS	NS	NS	NS	NS
C.V.%				12.47	14.40	14.11	10.82	10.40

Table 2: Effect of nitrogen, phosphorus and FYM levels on number of tillers per meter row length at harvest of forage oat

Treatments				Number of tillers per meter row length	
				1st cut	2nd cut
A.	**Nitrogen levels**				
	N_1	:	80 kg/ha	60.05	63.04
	N_2	:	100 kg/ha	64.13	64.79
	N_3	:	120 kg/ha	70.52	71.13
	S.Em. ±			2.16	1.99
	C.D. at 5%			6.32	5.82
B.	**Phosphorus levels**				
	P_1	:	40 kg/ha	62.34	63.40
	P_2	:	60 kg/ha	67.90	68.80
	S.Em. ±			1.76	1.62
	C.D. at 5%			5.16	4.75
C.	**FYM levels**				
	F_0	:	No FYM	62.45	62.54
	F_1	:	10 t/ha	67.79	69.65
	S.Em. ±			1.76	1.62
	C.D. at 5%			5.16	4.75
Interactions					
N x P				NS	NS
N x F				NS	NS
P x F				NS	NS
N x P x F				NS	NS
C.V.%				11.47	10.40

Table 3: Effect of nitrogen, phosphorus and FYM levels on leaf area index and leaf: stem ratio of forage oat

Treatments				Leaf area index		Leaf: Stem ratio	
				1st cut	2nd cut	1st cut	2nd cut
A.	**Nitrogen levels**						
	N_1	:	80 kg/ha	1.21	1.17	0.254	0.242
	N_2	:	100 kg/ha	1.35	1.21	0.277	0.265
	N_3	:	120 kg/ha	1.51	1.36	0.311	0.299
	S.Em. ±			0.05	0.05	0.008	0.008
	C.D. at 5%			0.16	0.14	0.025	0.025
B.	**Phosphorus levels**						
	P_1	:	40 kg/ha	1.30	1.19	0.276	0.264
	P_2	:	60 kg/ha	1.42	1.31	0.285	0.273
	S.Em. ±			0.04	0.04	0.007	0.007
	C.D. at 5%			NS	0.12	NS	NS
C.	**FYM levels**						
	F_0	:	No FYM	1.36	1.22	0.266	0.254
	F_1	:	10 t/ha	1.36	1.28	0.294	0.282
	S.Em. ±			0.04	0.04	0.007	0.007
	C.D. at 5%			NS	NS	0.020	0.020
Interactions							
N x P				NS	NS	NS	NS
N x F				NS	NS	NS	NS
P x F				NS	NS	NS	NS
N x P x F				NS	NS	NS	NS
C.V.%				13.71	13.68	10.35	10.82

Table 4: Effect of nitrogen, phosphorus and FYM levels on green forage yield and dry matter yield of forage oat

Treatments				Green forage yield (q/ha)			Dry matter yield (q/ha)		
				1st cut	2nd cut	Total	1st cut	2nd cut	Total
A.	**Nitrogen levels**								
	N_1	:	80 kg/ha	188.2	127.0	315.2	44.3	33.4	77.7
	N_2	:	100 kg/ha	206.3	148.8	355.1	48.7	37.6	86.3
	N_3	:	120 kg/ha	227.1	174.1	401.2	52.9	41.4	94.3
	S.Em. ±			3.12	4.22	5.50	0.50	0.23	0.57
	C.D. at 5%			9.16	12.36	16.12	1.47	0.67	1.67
B.	**Phosphorus levels**								
	P_1	:	40 kg/ha	203.1	144.3	347.4	47.6	36.5	84.1
	P_2	:	60 kg/ha	211.4	155.7	367.1	49.7	38.4	88.1
	S.Em. ±			2.55	3.44	4.49	0.41	0.19	0.46
	C.D. at 5%			7.48	10.10	13.16	1.20	0.55	1.36
C.	**FYM levels**								
	F_0	:	No FYM	202.6	142.4	345.0	48.1	36.1	84.2
	F_1	:	10 t/ha	211.8	157.6	369.4	49.2	38.8	88.0
	S.Em. ±			2.55	3.44	4.49	0.41	0.19	0.46
	C.D. at 5%			7.48	10.10	13.16	NS	0.55	1.36
Interactions									
N x P				NS	NS	NS	NS	NS	NS
N x F				S	S	S	S	S	S
P x F				NS	NS	NS	NS	NS	NS
N x P x F				NS	NS	NS	NS	NS	NS
C.V.%				7.48	9.73	8.35	11.84	9.68	10.81

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