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EVALUATION OF SWEET SORGHUM GENOTYPES FOR FODDER YIELD AND QUALITY UNDER DIFFERENT LEVELS OF NPK

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SUMMARY

Sweet sorghums are high energy crops with better growth and yield than fodder sorghums and corn. These are more palatable owing to their sweetness and highly preferred by livestock. Besides, bio-fuel generation these are gaining popularity as fodder crops. Four states released genotypes of sweet sorghum were tested at different levels of nitrogen for green fodder yield and fodder quality. SSV84, CSV19SS, CSV24SS and CSH22SS were grown during **kharif** 2013 and 2014. The study revealed that CSV19SS performed better than all genotypes tested in terms of green fodder yield at 50 per cent flowering as well as at physiological maturity yielding 41.5 and 44.36 t/ha, respectively. At flowering, the yield responses were only up to 100 kg N/ha. The fodder crude protein per cent was higher at flowering stage (10.05%) compared to physiological maturity (7.96%), while fibre followed a reverse trend. At physiological maturity, the response was 130 kg GFY per kg of N applied at N_2, while it was 85 kg per kg N at N_3 at maturity. This indicated more N use efficiency at lower N levels and vice-versa. Crude protein also increased significantly from 100 to 120 kg N/ha. Among all genotypes tested, CSV19SS proved superior in terms of fodder yield and quality and hence could be utilized as ideal fodder.

Key words : Sweet sorghum genotypes, fodder yield, quality, N levels

Sweet sorghum [*Sorghum bicolor* (L.) *Moench*] is a crop popular as food, fodder and more recently for bio-fuel. Sorghum is an important food crop of India with 5793 thousand hectares of area under production during 2013 (*indiastat.com*), while sweet sorghum occupies only a small portion of sorghum area. Owing to its very high palatability, sweet sorghums are more sought after as fodder crop by the dairy farmers. It is highly preferred even when fed as stover or bagasse. These are also reported to be more promising than forage sorghums (Maughan *et al.,* 2012) and even corn (Samarappuli *et al.,* 2014) in green fodder yield and fodder quality. In India, sweet sorghums are encouraged for fuel production and lately, new genotypes were released for bio-fuel purpose. Nevertheless these genotypes gained popularity as fodder varieties as bio-fuel production is unconventional practice at the homesteads of small and marginal farmers. However, the dose of nitrogen recommended for bio-fuel may not be suitable when grown as a fodder crop. A little higher dose of nitrogen promotes more vegetative and lanky growth which is favourable fodder trait. Besides, higher dose of nitrogen also enhances the plant height. Besides, the performance and fodder quality under different levels of N need to be studied as it is harvested at flowering when grown for fodder unlike the bio-fuel crop. This paper studies and compares various state released sweet sorghum genotypes for fodder quality at flowering and physiological maturity and performance at different levels of nitrogen.

MATERIALS AND METHODS

An experiment was laid at fields of All India Coordinated Research Project on Forage Crops and Utilization for two years at Agricultural Research Institute, Rajendranagar, Hyderabad. **Kharif** season (rainy season) was chosen for study as the dry matter accumulation and partitioning trends in sweet sorghum. The experiment was laid at N17°32' latitude and E78°389' longitude during **kharif** 2013 and at N17°32' latitude and E78°39' longitude during 2014 at an altitude of 578 m above mean sea level. The soils are low in nitrogen, medium in phosphorus and high in potassium. The initial status of N, P_2O_5 and K_2O were 166, 24, 388 and 180, 32, 350 kg/ha during 2013 and 2014, respectively. The texture is sandy loam with medium depth. Four state released sweet sorghum genotypes were taken up for study which include three varieties and a hybrid viz., SSV84SS, CSV19SS,

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CSV24SS and CSH22SS, respectively. The experiment was laid in a split plot design with the four genotypes constituting the main treatments and three levels of nitrogen as sub-treatments. The treatments were replicated thrice. The state recommended fertilizer dosage for sweet sorghum was N : P : K :: 80 : 40 : 30 under irrigated conditions. The full dose of phosphorus and potassium were applied as basal after the last ploughing and field plan layout. Nitrogen was applied as per the treatments in the form of urea in three equal splits (1/3 basal, 1/3 at knee height stage (25 DAS) and 1/3rd at panicle initiation stage of crop.

Urea, single super phosphate and muriate of potash were used as the sources of N, P_2O_5 and K-$_2$O during the two years of the study. The plot size was 6.0 x 4.8 m where in 20 rows of sweet sorghum were sown in each plot. Ten rows were harvested at 50 per cent flowering and the rest 10 rows were harvested at physiological maturity. During the two years of study, the experiment was conducted during rainy season and the common crop management practices were adopted.

The samples were drawn at 50 per cent flowering and at physiological maturity of crop. Soil samples were collected at the beginning and at harvest of crops during the two years of study.

Standard procedures were adopted for analysis of plant nitrogen (Piper, 1966) and crude fibre (AOAC, 1990), respectively. Crude protein was calculated by multiplying N per cent with 6.25. The brix in the cane was measured using refractometer (Hanna Instruments). Soil samples were analyzed for available N, P and K by following procedures of Subbiah and Asija (1956), Olsen *et al.* (1965) and Muhr *et al*. (1965), respectively.

RESULTS AND DISCUSSION

Yield at 50% Flowering

The genotypes tested differed significantly from each other regarding green fodder yield (GFY) at 50 per cent flowering. During the two years of study, the highest mean green fodder yield (GFY) of 41.5 t/ha was observed in variety CSV19SS and this was significantly higher over the other genotypes tested. The GFY in this variety was higher than that of CSH22SS, CSV24SS and SSV84, by 9.8, 36.4 and 45.1 per cent, respectively. The interactions between genotypes and N levels were also significant. The GFY of SSV84 did not vary with N levels and were on par with that of CSV24SS at 80 kg N/ha. Irrespective of N level added the GFY of CSV19SS was on par with that of CSH22SS at 120 kg N/ha. It is important to infer that in none of the genotypes the GFY varied significantly with N levels. However, the mean GFY values indicated slight increase only up to 100 kg N/ha (Table 1).

Variations observed in GFY were also reflected in dry fodder yield (DFY). The dry fodder yield was in order CSV19SS (10.2 t/ha) > CSH 22SS (8.8 t/ha) > CSV 24SS (7.8 t/ha) > SSV 84 (7.0 t/ha). The effect of N levels on DFY was significant only up to N_2 level i. e. 100 t/ha. There was a commendable 10 per cent increase in DFY with 20 kg increase in N application up to 100 kg/ha. The interaction effects also indicated that the effect of N in all the genotypes tested was positive only up to 100 kg N/ha, while hybrid CSH22SS responded up to 120 kg N/ha though this increase was not significant. The DFY of SSV84 at all N levels was on par with that of CSV24SS at 80 kg/ha. Poor performance of SSV84 with regards to GFY and DFY could be due to the fact that it is one of the earliest varieties released as sweet sorghum. The hybrid proved its superiority by responding up to 120 kg N, unlike varieties. Such increases in green and dry fodder yield with increasing N dose were reported by Singh *et al.*, (2014) and Szydelko-Rabska and Sowin Ski (2014). Response to N up to 150 kg/ha was reported by Sawargoankar and Wani (2016); however these increases were significant only up to 90 kg N/ha, likewise Kurai *et al*. (2015) reported increases only up to 90 kg N/ha. On the contrary, Holou *et al.* (2014) and Bonin *et al*. (2016) expressed few impacts on growth and biomass yield of sweet sorghum due to nitrogen.

The dry matter per cent of CSV24SS (25.8%), CSV19SS (25.4%) and SSV84 (24.4%) was on par with each other. Lowest DM per cent was observed in CSH22SS at 50 per cent flowering stage. There was a significant increase in mean DM (%) as we moved from N_1 (80 kg N/ha) to N_2 (100 kg N/ha) but not beyond. The interaction effects were significant and indicated that at 80 kg N/ha CSV24SS recorded significantly higher DM (%) among all genotypes tested, while at 100 kg N all the genotypes were at par except hybrid CSH22SS (23.8%). However, it was important to observe that no genotype responded significantly up to 120 kg N/ha.

Forage Quality at Flowering

The crude protein per cent (CP%) was neither influenced by genotypes nor N levels. Nevertheless the crude protein varied from 9.28 (CSV24SS) to 10.05 per cent (CSV19SS) (Table 2). Though not significant, there was a slight increase in CP (%) with N levels. Luo Feng *et al*. (2013) reported a continuous increase in CP (%) with increasing N levels. The interactions between genotypes and N levels indicated that CP of CSV24SS at 100 kg N was on par with CP (%) of CSH22SS and SSV84 at all three N levels tested.

The crude fibre per cent (CF%) ranged between 24.8 (SSV 84) and 25.8 per cent (CSV24SS and CSV19SS). These variations were very negligible

TABLE 1

Effect of varied levels of nitrogen on yield of sweet sorghum genotypes at 50 per cent flowering (Pooled data of two years)

N levels	GFY at flowering (t/ha)					DFY at flowering (t/ha)					Flowering DM (%)				
	CSV24SS	SSV84	CSH22SS	CSV19SS	Mean	CSV24SS	SSV84	CSH22SS	CSV19SS	Mean	CSV24SS	SSV84	CSH22SS	CSV19SS	Mean
N_1	26.7	27.0	36.8	41.5	33.5	6.9	6.3	8.5	10.2	8.0	25.8	23.4	23.1	23.4	23.8
N_2	33.3	28.6	35.6	42.8	35.1	8.9	7.6	8.5	10.0	8.8	26.7	26.5	23.8	26.8	25.9
N_3	31.2	30.2	41.0	40.3	35.7	7.6	7.1	9.4	10.4	8.6	24.3	23.3	23.1	26	24.2
Mean	30.4	28.6	37.8	41.5		7.8	7.0	8.8	10.2		25.5	24.4	23.3	25.4	
		S. Em±	C. D.				S. Em±	C. D.				S. Em±	C. D.		
	M	1.12	3.19			M	0.30	0.85			M	0.42	1.21		
	S	0.67	NS			S	0.26	0.74			S	0.37	1.04		
	M x S	1.94	5.52			M x S	0.52	1.48			M x S	0.73	2.09		

NS–Not Significant.

TABLE 2

Effect of varied levels of nitrogen on fodder quality of sweet sorghum genotypes at flowering (Pooled data of two years)

N levels	Flowering CP (%)					Flowering CF (%)					Brix (%)				
	CSV24SS	SSV84	CSH22SS	CSV19SS	Mean	CSV24SS	SSV84	CSH22SS	CSV19SS	Mean	CSV24SS	SSV84	CSH22SS	CSV19SS	Mean
N_1	9.75	9.98	9.03	9.52	9.57	23.9	24.4	25.6	27	25.2	8.7	8.4	6.7	8.5	8.1
N_2	8.93	9.25	10.43	9.87	9.62	26.2	25.2	24.9	25	25.3	8.7	9.4	7.4	9.5	8.8
N_3	9.15	9.47	10.4	10.75	9.94	27.3	24.9	25	25.4	25.7	7.9	6.3	7.4	9.1	7.7
Mean	9.28	9.57	9.95	10.05		25.8	24.8	25.2	25.8		8.4	7.9	7.1	9.0	
		S. Em±	C. D.				S. Em±	C. D.				S. Em±	C. D.		
	M	0.28	NS			M	0.28	0.77			M	0.61	NS		
	S	0.26	NS			S	0.23	NS			S	0.71	NS		
	M x S	0.53	1.5			M x S	0.47	1.34			M x S	1.00	NS		

NS–Not Significant.

making the fodder of all the genotypes favourable as fodder. Nitrogen levels did not influence CF (%), while interactions were significant. However, the CF (%) indicated that the magnitude of this fodder quality parameter made it ideal animal feed.

Brix of cane juice at the fourth internode varied insignificantly with genotypes and N levels. CSV19SS registered highest brix of 9.0 making it sweeter and hence, more palatable amongst all genotypes tested. There was an increase in brix from 8.1 to 8.8 per cent from N_1 to N_2 which cannot be overlooked though proved non-significant statistically.

Yield at Physiological Maturity

Highest green fodder yield was observed in CSV19SS (44.36 t/ha) which was significantly superior to all other genotypes, while the rest of the other genotypes tested also differed significantly from each other. The hybrid CSH22SS recorded 12.2 per cent less yield than the best variety, while lowest yield was recorded in SSV84 (33.8 t/ha). The N levels also influenced yield significantly. Significantly highest yield was registered in N_3 i. e, 120 kg N/ha while yield at all N levels varied significantly (Table 3). The yield response was 130 kg GFY per kg of N applied at N_2, while it was 85 kg per kg N at N_3. This indicates more N use efficiency at lower N levels and vice-versa. The interaction effects were significant and GFY invariably increased in all genotypes with increasing N levels. The GFY of CSV19SS at N_1 was on par with that of CSH22SS at N_3. The yield recorded by SSV84 at N_3 was on par with that of CSV24SS and CSH22SS at N_1.

The dry fodder yield was also influenced by genotypes and N levels. All genotypes tested differed significantly, while the variety CSV19SS registered highest value of 13.4 t/ha. The trends expressed in GFY were exactly reflected in DFY at maturity. The DFY varied significantly between N_2 and N_3 with an increase of 6.8 per cent between these two levels. The interactions indicated on par DFY in CSV19SS at all levels of N tested which were on par with that of CSH22SS at N_2 and N_3. Similarly, there were no significant differences in DFY between all N levels tried in CSV22SS which were also on par with that of SSV84 at N_3.

Hybrid CSH22SS proved its superiority in dry matter per cent (31.4 DM %), though CSV19SS and CSV24SS also recorded on par DM (%). The effect of N levels on DM (%) was significant, there was a slight increase in DM (%) with increasing N levels. The increase in DM (%) was significant from 80 kg N to 120 kg N/ha. The interaction effects indicated higher DM (%) at all levels of N tested in CSH22SS when compared to other genotypes, however, these values were at par with each other. The DM (%) of CSV24SS and SSV84 at N and N_2 were with each other. The DM (%) also increased rapidly from 50 per cent flowering to maturity stage of crop i. e. from 24.65 to 30.58 per cent, respectively. This could be attributed to the reduction in moisture content and increase in fibre and mineral composition of crop with age.

Forage Quality of Physiological Maturity

The forage quality in terms of crude protein varied from 7.69 (CSH22SS) to 8.37 per cent (CSV 24SS), respectively. Crude protein increased significantly from 100 to 120 kg N/ha. Similar increase in crude protein per cent at 120 kg N/ha was reported by Verma *et al*. (2005) in fodder sorghum. The increase was 4.3 per cent between 80 and 100 kg N/ha while this was 6.0 per cent between 100 and 120 kg/ha. In all genotypes, CP (%) increased with increasing N levels though not always significantly (Table 4). Besides, the forage quality varied with stage of crop. The mean CP (%) at 50 per cent flowering which was 9.71 per cent reduced to 8.02 per cent at maturity.

Crude fibre varied from 34.3 (CSV19SS) to 38.1 per cent (CSH22SS). The variety recording highest yields recorded lowest crude fibre content. Nitrogen levels significantly influenced the crude fibre content increasing with every level significantly. The mean crude fibre per cent at harvest was 36.2 per cent which was more than that of 50 per cent flowering by 42.5 per cent. This could be attributed to the increased accumulation of mineral matter and fibre with age of crop. These results are in conformity with Luo Feng *et al*. (2013) who also reported continuous increase in CF and CP with increasing N levels. While comparing a few elite fodder sorghum varieties, Singh *et al*. (2014) also observed higher green fodder, dry fodder yield and improvement in fodder quality parameters at 120 kg N/ha over lower levels of nitrogen.

Regarding the brix per cent, there were no significant variations among the genotypes or among N levels even at physiological maturity of crop. There was no clear trend regarding variations in brix among genotypes. Parvatikar and Manjunath (1991) also found wide variations in brix among sweet sorghum genotypes. Ratnavati *et al*. (2003) also reported genotypic differences for brix and juice yield. The brix increased from 8.1 at flowering to 13.7 at physiological maturity indicating 69 per cent increase from flowering to harvest. This increase could be attributed to reduced moisture in plant with increasing age of crop besides the increasing potential of crop to accumulate total soluble sugars with age. Patil *et al*. (2005) and Gadakh *et al*. (2012) also reported maximum brix at physiological maturity than flowering and dough stages.

Soil Status

There was no significant effect of N levels on the soil available nutrient status with respect to N, P_2O_5 and K_2O during the two years of study (Table 5). Singh *et al*. (2015) observed no variations due to implementation of various INM treatments in sweet sorghum.

TABLE 3

Effect of varied levels on yield of sweet sorghum genotypes at physiological maturity (Pooled data of two years)

N levels	GFY at maturity (t/ha)					DFY at maturity (t/ha)					Harvest DM (%)				
	CSV24SS	SSV84	CSH22SS	CSV19SS	Mean	CSV24SS	SSV84	CSH22SS	CSV19SS	Mean	CSV24SS	SSV84	CSH22SS	CSV19SS	Mean
N_1	35.8	32.1	35.4	42.0	36.3	11.5	9.1	11.2	12.9	11.2	29.9	28.5	31.5	30.7	30.1
N_2	36.4	33.9	40.8	44.5	38.9	10.9	10.4	12.8	13.2	11.8	29.9	30.7	31.2	29.8	30.4
N_3	38.0	35.4	42.3	46.5	40.6	12.0	11.1	13.3	14.1	12.6	31.5	31.3	31.5	30.3	31.2
Mean	37.7	33.8	39.5	44.3		11.5	10.2	12.4	13.4		30.4	30.2	31.4	30.3	
		S. Em±	C. D.				S. Em±	C. D.				S. Em±	C. D.		
	M	0.55	1.58			M	0.25	0.71			M	0.42	1.18		
	S	0.48	1.37			S	0.21	0.61			S	0.36	1.03		
	M x S	0.96	2.74			M x S	0.43	1.22				0.72	2.09		

TABLE 4

Effect of varied levels of nitrogen on fodder quality sweet sorghum genotypes at physiological maturity (Pooled data of two years)

N levels	Maturity CP (%)					Maturity CF (%)					Brix (%)				
	CSV24SS	SSV84	CSH22SS	CSV19SS	Mean	CSV24SS	SSV84	CSH22SS	CSV19SS	Mean	CSV24SS	SSV84	CSH22SS	CSV19SS	Mean
N_1	7.95	7.78	7.38	7.43	7.64	34.3	33.9	33.6	34.4	34	12.8	12.6	13.4	14.1	13.2
N_2	8.52	7.93	7.87	7.55	7.97	36.5	36.1	40.8	33.2	36.6	14.0	13.7	14.3	13.5	13.9
N_3	8.65	8.43	7.82	8.88	8.45	37.8	39.3	39.9	35.3	38.1	13.9	13.1	14.3	14.3	13.9
Mean	8.37	8.05	7.69	7.96		36.2	36.4	38.1	34.3		13.6	13.3	14.0	14.0	
		S. Em±	C. D.				S. Em±	C. D.				S. Em±	C. D.		
	M	0.14	0.39			M	0.58	1.65			M	0.43	NS		
	S	0.12	0.34			S	0.5	1.43			S	0.36	NS		
	M x S	0.24	0.68			M x S	1	2.86			M x S	0.51	1.09		

NS–Not Significant.

CONCLUSION

The sweet sorghum variety CSV19SS performed better than all the sweet sorghum genotypes tested yielding 41 and 44 t/ha at 50 per cent flowering and at physiological maturity, respectively. At flowering, the fodder quality in terms of crude protein was commendably high in CSV19SS compared to other genotypes tested. It is also important to understand that as we moved from flowering to maturity the crude protein decreased and crude fibre increased which infered that fodder quality parameters were at their best at flowering. Hence, it was advised to harvest CSV19SS at 50 per cent flowering rather than waiting up to physiological maturity. This would give farmer a buffer period of 45-50 days to enable him to go for a short duration crop in this period or advance sowing of next crop.

TABLE 5

Effect of varied levels on sweet sorghum genotypes on soil available nutrient status (Pooled data of two years)

Genotypes	Av. N	Av. P	Av. K
CSV24SS	148.5	34.7	442.9
SSV84	126.6	34.7	437.3
CSH22SS	145.6	34.4	444.9
CSV19SS	131.6	33.0	430.6
Mean	138.1	34.2	438.9
S. Em±	17.7	1.1	6.9
C. D. (P=0.05)	NS	NS	NS
N levels			
N_1	137.9	33.4	433.2
N_2	132.1	34.0	441.0
N_3	144.3	35.2	442.7
Mean	138.1	34.2	439.0
S. Em±	9.9	1.1	6.2
C. D. (P=0.05)	NS	NS	NS

NS–Not Significant.

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