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PERFORMANCE OF SINGLE-CUT FORAGE SORGHUM CULTIVARS AT DIFFERENT FERTILIZER LEVELS

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SUMMARY

A field experiment to assess the effect of different fertilizer levels on production, productivity, quality and economics of single cut forage sorghum [*Sorghum bicolor* (L.) Moench] genotypes was conducted at Hisar (Haryana), India during *kharif* season of 2019. Nine forage sorghum cultivars (SPH 1890, SPH 1891, CSV 30F, CSV 32F, SH 1514, SHH 1513, HJ 513, HJ 541 and CSV 21F) were tested at three recommended dose of fertilizers (RDF) *i.e.* 75, 100 and 125% RDF in factorial RBD with three replications. SHH 1513 cultivar being at par with SH 1514 and SPH 1890 recorded highest green fodder (GF) dry matter (DM), crude protein yield (CPY) and digestible dry matter yield (DDMY) and net income (531.5, 137.0, 14.24, 74.71 q/ha and₹30938, respectively). Highest *in-vitro* dry matter digestibility (IVDMD) content (56.40%) was observed in SPH 1891 which was on a par with SPH 1890. HCN content was below critical limit in all cultivars. Among RDF levels, significantly higher green, dry, CPY, DDMY, IVDMD and net income (511.6, 133.9, 13.85, 73.02 q/ha, 54.53% and₹28080, respectively) were recorded with 125% RDF. Application of 125% RDF has brought an improvement of 18.8 and 8.74 per cent in GFY; 31.4 and 11.1 per cent in DFY; 37.7 and 14.7 per cent in CPY and 37.9 and 13.4 per cent in DDMY over 75% and 100% RDF, respectively. With increased fertilizer levels, the HCN content at 30 days after sowing increased from 75 to 103 µg/g on fresh weight basis but it was less than the critical limit. It is concluded that use of SC forage sorghum hybrids SH 1513, SH 1514 and SPH 1890 and application of 125% RDF was recommended for higher fodder yield, quality and income.

Key Words : Sorghum, single-cut, fertilizer levels, fodder yield, HCN, crude protein and IVDMD

Sorghum [*Sorghum bicolor* (L.) Moench] is widely grown to meet the requirement of fodder, feed, food and fuel. It is highly adaptive to wide edapho-cliamtic conditions and provides palatable nutritious fodder to huge livestock population of India *i.e.* 536.76 million (Anonymous, 2020). Sorghum as a source of fodder and feed has the potential to meet the by dairy sector needs. Single cut forage sorghum varieties yields about 400-500 and 100-150 q/ha of green and dry fodder rich in quality. In terms of quality, it contains 8-10% crude protein, 60-65%, NDF, 37-42% ADF, 32% cellulose and 21-23% hemi-cellulose when harvested at 50% flowering stage (Sunil Kumar *et al.*, 2012). Beside this, sorghum is also a moderately salt tolerant crop (Devi et al., 2018). However, under drought and or imbalanced soil nutrient status were found to alter hydrocyanic acid (HCN) content and to a level that may prove lethal livestock feeding on it (Karthika and Kalpana, 2017). Identification of location specific genotypes with good quality, higher fodder yields and early stage of harvesting (days to 50% flowering) are essential to achieve sustainable productivity of livestock. Primary nutrients (N, P and K) 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 fodder produced, it is essential to determine the fertilizer requirements of single-cut sorghum as new varieties emerge every year. Hence, the present study was undertaken to assess the impact of different fertilizer levels on production, productivity and quality of promising single-cut forage sorghum genotypes.

MATERIALS AND METHODS

A field experiment was conducted during rainy (*kharif*) season of 2019 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) having semi-arid and sub-tropical climate with hot dry summer and severe cold winters and receives 450 mm precipitation per annum. Weekly weather parameters *i.e.* temperature (°C), relative humidity (%) and rainfall (mm) during the season are given Fig 1. The experimental sandy loam soil with pH 7.6 has 0.5% organic carbon, 126.0 -14.1 - 226.0 kg/ha of available N-P-K at the start of study in plough layer. The experiment consisted of 27 treatment formed by combination of nine single-cut forage sorghum cultivars (SPH 1890, SPH 1891, CSV 30F, CSV 32F, SH 1514, SHH 1513, HJ 513, HJ 541 and CSV 21F) and three recommended dose of fertilizer (RDF) levels *viz.* 75, 100 and 125 per cent . These treatments were tested in factorial randomized block design with three replications. Recommended dose of fertilizer (75-15 kg/ha N-P_2O_5) was used in the study. Entire P along with 75% N was applied basal at the time of sowing and remaining N was top dressed at 30 days after sowing (DAS). Sorghum cultivars as per treatment were sown manually on 23 June 2019 (standard week 25) in soiled rows at 30 cm apart. 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). Sorghum crop was harvested at 50 per cent flowering stage. 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 as per Hogg and Ahlgren (1942). The amount of HCN on fresh weight basis was calculated by calibrating the absorbance with HCN (5-40×10^{-3} g/l) in water as standard. Crude protein and in vitro dry matter digestibility (IVDMD) per cent were estimated in dried and grinded samples (2 mm sieve size), collected at 50 per cent flowering stage. Crude protein content (CPC) was calculated by multiplying the nitrogen content (%) with 6.25, estimated by conventional micro-kjeldal method (AOAC, 1995). IVDMD was determined as per Barnes *et al.* (1971). Crude protein and digestible dry matter yield (q/ha) were

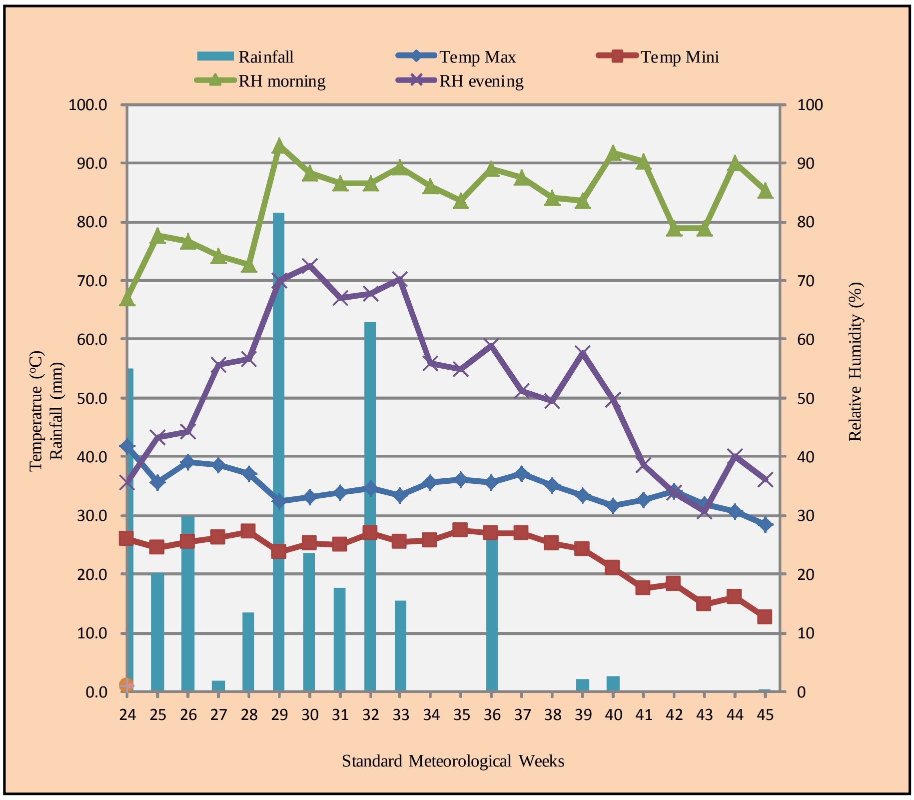

Fig. 1. Weekly weather parameters during *kharif* 2019 at the experimental site.

calculated by multiplication of CPC and IVDMD with dry matter yield (q/ha), respectively. 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 (Table 1) reveal that among genotypes, highest plant height was observed in SPH 1513 which was on a par with SH 1514, HJ 513, HJ 541 and CSV 21F. Leaf: stem ratio was significantly higher in SPH 1890 over all other cultivars. Significantly higher days were taken to reach 50% flowering by CSV 30F over rest of the cultivars. Green and dry matter yields recorded were significantly higher in SHH 1513 (531.5 and 137.0 q/ha,) than 6 cultivars while SH 1514 and SPH 1890 have at par values. Maximum per day green and dry matter productivity (6.26 and 1.61 q) were recorded in the genotype SHH 1513 which were on a par with SH 1514. The differential yields by sorghum cultivars could be ascribed to their genetic makeup (Hanuman *et al*., 2008 and Meena *et al*., 2012).

Perusal of the HCN data at 30 DAS from Table 2 reveal that among genotypes, maximum HCN content (108 µg/g on fresh weight basis) was estimated in SPH 1890. However, it remained (54 to 108 µg/g) remains below critical limit in all the cultivars. Highest crude protein content (10.47%) was estimated in SPH 1890 which was on a par with SPH 1891, CSV 30F, SH 1514 and SH 1513. Highest *in-vitro* dry matter digestibility (IVDMD) content (56.40%) was estimated in SPH 1891 which was on a par with SPH 1890. Among cultivars, CP and IVDMD content ranged from 9.47 to 10.47 and 49.87 to 56.40 per cent, respectively. Highest crude protein yield and digestible dry matter yield were recorded in SHH 1513 which were on a par with SPH 1890 and SH 1514.

Perusal of the data from Table 3 reveal that among cultivars, maximum chlorophyll content (SPAD Units) at 30 DAS was recorded in SHH 1513 which was on a par with HJ 541 and CSV 21F. At harvest, also maximum chlorophyll content was recorded in SHH 1513 which was on a par with SPH 1890, SH 1514 and HJ 541. However, at 60 DAS, the chlorophyll content did not vary among cultivars.

TABLE 1
Performance of single cut sorghum cultivars at different fertilizer levels

Treatment	Plant height (cm) at harvest	Leaf : Stem ratio at harvest	Days to 50% flowering	Green fodder yield (q/ha)	Dry matter yield (q/ha)	Per day productivity of GFY (q/ha-day)	Per day productivity of DMY (q/ha-day)
A Cultivar							
SPH 1890	235.8	0.40	102	510.6	131.6	4.98	1.28
SPH 1891	223.6	0.30	85	424.4	105.0	5.00	1.24
CSV 30F	240.7	0.33	104	454.9	115.8	4.37	1.11
CSV 32F	216.6	0.32	96	378.4	90.1	3.94	0.94
SH 1514	245.4	0.32	88	524.8	131.9	5.93	1.49
SHH 1513	246.6	0.30	85	531.5	137.0	6.26	1.61
HJ 513	244.2	0.25	86	464.1	118.8	5.37	1.38
HJ 541	244	0.26	91	479.1	119.8	5.28	1.32
CSV 21F	242.8	0.27	97	470.3	118.9	4.87	1.23
S. Em±	3.95	0.01	0.5	14.4	3.9	0.15	0.04
C. D. (P=0.05)	5.58	0.02	1.4	40.9	11.2	0.43	0.12
B. Fertilizer Level (% RDF)							
75% RDF	228.27	0.29	92	430.5	101.9	4.72	1.12
100% RDF	238.11	0.31	93	470.5	120.5	5.12	1.31
125% RDF	246.87	0.32	93	511.6	133.9	5.50	1.44
S. Em±	2.28	0.01	0.3	8.3	2.3	0.09	0.02
C. D. (P=0.05)	3.22	0.01	0.8	11.7	6.5	0.25	0.07
A X B							
S. Em±	6.83	0.01	0.8	24.9	6.8	0.26	0.07
C. D. (P=0.05)	NS	0.03	NS	NS	NS	NS	NS
CV (%)	5.01	6.58	1.55	9.14	9.91	8.97	9.81

TABLE 2
Quality of single-cut sorghum cultivars as influenced by different fertilizer levels

Treatment	HCN (µg/g)	Crude protein (%)	IVDMD (%)	Crude protein yield (q/ha)	Digestible dry matter yield (q/ha)
A. Cultivar					
SPH 1890	108	10.47	56.13	13.91	74.17
SPH 1891	103	10.23	56.40	10.75	59.33
CSV 30F	101	10.08	53.47	11.64	61.99
CSV 32F	78	9.85	53.63	8.91	48.46
SH 1514	104	10.20	53.60	13.42	70.75
SHH 1513	94	10.37	54.40	14.24	74.71
HJ 513	75	9.47	49.87	11.27	59.37
HJ 541	54	9.90	50.93	11.89	61.17
CSV 21F	90	10.03	51.26	11.93	60.97
S. Em±	0.9	0.13	0.24	0.41	2.09
C. D. (P=0.05)	2.6	0.37	0.67	1.15	5.94
B. Fertilizer Level (% RDF)					
75% RDF	75	9.86	51.96	10.06	52.92
100% RDF	91	10.01	53.41	12.08	64.37
125% RDF	103	10.33	54.53	13.85	73.02
S. Em±	0.5	0.08	0.14	0.23	1.21
C. D. (P=0.05)	1.5	0.21	0.39	0.67	3.43
A × B					
S. Em±	1.6	0.22	0.41	0.70	3.62
C. D. (P=0.05)	4.4	0.64	1.16	NS	NS
CV (%)	3.01	3.85	1.33	10.14	9.87

Fertilizer levels

Perusals of the data from Table 1 reveal that among fertilizer levels, significantly higher plant height was recorded with 125% RDF over the lower fertilizer levels. Highest leaf to stem ratio was recorded with 125% RDF which was on a par with 100% RDF. The days to 50% flowering were significantly increased with 125% RDF over 75% RDF. Green fodder, dry matter yields (511.6 and 133.9 q/ha, respectively) were significantly higher with 125% RDF over the lower fertilizer levels. The increase in green fodder and dry matter yields were 18.84, 31.4 and 8.74, 11.12 per cent with 125% RDF over 75% and 100% RDF, respectively. Similar increases in GFY and DMY were also reported by Satpal *et al*. (2019) and Satpal *et al*. (2018). Per day productivity of green fodder and dry matter (5.50 and 1.44 q) were significantly higher with 125% RDF over lower fertilizer levels. This clearly indicates that with increasing RDF from 100% to 125%, there was significant improvement in fodder production and productivity. 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 75 to 103 µg/g, but it remained below the critical limit (200 µg/g) at 30 days after sowing. It was mainly due to increase in nitrogen absorption by plants which was used for the synthesis of HCN. HCN content is heritable and subjected to modification through selection and breeding, as well as by climate, stage of maturity, stunting of plant, type of soil and fertilizer (Khatri *et al*., 1997). Nitrogen application is considered essential for growth of the crop. However, higher levels of N application may increase HCN content of forage sorghum (Aziz-Abdel and Abdel-Gwad, 2008). Significantly higher CP and IVDMD contents (10.33 and 54.53 %) were estimated with 125% RDF. The increase in CP and IVDMD content with increase in fertilizers levels were ascribed to increases in Leaf : Stem ratio (L:S ratio), both protein and IVDMD were positively correlated with L:S ratio and also observed increase in crude protein and IVDMD percentage with increase in N fertilizer doses (Joshi *et al*., 2009). Significantly higher CP and digestible dry matter yield (13.85 and 73.02 q/ha, respectively) were estimated with 125% RDF. Data presented in Table 3 reveal that maximum chlorophyll content was recorded at 125% RDF at 30 DAS, 60 DAS and at harvest *viz*. 30.05, 41.72 and 47.27 respectively, which was significantly superior over 75% RDF and 100% RDF at 30 DAS, 60 DAS and at harvest.

TABLE 3
Chlorophyll content of single-cut sorghum cultivars as influenced by different fertilizer levels

Treatment	Chlorophyll content (SPAD Units)		
	30 DAS	60 DAS	At harvest
A. Cultivar			
SPH 1890	28.10	39.60	45.64
SPH 1891	24.80	37.98	42.67
CSV 30F	26.24	39.59	43.10
CSV 32F	27.50	37.23	42.77
SH 1514	26.86	39.02	45.58
SHH 1513	30.56	40.06	46.54
HJ 513	26.79	37.77	43.39
HJ 541	29.73	38.83	44.96
CSV 21F	29.94	38.72	43.58
S. Em±	0.60	0.71	0.77
C. D. (P=0.05)	1.70	NS	2.18
B. Fertilizer Level (% RDF)			
75% RDF	25.18	35.43	40.87
100% RDF	28.28	39.12	44.59
125% RDF	30.05	41.72	47.27
S. Em±	0.34	0.41	0.44
C. D. (P=0.05)	0.98	1.16	1.26
A X B			
S. Em±	1.03	1.22	1.33
C. D. (P=0.05)	NS	NS	NS
CV (%)	6.43	5.47	5.72

TABLE 4
Economics of single-cut sorghum cultivars as influenced by different fertilizer levels

Treatment	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B : C ratio
A. Cultivar				
SPH 1890	35500	63829	28329	1.80
SPH 1891	35500	53046	17545	1.49
CSV 30F	35500	56865	21365	1.60
CSV 32F	35500	47302	11801	1.33
SH 1514	35500	65605	30105	1.85
SHH 1513	35500	66439	30938	1.87
HJ 513	35500	58006	22506	1.63
HJ 541	35500	59891	24390	1.69
CSV 21F	35500	58790	23289	1.66
C. D. (P=0.05)	-	5106	5106	0.14
B. Fertility Level (%RDF)				
75% RDF	35114	53810	18696	1.53
100% RDF	35499	58813	23314	1.66
125% RDF	35889	63968	28080	1.78
C. D. (P=0.05)	-	2948	2948	0.08

Economic analysis

Perusal of the data from Table 4 reveal that among cultivars, maximum gross returns, net returns and BC ratio (₹ 66439, ₹30938 and 1.87 respectively) were recorded in SHH 1513 followed by SH 1514. Among fertilizer levels, maximum gross returns, net returns and BC ratio (₹63968, ₹28080 and 1.78, respectively) were recorded with 125 % RDF.

CONCLUSION

Among cultivars, highest green fodder, dry matter, crude protein and digestible dry matter yields (531.5, 137.0, 14.24 and 74.71 q/ha, respectively) were recorded in SHH 1513 which were on a par with SH 1514 and SPH 1890. Cultivars SHH 1513 and SH 1514 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 these cultivars are equally good in other quality parameters like digestible dry matter yield, crude protein yield, crude protein content and IVDMD. Among fertilizer levels, significantly highest green fodder, dry matter, crude protein and digestible dry matter yields were recorded with 125% RDF. In crux, the test cultivars SHH 1513, SH 1514 and SPH 1890 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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REFERENCES

Anonymous. 2017 : Package of Practices for *kharif* crops of Haryana, Directorate of Extension Education, CCS HAU, Hisar, pp. 171-176.

AOAC. 1995: Association of Official Analytical Chemists, 16th edn. Official Methods of Analysis, Arlington, USA, ID No. 984.13.

Aziz-Abdel, T. K. and M. A. S. Abdel-Gwad, 2008 : Yield and quality of tunis grass as affected by plant height at cutting and N fertilizer. *Animal Agric. Sci.*, (Cairo), **53** : 157-169.

Anonymous, 2020 : 20th Livestock Census – 2019 All India Report. Department of Fisheries, Animal Husbandry & Dairying, Department of Animal Husbandry & Dairying, Statistics Division, Krishi Bhawan, New Delhi. http://dadf.gov.in/sites/default/filess/20th%20Livestock%20census-2019%20All%20India%20Report.pdf.

Barnes, R. F., L. D. Muller, L. F. Bauman, and V. F. Colenbrander, 1971 : *In vitro* dry matter disappearance of brown midrib mutants of maize (*Zea mays* L.). *J. Anim. Sci*., **33** : 881-884.

Devi, S., Satpal, H. S. Talwar, Ramprakash and V. Goyal, 2018 : Performance of sorghum [Sorghum bicolor (L.) Moench] under salt stress. *Forage Res.,* **44** : 209-212.

Hanuman, S., S. Pushpendra and H. K. Sumeriya, 2008 : Effect of fertility levels on fodder yield and HCN content of fodder sorghum genotypes. *Int. J. Trop. Agric*., **26** : 417-420.

Hogg, P. G. and H. L. Ahlgren, 1942 : A rapid method of determining hydrocyanic acid content of single plant of sudan grass. *J. Am. Soc. Agron*., **43** : 199-200.

Joshi, U. N., Arora, R. N., Phogat, D. S., Jhorar, B. S., Avtar R., and R. S. Sheoran, 2009 : Current status of crude protein and in vitro dry matter digestibility in forage crops. In : Emerging Trends in Forage Res. & Livestock production (eds. S. K. Pahuja, U. N. Joshi, B. S. Jhorar and R. S. Sheoran) published by Indian Society of Forage Research, Hisar, India. pp. 146-153.

Karthika, N. and R. Kalpana, 2017 : HCN Content and Forage Yield of Multi-Cut Forage Sorghum under Different Organic Manures and Nitrogen Levels. *Chem. Sci. Rev. Lett*., **6** : 1659-1663.

Khatri, A., I. A. Khan, S. H. Siddiqui, M. Ahmed and K. A. Saddiqui, 1997: *In vitro* culture of indigenous and exerted banana clones for maximizing multiplication. *Pakistan J. Bot*., **29** : 143-150.

Meena, A. K., Singh, P. and Kanwar, P. 2012. Effect of nitrogen levels on yield and quality of sorghum (*Sorghum bicolor* L.) genotypes. *Forage Res*., 37 : 238-240.

Satpal, J. Tokas, K. K. Bhardwaj, S. Devi, P. Kumari, S. Arya, Neelam and Suresh Kumar, 2019 : Evaluation of forage sorghum genotypes for production, productivity and quality at different fertilizer levels. *Forage Res*., **45** : 64-68.

Satpal, J. Tokas, Anil Kumar and S. Ravi Kumar, 2018 : Potential productivity and radiation use efficiency of multi-cut forage sorghum [*Sorghum bicolor* (L.) Moench] genotypes. *Journal of Agrometeorology*, **20** (Special issue) : 364-367.

Satpal, B. S. Duhan, S. Arya, Pummy Kumari and S. Devi. 2016 : Performance of single cut forage sorghum genotypes to different fertility levels. *Forage Res*., **42** : 184-188.

Sheoran, O. P., D. S. Tonk, L. S. Kaushik, R. C. Hasija and R. S. Pannu, 1998 : Statistical Software Package for Agricultural Research Workers. Recent Advances in information theory, Statistics & Computer Applications by D.S. Hooda & R.C. Hasija, Department of Mathematics Statistics, CCS HAU, Hisar (139-143).

Sunil Kumar, R. K. Agrawal, A. K. Dixit, A. K. Rai and S. K. Rai, 2012 : Forage Crops and their Management. Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh, India. pp. 3-3.