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EVALUATION OF FORAGE SORGHUM GENOTYPES FOR PRODUCTION, PRODUCTIVITY AND QUALITY AT DIFFERENT FERTILIZER LEVELS

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SUMMARY

A field experiment was conducted at Hisar (Haryana), India during the *Kharif* season of 2017 to study the effect of different fertilizer levels on production, productivity and quality of forage sorghum [*Sorghum bicolor* (L.) Moench] genotypes. Seven single-cut forage sorghum genotypes (SPH 1822, SPV 2316, SPV 2387, SPV 2388, CSH 13, CSV 21F and CSV 30F) were tested at three fertilizer levels (75, 100 and 125% recommended dose of fertilizer) in factorial RBD. Among genotypes, highest green fodder and dry matter yields were recorded in SPV 2387 (45.89 and 12.32 t/ha, respectively) which were on a par with SPV 2388, CSV 21F and CSV 30F. The highest crude protein yield (CPY) and digestible dry matter yield (DDMY) were also recorded in SPV 2387 being on a par with CSV 21F & CSV 30F for CPY and CSV 30F & SPV 2388 for DDMY. The crude protein content was not affected significantly among genotypes. The highest IVDMD content estimated in test hybrid SPH 1822 was on a par with SPV 2387, SPV 2388, CSH 13 and CSV 30F. Highest TSS (11.74%) estimated in CSV 30F which was on a par with SPV 2387. Among fertilizer levels, significantly highest green fodder, dry matter, CPY and DDMY (44.40, 11.79, 1.01 and 6.26 t/ha, respectively) were recorded with 125% RDF over the lower fertilizer levels. The magnitude of the increase in yield with 125% RDF was 20.0 and 8.1 per cent in GFY; 20.3 and 7.8 per cent in DMY; 36.5 and 13.5 per cent in CPY and 31.8 and 11.2 per cent in DDMY over 75% and 100% RDF, respectively. With increased fertilizer levels, the HCN content at 30 days after sowing increased from 66 to 107 µg/g on fresh weight basis but it was less than the critical limit. Significantly highest crude protein content and IVDMD (8.55 and 53.03 %) were estimated with 125% RDF. In nutshell, genotype SPV 2387 and CSV 21F performed better and application of 125% RDF was the most suitable fertilization practice to achieve the maximum fodder yield with better quality.

Key Words : Fertilizer levels, Forage sorghum, HCN, Crude protein, IVDMD and TSS

Sorghum [Sorghum bicolor (L.) Moench] is widely grown to meet the requirement of fodder, feed, food and fuel. It is adaptive to vast environmental condition and provides palatable nutritious fodder to the animals. India supports 512 million of livestock (DAHD & F, 2012), being the leader in cattle and buffalo population. Sorghum as a source of feed and fodder has the potential to meet the demand set by dairy industry. Looking to the chemical composition of forage sorghum on dry matter basis, on an average it contains 9-10% crude protein, 65-65%, neutral detergent fibre, 37-42% acid detergent fibre, 32% cellulose and 21-23% hemi-cellulose when harvested at 50 per cent flowering stage (Sunil Kumar *et al*., 2012). Protein content and digestibility are two important components of quality in fodder sorghum. Plant breeding efforts are in vogue since a long time to improve protein content and digestibility and to reduce the anti-nutritional components in forage sorghum. Sorghum is considered to be a palatable and nutritious green fodder under ordinary conditions but when its normal growth is affected by drought or imbalanced soil nutrients, hydrocyanic acid (HCN) content may develop to such an extent that the toxic level may reach lethal level when fed to animals (Karthika and Kalpana, 2017). Cyanide occurs in the leaves of sorghum as cyanogenic glucoside dhurrin. Degradation of dhurrin yields equimolar amount of hydrocyanic, glucose and P-hydroxybenzaldehyde (P-HB) (Francis *et al*., 1988). It is observed that when

HCN is readily absorbed into the blood stream of grazing ruminants, it causes cellular asphyxiation leading to illness of cattle eventually resulting in the death of animals and even at doses as little as 0.5 g are sufficient to kill a cow. The critical limit of HCN in green forage for livestock is 200 ppm on fresh weight basis. Identification of location specific forage sorghum genotype with good quality, higher fodder yield and early stage of harvesting (days to 50% flowering) are essential to achieve sustainable productivity of livestock. Primary nutrients (Nitrogen and phosphorus) play an important role in the growth and development of sorghum. Thus, location specific genotype and recommended nutrients application are very important to realize potential fodder yield with better quality. The varieties also vary in their response to fertilizer application. To improve the quality and quantity of green fodder, it is therefore much essential to determine the fertilizer requirements of varieties. Hence, the present study was undertaken to study the effect of different fertilizer levels on production, productivity and quality of promising single-cut forage sorghum genotypes.

TABLE 1
Weekly weather data pertaining to temperature (°C), relative humidity (%) and rainfall (mm) during the crop season of 2017

Standard Week	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
	Max	Mini	M	E	
28	36.3	27.9	83	60	0.0
29	34.9	27.2	92	71	34.0
30	33.8	27.0	91	79	0.0
31	33.2	26.0	93	73	6.0
32	35.6	27.4	88	62	10.0
33	35.8	26.1	86	62	23.0
34	35.1	26.7	93	71	33.0
35	32.5	25.6	93	81	49.0
36	34.4	24.4	92	64	22.0
37	35.7	25.2	87	54	0.0
38	35.4	22.0	86	36	0.0
39	35.4	21.7	82	33	0.0
40	36.8	19.0	78	29	0.0
41	35.3	18.8	89	30	0.0
42	35.7	16.2	91	25	0.0
43	33.8	15.5	84	26	0.0
44	31.0	15.3	88	43	0.0
45	29.8	12.7	99	46	0.0
46	25.0	13.7	90	51	2.0

MATERIALS AND METHODS

The field experiment was conducted during rainy (*kharif*) season of 2017 at Forage Section Research Area, Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar (29° 10' N of 75° 46' E, at an average elevation 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. The weekly weather data during the crop season is given in Table 1. The soil was sandy loam in texture with pH 7.9, available N 154 kg/ha, available P 10 kg/ha and available K 240 kg/ha. The experiment consisted of 21 treatment combinations comprising seven single-cut forage sorghum genotypes (SPH 1822, SPV 2316, SPV 2387, SPV 2388, CSH 13, CSV 21F and CSV 30F) and three fertilizer levels *viz.* 75, 100 and 125 per cent of recommended dose of fertilizer (RDF). These treatments were tested in factorial randomized block design in three replicates. Recommended dose of fertilizer (RDF) is 75 kg N + 15 kg P_2O_5/ha and its application is, full dose of phosphorus + 50 kg nitrogen/ha was applied basal at the time of sowing and 25 kg N/ha was top dressed at 30 days after sowing. The sorghum genotypes as per treatment were sown manually on 18 July 2017 (standard week 29). All the other standard agronomic practices were followed uniformly in all the treatments as per the package of practices for *kharif* crops of CCS Haryana Agricultural University, Hisar, India (Anonymous, 2017). All the genotypes were harvested just after 50 per cent flowering. The samples for estimation of HCN were taken at 30 DAS from the portion of the plant immediately below the uppermost leaf collar and HCN content was determined by the method given by Hogg and Ahlgren, 1942. The amount of HCN on fresh weight basis was calculated by calibrating the absorbance with HCN (5-40 X 10-3 g/l) in water as standard. Crude protein and in vitro dry matter digestibility (IVDMD) was 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 content (%) with 6.25, estimated by conventional micro-kjeldal method (AOAC, 1995). IVDMD was determined by method of Barnes *et al*, 1971. Crude protein yield and digestible dry matter (q/ha) were calculated by multiplication of crude protein content and IVDMD with dry matter yield (q/ha), respectively. The content of total soluble solids (TSS) was determined using hand held refractometer. Data were analyzed by using OPSTAT software available at CCS Haryana Agricultural University website (Sheoran *et. al*., 1998). The results are presented at five per cent level of significance (P=0.05) for making comparison between treatments.

RESULTS AND DISCUSSION

Genotypes

Data presented in Table 2 reveal that among genotypes, highest green fodder and dry matter yields were recorded in SPV 2387 (45.89 and 12.32 t/ha, respectively) which were on a par with SPV 2388, CSV 21F and CSV 30F. The highest crude protein yield (CPY) and digestible dry matter yield (DDMY) were also recorded in SPV 2387 being on a par with CSV 21F & CSV 30F for CPY and CSV 30F & SPV 2388 for DDMY. Maximum days to 50% flowering (94) were taken by SPV 2388 which were on a par with CSV 30F and SPV 2387. The difference yielded by sorghum cultivars might be the result of variation in their genetic makeup (Hanuman *et. al*, 2008). The differential behavior of these genotypes could also be explained solely by the variation in their genetic constituent (Meena *et. al*., 2012). Perusal of the data from Table 3 reveal that among genotypes, highest per day productivity for green fodder and dry matter (541.43 and 139.29 kg/ha) were observed in CSV 21F being on a par with SPV 2387 for green fodder and SPV 2387 & CSV 30F for dry matter. Per day productivity of crude protein was also significantly highest in CSV 21F. CSV 21F being the maximum efficient genotype, recorded highest per day productivity for green fodder, dry matter and crude protein which was 8.12, 3.58 and 1.58 per cent higher over SPV 2387. However, maximum per day productivity for DDMY (70.41 kg/ha) was recorded in SPV 2387 being on a par with CSV 21F, CSV 30F, SPH 1822 and SPV 2388. This clearly indicates that production efficiency-wise CSV 21F and SPV 2387 were the most efficient genotypes. The per day productivity of genotypes in terms of green fodder and dry matter is given in Fig. 1 and of crude protein and digestible dry matter is given in Fig. 2. At 30 days after sowing, maximum HCN content (105 µg/g on fresh weight basis) estimated in the genotype SPV 2316 was significantly superior over all the other genotypes. Although, the HCN content was below the critical limit among all the genotypes. Crude protein content was not affected significantly among the genotypes. However, it ranged from 7.81 to 8.43 %. The *in-vitro* dry matter digestibility (IVDMD) ranged from 47.80 to 52.90% among genotypes being the maximum in the test hybrid SPH 1822 which was on a par with SPV 2387, SPV 2388, CSH 13 and CSV 30F. Highest TSS (11.31%) was recorded in SPV 2387 which was on a par with CSV 30F. For most of the quality parameters, the test genotype SPV 2387 proved superior, particularly in terms of crude protein content, TSS% and IVDMD%. HCN content was also lowest in this genotype.

TABLE 2
Performance of forage sorghum genotypes at different fertilizer levels

Treatment	Green fodder yield (t/ha)	Dry matter yield (t/ha)	Crude protein yield (t/ha)	Digestible dry matter yield (t/ha)	Days to 50% flowering
Genotypes					
SPH 1822	39.11	10.50	0.84	5.57	85
SPV 2316	37.20	9.86	0.77	4.73	89
SPV 2387	45.89	12.32	1.04	6.45	92
SPV 2388	42.48	11.38	0.91	5.90	94
CSH 13	35.43	8.86	0.71	4.59	85
CSV 21F	44.21	11.38	0.94	5.56	82
CSV 30F	41.47	11.63	0.95	6.03	92
S. Em±	1.74	0.40	0.04	0.24	0.7
C. D. (P=0.05)	5.00	1.14	0.10	0.69	2.0
Fertility Levels					
75% RDF	37.00	9.80	0.74	4.75	87
100% RDF	41.08	10.94	0.89	5.63	88
125% RDF	44.40	11.79	1.01	6.26	89
S. Em±	1.14	0.26	0.02	0.16	0.5
C. D. (P=0.05)	3.27	0.75	0.07	0.45	1.3
G X F					
S. Em±	3.02	0.69	0.06	0.41	1.19
C. D. (P=0.05)	NS	NS	NS	NS	NS
CV (%)	12.79	11.01	12.32	12.92	2.33

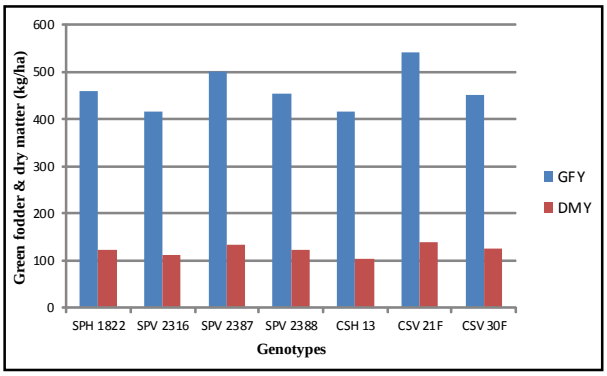

Fig. 1. Per day productivity of green fodder & dry matter.

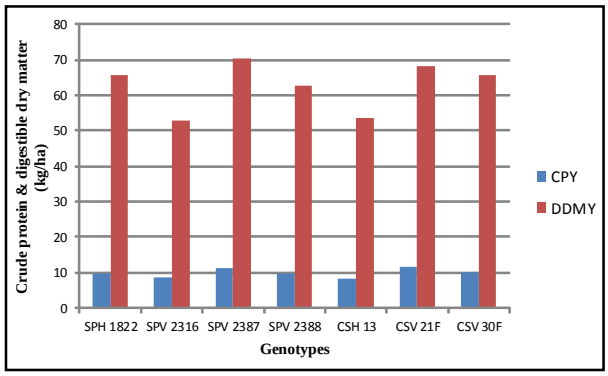

Fig. 2. Per day productivity of crude protein & digestible dry matter.

Fertilizer levels

Perusal of the data from Table 2 reveal that among fertilizer levels, significantly highest green fodder, dry matter, crude protein and digestible dry matter yields (44.40, 11.79, 1.01 and 6.26 t/ha, respectively) were recorded with 125% RDF over the lower fertilizer levels. The increase in green fodder, dry matter, crude protein and digestible dry matter yields were 20.0, 20.3, 36.5, 31.8 and 8.1, 7.8, 13.5, 11.2 per cent with 125% RDF over 75% and 100% RDF, respectively. A progressive increment in crude protein and dry matter was observed with the increase in N and P levels (Mahmud *et* al., 2003). The similar increase in green fodder and dry matter yield was also reported by Satpal *et al*. (2015). Maximum days to 50 % flowering were recorded with 125% RDF which were at par with 100% RDF. Data presented in Table 3 reveal that among fertilizer levels, highest per day productivity of green fodder and dry matter (498.13 and 132.20 kg/ha) were recorded at 125% RDF which were on a par with 100% RDF. However, significantly highest per day productivity of crude protein and digestible dry matter (11.31 and 70.11 kg/ha) were recorded at 125% RDF. This clearly indicates that with increasing fertilizer dose from 100% to 125%, there is significant improvement in production efficiency of quality fodder. Satpal *et. al*. (2016) also reported increase in per day productivity of green fodder up to 100 % RDF and up to 125% RDF in dry matter. With increased fertilizer levels (75 to 125% RDF), the HCN content increased from 65.8 to 106.6 µg/g but it was

TABLE 3
Per day Productivity of forage sorghum genotypes at different fertilizer levels

Treatment	Per day Productivity of yield (kg/ha)			
	Green fodder	Dry matter	Crude protein	Digestible dry matter
Genotypes				
SPH 1822	459.28	123.34	9.82	65.48
SPV 2316	416.23	110.40	8.64	52.92
SPV 2387	500.76	134.47	11.37	70.41
SPV 2388	453.31	121.41	9.75	62.86
CSH 13	414.58	103.66	8.32	53.69
CSV 21F	541.43	139.29	11.55	68.12
CSV 30F	450.79	126.42	10.26	65.48
S. Em±	20.34	4.61	0.004	2.73
C. D. (P=0.05)	58.35	13.23	0.01	7.82
Fertility Levels				
75% RDF	424.27	112.21	8.50	54.41
100% RDF	464.62	123.72	10.07	63.60
125% RDF	498.13	132.20	11.31	70.11
S. Em±	13.32	3.02	0.003	1.78
C. D. (P=0.05)	38.20	8.66	0.01	5.12
G X F				
S. Em±	35.23	7.99	0.01	4.72
C. D. (P=0.05)	NS	NS	NS	NS
CV (%)	13.20	11.21	12.59	13.04

TABLE 4
Quality of forage sorghum genotypes at different fertilizer levels

Treatment	HCN content (µg/g)	Crude protein (%)	IVDMD (%)	TSS (%)
Genotypes				
SPH 1822	91	7.95	52.90	7.63
SPV 2316	105	7.81	47.80	8.40
SPV 2387	68	8.43	52.33	11.31
SPV 2388	80	8.02	51.60	10.48
CSH 13	77	8.00	51.43	7.79
CSV 21F	93	8.27	48.87	9.16
CSV 30F	77	8.06	51.67	11.74
S. Em±	2	0.16	0.99	0.38
C. D. (P=0.05)	6	NS	2.85	1.08
Fertility Levels				
75% RDF	66	7.55	48.34	9.35
100% RDF	81	8.13	51.46	9.66
125% RDF	107	8.55	53.03	9.50
S. Em±	1	0.10	0.65	0.25
C. D. (P=0.05)	4	0.29	1.86	NS
G X F				
S. Em±	4	0.27	1.72	0.65
C. D. (P=0.05)	11	NS	NS	NS
CV (%)	7.56	5.79	5.85	11.90

less than the critical limit (200 µg/g of the fresh weight basis) at 30 days after sowing. HCN content is heritable and subjected to modification through selection and breeding, climate effect, growth stage, stunting of plant, type of soil and fertilizer level (Khatri *et* al., 1997). Nitrogen application is considered essential for the growth and development of forage sorghum. However, higher levels of N application may increase HCN content (Aziz-Abdel and Abdel- Gwad, 2008). Significantly highest crude protein content and IVDMD (8.55 and 53.03 %) were estimated with 125% RDF. Highest TSS (9.66%) was estimated at 100% RDF being on a par with 125% RDF. Similar results were also reported by Satpal *et al*. (2018)

CONCLUSION

Among genotypes, highest green fodder and dry matter yields were recorded in SPV 2387 (45.89 and 12.32 t/ha, respectively) which were on a par with SPV 2388, CSV 21F and CSV 30F. The highest crude protein yield (CPY) and digestible dry matter yield (DDMY) were also recorded in SPV 2387 being on a par with CSV 21F & CSV 30F for CPY and CSV 30F & SPV 2388 for DDMY. CSV 21F and SPV 2387 were found to be the most efficient genotypes in terms of per day productivity for green fodder, dry matter and crude protein and digestible dry matter. Both of these genotypes are equally good in other quality parameters like digestible dry matter yield, crude protein yield, crude protein content (%), IVDMD%, TSS%. Among fertilizer levels, significantly highest green fodder, dry matter, crude protein and digestible dry matter yields were recorded with 125% RDF (93.75 kg N+18.75 kg P_2O_5/ha). In crux, the test genotype SPV 2387 and check variety CSV 21F performed better and application of 125% RDF (93.75 kg N+18.75 kg P_2O_5/ha) is the most suitable fertilization practice to achieve the maximum fodder yield with better quality.

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