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NUTRIENT MANAGEMENT IMPACTS ON GRAIN AND STOVER QUALITY AND NUTRIENT UPTAKE OF SORGHUM [*SORGHUM BICOLOR* (L.) MOENCH] CULTIVARS UNDER RAINFED SITUATION

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SUMMARY

A field investigation was carried out during *Kharif* 2018, at the Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur to study the nutrient management impacts on grain and stover quality and nutrient uptake of sorghum cultivars under rainfed situation. The experiment comprised of three fertilizer application levels (75, 100 and 125% RDF) and nine genotypes (SPH 1820, SPH 1849, CSH 25, CSH 30, SPV 2433, SPV 2437, SPV 2438, CSV 27 and CSV 31), replicated thrice in a factorial randomized block design. Results revealed that fertilization with 125% RDF improved the protein content, protein yield in grain and stover as well as stover quality over 75% RDF and 100% RDF applications. The N, P_2O_5 and K_2O uptake was higher by 18.14, 14.57 and 12.93 % with application of 125% RDF over 100% RDF respectively. Among the genotypes, SPH 1849 was superior in terms of protein content, grain protein yield and stover quality (acid detergent fibre and neutral detergent fibre) than other genotypes. The genotype CSH 25 recorded higher stover protein yield, along with nitrogen and phosphorus uptakes, whereas largest potassium accumulation in straw was observed in SPV 2438 genotype.

Key words : Sorghum stover, nutrient management, protein content, NDF, ADF, genotype, uptake

Livestock is an important component of various farming systems of India and have significant contribution in food and nutritional security, rural economy and livelihoods. During 2019-20 the gross value addition from livestock to total and agriculture sector was 4.35 and 29.34%, respectively (Anonymous 2021a). The livestock productivity in India is very less, which can be attributed to poor feed and fodder availability. India needs to feed 512 million livestock population, which is largest in the world, from its 2.4% of geographical area creating pressure on land and water resources. However, only 4.4% of the net cultivated area is under fodder cultivation in the country (Kumar and Chaplot, 2020). There lies a net deficit of green fodder (35.6%), dry fodder (10.95%) and concentrated feeds (44%) (IGFRI Vision-2050). By 2050 this deficit is expected to increase continuously to the tune of 1012 mt green fodder and 631 mt dry fodder (Ghosh *et al.*, 2016). Due to unavailability of adequate amount of green fodder the livestock are fed with straws, husks and stovers. Furthermore, increased population growth coupled with rapid urbanization necessitates proper residue management to fulfil livestock demands and increasing their production (Katoch *et al.*, 2017). In India about 500 mt crop residues are produced annually, of which stover is 15% (Bhuvaneshwari *et al.*, 2019). This stover could be utilized for feeding the livestock though these have low nutritive value.

Sorghum, popularly known as "Jowar" in India, is a cross pollinated crop with C_4 mechanism of photosynthesis. It is used as an important food, feed and fodder for human, poultry and cattle, respectively. It is an important food crop in semi-arid tropical regions of India where mixed cropping and livestock farming systems are predominant. Both grain and stover are important to farmers as the stover is utilized as fodder for livestock. The sorghum stover has the potential to fulfil the dry fodder demand. However, the nutritive value of sorghum stover is low. This is mainly due to limited adoption of improved varieties by the farmers as well as lack of proper knowledge about the quantity of fertilizer to be applied. Improved genotypes are the basis of higher quality grain and stover production and their response to different nutrient management options is of utmost importance to realise their yield potential. So, it is necessary to assess the performance of different sorghum genotypes with different fertility levels under rainfed environment to find out suitable genotype with better grain and stover quality to be recommended to the farmers.

MATERIALS AND METHODS

A field experiment was carried out at the Agronomy Research Farm, Rajasthan College of Agriculture, Udaipur (582.17 m above mean sea level and at 24° 35' N latitude and 73° 42' E longitude) during *Kharif*, 2018 to study the nutrient management impacts on grain and stover quality and nutrient uptake of sorghum cultivars under rainfed situation. The soil of the experimental field was clay loam in texture, moderately alkaline in reaction (8.1 pH), medium in organic matter content (0.71 %), low in available nitrogen (249.2 kg/ha), medium in available phosphorus (21.6 kg/ha) and high in available potassium (378.7 kg/ha) with an electrical conductivity of 0.76 dS/m. During the crop growing season, the range of the minimum and maximum temperature were from 12.1 to 25.5°C and 24.0 to 35.6°C, respectively. Whereas, the morning and evening relative humidity ranged from 16 to 100 per cent and 46 to 100 per cent, respectively. Total rainfall received during crop growing season was 455.6 mm.

The experiment comprised of 27 treatment combinations including three fertility levels (75, 100 and 125 % of recommended dose of fertilizer: RDF) and nine genotypes (SPH 1820, SPH 1849, CSH 25, CSH 30, SPV 2433, SPV 2437, SPV 2438, CSV 27 and CSV 31) laid out in a factorial randomized block design, replicated thrice. Sorghum genotypes were sown using a seed rate of 10 kg ha^{-1} in a row maintaining a row to row spacing of 45 cm. Thinning was done around 15 days after sowing to bring the plant to plant spacing to 15 cm. The recommended dose of fertilizer (RDF) was 80 kg N, 40 kg P_2O_5 and 40 kg K_2O. The entire amount of phosphorous and potassium along with 1/3rd of nitrogen dose was applied as basal. Phosphorous was supplied through DAP (di-ammonium phosphate), potassium was supplied through MOP (muriate of potash) and nitrogen was supplied through urea after subtracting the amount of nitrogen added through DAP from the required amount of nitrogen to be applied to the crop. The remaining dose of nitrogen was applied in two splits (1/3rd N in each split) by top dressing through urea at 35 and 47 DAS.

To determine the soluble protein content in grain the method proposed by Lowry *et al.* (1951) was followed. Crude protein content in stover was computed following standard AOAC (2000) method. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were estimated by sequential procedure of Van Soest *et al.* (1991) using fibre analyser (Fibra Plus FES 6, Pelican, Chennai, India). Nutrient uptake by grain and stover were computed using the following formula:

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content in grain/straw} \times \text{grain/stover yield (kg/ha)}}{100}$$

Statistical analysis was carried out using MS Excel 2016.

RESULTS AND DISCUSSION

Quality parameters of grain and stover

Increased application of fertilizers brought about significant variation in protein content of grain and stover and also protein yields. Significantly higher protein content in grain (10.44%) and stover (3.29%) and protein yield from grain (427.43 kg/ha) and stover (362.52 kg/ha) were recorded with application of 125% RDF over application of 75% RDF and 100% RDF (Table 1). These higher values may be attributed to higher nitrogen contents in grain and stover owing to improvement in plant available nitrogen in soil with application of increased level of fertilizers. Similar findings were also reported by Sujathamma *et al.* (2015). However, higher neutral detergent fibre (NDF) (73.24%) and acid detergent fibre (ADF) (52.19%) contents were registered with application of 75% RDF than that of 100% RDF and 125% RDF (Table 1). Since, higher crude protein and lower NDF and ADF values are indications of good quality fodder, it is obvious that good quality stover is obtained with 125% RDF application.

An examination of data (Table 1) reveals that the grain protein content (10.32%), grain protein yield (501.81 kg/ha) and stover protein content (3.19%) were higher in the genotype SPH 1849 over rest of the genotypes under study, whereas the significantly higher stover protein yield (333.62) was recorded in CSH 25. The higher values in SPH 1849 might be attributed to its high potential in nitrogen uptake from soil as protein is the function of nitrogen content in plant tissues. It was at par with CSH 25, CSH 30 and SPH 1820 in grain protein content, with CSH 25 in grain protein yield and with CSH 25 and SPH 1820 in terms of stover protein content. At par stover protein yield with CSH 25 was recorded in SPV 2437 and SPV 2438. The higher NDF (72.12%) and ADF (52.90%) values were found in the genotype SPV 2438. Similar values of NDF with SPV 2438 were recorded in CSV 31, CSV 27, SPV 2433 and CSH 25 and that of ADF were recorded in CSV 31, CSV 27 and SPV 2437. The genotype SPH 1849 recorded the lowest NDF (68.57%) and ADF (48.99%) values, representing its suitability as a good quality stover over rest of the genotypes.

The interaction effect of fertilizer levels and genotypes was found significant in case of grain and stover protein contents. CSH 30 with 125% RDF application recorded higher grain protein content (11.31%), whereas SPH 1849 with 125% RDF application recorded significantly higher protein content in stover.

Nutrient uptake by grain and stover

Significant improvements in nutrient uptakes by grain and stover and hence total uptake were observed with increase in fertility level (Table 3). Application of 125 per cent RDF recorded significantly higher total N, P and K uptakes by the sorghum crop (126.90, 38.12 and 258.36 kg/ha, respectively) over 75 and 100 per cent RDF. The N uptake with application of 125 per cent RDF was to the tune of 18.14 and 41.80 per cent over 100 and 75 per cent RDF, respectively. Similarly, the P uptake with this fertility level was higher by 14.34 and 39.48 per cent and K uptake was higher by 12.89 and 30.06 per cent than that of 100 and 75 per cent RDF, respectively. Increased grain and stover yields and nutrient (N, P and K) contents in plant were the reason for this increased nutrient uptake due to increase in fertility level. Higher concentration of nutrients in plant available form in the plant root zone caused higher N, P and K extraction resulting greater uptake of nutrients. Similar findings were also reported by Sujathamma *et al*. (2015).

TABLE 1

Effect of nutrient management on grain and stover quality of sorghum cultivars

Treatments	Grain		Stover			
	Protein content (%)	Protein yield (kg/ha)	Protein content (%)	Protein yield (kg/ha)	NDF (%)	ADF (%)
Fertility levels						
75 % RDF	9.48	324.45	2.37	227.25	73.24	52.19
100 % RDF	9.97	381.80	2.73	283.74	70.63	50.71
125 % RDF	10.44	427.43	3.29	362.52	68.32	48.80
SEm±	0.07	8.74	0.02	7.16	0.46	0.44
CD (P= 0.05)	0.21	24.82	0.06	20.33	1.31	1.24
Genotypes						
SPH 1820	10.02	440.18	3.09	276.10	69.66	49.21
SPH 1849	10.32	501.81	3.19	295.40	68.57	48.99
CSH 25	10.17	477.34	3.11	333.62	69.05	49.15
CSH 30	10.13	407.79	2.92	261.50	70.38	50.28
SPV 2433	9.78	338.39	2.52	285.75	72.01	51.30
SPV 2437	9.88	362.14	2.62	314.64	71.23	50.81
SPV 2438	9.76	210.34	2.48	312.22	72.12	52.90
CSV 27	9.85	264.86	2.63	272.48	71.68	51.15
CSV 31	9.75	398.20	2.63	268.82	71.88	51.30
SEm±	0.13	15.15	0.04	12.41	0.80	0.75
CD (P= 0.05)	0.37	42.98	0.10	35.21	2.28	2.14

TABLE 2
Interaction effect of nutrient management and sorghum cultivars on protein content

Treatments	Grain protein (%)			Stover protein (%)		
Genotypes	75% RDF	100% RDF	125% RDF	75% RDF	100% RDF	125% RDF
Fertility levels						
SPH 1820	9.40	9.58	11.07	2.59	2.91	3.76
SPH 1849	9.59	10.08	11.30	2.76	3.02	3.80
CSH 25	9.52	9.86	11.13	2.68	2.95	3.70
CSH 30	9.35	9.72	11.31	2.48	2.73	3.55
SPV 2433	9.60	9.82	9.92	2.07	2.61	2.86
SPV 2437	9.61	10.12	9.91	2.10	2.62	3.14
SPV 2438	9.48	10.10	9.69	2.02	2.63	2.79
CSV 27	9.47	10.22	9.85	2.37	2.47	3.05
CSV 31	9.32	10.19	9.73	2.29	2.59	3.00
SEm±		0.22			0.06	
CD (P= 0.05)		0.63			0.18	

Sorghum genotypes recorded different nutrient uptakes. The highest total N and P uptakes were recorded in CSH 25 (130.80 and 37.29 kg/ha) which was significantly higher over rest of the genotypes except SPH 1849 in terms of N uptake and SPH 1849 and SPV 2437 in terms of P uptake. Whereas genotype SPV 2438 recorded the highest K uptake (254.96 kg/ha) which was significantly higher than that of CSH 30, CSV 31, SPH 1820, CSV 27, SPH 1849 and SPV 2433 and was at par with that of SPV 2437 and CSH 25. The nutrient accumulation in plants is influenced by sorghum genotypes due to variation in rate of absorption, translocation and assimilation of nutrients in their tissues. Further, nutrient uptake by the crop is the multiplication of nutrient concentration and yield. Hence nutrient uptake by plants is directly proportional to both yield and nutrient content. The variation in nutrient uptakes by different genotypes was because of their different yield and nutrient concentration in the plant which were the resultant of their varied genetic combination. Genetic variability in sorghum with respect to N, P and K uptakes has also

TABLE 3
Effect of nutrient management on nutrient uptake by sorghum cultivars

Treatments	Nutrient uptake (kg/ha)								
	Nitrogen			Phosphorous			Potassium		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
Fertility levels									
75 % RDF	53.13	36.36	89.49	9.00	18.32	27.33	15.24	183.40	198.64
100 % RDF	62.01	45.40	107.41	10.69	22.64	33.34	17.68	211.17	228.85
125 % RDF	68.89	58.00	126.90	11.71	26.41	38.12	20.26	238.10	258.36
SEm±	1.41	1.15	1.77	0.26	0.61	0.66	0.38	4.91	4.94
CD (P= 0.05)	3.99	3.25	5.02	0.73	1.73	1.87	1.08	13.94	14.01
Genotypes									
SPH 1820	72.20	44.18	116.38	12.43	20.15	32.58	22.20	190.26	212.45
SPH 1849	81.50	47.26	128.76	13.95	21.61	35.56	24.90	202.90	227.81
CSH 25	77.42	53.38	130.80	13.32	23.97	37.29	23.63	230.30	253.93
CSH 30	66.11	41.84	107.95	11.15	19.24	30.39	20.31	185.73	206.04
SPV 2433	54.73	45.72	100.45	9.46	23.40	32.86	14.78	215.55	230.33
SPV 2437	58.44	50.34	108.78	9.98	25.01	34.99	15.62	231.08	246.69
SPV 2438	34.03	49.96	83.98	5.76	26.01	31.78	8.96	246.00	254.96
CSV 27	43.03	43.60	86.63	7.22	21.51	28.73	11.54	202.23	213.77
CSV 31	64.63	43.01	107.65	10.96	21.24	32.20	17.61	193.93	211.53
SEm±	2.44	1.98	3.06	0.45	1.06	1.14	0.66	8.51	8.55
CD (P= 0.05)	6.92	5.63	8.70	1.27	3.00	3.23	1.86	24.14	24.26

been reported by Sujathamma *et al*. (2015) and Panwar *et al.* (2017).

CONCLUSION

The sorghum stover is a potential alternative to bridge the deficit of dry fodder in the country. From the study, it can be concluded that the sorghum cultivar SPH 1849 when cultivated with 125% RDF application will provide better stover quality and thus, can be recommended to the farmers in the rainfed regions.

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