Forage Res., **43** (1) : pp. 39-45 (2017) **http://forageresearch.in**

POTENTIAL PRODUCTIVITY, FORAGE QUALITY AND RELATIVE ECONOMICS OF MULTI-CUT SORGHUM GENOTYPES UNDER DIFFERENT FERTILIZER RATES

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(Received : 10 March 2017; Accepted : 18 April 2017)

SUMMARY

A two-factor field experiment consisting of five multi-cut forage cultivars and three fertilizer levels was conducted at Forage Section Research Farm, CCS Haryana Agricultural University, Hisar (Haryana), India during **kharif** 2015. Sorghum cultivars were test hybrid SPH 1700 and variety SPV 2242, which were compared with check hybrids CSH 20MF, CSH 24MF and check variety SSG 59-3. The fertilizer levels were 50, 75 and 100 per cent recommended dose of fertilizer (RDF), which had a combination of nitrogen (80 kg)+phosphorus (40 kg)+potassium (40 kg) per hectare. The forage hybrid SPH 1700 recorded maximum total green fodder (690.2 q/ha) which was at par with SPV 2242 (669.9 q/ha) but significantly superior over the checks CSH 20MF, CSH 24MF and SSG 59-3. Forage variety SPV 2242 recorded maximum total dry matter (119.1 q/ha), which was at par with rest of the genotypes except CSH 24MF.The maximum B : C ratio (2.11) was derived with hybrid SPH 1700. The crop fertilized with 100 RDF recorded significantly higher total green and dry fodder yield over the application of 50 and 75 per cent RDF. The magnitude of the increase with RDF was 33.95 and 12.84 per cent in total green fodder; and 55.31 and 21.14 per cent in total dry fodder yield over 50 and 75 per cent RDF, respectively. The maximum B : C ratio was derived with the application of 100 per cent RDF (2.16). Conclusively, among genotypes SPH 1700 and SPV 2242 performed better and among fertilizer levels, application of 100 per cent RDF was the most beneficial practice.

Key words : Multi-cut forage sorghum, fodder yield, fertilizer levels, hydro cyanic acid (HCN), crude protein content and *in vitro* dry matter digestibility (IVDMD)

Forage sorghum [*Sorghum bicolor* (L.) Moench], belonging to family Poaceae, is an important **kharif** season crop which is widely grown to meet the green as well as dry fodder requirement of the livestock. It is fast growing, adaptive to different environmental conditions, palatable, nutritious which is fed to the animals as green fodder, dry stover, silage and as well as hay. India supports 512.05 million livestock population but only 4.4 per cent of the total cultivated area in the country is under fodder crops. There is tremendous pressure on the availability of feed and fodder for the livestock (Singh *et. al*. 2016). India faces a net deficit of 61.1 per cent green fodder, 21.9 per cent dry crop residues and 64 per cent feed (Sunil Kumar *et al*., 2012). The available varieties of single-cut forage sorghum are not sufficient to provide fodder for longer period of the year. Considering this, multi-cut genotypes were bred for continuous supply of green fodder over a longer period. Forage cultivars with a high yield potential along with adequate fertilization are two major factors that can help increase forage sorghum production in our country. Identification of high yielding multi-cut forage sorghum genotypes with better regeneration capacity and development of location-specific production technology offers an excellent opportunity to provide nutritious forage to bovine population. Being an exhaustive crop, yield and quality of sorghum fodder suffers heavily if recommended fertilizer is not applied. The objectives of the experimentation were to evaluate new multi-cut genotypes under different fertilizer levels so as to quantify the fodder production potential and as well as nutritive value.

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MATERIALS AND METHODS

The field experiment was conducted during **kharif** 2015 at Forage Section Research Farm, CCS Haryana Agricultural University, Hisar (Haryana, India) (29° 10' N of 75° 46' E, at an average elevation of 215.2 m above mean sea level). The site experiences semi-arid and sub-tropical climate with hot dry summer and severe cold winter. Average annual rainfall was about 450 mm, 75 per cent of which was received in three months (July to September) during the south-west monsoon. The crop received 363.1 mm rainfall before the first cut and 28.6 mm rainfall during second cut for all the genotypes. 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 in texture, slightly alkaline in reaction (pH 7.2), low in available nitrogen (196.4 kg/ha), medium in available phosphorus (10.0 kg/ha) and potassium (153.0 kg/ha). The experiment consisted of 15 treatment combinations comprising five multi-cut forage sorghum genotypes (SPV 2242, SPH 1700, SSG 59-3, CSH 20 MF and CSH 24 MF) and three fertilizer levels viz. 50, 75 and 100 per cent of recommended dose of fertilizer (RDF). RDF was 80 kg N+40 kg P_2O_5+40 kg K_2O/ha. These treatments were tested in factorial randomized block design with three replications. As per treatment, full dose of phosphorus, potassium and half of the nitrogen was applied at the time of sowing and rest half of the nitrogen was applied in two splits one at 30 days after sowing and another just after first cut. Diammonium phosphate (DAP), muriate of potash (MOP) and urea fertilizers were used as a source of P_2O_5, K_2O and N nutrients, respectively. The genotypes were sown manually on 10 June 2015 in opened furrows at 25 cm apart. All the other standard agronomic practices for the cultivation of forage sorghum were followed uniformly in all the treatments. First cut was taken 70 days after sowing and second cut was taken 60 days after first cut for all the genotypes. Just before the cut, the leaf area index (LAI) was recorded with the instrument viz., SS1 SunScan (Canopy Analysis System, AT Delta-T Devices Ltd., Cambridge CB25 0EJ, UK). 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 harvest, chopped well and put into paper bag. These bags were aerated by making small holes all over. The samples were first sun-dried 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 these samples, the green fodder yield was converted into dry matter yield (q/ha). Crude protein and *in vitro* dry matter digestibility (IVDMD) were estimated in dried and grinded samples (2 mm sieve size), collected at the time of first and second cut. The crude protein content was calculated by multiplying the nitrogen percentage with 6.25 by conventional micro-Kjeldhal 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 samples for estimation of HCN were taken at 30 DAS from the portion of the tiller 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. The content of total soluble solids (TSS) was determined using refractometer. Economics was worked out on the basis of prevailing market prices of inputs and outputs in the local market. Data were analyzed by using OPSTAT software available on CCS Haryana Agricultural University website (Sheoran *et al*., 1998). The results are presented at 5 per cent level of significance (P=0.05) for making comparison between treatments.

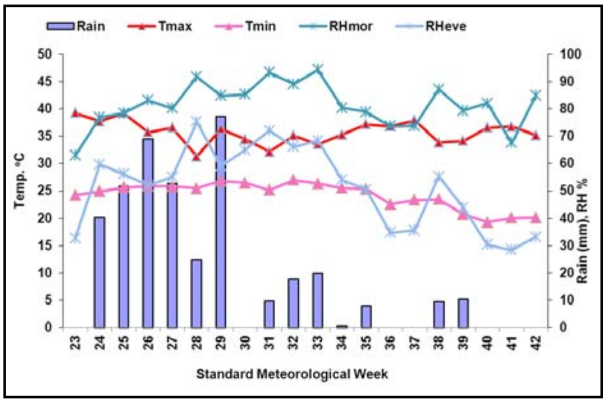

Fig. 1. Weekly weather parameters viz., temperature °C , relative humidity (%) and rainfall (mm).

RESULTS AND DISCUSSION

Fertilizer Levels

Data presented in Table 1 reveal that among different fertilizer levels, highest number of tiller (31.47) at first cut was recorded with RDF which was on a par with 75 per cent RDF but significantly

TABLE 1
Yield attributes of multi-cut forage sorghum genotypes as influenced by different fertilizer levels

Treatment	Tillers/mrl				Plant height (cm)		Leaf area index		L : S ratio	
	20 DAS	At 1st cut	20 days after 1st cut	At 2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
A. Fertilizer levels										
50% RDF	20.56	27.44	21.98	20.87	167.89	165.27	3.47	2.05	0.357	0.201
75% RDF	23.47	30.13	24.98	23.93	180.11	172.91	3.93	2.47	0.370	0.236
100% RDF	26.51	31.47	27.09	27.47	191.16	178.62	4.29	2.68	0.398	0.263
S. Em±	0.93	0.84	0.73	0.94	3.89	2.21	0.13	0.12	0.016	0.006
C. D. (P=0.05)	2.72	2.45	2.13	2.74	11.32	6.43	0.38	0.35	NS	0.017
B. Genotypes										
SPV 2242	38.78	48.89	45.63	44.00	161.26	159.96	4.54	3.20	0.399	0.252
SPH 1700	18.00	19.26	14.85	14.89	183.07	167.15	4.06	2.24	0.384	0.234
SSG 59-3	22.44	36.63	32.93	30.11	200.04	194.04	3.66	2.43	0.323	0.209
CSH 20MF	21.96	24.82	13.41	14.67	180.74	168.30	3.81	2.07	0.383	0.237
CSH 24MF	16.37	18.81	16.59	16.78	173.48	171.89	3.42	2.07	0.387	0.235
S. Em±	1.21	1.09	0.94	1.21	5.02	2.85	0.17	0.15	0.021	0.008
C. D. (P=0.05)	3.51	3.16	2.74	3.53	14.62	8.30	0.49	0.45	NS	0.022
C. V. (%)	15.38	10.97	11.46	15.11	8.38	4.96	12.9	19.2	16.86	13.55
A x B										
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Tillers/mrl–Tillers per metre row length, L : S ratio–Leaf to stem ratio and NS–Not Significant.

TABLE 2
Yield of multi-cut forage sorghum genotypes as influenced by different fertilizer levels

Treatment	Green fodder (q/ha)		Dry matter (q/ha)	
	1st cut	2nd cut	1st cut	2nd cut
A. Fertilizer levels				
50% RDF	361.8	173.0	56.4	30.8
75% RDF	437.9	197.0	73.2	38.5
100% RDF	490.1	226.4	88.5	46.9
S. Em±	14.47	6.88	3.01	1.78
C. D. (P=0.05)	42.13	20.02	8.75	5.18
B. Genotypes				
SPV 2242	444.8	225.2	75.1	44.0
SPH 1700	488.2	202.0	80.1	33.8
SSG 59-3	410.7	186.2	75.0	37.4
CSH 20MF	430.9	192.1	72.3	41.5
CSH 24MF	375.1	188.6	61.0	37.1
S. Em±	18.68	8.88	3.88	2.30
C. D. (P=0.05)	54.39	25.85	11.30	6.68
C. V. (%)	13.03	13.40	16.01	17.77
A x B				
C. D. (P=0.05)	NS	NS	NS	NS

NS–Not Significant.

superior over 50 per cent RDF. Highest number of tiller at 2nd cut (27.47) was recorded with the application of 100 per cent RDF which was significantly superior over rest of the treatments. Highest plant height at 1st cut (191.16 cm), 2nd cut (178.62 cm), LAI at 1st cut (4.29) and at 2nd cut (2.68) were recorded with the application of 100 per cent RDF which were on a par with 75 per cent RDF but significantly superior over 50 per cent RDF. Data presented in Table 2 reveal that among different fertilizer levels, highest green fodder yield at 1st cut (490.1 q/ha), at 2nd cut (226.4 q/ha), 1st cut+2nd cut (716.5 q/ha), dry matter yield at 1st cut (88.5 q/ ha), at 2nd cut (46.9 q/ha) and 1st+2nd cut (135.4 q/ ha) were recorded with the application of 100 per cent RDF which were significantly superior to rest of the treatments. Data of total green fodder (a) and dry matter yield (b) are represented in Fig. 2 graphically. Plant height, number of tillers per meter row length, green fodder yield and dry matter yield of sorghum increased with successive increase in fertilizer levels in both the cuts. This may be due to the fact that nitrogen, phosphorus and potash application enhanced the growth parameters such as tillers and plant height which ultimately reflected in increased total green fodder and dry matter yield. Rana *et al*. (2013) also reported significant increase in plant height, number of tillers, green fodder and dry matter yield of sorghum at 150 per cent RDF over the lower levels of fertilizer. The maximum number of tillers per metre row length, plant height, green fodder and dry matter yield were recorded at 100 per

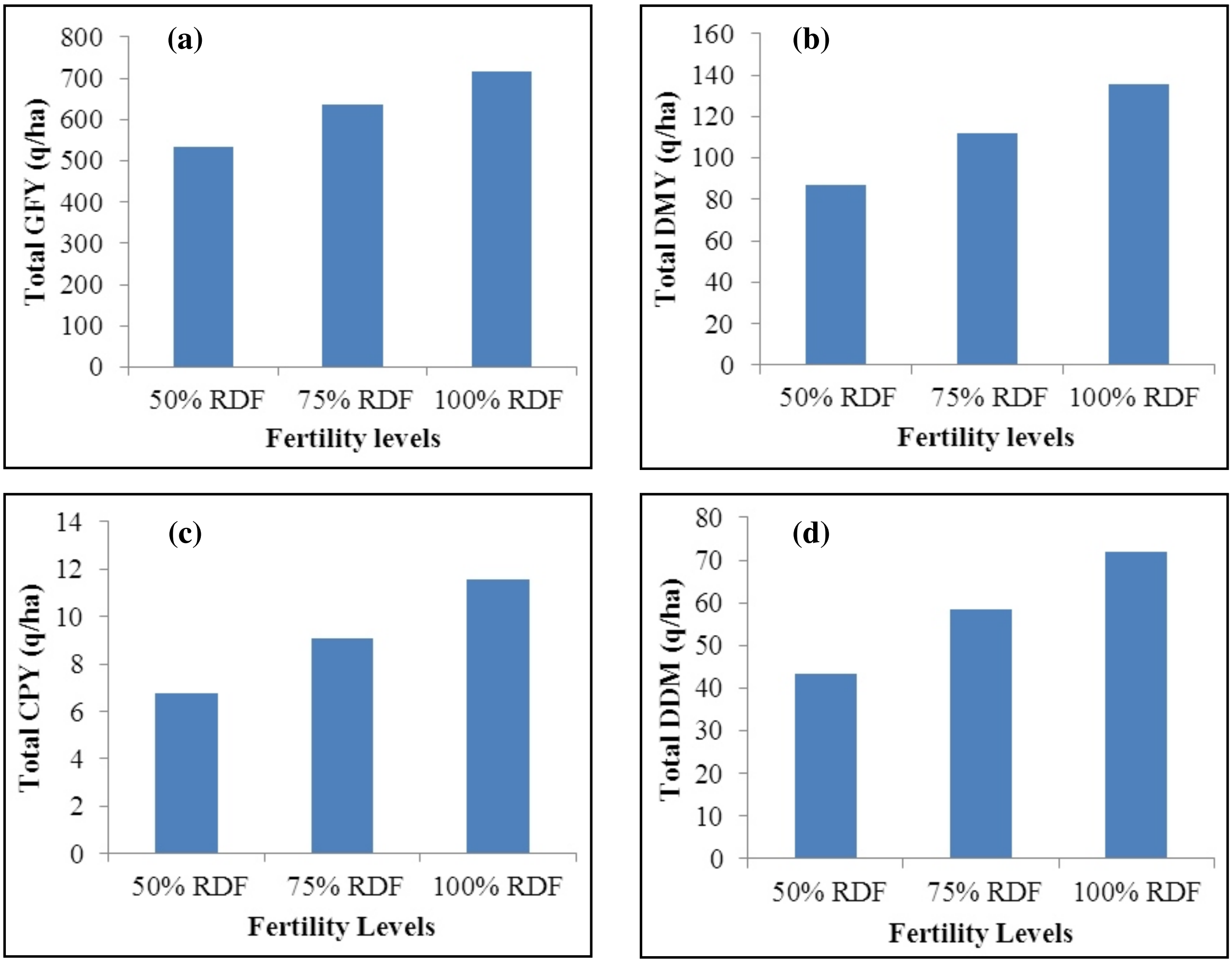

Fig. 2. Effect of fertilizer levels on (a) GFY, (b) DMY, (c) CPY and (d) DDM of multi-cut forage sorghum.
GFY–Green fodder yield, DMY–Dry matter yield, CPY–Crude protein yield and DDM–Digestible dry matter.

cent RDF. Data presented in Table 3 reveal that HCN content increased with increasing fertilizer levels and was highest at 100 per cent RDF (104 µg/g)at 30 days after sowing which was significantly higher over rest of the treatments but was below critical limit of 200 µg/g on fresh weight basis. HCN content increased from 75 to 104 µg/ g with increasing fertilizer levels from 50 to 100 per cent RDF. It was mainly due to increase in nitrogen absorption by plants which was used for the synthesis of HCN. Nitrogen application is considered essential for growth and regrowth during growing season. However, higher level of nitrogen application may increase HCN content of forage sorghum (Aziz-Abdel and Abdel-Gwad, 2008). Highest crude protein at 1st cut (8.05%), 2nd cut (9.54%), crude protein yield (CPY) at 1st cut (7.13 q/ ha), 2nd cut (4.47 q/ha), total CPY (11.59 q/ha), digestible dry matter (DDM) at 1st cut (45.06 q/ha), 2nd cut (27.01 q/ha) and total DDM (72.07 q/ha) were estimated with the application of 100 per cent RDF which were significantly superior to rest of the treatments. Fig. 2 depicts the graphical form of the data on total crude protein yield (c) and total digestible dry matter (d). Average crude protein content and *in vitro* dry matter digestibility (IVDMD) percentage increased with increasing fertilizer levels and became highest at 100 per cent RDF (8.80 and 54.18%, respectively). Highest IVDMD at 1st cut (51.04%) and at 2nd cut (57.32%) was estimated with the application of RDF which was at par with 75 per cent RDF. The TSS (total soluble solids) was not affected significantly by different fertilizer levels at first cut. However, significant difference was observed at second cut in TSS (%). The highest TSS (4.80%) was estimated with 100 per cent RDF which was at par with 75 per cent RDF. The incremental trend was observed in TSS (%) from 50 to 100 per cent RDF at second cut. Satpal *et al*. (2015) also reported incremental trend in TSS percentage of single-cut forage sorghum from 50 to 100 per cent RDF.

TABLE 3
Quality of multi-cut forage sorghum genotypes as influenced by different fertilizer levels

Treatment	HCN (μg/g)	Crude protein (%)			IVDMD (%)			CPY (q/ha)			DDM (q/ha)			TSS	
	30 DAS	1st cut	2nd cut	Av.	1st cut	2nd cut	Av.	1st cut	2nd cut	Total	1st cut	2nd cut	Total	1st cut	2nd cut
A. Fertilizer levels															
50% RDF	75	7.14	8.80	7.97	47.44	53.58	50.51	4.03	2.72	6.75	26.64	16.61	43.25	4.27	3.93
75% RDF	84	7.57	9.19	8.38	50.76	55.56	53.16	5.55	3.53	9.08	37.12	21.41	58.53	4.60	4.67
100% RDF	104	8.05	9.54	8.80	51.04	57.32	54.18	7.13	4.47	11.59	45.06	27.01	72.07	4.53	4.80
S. Em±	1.85	0.11	0.11	-	0.653	0.83	-	0.26	0.17	0.32	1.46	1.11	1.75	0.21	0.22
C. D. (P=0.05)	5.39	0.31	0.32	-	1.901	2.43	-	0.76	0.49	0.93	4.24	3.22	5.10	NS	0.63
B. Genotypes															
SPV 2242	95	7.51	8.90	8.21	47.80	58.53	53.17	5.69	3.91	9.60	35.99	25.80	61.79	4.44	4.11
SPH 1700	46	7.73	8.97	8.35	48.33	53.47	50.90	6.27	3.04	9.31	38.87	18.19	57.06	5.00	4.78
SSG 59-3	85	7.37	9.19	8.28	50.60	55.47	53.04	5.59	3.45	9.04	37.90	20.90	58.80	4.33	4.33
CSH 20MF	120	7.45	9.63	8.54	52.00	55.83	53.92	5.44	4.01	9.45	38.03	23.30	61.33	4.89	5.33
CSH 24MF	92	7.88	9.19	8.54	50.00	54.13	52.07	4.84	3.44	8.28	30.59	20.17	50.76	3.67	3.78
S. Em±	2.39	0.14	0.14	-	0.84	1.08	-	0.34	0.22	0.41	1.88	1.43	2.26	0.26	0.28
C. D. (P=0.05)	6.96	NS	0.41	-	2.45	3.13	-	NS	0.63	NS	5.47	4.16	6.59	0.77	0.82
CV (%)	8.17	5.39	4.61	-	5.08	5.82	-	18.09	18.24	13.59	15.54	19.78	11.70	17.76	18.80

HCN–Hydrocyanic acid, IVDMD–In vitro dry matter digestibility, CPY–Crude protein yield, DDM–Digestible dry matter, TSS–Total soluble solids, Av.–Average and NS–Not Significant.

Genotypes

Data presented in Table 1 reveal that among different genotypes, highest number of tillers/mrl after final thinning i. e. 20 days after sowing (38.78), at 1st cut (48.89), 20 days after 1st cut (45.63) and at 2nd cut (44.00) were observed with SPV 2242 which were significantly superior over rest of the genotypes. Highest plant height at 1st cut (200.04 cm) and 2nd cut (194.04 cm) was recorded with SSG 59-3 which was significantly superior to rest of the genotypes. The variation in plant height and number of tillers of the genotypes might be related to inherent difference and their high vigour. The differential behaviour of these genotypes could also be explained solely by the variation in their genetic constituent (Meena *et al.*, 2012). Highest LAI at 1st cut (4.54) was recorded with SPV 2242 which was at par with SPH 1700 but significantly superior to rest of the genotypes. Highest LAI at 2nd cut (3.20) was recorded with SPV 2242 which was significantly superior to rest of the genotypes. Highest L : S ratio at 2nd cut (0.252) was recorded with SPV 2242 which was significantly superior to SSG 59-3 but at par with rest of the genotypes.

Data presented in Table 2 reveal that among different genotypes, highest GFY at first cut (488.2 q/ ha) was recorded with SPH 1700 which was at par with SPV 2242 but superior to rest of the genotypes. Highest GFY at second cut (225.2 q/ha) was recorded with SPV 2242 which was at par with SPH 1700 but superior to rest of the genotypes. Highest total GFY of 1st+2nd cut (690.2) was recorded with SPH 1700 which was at par with SPV 2242 but superior to rest of the genotypes. The green fodder yield and dry matter yield is a resultant of plant height and number of tillers. Highest DMY at 1st cut (80.06) was recorded with SPH 1700 which was significantly superior over CSH 24MF except rest of the treatments. Highest DMY at 2nd cut (44.00) was recorded with SPV 2242 which was at par with CSH 20MF and SSG 59-3 but superior to rest of the genotypes. Highest total DMY of 1st+2nd cut (119.1) was recorded with SPV 2242 which was significantly superior over CSH 24MF except rest of the genotypes. Data of total green fodder (a) and dry matter yield (b) are graphically represented in Fig. 3.

Data presented in Table 3 reveal that among different genotypes, highest HCN content 30 days after sowing (120 μg/g on fresh weight basis) was estimated in CSH 20MF which was significantly superior to rest of the genotypes. Highest crude protein at 2nd cut (9.63%) was estimated in CSH 20MF which was significantly superior to rest of the genotypes. Maximum average crude protein content was estimated in the genotypes CSH 20MF and CSH 24MF (8.54%). Maximum average *in vitro* dry matter digestibility (IVDMD) was estimated in the genotype CSH 20 MF (53.92%). Highest IVDMD at 1st cut (52.00%) was estimated in CSH 20MF which was significantly superior to SPH 1700 and SPV 2242. Highest IVDMD

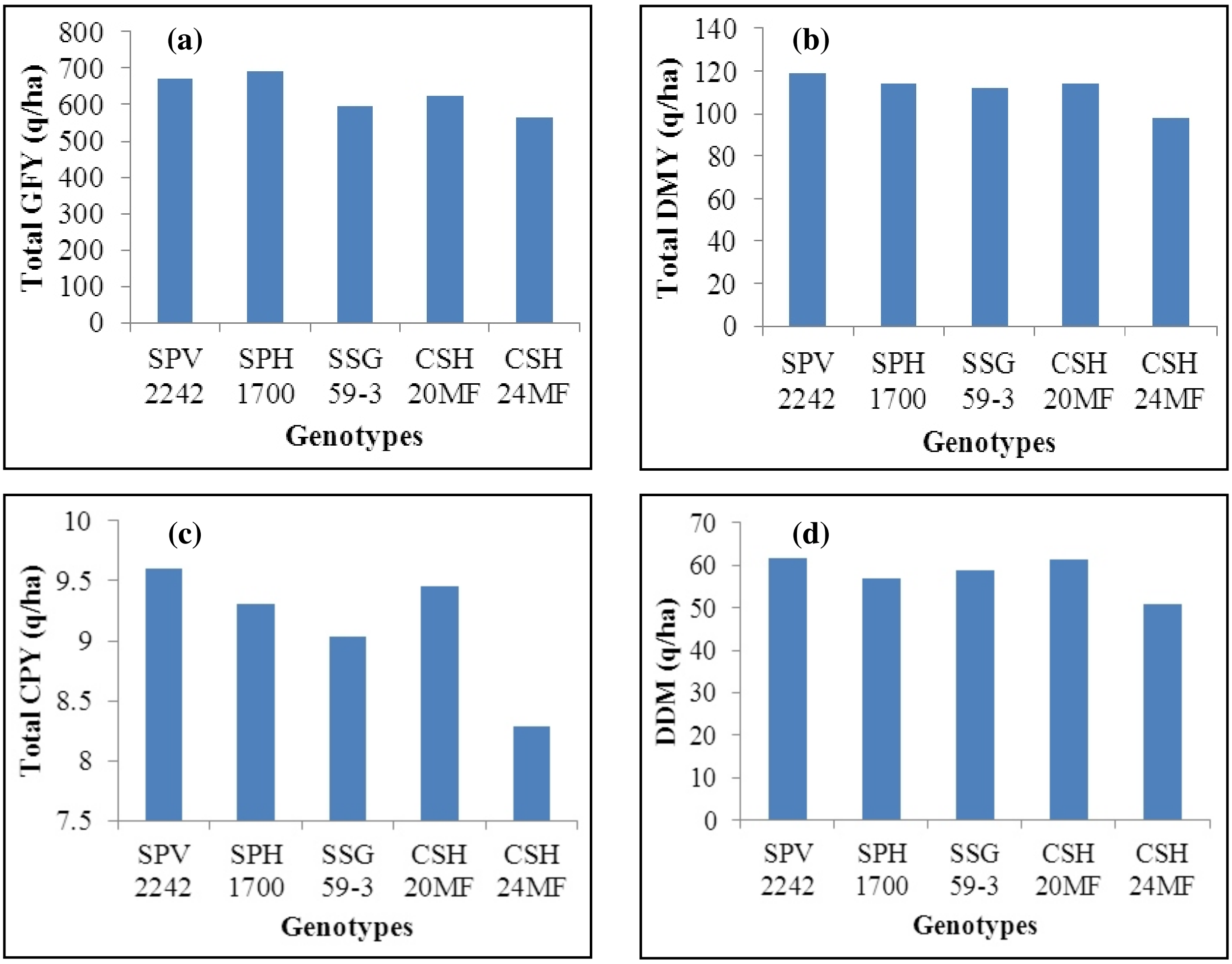

Fig. 3. Effect of genotypes on (a) GFY, (b) DMY, (c) CPY and (d) DDM of multi-cut forage sorghum.
GFY–Green fodder yield, DMY–Dry matter yield, CPY–Crude protein yield and DDM–Digestible dry matter.

at 2nd cut (58.53%) was estimated in SPV 2242 which was significantly superior to SPH 1700 and CSH 20MF. Crude protein yield (CPY) at 1st cut and total CPY were not affected significantly among different genotypes. However, highest CPY at 2nd cut (4.01 q/ha) was recorded with CSH 20 MF which was significantly superior over SPH 1700 except rest of the genotypes. Highest digestible dry matter (DDM) at 1st cut (38.87 q/ha) was estimated with SPH 1700 which was significantly superior to CSH 24MF. Highest DDM at 2nd cut (25.80 q/ha) was estimated with SPV 2242 which was on a par with CSH 20MF except rest of the genotypes. Highest total DDM (61.79 q/ha) was estimated with SPV 2242 which was significantly superior to CSH 24MF (50.76 q/ha). Fig. 3 depicts the graphical form of the data on total crude protein yield (c) and total digestible dry matter (d). Several workers have also noticed the variation among the genotypes of sorghum for fodder yield, growth and quality (Meena *et al.*, 2012; Rana *et al.*, 2012; Rana *et al.,* 2013; Yadav *et al.*, 2016). The highest total soluble solids (5.00%) were observed with the genotype SPH 1700 at first cut which were

TABLE 4
Economics of multicut forage sorghum genotypes as influenced by different fertilizer levels

Treatment	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B : C ratio
A. Fertilizer levels				
50% RDF	45661	112322	66661	1.46
75% RDF	46256	133334	87078	1.88
100% RDF	47569	150461	102892	2.16
B. Genotypes				
SPV 2242	46495	140687	94192	2.02
SPH 1700	46495	144944	98449	2.11
SSG 59-3	46495	125339	78844	1.69
CSH 20MF	46495	130835	84340	1.81
CSH 24MF	46495	118391	71896	1.54

significantly superior over CSH 24MF except rest of the genotypes. At the time of second cut, highest TSS (5.33%) was in CSH 20MF which was on a par with SPH 1700 except rest of the genotypes. TSS is an indicator of sweetness and is a desirable quality parameter in forage sorghum.

Economics

Data presented in Table 4 reveal that among different fertilizer levels, maximum net returns (Rs. 102892/ha) and B : C ratio (2.16) were recorded with the application of 100 per cent RDF followed by 75 per cent RDF. Among different genotypes, maximum net returns (Rs. 98449/ha) and B : C ratio (2.11) were recorded with SPH 1700 followed by SPV 2242.

CONCLUSION

Based on the results, it can be concluded that test hybrid SPH 1700 recorded highest total green fodder yield in two cuts (690.2 q/ha), which was at par with variety SPV 2242. However, maximum dry matter yield was recorded with SPV 2242 which was at par with SPH 1700, CSH 20MF and SSG 59-3. The maximum B : C ratio was recorded with the genotype SPH 1700 followed by SPV 2242. Among fertilizer levels, the highest total green fodder (716.5 q/ha) and total dry matter (135.4 q/ha), total crude protein (11.6 q/ha) and digestible dry matter yield (72.1 q/ha) were recorded with the application of 100 per cent RDF which were significantly superior over the 75 and 50 per cent RDF levels. The maximum B : C ratio was recorded with the application of 100 per cent RDF (2.16) followed by 75 per cent RDF (1.88). In conclusion, the genotypes SPH 1700, SPV 2242 and CSH 20MF performed better and application of 100 per cent RDF was the most profitable fertilization practice to achieve the maximum yield of green fodder and dry matter.

ACKNOWLEDGEMENTS

The authors are thankful to forage sorghum breeders of All India Coordinated Research Project on Sorghum, Hyderabad for providing the seed of multi-cut forage sorghum genotypes used in the experiment and necessary guidelines to conduct the agronomy trial under AICRP on sorghum.

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