Effect of nitrogen on morphological characters, yield and quality of forage oat (*Avena sativa* L.)

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Abstracts

Experiment was conducted at the Govind Ballabh Pant University of Agriculture and Technology, India to study morphological characters, yield and quality of forage oat (*Avena sativa*) under different levels of nitrogen. The soil of the experimental site was Beni silty clay loam under the order *Mollisol*, slightly alkaline in reaction (7.3), low in available nitrogen (238 kg ha^{-1}), medium in organic carbon (0.7%), P_2O_5 (47.3 kg ha^{-1}) and K_2O (284.37 kg ha^{-1}). The experiment was conducted in a Randomized Complete Block Design with four replications consisting of five levels of nitrogen (0, 40, 80, 120 and 160 kg ha^{-1}) and two forage oat varieties namely Kent and UPO-212. The result revealed that increased application of nitrogen significantly ($P< 0.05$) affected morphological characters of the crop. Higher number of shoot, leaves and dry matter accumulation were recorded at 120 kg N ha^{-1} with maximum plant height, leaf area index, emergence count and lodging percentage being at 160 kg N ha^{-1}. Green forage, dry matter, crude protein and digestible dry matter yields were significantly ($P < 0.05$) higher upto 120 kg N ha^{-1} with better quality forage in terms of digestibility and crude fiber content. Between the two varieties, UPO-212 revealed significantly ($P < 0.05$) higher performance in terms of most morphological characters with significantly ($P < 0.05$) higher green forage, dry matter, digestible dry matter and crude protein yields than Kent. Whereas, crude protein and digestible dry matter contents were better in Kent than in UPO-212.

Key words: Forage oat; morphological characters; nitrogen levels; quality; yield

Introduction

The mismatch between general paucity in area devotion to forage cultivation at 6.9 million hectares for the last four decades and the livestock population growing at 1.4 per cent per annum is the challenge to the Indian feed production. The available feed resource in the country is merely meager. Only 550 million tons dry fodder from crop residues, pasture and grazing resources; 370 million tons green fodder from cultivated forages, tree fodders, weeds and sugar cane tops is available against the 949 million tons dry fodder, 1136 million tons green forages and 6.0 million tons concentrates (Hazra and Singh, 1996; ICAR, 1997) required to feed the livestock population of the country.

In efforts to bridge the gap, oat has gained great attention particularly in the northern and western parts of the country where the climate is very conducive for production. To date, several varieties have been released (Mishra and Verma, 1992; Bhagmal, 1998) which are grown on over 100 thousand hectares of land (Hazra and Singh, 1996) with 35 to 50 tons ha^{-1} green forage productivity (Hazra and Singh, 1996). On the other hand, there is a long established universal fact that apart from genetics, the external factors viz, climate, nutrient and humans managerial interventions, collectively called environment, contributes up to 79.96% to the full production potential of a crop (Gezahegn *et al*., 2008). Climate mainly through temperature and moisture, determines the spatial and seasonal distribution of crops, while nutrients play decisive role on growth and productivity of the crop in its area of adaptation.

Among the essential nutrients to plant, nitrogen is the most important element taken-up by plants (Miles and Manson, 2000). Both the deficiency and excess supply of this nutrient has adverse effect on growth and yield of crops, animal health and on socio-economic and environmental welfare. As one way to get out of it, interests of identifying genetic differences in responsiveness to nitrogen fertilizer are intensifying. Producers, agricultural consultants and researchers often see genotypic variation as one way to fine-tune fertilizer management (Below, 1995). There is a desire to develop or identify genotypes that perform well under low nitrogen supply or conversely to find genotypes that will respond to high fertility conditions (Below, 1995). Therefore, it was with this in mined that study was conducted using two commercial varieties of forage oat to see the response to different levels of nitrogen in terms of morphological characters, yield and quality.

Materials and Methods

The study was conducted at Govind Ballabh Pant University of Agriculture and Technology, India, situated at an altitude of 243.8 meters above mean sea level between 29.5^{o} N latitude and 79.3^{o}E longitude. The region is characterized by subhumid tropical and subtropical climate having shallow water table and gentle slope with mean annual rainfall of 1385mm.The air temperature ranges from below 10^{o}C in winter to over 40^{o}C in summer. The soil was slightly alkaline in reaction (7.3), low in available nitrogen (230 kg ha^{-1}), medium in organic carbon (0.7%), P_2O_5 (47.3 kg ha^{-1}) and K_2O (284.37 kg ha^{-1}).

Experimental design, treatments and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. The treatments consist of five nitrogen levels (0, 40, 80, 120, and 160 $kgha^{-1}$) and two forage oat varieties namely Kent and UPO-212. Kent was introduced from USA in 1960's and adapted well to the Indian condition. It is a medium to late maturing variety with long, narrow and droopy light green leaves; resistant to rust, blight and lodging (Singh, 1998). Whereas, UPO-212 is a medium late variety released from Pantnagar in 1990. It is resistant to crown rest, blight, lodging and shattering (Mishra and Verma, 1992). The two varieties and the five levels of nitrogen were combined factorally making a total of ten treatments each with gross and net plot size of 4 m x 3 m = 12 m^2 and 2 m X 2 m = 4 m^2, respectively in four replication.

Experimental plots management

The field was disc-ploughed once followed by two cross harrowing and plank-ing. Seeds were sown at 100kg ha^{-1} seed rates by drilling in rows with 25 cm spacing in between. Each plot was supplied at planting with a uniform two-third quantity of the total dose of nitrogen through urea as per treatment, 40 kg ha^{-1} K_2O as murate of potash and 60 kg ha^{-1} P_2O_5 as single supper phosphate as basal dressing. The remaining one-third of the total dose of nitrogen left after basal application was top-dressed 30 days after sowing. Irrigation was given to all plots a week after planting and subsequently at 20-25 days interval depending on moisture /precipitation/ condition and the need of the crop. A total of 4 irrigations were given to meet water requirement of the crop. Herbicide 2-4,D was also applied 25 days after sowing at 1.0 kg ha^{-1} a. i. and supplemented with hand-weeding once 50 days after sowing.

Data collection and Analysis

Morphological characters

The crop was harvested at 50% heading stage(D50)after taking measurement on plant height (PLH) and counting number of shoot (NSH) from a half meter row length. The entire herbage from the half meter row length was cut close to the ground and separated into leaves and stem; count was taken on number of

green leaves (NGL), number of dry leaves (NDL), and total number of leaves (TNL). Leaf area, leaf area index (LAI), dry matter accumulations through leaves (DMAL), stem (DMAS), and whole aerial plant part (TDMA), and the leaf to stem ratio (L/S) were all determined (Aklilu and Alemayehu (2007). Lodging percentage (LGP) was determined as percentage of the ratio of lodged area to the total area of the plot as given by Bhat *et al*. (2000). Emergence count (EGC) was taken at 15 days after planting by counting all plants from
0.5 meter row length.

Yield and quality

For the purpose of yield determination, the entire herbage from the net plot area (2m x 2m) was cut close to the ground, fresh weight was measured and the green forage yield (GFY) in q ha^{-1} determined. Subsamples of about 250 g was taken from each plot and dried in oven at 70^{O}C to constant weight from which the dry matter content (DM) and the dry matter yield (DMY) in qha^{-1} were determined. For crude protein, crude fiber and digestibility determination, the oven-dried samples were ground by laboratory Willey mill to pass 1 mm sieve size; two hundred mg samples were analyzed for total nitrogen content by Micro-kjeldhal method (Jackson, 1973) and the nitrogen content was multiplied by 6.25 to determine the per cent crude protein content (CP). The crude protein yield (CPY) in qha^{-1} was determined by multiplying the DMY with the CP and dividing by 100. The crude fiber content (CF) was determined according to the procedure of AOC (1980). At the same time, five gram of the ground sample was incubated in rumen of three rumen fistulated animals for 72 hours according to *Ørskov and McDonald (1979). And the* digestibility of the samples (DDM) were calculated by dividing the difference in dry weight between the before and the after incubation with that of the weight before incubation multiplied by 100. Digestible dry matter yield (DDMY) in qha^{-1} was then determined by multiplying DMY with that of the DDM divided by 100.

Finally the data on all parameters were subjected to analyses of variance for RCBD as described by Cocharan and Cox (1957) at probability level of 5 per cent.

Results and discussions

Morphological characters

Analyses of variance showed significant ($P<0.05$) difference in all morphological characters due to application of different nitrogen levels (Table 1). PLH,

NSH, NGL, NDL, TNL, LAI, DMAL, DMAS, TDMA, and EGC all increased with levels of nitrogen. Maximum NSH (51.9), NGL (158), NDL (83.4), TNL (241.4), DMAL (33.25), DMAS (86.13) and TDMA (119.38) were recorded at 120 kg N ha^{-1}, while the PLH, LAI, EGC and LGP continued to increase up to the maximum level of nitrogen, indicating the need for higher amount of nitrogen to establish apparatuses involved in photosynthesis (Below, 1995).

Application of nitrogen at beyond 120 kg N ha^{-1}, however, resulted in slight decrease in NSH, NGL, NDL and TNL. The observed decrease might be due to increased EGC, because of nitrogen effect, which might have caused death of weaker and less competitive tillers (Joshi, 1996) and decomposition of leaves. Sexton (1995) also observed leaf losses associated with low light intensity in crop canopy. The observed increase in LAI (Table 1) with nitrogen could also be due to enhanced synthesis of enzymes, co-enzymes, chlorophyll and other nitrogen containing compounds (Rusel, 1973) which are essential for full expansion of individual leaf. Higher leaf area enables the crop to intercept more solar energy and synthesize more sugars for higher dry matter accumulation as reported by Saxena *et al.* (1971), Tiwari *et al.* (19 71), Verma (1984) and Chakraborty *et al.* (1999). A positive correlation of dry matter accumulation with LAI has also been documented by Rao *et al.* (1978) and Joshi (1980). The observed increase in total dry matter accumulation with the increasing levels of nitrogen could thus be due to better root growth and uptake of other essential elements (Hopkins *et al.*, 1994; Brady and Weil, 2002) with increased LAI and more light interception (Dhaliwal *et al.,* 1984).

Though not significant (P>0.05) the D50 of present study decreased progressively with levels of nitrogen from 111.6 days to 105.1 days. The implication is that application of nitrogen hastens plant growth and development to early maturity. Likewise the leaf to stem ratio of present study declined significantly (P<0.05) with successive level of nitrogen from 0.54 at 0 kg N ha^{-1} to 0.37 at 160 kg N ha^{-1}. The reason could be due to more accumulation of dry matter in the stem than in leaves (Table 1) and leaf senescence as reported by Sexton (1995).

Between the two varieties UPO-212 showed significantly (P<0.05) superior performance with respect to most morphological characters vis PLH, NSH, NDL, TNL, LAI, DMAS, TDMA, D50 and LGP. It was also responsive to higher doses of nitrogen in terms of TNL, DMAS, TDMA and PLH (Table 2). The higher dry matter accumulation of UPO-212 could be due to more assimilatory surface areas reflected by more number of shoots with higher LAI (Table 1). The dry matter accumulation through leaves however, was significantly ($P<0.05$) higher in kent than in UPO-212. The possible reason might be better leaf thickness and specific leaf weight which were not considered in the present study. But Rao *et al.* (1978) reported negatively correlated leaf area index with specific leaf weight in some genotypes.

The higher total dry matter accumulation in UPO-212 might be doing to the observed L/S and late heading (Table 1). Collin *et al.* (1990) also reported more dry matter accumulation in late heading genotypes than in early heading genotypes. Higher percentage of lodging was also observed in UPO-212 which might be due to nitrogen-induced excessive vegetative growth (Das,1996) and more number of shoots with greater crop canopy development (Pinthus, 1973).

Yield and quality

Application of nitrogen significantly ($P<0.05$) affected the measured yield and quality parameters (Table 3). The GFY increased up to the maximum dose of nitrogen, while the increase in DMY, CPY, and DDMY was only up to 120 kg N ha^{-1} with a short fall thereafter, indicating that application of nitrogen above this dose level might not be beneficial under similar environmental and management conditions. Similar trends of increase in yield were reported by several authors, among which Thakuria and Gogoi (2001) in experiment with three levels of nitrogen (0, 40, and 80 Kg N ha^{-1}) noticed significant improvement in GFY with 80 kg N ha^{-1} and DMY with 40 kg N ha^{-1}. Hasen *et al.* (2000) also investigated increased GFY and DMY both up to 160 kg N ha^{-1}. Singh *et al.* (2000) in turn reported 55.5, 85.5 and 106.5 percent increment in green forage yields each with application of 30, 60 and 90 kg N ha^{-1}, respectively. The increase in green forage yield with nitrogen at above 120 kg N ha^{-1} level could be attributed to lush growth of the crop with formation of more protoplasm and increase in cell volume. Since protoplasm is highly hydrated, there would be more succulent plant growth with excessive moisture in tissues as the level of nitrogen increased (Das, 1996). The DM content of present study thus decreased with successive levels of applied nitrogen (Table 3) and the observation corroborates reports of Kumar *et al.* (2001), Thakuria and Gogoi (2001) and Singh *et al.* (2000). The decrease in DM content with increased level of nitrogen might be due to loss of significant portion of the weight of plant tissue upon dehydration.

Contrary to the DM and DDM, the CP and CF of present study showed increasing trend which is in agreement with Ayub, *et al.*(2001) in Maize and Ammaji and Suryanaraana (2003) in sorghum. The implication is that application of nitrogen made more nitrogen to be available in soil for increased uptake and contents in plant tissue. The increase in CF with nitrogen level could also be related to the observed decrease in L/S (Table 1). Kilcher and Troelsen (1973) found much higher structural cell wall constituents in stems than in leaves of oat. Since the structural carbohydrates (lignin, cellulose and hemicelluloses) are less digestible, the observed increase in CF with nitrogen levels might have reduced the DDM in plant tissue (Table 2). The observation is in agreement with Collin *et al*. (1990) and Kumar *et al.* (2001) who found more indigestible components of fibre with increased levels of nitrogen. Kilcher and Troelsen (1973) also reported negative correlation of digestibility with lignin in oat.

Between the two varieties UPO-212 revealed significantly ($P < 0.05$) higher GFY, DMY, CPY, and DDMY (Table 3) with significantly ($P< 0.05$) more response to the higher doses of nitrogen at 120 and 160 kg N ha^{-1} (Table 4) which is in conformity with earlier reports of Kumar *et al.* (2001). The higher yield of UPO-212 over Kent could be due to better genetic makeup of the variety with inherently higher potential for taller growth, more number of shoots, and leaves, better LAI, and more dry matter accumulation (Table1 and 2).

In the present study UPO-212 also showed non-significantly ($P>0.05$) more DM than Kent (Table 3 and 4) which is in conformity with reports of Kumar (2001). The higher dry matter content of UPO-212 might be due to the observed more number of days taken to attain 50% heading, more dry matter accumulations in stem and lower L/S. This is in agreement with findings of Collin *et al.* (1990) who reported more dry matter content in late heading cultivars than in early heading cultivars. The higher crude fibre content observed in UPO-212 than in Kent (Table 3 and 4) could also be due to more structural carbohydrates

deposit such as, lignin, cellulose, and hemicelluloses.

In the present work Kent showed higher digestible dry matter content than UPO-212 is in agreement with findings of Raghubanshi *et al.* (2002) and Kumar *et al.* (2001). The higher digestible dry matter content in Kent could be due to more L/S in Kent than in UPO-212 is in agreement with the higher digestibility of leaves than stem reported by Kilcher and Troelson (1973). The non-significantly ($P> 0.05$) higher CP observed in Kent (Table 3 and 4) contradicts Raghubanshi *et al*. (2002) and Kumar *et al.* (2001). The deviation of the present finding might be due to combined effects of high nitrogen induced lodging and late heading in UPO-212 (Table 1). Lodged plants are often subjected to nutrient loss due to leaf shattering and decomposition. Similarly late heading cultivars have less crude protein with more fiber contents than early heading ones (Collin *et al.,* 1990*)* 1990. In the present work UPO-212 recorded significantly (P<0.05) higher crude fiber content than Kent is in agreement with Raghubanshi *et al.* (2002).

Conclusions

Apart from genetics, the type and level of management also influences the yield and quality of forage crops. In the present study application of nitrogen significantly affected the morphological characters, yield and quality of the crop. The observation revealed that, increased application of nitrogen fertilizer increased plant height, number of shoot, number of leaves, leaf area index, and dry matter accumulations. The increase in these yield contributing traits has been reflected in yield and quality of the crop. The green forage yield increased up to the maximum dose, while the increase in dry matter, crude protein and digestible dry mater yields were up to 120 kg N ha^{-1}. The dry matter and the digestible dry matter contents of the crop however decreased with increased levels of nitrogen while there was consistent increase in crude protein and crude fiber contents. The present study also revealed varietal difference in response to levels of nitrogen. UPO-212 showed superior performance with respect to most morphological characters and thus gave more green forage yield, dry matter yield, crude protein yield and digestible dry matter yields with more dry matter and crude fiber contents than Kent. Kent however, revealed more crude protein and digestible dry matter contents than UPO-212. In a nutshell, it can be concluded that application of nitrogen up to 120 kg ha^{-1} might be recommendable for higher biological yield and further work need to be done to exploit more varietal differences in improving fertilizer use-efficiency.

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Table 1: Effect of applying different levels of nitrogen on morphological characteristics of forage oat

Morphological characters	PLH (num-ber 0.5m-1 row)	NSH (number 0.5m-1 row)	NGL (number 0.5m-1 row)	NDL (number 0.5m-1 row)	TNL (number 0.5m-1 row)	LAI (g 0.5m-1	DMAL (g 0.5m-1 row)	DMAS row)	TDMA (g 0.5m-1 row)	L/S (number 0.5m-1 row	EGC (days)	D50	LGP (%)
Nitrogen level (kg ha-1)													
0	113.9d	33.6d	101.1d	54.6b	155.6d	4.11d	22.38c	41.80d	64.18e	0.54a	26.4c	111.6a	0
40	134.6c	41.8c	113.3c	76.6a	189.9c	6.65c	28.38b	65.50c	93.88d	0.43b	27.8bc	106.0b	0
80	145.4b	48.3b	129.4b	79.4a	208.8bc	7.78b	31.38a	77.00b	108.38c	0.41bc	28.9abc	104.5b	0
120	149.1a	51.9a	158.0a	83.4a	241.4a	8.33a	33.25a	86.13a	119.38a	0.39bc	29.6ab	104.1b	16.3b
160	151.2a	49.5ab	136.0b	79.5a	215.5b	8.40a	31.75a	85.13a	116.88b	0.37c	31.0a	105.1b	28.1a
SEm+	0.8	1.1	3.6	5.8	7.6	0.14	0.73	1.55	0.50	0.02	0.8	1.1	2.7
LSD (p < 0.05)	2.8	3.3	10.5	16.9	21.9	0.42	2.14	2.94	1.43	0.04	2.5	3.3	7.8
Variety													
Kent	130.4b	43.3b	130.4	68.3b	193.0b	6.99b	30.95a	68.38b	99.33b	0.45	31.2a	104.9b	2.3b
UPO-212	147.3a	46.9a	127.6	81.1a	211.5a	7.05a	27.90b	73.84a	101.74a	0.38	26.3b	107.7a	15.5a
SEm+	1.0	0.7	2.3	3.8	5.9	0.90	0.47	0.98	0.31	0.01	1.3	0.6	1.7
LSD (p < 0.05)	1.8	2.1	NS	10.7	13.9	0.26	1.35	1.86	0.90	NS	3.9	1.72	4.9

Figures with different alphabetical letters in a column are significantly different at P< 0.05

PLH= Plant height, NSH= Number of shoot, NGL= Number of green leaf NDL= Number of dry leaf, TNL= Total number of leaf, LAI= leaf area index, DMAL = Dry matter accumulation through leaf, DMAS= Dry matter accumulation through stem, and TDMA= total dry matter accumulation through aerial plant part, L/S leaf to stem ratio, EGC= Emergence count, D50= days to 50% heading, LGP= lodging percentage and NS= non significant

Table2: Interaction effect of level of nitrogen and variety on morphological characteristics of forage oat

morphological characteristics	PLH (number 0.5m-1 row)		NSH (number 0.5m-1 row)		NGL (number 0.5m-1 row)		TNL (number 0.5m-1 row)		DMAS (g 0.5m-1 row)		TDMA (g 0.5m-1 row)	
Nitrogen level (kg ha-1)	Kent	UPO-212	Kent	UPO-212	Kent	UPO-12	Kent	UPO-212	Kent	UPO-212	Kent	UPO-212
0	89.5g	38.4h	30.8de	36.5d	95.8f	106.5ef	174.5d	137.0e	40.62g	42.97g	62.38h	65.97g
40	126.8f	142.5d	35.3de	48.3b	108.3ef	118.3de	181.0cd	198.8bcd	62.75f	68.25ef	89.25f	98.50e
80	148.6bc	142.2d	46.5bc	50.0b	133.5bc	125.3cd	187.8cd	229.8b	74.00de	80.00cd	103.25d	113.50c
120	151.4b	146.8c	48.0b	55.8a	174.8a	141.3b	210.5bc	272.3a	81.50bc	90.75a	112.75c	126.25a
160	134.9e	166.6a	56.8a	42.3c	139.8bc	132.3bc	211.3bc	219.8	83.00bc	87.25ab	114.00c	120.00b
SEm+	1.4		1.6		5.12		10.7		2.20		0.70	
LSD (p < 0.05)	4.0		4.7		14.86		31.1		6.38		2.02	

Figures with different alphabetical letters in a column are significantly different at P< 0.05

PLH= Plant height, NSH= Number of shoot, NGL= Number of green leaf, TNL= Total number of leaf, DMAS= Dry matter accumulation through stem and TDMA= total dry matter accumulation through aerial plant part

Table 3. Effect of application of different level of nitrogen on yield and quality of forage oat

Yield and quality	GFY (kg ha-1)	DMY (kg ha-1)	CPY (kg ha-1)	DDMY (kg ha-1)	DM (%)	CP (%)	DDM (%)	CF (%)
Nitrogen level (kg ha-1)								
0	239.2d	51.3e	3.8d	40.1e	21.4ab	7.3d	78.0a	27.7e
40	345.5c	75.1d	6.1c	58.0d	21.8a	8.1c	77.2ab	29.3d
80	418.8b	86.7c	8.3b	65.7c	20.7ab	9.5b	75.6abc	30.4c
120	491.2a	95.6a	10.4a	71.4a	19.5bc	10.7a	74.7bc	31.2b
160	495.2a	93.6b	10.1a	69.4b	18.9c	10.7a	74.2c	31.9a
SEm+	4.9	0.4	0.1	0.6	0.5	0.3	1.0	0.1
LSD ($p < 0.05$)	14.3	1.2	0.3	1.7	1.49	0.8	2.9	0.3
Variety								
Kent	379.1b	77.1b	7.5b	59.1b	20.3	9.7	76.7	29.8b
UPO-212	407.5a	83.9a	8.0a	63.1a	20.6	9.5	75.3	30.5b
SEm+	3.1	0.3	0.1	0.4	0.3	0.5	0.7	0.06
LSD ($p < 0.05$)	9.1	0.7	0.2	1.1	NS	NS	NS	0.2

Figures with different alphabetical letters in a column are significantly different at P< 0.05
GFY= Green forage yield, DMY= Dry matter yield, CPY=Crude protein yield, DDMY=Digestible dry matter yield, DM= Dry matter content, CP= crude protein content, DDM= digestible dry matter content, CF= crude fiber content and NS= non significant

Table 4: Interaction effect of nitrogen and variety on yield and quality of forage oat

	Yield and quality									
	GFY (kg ha-1)		DMY (kg ha-1)		CPY (kg ha-1)		DDMY (kg ha-1)		CF (%)	
Nitrogen level (kg ha-1)	Kent	UPO-212	Kent	UPO-212	Kent	UPO-212	Kent	UPO-212	Kent	UPO-212
0	235.4f	243.3f	49.9h	52.8g	3.6g	4.0f	39.8g	40.3g	27.4i	28.0h
40	313.2e	378.9d	71.4f	78.8e	5.7e	6.5d	56.2f	59.7e	29.0g	29.5f
80	418.2c	419.4c	82.6d	90.8c	7.3c	9.3b	62.8d	68.6c	30.1e	30.7d
120	471.2b	508.3a	90.1c	100.9a	9.5b	11.2a	67.0c	75.9a	30.9c	31.5b
160	483.8b	506.3a	91.2c	96.0b	9.3b	10.8a	68.2c	70.7b	31.1c	32.7a
SEm+	6.9		0.7		0.2		0.8		0.14	
LSD (p < 0.05)	20.2		1.6		0.5		2.4		0.14	

Figures with different alphabetical letters in a column are significantly different at P< 0.05

GFY= Green forage yield, DMY= Dry matter yield, CPY=Crude protein yield, DDMY=Digestible dry matter yield and CF crude fiber content

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