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Quality, yield and economics of oat (*Avena sativa* L.) Genotypes for fodder under different nitrogen levels

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Abstract
A two factor field experiment of eleven single-cut oat genotypes and three nitrogen levels was conducted in split plot design at Forage Section Research Farm, CCS Haryana Agricultural University, Hisar during *rabi*, 2016-17. Oat genotypes OS 424, OL-1769-1, OL-1802, SKO-225, JO-04-19, UPO-10-3, OL-1766-1 and OS-432 were compared with three checks (OS-6, Kent and OL-125). The nitrogen levels were 40, 80 and 120 kg per hectare. OL-1802 was superior for green fodder, dry matter and crude protein yield (754.6, 139.7 and 11.2 q/ha, respectively). Number of tillers/m row length, plant height, green fodder, dry matter yield, CPY and DDM were influenced with increasing nitrogen levels. Among genotypes, maximum net returns (Rs. 66257/ha) and B: C ratio (3.36) were fetched in OL-1802, whereas the application of 120 kg nitrogen/ha realized the maximum net returns (Rs. 48341/ha) and B:C ratio (2.69).

Keywords: Oat, fodder yield, dry matter, crude protein, net returns, B:C ratio

Introduction
The low productivity and poor performance of the livestock are mainly due to scarcity of nutritious fodder and feed in sufficient quantity. The availability of nutritious fodder is inadequate in the country. The fodder demand will reach to 1012 million tonnes of green fodder and 631 million tonnes of dry forage by the year 2050. At the current level of growth in forage resources, there will be 18.4 % deficit in green and 13.2% deficit in dry fodder in the year 2050 [1]. Oat (*Avena sativa* L.) belonging to family *Poaceae* is a cereal crop. Oat both as fodder and grain is a good source of protein, fibre and minerals. It is used as a green crop and silage for animals [2]. Oat can provide nutritious and palatable fodder, grown in the winter season in the North-Western and Central India and now extended to the Eastern region also. For higher green fodder yield, vegetative growth of that crop is very important. Although the vegetative growth of any crop is largely dependent on the potential of the genotype, nutrient supply system, inherent capacity of the soil to supply the nutrients to the crop and capacity of the crop plants to take and use the nutrients in unit time. Among all the primary nutrients, nitrogen plays an important role in quantitative as well as qualitative improvement in the productivity of the crop. The soils of Haryana are generally low in nitrogen and if the required amount of nitrogen of any crop is not supplied in sufficient amount then the deficiency of nitrogen will be reflected in the straw and grain. Since nitrogen is a constituent of amino acid and deficiency of nitrogen in grain and straw of the cereals as well in the fodder crops may cause severe disorders in animals [3]. Therefore, it is essential to find out the optimum dose of nitrogen for fetching potential green fodder and dry matter yield of oat. Hence, the present investigation was undertaken to study the performance of different promising genotypes of oat with different nitrogen levels.

Materials and methods
A field experiment was conducted during *rabi* season of 2016-17 at Forage Section Research Farm of CCS Haryana Agricultural University, Hisar (Haryana, India) situated at 29°10' N latitude, 75°46' E longitude, and altitude of 215.2 m above mean sea level. The site has semi-arid and sub-tropical climate with hot dry summer and severe cold winter. Average annual rainfall is about 450 mm, 75 per cent of which is received in three months, from July to September during south-west monsoon. July and August are the wettest months. The crop received 41.2 mm rainfall during crop season.

Fig. 1 represents the weekly weather parameters i.e. temperature °C, relative humidity (%) and rainfall (mm) during the study. The soil of the experimental field was sandy loam, having pH 8.2, organic carbon 0.52%, available P and K of 12.0 and 202.0 kg/ha respectively.

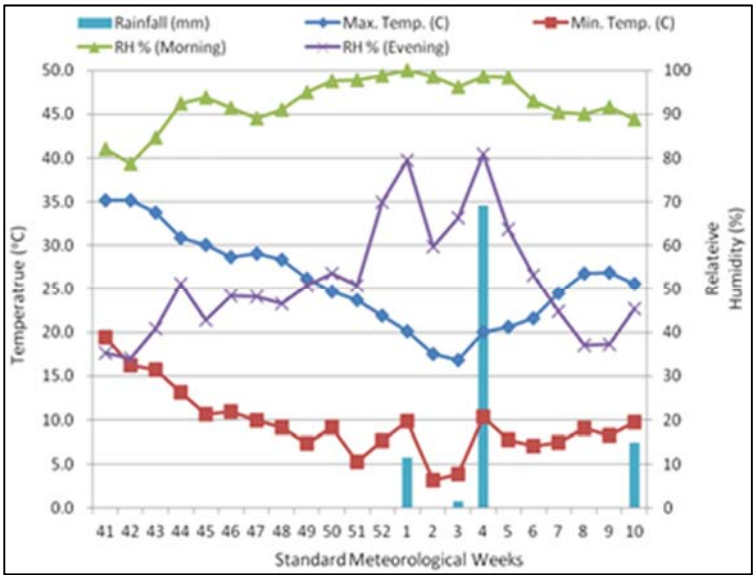

Fig 1: Weekly weather parameters viz., temperature °C, relative humidity (%) and rainfall (mm)

The experiment was laid out in split plot design with three replications. The main plot consisted of eleven oat genotypes (OS 424, OL-1769-1, OL-1802, SKO-225, JO-04-19, UPO-10-3, OL-1766-1, OS-432, OS-6, Kent and OL-125), whereas sub-plot had three nitrogen levels (40, 80 and 120 kg N/ha). The sowing was done on 25 October 2016 in opened furrows at 25 cm apart using the seed rate of 100 kg/ha. All the other standard agronomic practices for the cultivation of oat were followed uniformly in all the treatments. All the genotypes were harvested just after 50 per cent flowering. The harvested green fodder from each plot was weighed *in-situ* in kg/plot and then converted into q/ha. A random sample of 500 g was taken from each plot at the time of green fodder at harvest, chopped well and put into paper bag. These bags were aerated by making small holes all over. The samples were first dried in the sun for 15 days and then transferred in an electric hot air oven for drying at a temperature of 60±5 °C till constant weight was achieved. On the basis of dry weight of these samples, the green fodder yield was converted into dry matter yield (q/ha). Crude protein content and *in-vitro* dry matter digestibility (IVDMD) were estimated in dried and grinded samples (2 mm sieve size), collected at 50 per cent flowering stage. The crude protein content was calculated by multiplying the nitrogen percentage with 5.83 by conventional micro-Kjeldal method [4]. IVDMD was determined by standard method [5]. Crude protein yield and digestible dry matter yield were calculated by the multiplication of crude protein content (%) and *in-vitro* dry matter digestibility (%) with dry matter yield (q/ha), respectively. Economics was worked out on the basis of prevailing prices of inputs and outputs in the local market. The experimental data were analyzed by using OPSTAT software available on CCS Haryana Agricultural University website [6]. The results are presented at 5 per cent level of significance (P=0.05) for making comparison between treatments.

Results and discussion

Effect of Genotypes

Data presented in Table 1 reveal that among genotypes, maximum number of days to 50 per cent flowering (127.4) was recorded in UPO-10-3 which were significantly superior over OL-1769-1, OS-432, OS-6, Kent and OL-125. The highest number of tillers/m row length (111.9) was recorded with OL-1802 which was on a par with SKO-225 and UPO-10-3 but significantly superior over rest of the genotypes. However, the lowest number of tillers/m row length (88.4) was recorded with the genotype OS-432. Maximum plant height (164.2 cm) was recorded with OL 1802 genotype which was on a par with OL-1769-1, OL-1766-1 and OS-6. However, lowest plant height (91.3 cm) was recorded with the genotype OS-432. Highest L:S ratio (0.69) was recorded in OS 432 which was significantly superior over all the other genotypes. Highest green fodder and dry matter yields were recorded in the genotype OL-1802 (754.6 q/ha and 139.7 q/ha, respectively), which were significantly superior over rest of the genotypes. Highest per day productivity of green fodder yield (5.98 q/ha) was recorded in the genotype OL-1802 which was on a par with OS-6 and OL-1766-1. Significantly highest per day productivity of dry matter yield (1.11 q/ha) was also recorded in the genotype OL-1802.

Table 1: Performance of promising entries of single cut oat during *Rabi* 2016-17

Entry	Days to 50% Flowering	No. of Tillers/m row length	Plant height (cm)	Leaf : Stem ratio	Green fodder yield (q/ha)	Dry matter yield (q/ha)	Per day productivity (q/ha)	
							Green fodder	Dry matter
OS-424	127.3	101.0	145.7	0.49	529.4	100.6	4.16	0.79
OL-1769-1	117.2	102.3	160.6	0.47	570.3	95.0	4.86	0.81
OL-1802	126.1	111.9	164.2	0.50	754.6	139.7	5.98	1.11
SKO-225	122.6	106.6	151.3	0.52	572.5	105.8	4.68	0.86
JO-04-19	126.0	103.3	153.3	0.53	539.6	97.4	4.28	0.77

UPO-10-3	127.4	105.9	148.2	0.56	598.2	100.0	4.70	0.78
OL-1766-1	125.1	102.3	156.6	0.49	630.2	119.8	5.04	0.96
OS-432	94.1	88.4	91.3	0.69	411.3	58.2	4.37	0.62
OS-6 (NC)	121.6	101.4	163.9	0.41	639.9	117.7	5.27	0.97
Kent (NC)	118.8	99.2	152.6	0.45	564.6	95.7	4.75	0.81
OL-125 (NWZ)	118.8	96.1	152.9	0.43	520.6	91.4	4.39	0.77
SEm±	1.75	2.75	3.33	0.008	36.81	5.14	0.33	0.05
CD (P=0.05)	5.21	8.18	9.90	0.025	109.36	15.25	0.98	0.13
N level (kg/ha)								
40	119.1	90.9	142.7	0.46	526.0	90.0	4.41	0.75
80	120.6	103.0	149.7	0.51	585.6	104.7	4.85	0.86
120	121.7	111.1	155.1	0.54	615.2	111.0	5.05	0.91
SEm±	0.13	1.19	1.43	0.003	10.15	1.58	0.08	0.01
CD (P=0.05)	0.36	3.40	4.10	0.009	29.02	4.53	0.24	0.04
CV (%)	1.00	6.71	5.52	-	10.13	8.93	9.99	8.42

Interaction detail: Interaction of Entry × N level was found non-significant for all the above characters except for Leaf: Stem ratio.

The Interaction of Entry × N level was found significant for Leaf:Stem ratio. The interaction data is given in table 2.

Data presented in table 3 reveal that maximum crude protein content (8.26 %) was estimated in genotype OL-1766-1 which was on a par with OL-1802 but significantly superior over rest of the genotypes. The maximum crude protein yield (11.2 q/ha) was estimated with OL-1802 which was significantly superior over rest of the genotypes. Highest *in-vitro* dry matter digestibility (IVDMD) (62.0 %) was estimated in the genotype OS-6 which was significantly superior over SKO-225, JO-04-19, UPO-10-3 and OS-432. Digestible dry matter yield ranged from 34.2 to 82.7 q/ha in the genotypes under investigation. Highest digestible dry matter was recorded in the genotype OL-1802 (82.7 q/ha) which was on a par with OS-6 except rest of the genotypes.

Table 2: Two way table for L:S ratio

Entry	40	80	120	Mean of Entry
OS-424	0.47	0.50	0.48	0.49
OL-1769-1	0.40	0.49	0.52	0.47
OL-1802	0.44	0.50	0.57	0.50
SKO-225	0.46	0.53	0.58	0.52
JO-04-19	0.50	0.55	0.54	0.53
UPO-10-3	0.53	0.57	0.58	0.56
OL-1766-1	0.48	0.48	0.52	0.49
OS-432	0.64	0.69	0.72	0.69
OS-6 (NC)	0.35	0.39	0.47	0.41
Kent (NC)	0.40	0.45	0.49	0.45
OL-125 (NWZ)	0.37	0.40	0.51	0.43
Mean of N Level	0.46	0.51	0.54	

Interaction CD: N level at same level of Entry (CD at 5% 0.032), Entry at same level of nitrogen (CD at 5% 0.036)

Table 3: Performance of promising entries of single cut oat during *Rabi* 2016-17

Treatments	Crude protein (%)	IVDMD (%)	CPY (q/ha)	DDM (q/ha)	N content (%)	N uptake (kg/ha)
Entry						
OS-424	7.11	60.20	7.2	60.6	1.22	122.88
OL-1769-1	7.45	60.83	7.1	57.6	1.28	121.86
OL-1802	8.01	58.90	11.2	82.7	1.37	192.81
SKO-225	7.33	56.20	7.8	59.9	1.26	133.38
JO-04-19	6.91	58.13	6.8	56.6	1.19	115.95
UPO-10-3	7.69	58.80	7.7	59.2	1.32	132.76
OL-1766-1	8.26	59.80	9.9	71.7	1.42	169.55
OS-432	7.11	58.60	4.2	34.2	1.22	71.29
OS-6 (NC)	7.21	62.00	8.5	73.0	1.24	146.04
Kent (NC)	7.82	61.23	7.5	58.6	1.34	128.53
OL-125 (NWZ)	7.33	59.73	6.7	54.6	1.26	115.13
SEm±	0.11	1.05	0.42	3.44	0.02	7.22
CD (P=0.05)	0.33	3.10	1.25	10.21	0.06	21.44
N level (kg/ha)						
40	7.17	58.43	6.5	52.6	1.23	111.69
80	7.33	59.16	7.7	62.1	1.26	131.80
120	7.93	60.90	8.9	67.7	1.36	152.02
SEm±	0.06	0.51	0.14	1.14	0.01	2.35
CD (P=0.05)	0.17	1.46	0.39	3.27	0.03	6.72
CV (%)	4.65	10.24	4.93	10.8	4.93	10.24

Interaction detail: Interaction of Entry × N level was found non-significant for all the above characters

Highest nitrogen content (1.42%) was estimated with OL-1766-1 which was on a par with OL-1802 only. Significantly highest nitrogen uptake (192.81 kg/ha) was recorded with the genotype OL-1802. Researchers[7] have also noticed the variation among the genotypes of oats for fodder yield, growth and quality. Data presented in table 4 reveal that among genotypes, maximum gross returns (Rs. 94329/ha), net returns (Rs. 66257/ha) and B:C ratio (3.36) were fetched with OL-1802 followed with OS-6 (gross returns Rs. 79988/ha, net returns Rs. 51916/ha and B:C ratio 2.85).

Effect of Nitrogen Levels

Data presented in Table 1 reveal that among different nitrogen levels, maximum number of days to 50 per cent flowering, number of tillers/m row length, and plant height (121.7 day, 111.1 tiller and 155.1 cm respectively) were recorded with 120 kg N/ha which were significantly superior over 40 and 80 kg N/ha. Significantly highest L:S ratio (0.54) was recorded with 120 kg N/ha.

Table 4: Economics of single-cut oat entries as influenced by different N levels during *Rabi* 2016-17

Treatments	Cost of cultivation (Rs.)	Gross returns (Rs.)	Net returns (Rs.)	B:C ratio
Entry				
OS-424	28072	66169	38097	2.36
OL-1769-1	28072	71285	43213	2.54
OL-1802	28072	94329	66257	3.36
SKO-225	28072	71563	43491	2.55
JO-04-19	28072	67454	39382	2.40
UPO-10-3	28072	74780	46708	2.66
OL-1766-1	28072	78773	50701	2.80
OS-432	28072	51412	23340	1.83
OS-6 (NC)	28072	79988	51916	2.85
Kent (NC)	28072	70579	42507	2.51
OL-125 (NWZ)	28072	65081	37009	2.32
N levels (kg/ha)				
40	27591	65748	38157	2.38
80	28072	73198	45126	2.61
120	28553	76894	48341	2.69

Highest green fodder and dry matter yields (615.2 and 111.0 q/ha, respectively) were also recorded with 120 kg N/ha which were significantly superior over 40 and 80 kg N/ha. The application of 80 kg N/ha significantly increased the green fodder and dry matter yields from 526.0 to 586.6 q/ha and 90.0 to 104.7 q/ha, respectively, over 40 kg N/ha. Reports [8] revealed that application of nitrogen up to 120 kg/ha significantly increased the growth and produced 309.0 and 62.2 q/ha green and dry matter yields, respectively over the lower doses of nitrogen. Highest per day productivity of green fodder and dry matter yield (5.05 and 0.91 q/ha) were recorded with 120 kg N/ha which were significantly superior over the lower doses of nitrogen.

Data presented in table 3 reveal that highest crude protein content (7.93%) was estimated with the application of 120 kg N/ha which was significantly superior over the lower doses. The increase in crude protein content was 7.17 to 7.33 per cent with the application of 80 kg N/ha over 40 kg N/ha and it further improved to 7.93 per cent with the application of nitrogen at the rate of 120 kg/ha. Application of nitrogen increased the protein content in oat and this may be due to the nitrogen which helps in the synthesis of amino acid and protein in plant. Higher crude protein at 120 kg N/ha was attributed to more uptake of nitrogen which is constituent of amino acids and protein. The maximum crude protein yield (8.9 q/ha) was exhibited with the application of 120 kg N/ha. The increase in crude protein yield was 6.5 to 7.7 q/ha with the application of 80 kg N/ha over 40 kg N/ha and it further improved to 8.9 q/ha with the application of nitrogen at the rate of 120 kg N/ha. The increase in crude protein yield was due to increase in protein content and dry matter yield of oat because the protein yield proportionally increased with the increase in dry matter yield. Highest *in-vitro* dry matter digestibility (60.90%) was estimated with the application of 120 kg N/ha which was significantly superior over the lower doses of nitrogen. Digestible dry matter yield increased with increasing levels of nitrogen from 40 to 120 kg/ha being maximum with the application of 120 kg N/ha (67.7 q/ha). Significantly highest nitrogen content and nitrogen uptake (1.36% and 152.02 kg/ha, respectively) were estimated with the application of 120 kg N/ha. Data presented in table 4 reveal that among different nitrogen levels, the maximum gross returns (Rs. 76894/ha), net returns (Rs. 48341/ha) and B:C ratio (2.69) were obtained with the application of 120 kg N/ha followed by 80 kg/ha (gross returns Rs. 73198/ha, net returns Rs. 45126/ha and B:C ratio 2.61).

Conclusion

Based on the results, it can be concluded that among genotypes, OL-1802 proved to be significantly superior for green fodder (369.3 q/ha) and dry matter yield (71.6 q/ha) and crude protein yield (11.2 q/ha) over rest of the genotypes. DDM was also highest in this genotype (82.7 q/ha) which was on a par only to OS-6. Crude protein content and IVDMD values were also comparable to the highest ones in this genotype. The maximum net returns (Rs. 66257/ha) and B : C ratio (3.36) were also recorded in OL-1802. Among different nitrogen levels, the maximum green fodder, dry matter, crude protein, and digestible dry matter yields (615.2, 111.0, 8.9 and 67.7 q/ha, respectively) were recorded with the application of 120 kg N/ha. Maximum net returns (Rs. 48341/ha) and B : C ratio (2.69) were also fetched with120 kg N/ha. In crux, the genotype OL-1802 proved superior in yield, quality and economics. Application of 120 kg N/ha was the most suitable nitrogen fertilization practice to achieve the potential of fodder oat in terms of yield, quality and to fetch the maximum economic returns.

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