The Journal of Animal & Plant Sciences, 23(1): 2013, Page: 232-239
ISSN: 1018-7081

PERFORMANCE OF MULTICUT FORAGE SORGHUM UNDER VARIOUS SOWING METHODS AND NITROGEN APPLICATION RATES

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ABSTRACT

A field experiment was conducted to assess the different nitrogen levels and sowing methods on multicut sorghum at University of Agriculture, Faisalabad. Replicated three times the experiment was laid out in randomized complete block design (RCBD) with split plot arrangements with a plot size of 2.7m x 6m. The experimental treatments were viz. 0, 57.5, 28.75, and 45 kg N/ha N_1, N_2, N_3, N_4 respectively at sowing and after each cut and two sowing methods i.e. broadcast and drill sowing with 30 cm apart rows. The growth, yield and quality parameters differed significantly among the different nitrogen levels and sowing methods. The observations including plant height, number of leaves per plant, stem diameter, leaf area per plant, fresh weight per plant, dry weight per plant, total green forage yield, total dry matter yield, crude protein and ash % in three cuttings showed that drill sowing at 30 cm apart rows with nitrogen level of 57.5 kg ha^{-1} enhanced significantly the growth and yield of sorghum compared to the other treatments under the environmental conditions of Faisalabad.

Key words: Sorghum forage, Nitrogen, Sowing Methods, Yield, Quality.

INTRODUCTION

Green forage demands for rapidly expanding livestock industry is increasing day by day in Pakistan. Forage sorghum may give an acceptable, lower cost different to corn grown for silage as existing irrigation continues to decline in semiarid regions of the world. N fertilizer rates may affect yield and nutritive value of forage sorghum and corn when grown in limited irrigation situations (Marsalis *et al*., 2009).

Nitrogen application has significant importance regarding the fodder yield. Nitrogen application increases the green fodder yield, dry matter yield and quality of oat as reported by Iqbal *et al*. (2009). Furthermore, Saleem *et al*., (2009) reported that yield of different maize hybrids is significantly affected by time and methods of nitrogen application.

Although fodder is the cheapest form of feed for animals but the present fodder production in Pakistan does not meet the fodder requirement in terms of both quantity and quality, which consequently results in the poor nourishing of animals. There is a lot of scope and potential for increasing the supply of balanced quality fodder in the country. Average forage yield in Pakistan is low. The increasing feed requirements of the expanding livestock population necessitate the introduction of sorghum hybrid into the farming systems in irrigated areas. Among the kharif forage crops, multicut hybrid sorghum is an important one that possesses a wide range of ecological adaptability because of its xerophytic characteristics. The use of forage sorghum hybrids for pasture and silage has been increasing in recent years (Iptas *et al*., 1997). Therefore, these crops help to maintain a high level of production during the summer months when unfavorable climate conditions often bring about a decrease in the production and quality of perennial herbage (Shehu *et al*., 1999).

Forage sorghum-Sudan grass is usually managed with low nitrogen fertilizer inputs but has shown some growth and yield response to nitrogen application (Ram and Singh, 2001). Timing and placement of N fertilizer have a major effect on the efficiency of N management systems. Nitrogen should be applied to a crop at times that avoids periods of significant loss and provide adequate N when needed (Khosla *et al*., 2000). Multiple applications throughout the season have been suggested for optimum forage production of grass species (Lauriault *et al*., 2005). The amount of N to be applied to sorghum varieties depends on intended use of the sorghum cultivars (silage, hay or grazing) and on the ecological factors of the area (Cox and Cherney, 2001; Blumenthal *et al*., 2003; Monneveux *et al*., 2005 and Subedi *et al*., 2006).

In Pakistan a little information is available on the interactive effects of nitrogen and sowing methods on the quality and fodder yield of multicut sorghum. The present study was therefore planned with the object to determine the effects of different sowing methods and nitrogen levels for obtainig maximum fodder yield of sorghum under irrigated condition of Faisalabad.

MATERIALS AND METHODS

A field experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad (31.5° N, 73.09° S), during spring 2010. The experiment was laid out into a randomized complete block design with split arrangement having three replications. The pH of saturated soil paste was 8.2 and total soluble salts were 1.2 dSm^{-1}. While organic matter, total nitrogen, available phosphorus and potassium were 0.75%, 0.078 %, 22 ppm, and 106 ppm, respectively. The net plot size of 2.7m x 6m was used. The experiment comprised of 2 sowing methods viz broad cast and drill sowing with 30 cm apart rows and 4 nitrogen levels 0, 57.5, 28.75 and 45 kg ha^{-1}. Sorghum hybrid was sown in 3rd week of May, 2010 using hand drill in case of drill sowing and broadcasted. Seed rate of 25 kg ha^{-1} was used. Recommended dose of phosphorus is 60 kg ha^{-1}. Full dose of phosphorus was applied at the time of sowing. Nitrogen was applied at the rate of 0, 57.5, 28.75 and 45 kg ha^{-1} at each cutting. Urea and SSP (single super phosphate) were used as sources for nitrogen and phosphorus. First cutting was harvested after 40 days of sowing while second and third cutting was after each month. Quality parameters like crude protein contents %, total ash % were determined by using the methods recommended by (AOAC, 1990). The data on different agronomic traits, green forage yield, were collected and subjected to analysis of variance according to Steel *et al*. (1997) to sort out significant differences among treatments. Differences among means were compared using LSD at 5% probability level.

RESULTS AND DISCUSSION

Plant population: It is evident from the table 1, 2 and 3 that the effect of nitrogen levels on plant population was significant in 1st, 2nd and 3rd cutting, respectively. The effect of sowing methods was also significant while the interactive effect of both nitrogen levels and sowing methods (N x S) was non significant. Data regarding nitrogen levels showed that maximum plant population 46.33, 47.16 and 38.66 in 1st 2nd and 3rd cutting respectively in N_2 (57.5 kg N ha^{-1}) as compared to control N_1(0 kg N/ha) having plant population 40.04, 42.08 and 30.33 respectively. Results reflected that in first cutting plant population was less as compared to 2nd cutting which was 47.16 while in 3rd cutting the plant population was low as compared to other cuttings. Data regarding sowing methods showed that S_2 drill sowing at 30 cm apart rows gave better results in all three cutting systems. Maximum plant population was observed 43.66, 45.66, and 34.83 in 1st, 2nd and 3rd cutting respectively. Interaction among (N x S) was non significant in all cuttings. Bahrani and Ghenateghestani (2004) reported significant results of plant densities and nitrogen levels on forage sorghum. Similar results were also reported by Krishna *et al.* (1998) who reported that line sowing have better effect on plant population as compared to broadcast.

Plant height (cm): Data presented (table 1, 2, 3) showed significant effect of N levels and sowing methods as well as their interaction on plant height. However, interaction of N levels and sowing methods was not significant during the 2nd cutting regarding plant height. Maximum plant height (198.07 cm, 247.30 cm and 177.58 cm) was found in N_2 (57.5 kg N/ha) in 1st, 2nd and 3rd cutting, respectively. While minimum plant height was observed in N_1 (0 kg N/ha) for 1st, 2nd and 3rd cutting with mean values of 158.23, 178.93 and 139.58 cm, respectively. Statistically the maximum plant height (181.34 cm, 212.67 cm and 165.66 cm) was recorded where sorghum was sown 30 cm apart single row over Broadcast which have the plant height of 172.59cm, 199.67cm and 148.10 cm. The interaction among (N x S) in 1st and 3rd cutting was significant while in 2nd cutting no significant interactive effect was found. The maximum plant height in plants with planting geometry of 30 cm apart single row might be due to proper circulation of air, better light penetration and comparatively more nutritional area available to sole crop then broadcast due to suppressive effect of forage sorghum and less photosynthesis due to poor light penetration. Significant increase in plant height with nitrogen fertilizer has also been reported by Angadi *et al*. (2004). Similar results were reported by Mahmood *et al.* (2001) who found that sowing methods had little effect on plant height, plant population and number of leaves per plant.

Number of leaves per plant: Leaves plays an important role in manufacturing and supply food material synthesized during photosynthesis. Thus an increase or decrease in number of leaves per plant has a direct effect on the green forage yield of forage crops. The effect of N levels and sowing methods was significant regarding number of leaves per plant of forage sorghum at harvest (table 1, 3). The interactive effect of both nitrogen and sowing methods (N x S) was significant in 1st and 3rd cutting while it showed non significant effect in case of 2nd cutting. Maximum number of leaves per plant (10.72, 10.88 and 11.06) were recorded in N_2 (57.5 kg N ha^{-1}) as compared to control. Whereas, the maximum numbers of leaves per plant (10.05, 10.04, and 10.38) were found in Drill sowing at 30 cm apart single row (S_2) while the broad cast method of sowing (S_1) produced the statistically less number of leaves per plant (8.94, 9.27, 9.27) in three cuttings, respectively. Interactive results showed that nitrogen levels N_2S_2 (57.5 kg N/ha with drill sowing of 30 cm apart rows) showed better results in 1st and 3rd cutting while 2rd cutting showed non significant results. Olanite *et al*. (2010), Samia *et al*. (2010), Akram

et al., (2010), Khalid *et al*., (2010) and Shao *et al*. (1997) reported that numbers of leaves per plant are more in line sowing as compared to broad cast due to better resources available in line sowing to the crop plant. Significantly higher number of leaves per plant in sole crop of sorghum might be due to low plant population which resulted less competition among the plant to utilized resources for growth and minimum number of leaves per plant was due to more population and less availability of space for CO_2. Niamatullah *et al.* (2011) also reported significant effect of fertilizer application the number of leaves per plant.

Leaf area per plant (cm^2): Leaf area is the measure of size of assimilatory system of plant and is product of leaf length and breadth. Although, it is considered to be mainly concerned with accumulation and partitioning of photosynthesis to the economic parts of the plant but it has also an important role in the final biomass of the crop. The leaf area per plant (table 1, 2, 3) showed significant differences among the nitrogen levels and sowing methods while the interactive effect was not significant in 2^{nd} and 3^{rd} cutting except 1^{st} cutting. Maximum leaf area per plant (2657.4 cm^2, 2668.3 cm^2 and 2663.6 cm^2) was observed in N_2 (57.5 kg N/ha) over control having leaf area per plant (1986.5 cm^2 1992.3, 1987.4 cm2) in 1^{st}, 2^{nd} and 3^{rd} cuttings, respectively. In respect to the sowing methods, the maximum leaf area per plant (2384.1, 2389.8, 2385.2 cm^2) was recorded in sowing method S_2 (drill sowing with 30 cm apart single row) when compared with S_1 (broadcast method) with leaf area per plant of 2346.9, 2360.5 and 2355.6 cm^2 in three cuttings, respectively. These results are in accordance with the findings of Eltelib (2004) who reported significant variation in leaf area with increase in nitrogen levels. Similar results were also reported by Akram *et al.* (2010) and Khalid *et al*. 2010). Line sowing has better effect on leaf area per plant as reported by Nazir *et al.* (1997). The maximum leaf area per plant in combination of N_2S_2 was may be probably due to the maximum utilization of photo synthetically active substances.

Stem diameter (cm): Data regarding nitrogen levels in first cutting, reflected that the maximum stem diameter (1.6883 cm) was observed in N_2 (57.5 kg N/ha) which was followed by N_4 (45 kg N/ha) with stem diameter of 1.5950 cm. Minimum stem diameter (0.9833 cm) was observed in N_1 (0 kg N/ha). In second cutting maximum stem diameter (1.74 cm) was found in N_2 (57.5 kg N/ha) followed by N_4 (45 kg N/ha) with a stem diameter of 1.64 cm. While data regarding sowing methods presented showed that the maximum stem diameter (1.46, 1.51 cm, 1.24) was observed in S_2 (drill sowing with 30 cm apart single row). While the broad cast method of sowing method (S_1) have 140, 1.43, 1.15 cm stem diameter. Minimum stem diameter (0.9833 cm) was observed in N_1 (0 kg N/ha). Samia *et al*. (2010) and Khalid *et al*., (2010) found that progressive increase in nitrogen level stem diameter was also increased. Statistically maximum stem diameter (1.46 cm) was found in sowing method S_2 (Drill sowing at 30 cm apart) which was followed by S_1 (Broad cast) with a stem diameter of 1.40 cm.

Fresh weight per plant (g): The fresh weight per plant is an important factor in determining the total green forage yield. The growth and development of plant depends on the condition prevailing on the ground surface as well as in the rhizosphere. The reading of Fresh weight per plant showed (table 1, 2, 3) significant differences among the nitrogen levels and sowing methods and interaction of nitrogen and sowing methods (N x S) was also observed significant in first cutting while second and third cutting showed non-significant effect. The maximum Fresh weight per plant (253.80, 364.50, 270.81 g) was produced in the nitrogen treatment N_2 (57.5 Kg N/ha) while minimum fresh weight per plant was produced in N_1 (0 kg N/ha) having fresh weight per plant (175.11, 222.72, 186.41 g) in three cutting system. With respect to the sowing methods, the maximum fresh weight per plant (234.37, 294.72, 245.25 g) was recorded in sowing method S_2 (30 cm apart single row) which was statistically significant from sowing method S_1 (broadcast) with fresh weight per plant 203.33, 275.29, 217.42 g. Olanite *et al*. (2010), Samia *et al*. (2010) and Khalid *et al*. (2010) reported that higher rate of nitrogen leads to progressive increase in bio mass of the crop plant. The maximum fresh weight per plant was due to higher uptake of nitrogen and better availability of space which leads higher deposition of photosynthates in the crop plant.

Dry weight per plant (g): The data reflected in table (1, 2, 3) showed that the effect of nitrogen on dry weight per plant was highly significant. The effect of sowing methods was also significant. The interactive effect of both nitrogen levels and sowing methods (N x S) was non-significant. Maximum dry weight per plant (80.29, 121.90, 88.73 g) was found in N_2 (57.5 kg N/ha) while minimum dry weight per plant was found in N_1 (0 kg N/ha) having dry weight per plant (59.19, 73.19, 62.48 g). However, in case of sowing methods maximum dry weight per plant of 76.80g, 99.86g and 83.11g in three cuttings, respectively was found in S_2 (drill sowing having 30 cm apart rows) when compared with broad cast. Samia *et al*. (2010) and Khalid *et al*., (2010) who found significant variations regarding dry weight per plant and total dry matter yield due to increase in nitrogen application. Lewis and Cherney (2004) and Turgut *et al.* (2005) who found significant variations among different genotypes regarding dry weight per plant and total dry matter yield. But Bosch *et al.* (2001) found that sowing methods did not affect significantly dry weight per plant.

Crude protein contents (%): Protein contents are one of the most important parameter affecting the nutritional value of forage crops. The data presented in table 1, 2, 3 showed that effect of nitrogen on crude protein content % was highly significant. However, the effect of sowing methods and the interactive effect of nitrogen levels and sowing methods (N x S) was statistically non-significant. The highest value of crude protein (12.40 %) was observed in N_2 (57.5 kg N/ha) in 1st cutting while in 2nd and 3rd cutting crude protein was 12.43 % and 12.77 %, respectively. The increase in protein contents with increase in nitrogen level may be due to the reason that nitrogen application has enhanced the amino acid formation and resultantly increase in protein contents. These results are in accordance with the findings of Neylon and Kung (2003) who recorded significant differences for crude protein contents among the sorghum cultivar and nitrogen significantly improved the crude protein contents %. Similar results were also reported by Almodares *et al.* (2009), Khalid *et al.* (2010) and Duraisami *et al.* (2002).

Ash contents (%): Total ash contents in sorghum were influenced only by the nitrogen levels. While the sowing method and interaction of sowing method and nitrogen levels were non-significant (table 1, 2 and 3). Maximum ash contents (%) were observed in the treatment N_2 (57.5 Kg N/ha) having ash contents 6.34 %, 6.39 % and 6.22 % in three cuttings, respectively, whereas interactive effect among N levels and sowing methods (N x S) was significant in 1st and 2nd cutting and non-significant in case of 3rd cutting. Sowing methods have non-significant effect in whole of the experiment. The increase or decrease in ash contents (%) may be due to increase or decrease in dry matter production. These results are in accordance with the findings of Ayub *et al.* (2003) who reported significant effect of nitrogen levels on total ash contents (9.29 %). The increase in ash contents with increased nitrogen levels was also reported by Nadeem *et al.* (2009), Ayub *et al*. (2007) and Iqbal *et al* (2006).

Table 1: Influence of various sowing methods and N application rates on growth, yield and quality related attributes of multicut forage sorghum at 1st cutting.

Treatments	Plant Population at Harvest	Plant height (cm)	Number of Leaves per plant	Leaf Area per plant (cm^2)	Stem diameter (cm)	Fresh Weight per plant (g)	Dry Weight per plant (g)	Protein contents (%)	Ash contents (%)
Sowing methods (S)									
S_1	41.44 ^{b}	172.59^{b}	8.94^{b}	2346.9^{b}	1.40^{b}	203.33^{b}	65.86^{b}	9.75	6.19
S_2	43.66 ^{a}	181.34^{a}	10.05^{a}	2384.1^{a}	1.46^{a}	234.37^{a}	76.80^{a}	10.37	6.20
LSD (S)	1.45	4.35	0.50	18.02	0.028	10.93	9.98	ns	ns
N rates (N)									
N_1	40.04 ^{c}	158.23 ^{d}	8.73 c	1986.5^{d}	0.98 ^{d}	175.11 ^{d}	59.19 ^{c}	8.35 ^{c}	6.17^{b}
N_2	46.33 ^{a}	198.07 ^{a}	10.72 ^{a}	2657.4^{a}	1.68 ^{a}	253.80 ^{a}	80.29 ^{a}	12.40^{a}	6.34^{a}
N_3	41.33 ^{bc}	169.40 ^{c}	8.73 ^{c}	2366.1^{c}	1.46 ^{c}	217.23 ^{c}	71.81 ^{b}	8.74 ^{c}	6.13^{b}
N_4	42.50 ^{b}	182.16 ^{b}	9.78 ^{b}	2452.0^{b}	1.59 ^{b}	229.27 ^{b}	74.03^{ab}	10.75^{b}	6.14^{b}
LSD (N)	1.86	2.64	.322	6.27	0.018	11.09	7.44	.74	0.134
Interaction (S x N)									
S_1N_1	38.08	154.62 ^{f}	7.72 ^{e}	1977.4 ^{g}	0.95 ^{g}	161.72 ^{e}	53.13	7.86	6.13
S_1N_2	44.66	192.21 ^{b}	9.90 ^{b}	2629.5 ^{b}	1.64 ^{b}	243.14 ^{b}	74.65	12.06	6.31
S_1N_3	41.00	163.83 ^{e}	8.68 ^{d}	2349.0 ^{f}	1.42 ^{e}	191.35 ^{d}	67.96	8.58	6.00
S_1N_4	42.00	179.70^{cd}	9.45 ^{c}	2431.6^{d}	1.58 ^{c}	217.11 ^{c}	67.70	10.51	6.31
S_2N_1	42.00	161.83 ^{e}	9.75 ^{bc}	1995.5 ^{g}	1.01 ^{f}	188.50 ^{d}	65.25	8.85	6.21
S_2N_2	48.00	203.94 ^{a}	11.55 ^{a}	2685.4 ^{a}	1.73 ^{a}	264.45 ^{a}	85.94	12.75	6.36
S_2N_3	41.66	174.97 ^{d}	8.78 ^{d}	2383.1 ^{e}	1.50 ^{d}	243.12 ^{b}	75.67	8.90	6.26
S_2N_4	43.00	184.62 ^{c}	10.11 ^{b}	2472.4 ^{c}	1.60 ^{c}	241.42 ^{b}	80.37	11.00	5.98
LSD (S x N)	ns	3.73	0.456	8.87	0.026	15.69	ns	ns	Ns

S_1 = Broadcast, S_2 = Drill Sowing, N_1 = 0 (Control), N_2 = 57.5 Kg ha^{-1}, N_3 = 28.75 Kg ha^{-1}, N_4 = 45 Kg ha^{-1}, ns = non-significant at 5% level of probability

Table 2: Influence of various sowing methods and N application rates on growth, yield and quality related attributes of multicut forage sorghum at 2nd cutting.

Treatments	Plant Population at Harvest	Plant height (cm)	Number of Leaves per plant	Leaf Area per plant (cm^2)	Stem diameter (cm)	Fresh Weight per plant (g)	Dry Weight per plant (g)	Protein contents (%)	Ash contents (%)
Sowing methods (S)									
S_1	40.58[b]	199.67[b]	9.27	2360.5[b]	1.43[b]	275.29[b]	89.82[b]	10.31	6.12
S_2	45.66[a]	212.67[a]	10.04	2389.8[a]	1.51[a]	294.72[a]	99.86[a]	10.63	6.12
LSD (S)	2.11	12.39	ns	25.63	0.023	14.31	5.62	ns	ns
N rates (N)									
N_1	42.08 [bc]	178.93[d]	8.70 [c]	1992.3 [d]	0.99 [d]	222.73 [d]	73.19 [d]	8.08 [c]	5.96 [c]
N_2	47.16 [a]	247.30[a]	10.88 [a]	2668.3 [a]	1.74 [a]	364.50 [a]	121.90 [a]	12.43[a]	6.39 [a]
N_3	40.08 [c]	191.99[c]	9.38 [b]	2384.1 [c]	1.51 [c]	263.25 [c]	88.53 [c]	10.45[b]	5.98 [c]
N_4	43.16 [b]	206.48[b]	9.65 [b]	2456.0 [b]	1.64 [b]	289.55 [b]	95.76 [b]	10.92[b]	6.14 [b]
LSD (N)	2.21	6.34	0.48	11.85	0.018	19.68	5.90	0.56	0.12
Interaction (S x N)									
S_1N_1	38.16	168.54	8.40	1982.0	0.96 g	218.50	69.34	8.01	5.85 [c]
S_1N_2	45.33	239.54	10.30	2643.8	1.69 b	348.79	115.07	12.21	6.40 [a]
S_1N_3	38.16	189.17	9.06	2374.0	1.48 e	252.15	84.11	10.21	6.11 [b]
S_1N_4	40.66	201.45	9.31	2442.0	1.60 c	281.72	90.78	10.80	6.11 [b]
S_2N_1	46.00	189.32	9.01	2002.7	1.01 f	226.95	77.05	8.15	6.08 [b]
S_2N_2	49.00	255.06	11.46	2692.7	1.80 a	380.21	128.72	12.65	6.38 [a]
S_2N_3	42.00	194.81	9.70	2394.2	1.54 d	274.34	92.95	10.70	5.85 [c]
S_2N_4	45.66	211.52	10.00	2469.8	1.68 b	297.38	100.74	11.05	6.16 [b]
LSD (S x N)	Ns	Ns	ns	ns	0.02	ns	ns	ns	0.18

S_1 = Broadcast, S_2 = Drill Sowing, N_1 = 0 (Control), N_2 = 57.5 Kg ha^{-1}, N_3 = 28.75 Kg ha^{-1}, N_4 = 45 Kg ha^{-1}, ns = non-significant at 5% level of probability

Table 3: Influence of various sowing methods and N application rates on growth, yield and quality related attributes of multicut forage sorghum at 3rd cutting.

Treatments	Plant Population at Harvest	Plant height (cm)	Number of Leaves per plant	Leaf Area per plant (cm^2)	Stem diameter (cm)	Fresh Weight per plant (g)	Dry Weight per plant (g)	Protein contents (%)	Ash contents (%)
Sowing methods (S)									
S_1	32.83[b]	148.10[b]	9.27[b]	2355.6[b]	1.15[b]	217.42[b]	76.39[b]	9.85	6.05
S_2	34.83[a]	165.66	10.38[a]	2385.2[a]	1.24[a]	245.25[a]	83.11[a]	10.00	6.17
LSD (S)	1.39	4.47	0.118	26.96	0.81	12.54	6.02	ns	Ns
N rates (N)									
N_1	30.33[c]	139.58[d]	9.07 [c]	1987.4 [d]	0.91 [c]	186.41 [d]	62.48 [c]	7.87 [d]	6.02 [c]
N_2	38.66[a]	177.58[a]	11.06 [a]	2663.6 [a]	1.40 [a]	270.81 [a]	88.73 [a]	12.77[a]	6.22 [a]
N_3	33.33[b]	146.19[c]	9.06 [c]	2379.6 [c]	1.21 [b]	221.62 [c]	80.09 [b]	8.65 [c]	6.16[ab]
N_4	33.00[b]	164.16[b]	10.11 [b]	2451.1 [b]	1.24 [b]	246.50 [b]	87.69 [ab]	10.40 [b]	6.05[bc]
LSD (N)	1.76	4.47	0.55	11.98	0.0855	22.52	8.62	0.65	0.11
Interaction (S x N)									
S_1N_1	29.33	134.50[f]	8.05 [d]	1977.0	0.86	180.81	59.79	7.76	5.95
S_1N_2	37.66	162.38[c]	10.24 [b]	2638.8	1.37	267.08	84.45	12.60	6.13
S_1N_3	32.33	135.83[f]	9.01 [c]	2369.2	1.16	197.85	77.02	8.48	6.13
S_1N_4	32.00	159.70[cd]	9.78 [bc]	2437.5	1.21	223.95	84.30	10.55	6.01
S_2N_1	31.33	144.67[e]	10.08 [b]	1997.7	0.97	192.00	65.18	7.98	6.06
S_2N_2	39.66	192.79[a]	11.88 [a]	2688.3	1.43	274.55	93.01	12.95	6.31
S_2N_3	34.33	156.56[d]	9.11 [c]	2390.1	1.26	245.38	83.16	8.83	6.20
S_2N_4	34.00	168.62[b]	10.45 [b]	2464.7	1.28	269.05	91.09	10.25	6.10
LSD (S x N)	Ns	3.86	0.79	ns	ns	Ns	ns	ns	Ns

S_1 = Broadcast, S_2 = Drill Sowing, N_1 = 0 (Control), N_2 = 57.5 Kg ha^{-1}, N_3 = 28.75 Kg ha^{-1}, N_4 = 45 Kg ha^{-1}, ns = non-significant at 5% level of probability

Cumulative green forage yield (t ha^{-1}): Fodder yield is a function of genetic as well as the environmental factors, which plays a vital role in plant growth and development and ultimately contributed to fodder yield. The effect of nitrogen on green forage yield (t ha^{-1}) was highly significant. The effect of sowing methods was also significant. The interactive effect of both nitrogen and sowing methods (N x S) was non significant. Data regarding nitrogen levels revealed that the maximum total green forage yield (162.44 t ha^{-1}) was observed in N_2 (57.5 kg N/ha) which was followed N_4 (45 kg N/ha) with green forage yield (145.13 t ha^{-1}). Minimum total green forage yield was observed in N_1 (0 kg N/ha) with green forage yield 112.20 t ha^{-1}. These results are in line with the results found by Almodares *et al, (*2009) and Samia *et al*. (2010) who reported significant differences for green forage yield and quality with the increasing nitrogen level. While data regarding sowing methods reflected that maximum green forage yield (51.57 t ha^{-1}) was observed in the sowing method S_2 (30 cm apart single row) which was followed by the sowing method S_1 (broadcast method) with green forage yield of 46.75 t ha$^{-1.}$ Similar results were found by Ayub *et al.* (2002), Devi (2002), Ammaji and Suryanarayana (2003).

Cumulative dry matter yield (t ha^{-1}): The reading of total dry matter yield t ha^{-1} showed (table 4) significant differences among the nitrogen and sowing methods while the interaction of nitrogen levels and sowing methods was non significant. The total maximum dry matter yield (54.74 t ha^{-1}) was obtained in the N_2 (57.5 kg N/ha) that was followed by the treatment N_4 (45 kg N/ha) with dry matter yield of 46.58 t ha^{-1}. While the minimum dry matter yield was recorded in N_1 (0 kg N/ha) that was 37.63 t ha^{-1} in three cutting system. With respect to the sowing methods, the total maximum dry matter yield (48.29 t ha^{-1}) in three cuttings were recorded in sowing method S_2 (30 cm apart single row) which was followed by sowing method S_1 (broadcast) that was 42.20 t ha^{-1}. Almodares *et al, (*2009), Samia *et al*. (2010) reported significant differences for green forage yield and quality with the increasing nitrogen level. The variation in green forage yield and dry matter yield t/ha among nitrogen level can be attributed to the differences in nitrogen application to crop plants. Similar results were found by Ayub *et al.* (2002), Devi (2002), Ammaji and Suryanarayana (2003). Maximum green forage yield in the sowing method 30 cm apart single row can be attributed to efficient utilization of resources by crop plants.

Table 4: Influence of various sowing methods and N application rates on cumulative green forage and dry matter yield of multicut forage sorghum in 3 cuttings.

Treatments	Accumulative green forage yield (t ha^{-1})	Accumulative dry matter yield (t ha^{-1})
Sowing methods (S)		
S_1	129.63 ^{b}	42.20 ^{b}
S_2	144.73 ^{a}	48.29 ^{a}
LSD (S)	6.48	2.47
N rates (N)		
N_1	112.20 ^{d}	37.63 ^{d}
N_2	162.44 ^{a}	54.74 ^{a}
N_3	128.96 ^{c}	42.04 ^{c}
N_4	145.13 ^{b}	46.58 ^{b}
LSD (N)	4.56	1.64
Interaction (S x N)		
S_1N_1	104.08	34.40
S_1N_2	155.25	51.08
S_1N_3	120.85	39.59
S_1N_4	138.33	43.75
S_2N_1	120.32	40.86
S_2N_2	169.63	58.40
S_2N_3	137.07	44.49
S_2N_4	151.92	49.41
LSD (S x N)	ns	Ns

S_1 = Broadcast, S_2 = Drill Sowing, N_1 = 0 (Control), N_2 = 57.5 Kg ha^{-1}, N_3 = 28.75 Kg ha^{-1}, N_4 = 45 Kg ha^{-1}, ns = non-significant at 5% level of probability

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