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Impact Evaluation of Genotypes and Fertility Levels on Quality Traits, Nutrient Uptake, Yield and Economics of Single-Cut Fodder Sorghum [*Sorghum bicolor* (L.) Moench]

Gaurav Singh Gurjar[1], Ram Swaroop Choudhary[1]*, Gajanand Jat[2] and Roshan Choudhary[1]

[1]Dept. of Agronomy, [2]Dept. of Soil Science and Agricultural Chemistry, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture & Technology, Udaipur, Rajasthan (313 001), India

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Corresponding Author

Ram Swaroop Choudhary

e-mail: agroudr2013@gmail.com

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Abstract

An experimentwas carried out at Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture & Technology, Udaipur (Rajasthan), India during July to September in *Kharif,* 2018 on sandy clay loam soil to evaluate the effect of genotypes and fertility levels on single-cut fodder sorghum with three objectives to select suitable single-cut fodder sorghum genotype, to workout optimum fertility levels and to arrive at economically viable treatment. Fifteen treatment combinations consisted of five genotypes i.e. SPV 2296, SPV 2316, SPV 2445, CSV 21F and CSV 30F with three fertility level i.e. 75, 100 and 125% RDF (100% RDF equals to 80 kg N+40 kg P_2O_5+40 kg K_2O ha^{-1}) were laid out in Factorial RBD and replicated thrice. Results indicated that among the single-cut fodder sorghum genotypes, SPV 2445 of performed better in respect to HCN % (0.0250 at 30 DAS & 0.0164 at harvest), chlorophyll at 50% flowering (1.99 mg g^{-1} fresh wt.), quality traits % (crude protein 7.07, crude fibre 30.01, ether extract 1.72, mineral ash 6.75), while maximum nitrogen free extract % (56.97) and total digestible nutrient % (56.27) were recorded with genotype SPV2296. Simultaneously, nutrient content and uptake, fodder yield (green 57.34 t $ha^{-1}$and dry 14.22 t ha^{-1}) and net return (₹ 58375 ha^{-1}) were also proved significantly superior with genotypes, SPV 2445 than other genotypes. The crop fertilized with 125% RDF performed better in respect to all the quality traits, nutrient (content & uptake), yield and economics.

Keywords: Genotypes, fertility, quality traits, fodder yield, economics

1. Introduction

India is the largest livestock economy as it supports 512.05 million of livestock animals which is almost 17 per cent of world's livestock population (Anonymous, 2014). According to the 19th Livestock Census, India has vast resource of livestock comprising about 300 million bovines, 65.1 million sheep, 135.2 million goats and 10.3 million pigs. Livestock farming in India is part of a composite farming system characterized by crop-livestock interactions (Economic Survey, 2018-19). The livestock sector contributes Rs. 975739 crore to the annual revenue i. e. 9.3 per cent of total gross value added to agricultural sector (Anonymous, 2017). Grazing pastures are the major source of livestock feeding because forages are the major as well as important content of animal feed and the backbone of livestock industry. There is tremendous pressure of

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livestock on available total feed and fodder, as land available for fodder production has been decreasing. At present, the country faces a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients. To meet the current level of livestock production and its annual growth in population, the deficit in all components of fodder, dry crop residues and feed has to be met either from increasing productivity, utilizing untapped feed resources, increasing land area (may not possible due to human pressure for food crops) or through imports (IGFRI, 2013). The fodder supply situation in India is extremely precarious and the gap is very wide. Hence, all efforts should be focused for achieving higher fodder yield.

Sorghum [*Sorghum bicolor* (L) Moench] is the fifth most important cereal after rice, wheat, maize, and barley. It constitutes the main food grain for over 750 million people who live in the semi-arid tropics of Africa, Asia, and Latin America. The largest group of producers are small-scale subsistence farmers with minimal access to production inputs such as fertilizer(s), pesticides, improved seeds (hybrids or varieties), good soil and water and improved credit facilities for their purchase. (Anonymous, 1999). As sorghum can perform the best at higher temperature and dry land ecologies, it serves as to provide substantial amount of fodder of outstanding quality during summer season. It produce a tonnage of dry matter having digestible nutrients (50 %), crude protein (8 %), fat (2.5 %) and nitrogen free extracts (45 %) (Azam et al., 2010). However, sorghum fodder is poor in quality due to low protein content and presence of hydrocyanic acid (Hingra et al., 1995). It is, therefore, imperative to improve the quality and quantity of sorghum fodder. Mixed cropping especially with forage legumes can improve both the forage yield and quality, as legumes are a good source of protein (Moreira, 1989). In India, the area under sorghum is approximately 5.65 million hectare with annual production of 4.41 million tonnes and average production of 780 kg ha^{-1} (Anonymous, 2017). It is an important crop of Rajasthan with its cultivation in 0.63 million hectares having production of 0.34 million tonnes along with 545 kg ha^{-1} productivity (Anonymous, 2017). Ramanjaneyulu et al., (2012) observed that the fodder yield of sorghum with recommended dose of fertilizers (RDF, 60 kg N + 12.9 kg P ha-1) and half RDF + biofertilizers on fresh as well as dry weight basis was statistically similar and superior to half RDF and control. Sorghum is known as the king of millets and fourth important crop in the country after rice, wheat and maize. Introduction of multi-cut sorghum hybrids, single-cut and dual-purpose sorghum which can be grown for quality green fodder production in most of the states of India is helping to sustain livestock fodder security. In India, there is a short supply of about 38 per cent green fodder, especially during summer season. Sorghum is an important crop widely grown for grain and forage. It is fast growing, palatable, nutritious and utilized as silage and hay besides fresh feeding (Mal et al., 2006). Being an exhaustive crop, yield and quality of sorghum fodder suffers heavily if proper amount of fertilizer is not applied (Rana et al., 2013). In fact, the contribution of feed and fodder is upto 50% towards livestock productivity and production. So; it is rational to evaluate the relative performance of single-cut fodder sorghum genotypes in conjunction with various fertility levels. As a result of crop improvement programme, a number of promising strains of plants with diversified morphological and quality traits are available for general cultivation (Hussain et al., 1995). The changes in genetic material of crops resulted wide variations in the morphological and forage quality traits (Bukhsh et. al., 2010 and Ullah et al., 2007). Reducing plant densities and N fertilizer rates may affect yield and nutritive value of forage sorghum and corn when grown in limited irrigation situations (Marsalis et al., 2009). Keeping this in view, the field investigation was carried out to find out suitable single-cut sorghum genotype for maximumquality fodder production and its balance nutrient requirement.

2. Materials and Methods

Field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur (Rajasthan), Indiaat an altitude of 582.17 meter above mean sea level and at 24°35' N latitude and 73°42' E longitude during July to September in *Kharif,* 2018. The physio-chemical properties of experimental soil was sandy clay loam in texture, moderately alkaline (pH 8.1), low in available nitrogen (247.2 kg ha^{-1}), medium in phosphorus (20.8 kg ha^{-1}), high in available potassium (375.9 kg ha^{-1}) and medium in organic carbon content (0.69%).The research trial was framed with 15 treatment combinations having five single-cut fodder sorghum genotypes (SPV 2296, SPV 2316, SPV 2445, CSV 21F and CSV 30F) and three fertility levels i.e. 75, 100 and 125% of RDF (100% RDF equals to 80 kg N+40 kg P_2O_5+40 kg K_2O ha^{-1}). Statistically experiment was replicated thrice in Factorial Randomized Block Design. As per treatment, full dose of phosphorus and potassium and half dose of nitrogen were applied at the time of sowing. Remaining ¼ dose of nitrogen was top dressed at crop 35 days after sowing (DAS) and ¼ dose of nitrogen was top dressed at crop 45 DAS. The cropwas sown on 5th July, 2018 in opened furrows with crop geometry of 25 x 10 cm with 25 kg/ha seed rate. Other agronomic and plant protection measures were adopted as and when need arises. Being a fodder crop, sorghum was harvested at 50 per cent flowering stage. In order to statistical analysis of the data registered during the period of investigation was carried out through adoption of appropriate method of analysis of variance as described by Fisher (1950). Computation of critical difference was done to compare the treatments, wherever the F test was found significant at 5% level of significance.

3. Results and Discussion

3.1. Genotypes

The data in Table 1 indicated that the HCN content was

Table 1: Effect of single-cut fodder sorghum genotypes and fertility levels on HCN, chlorophyll and fodder quality traits

Treatments	HCN (%)		Chlorophyll at 50% flowering (mg g^{-1} fr. wt.)	Fodder quality traits (%)					
	30 DAS	At harvest		Crude protein	Crude fibre	Ether extract	Mineral ash	Nitrogen free extract	Total digestible nutrient
Genotypes									
SPV-2296	0.0275	0.0178	1.82	6.77	29.65	1.64	6.62	56.97	56.27
SPV-2316	0.0273	0.0173	1.88	6.85	29.72	1.65	6.63	56.75	56.25
SPV-2445	0.0250	0.0164	1.99	7.07	30.01	1.72	6.75	56.12	56.19
CSV-21F	0.0263	0.0172	1.89	6.89	29.83	1.66	6.64	56.64	56.26
CSV-30F	0.0261	0.0165	1.94	6.98	29.97	1.68	6.70	56.30	56.20
SEm±	0.0006	0.0004	0.03	0.05	0.09	0.02	0.03	0.16	0.02
CD (*p*= 0.05)	0.0018	0.0010	0.08	0.16	0.26	0.05	0.08	0.45	0.06
Fertility levels									
75 % RDF	0.0274	0.0178	1.68	6.47	29.03	1.58	6.36	58.15	56.44
100 % RDF	0.0267	0.0174	1.99	7.07	30.15	1.70	6.80	55.95	56.17
125 % RDF	0.0251	0.0161	2.04	7.19	30.33	1.73	6.85	55.57	56.10
SEm±	0.0005	0.0003	0.02	0.04	0.07	0.01	0.02	0.12	0.02
CD (*p*= 0.05)	0.0014	0.0008	0.06	0.12	0.20	0.03	0.07	0.35	0.05

*RDF: 80 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1}

significantly affected with genotypes where minimum HCN content (0.025%) in green fodder was recorded by genotype SVP 2445 at 30 DAS which proved significantly lower than all other genotypes wherein, maximum HCN content (0.0275%) was elucidated with genotype SPV 2296, which was significantly higher over genotype SPV 2445, but found statistically at par with the genotypes SPV 2316, CSV 21F and CSV 30F. Further, statistical analysis showed thatgenotype SPV 2296 registered significantly higher HCN content (0.0178%) at harvest as compared to rest of genotypes, whereas, genotypes SPV 2316 and CSV 21F proved statistically at par in HCN content and genotypes SPV 2445 and CSV 30F recorded significantly lower HCN content then SPV 2296 at harvest.The variation in HCN content of sorghum genotypes may be due to genetic makeup of various sorghum cultivars and climatic condition prevailing during the successive crop growth period which might be influenced the enzymatic activity. Initial stage of crop growth has maximum HCN content, but it reduced significantly with increase in crop duration upto harvest. Similar finding was also reported by Satpal et al. (2015) and Himani et al. (2017). Data explicate that genotype SPV 2445 recorded significantly higher chlorophyll content in leaves (1.99 mg g^{-1}) over rest of genotypes but it was found at par with the genotypes CSV30F (1.94 mg g^{-1}).Genotype SPV 2445 observed higher crude protein (7.07), crude fibre content (30.01), maximum ether extract (1.72), higher mineral ash content (6.75) whereasfound at par with SPV 30F in all respect over rest of genotypes.It is apparent from the data that the genotype SPV 2296 recorded maximum nitrogen free extract (56.97) i.e. proved significantly higher over SPV 2445 (56.12) and CSV 30F (56.30), but it was registered at par with genotypes SPV 2316 (56.75) and CSV 21F (56.30). The data further indicate that the genotype SPV 2296 registered maximum total digestible nutrient content (56.27%) *fb* CSV 21F and SPV 2316, but significantly higher over rest of genotypes. It was assumed that the nutritional values of the fodder crop influenced with the genotypes. The results of investigation strongly supported by the findings of Himani et al. (2017).

An assessment of data presented in Table 2 showed that the maximum N content (1.13%), P content (0.227%)and K content (1.230%) were recorded in genotype SPV 2445, which proved significantly superior over SPV 2296, SPV 2316 and CSV 21F but it was found at par with CSV 30F. The improvement in nutrient status of plant parts under genotype SPV 2445 might be due to their genetic makeup. Results indicated that the highest N uptake (161.07 kg ha^{-1}), P uptake (32.20 kg ha^{-1}) and K uptake (174.08 kg ha^{-1}) were recorded in the genotype SPV 2445, which was significantly higher over all the rest of genotypes. It is well established fact that nutrient uptake by the crop is largely depends on growth and development of crop. Hence, nutrient uptake by plants is directly proportional to both yield and nutrient content in plants dry fodder. Thus, improvement in both these might be due to genotype SPV 2445 that resulted

Table 2: Effect of single-cut fodder sorghum genotypes and fertility levels on nutrient (content & uptake), fodder yield and net return

Treatments	Content (%)			Uptake (kg ha^{-1})			Fodder yield (t ha^{-1})		Net return (ha^{-1})
	N	P	K	N	P	K	Green	Dry	
Genotypes									
SPV-2296	1.09	0.210	1.185	122.42	23.54	133.19	48.68	11.21	46251
SPV-2316	1.09	0.216	1.200	131.20	25.83	143.51	49.73	11.94	47727
SPV-2445	1.13	0.227	1.230	161.07	32.20	174.80	57.34	14.22	58375
CSV-21F	1.10	0.216	1.199	146.44	28.76	158.83	51.08	13.20	49622
CSV-30F	1.12	0.220	1.211	153.99	30.08	166.75	54.07	13.76	53797
SEm±	0.01	0.003	0.010	2.08	0.63	2.74	1.55	0.20	2164
CD (p= 0.05)	0.02	0.010	0.029	6.04	1.83	7.94	4.48	0.57	6270
Fertility levels									
75 % RDF	1.03	0.205	1.188	115.89	22.92	133.08	47.93	11.16	46256
100 % RDF	1.13	0.223	1.204	154.28	30.35	163.43	52.82	13.56	52058
125 % RDF	1.15	0.225	1.223	158.91	30.98	169.74	55.78	13.87	55150
SEm±	0.01	0.003	0.008	1.61	0.49	2.12	1.20	0.15	1677
CD (p= 0.05)	0.02	0.008	0.023	4.68	1.42	6.15	3.47	0.45	4857

*RDF: 80 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1}

in higher uptake of N, P and K by dry fodder. These results are corroborated with the finding of Kumar and Chaplot (2015). The genotype SPV2445 recorded higher green (57.34 t ha^{-1}) and dry (14.22 t ha^{-1}) fodder yields, which was significantly higher over rest of the genotypes under test but statically found at par with the genotype CSV 30F (54.07 t ha^{-1} & 13.76 t ha^{-1}). The higher fodder yield of genotype SPV 2445 could mainly be attributed to comparatively higher plant height, leaf to stem ratio, number of leaves and stem girth of genotype. Similar finding was also reported by Meena et al. (2017). Data further elucidated that genotypes significantly influenced the net return and registered maximum net return with genotype SPV 2445 (₹ 58375), which proved significantly higher over rest of genotypes, however it was at par with genotype CSV 30F (₹ 53797). Different genotypes have their potential to produced crop yield resulting in different net return as reported by Kumar and Chaplot (2015) and Meena et al. (2017).

3.2. *Fertility levels*

It is evident from the Table 1 that fertility levels had significant effect on HCN content at 30 DAS and at harvest. Maximum HCN content at 30 DAS and at harvest (0.0274& 0.0178%) was recorded with application of 75% RDF, however it was found statistically at par with 100% RDF (0.0267 and 0.174%) but significantly superior over 125 per cent RDF (0.0251 and 0.0161%), respectively. The site of dhurin synthesis shift from leaves to stem during plant development. In combination, the results demonstrate that dhurin content (HCN) in sorghum is largely determined by transcriptional regulation of the biosynthetic enzymes. These results confirm the earlier finding of Hanuman et. al. (2008). The data indicate that maximum chlorophyll content in leaves (2.04 mg g^{-1}) was registered with the application of 125% RDF (2.04 mg g^{-1}), which was significantly higher over 75% RDF, but found at par with the application of 100 per cent RDF (1.99 mg g^{-1}). Data further illustrate that the application of 125 per cent RDF registered significantly higher crude protein content (7.19), fibre content (30.33), higher ether extract content (1.73), maximum mineral ash (6.85%) over 75% RDF, but it was found statistically similar with 100 per cent RDF. Data further elucidate that crop fertilized with 75% RDF recorded maximum nitrogen free extract (58.15) and total digestible nutrient (56.44%) which was significantly higher over 125 per cent RDF and 100 per cent RDF. According to our findings, results were consistent with the results of Azam et al. (2010).

Data in Table 2 exhibited that application of 125% RDF registered maximum N content (1.15%), P content (0.225%) and K content (1.223%) whichwere proved significantly higher over 75 per cent RDF however, it was found statistically at par with 100 per cent RDF The noticeable improvement of N content in vegetative parts seems to be on account of its greater availability in plant rhizosphere and translocation to plant system. Further, it has been reported that shoot and root growth mutually inherent with each other. Thus, enhancement in photosynthetic efficiency of plants as proved from higher dry matter accumulation by above ground parts might have supplied sufficient metabolites for root proliferation and its functional activity. This might be the cause of greater extraction of other nutrients like P and

K resulting in improvement in their status. Perusal of data indicated that maximum N uptake (158.91 kg ha^{-1}), P uptake (30.98 kg ha^{-1}) and K uptake (169.74 kg ha^{-1}) were recorded with the application of 125% RDF which proved higher over 75% RDF, but it was found statistically at par with 100% RDF. It is well established fact that total uptake of nitrogen, phosphorus and potassium by the crop is primarily governed by total dry matter production and secondarily on nutrient status at cellular level. Thus, impact of N, P and K fertilizer ultimately led to higher accumulation of nutrients by plant parts along with total uptake by the crop. These results are close conformity with the finding of Sher et al. (2012). The maximum green (55.78 t ha^{-1}) and dry (13.87 t ha^{-1}) fodder yield were observed by the conjoint application of 125 per cent RDF which was significantly higher over 75% RDF but resulted at par with 100% RDF. Increasing rates of fertilizer application significantly enhance green and dry fodder yield which might be due to fact that all these nutrients were involved in increasing protoplasmic constituents, root and shoot growth thereby accelerating process of cell division, enlargement and elongation which in turn showed luxuriant vegetative growth and resulted in higher green and dry fodder yield. These results are in close agreement with the finding of Satpal et al. (2016), Yadav et al. (2016) and Meena et al. (2017). An examination of data indicated that higher net return was recorded with application of 125% RDF (₹ 55150) i.e. proved 19.23% higher over 75% RDF, but it was found statistically at par with 100 per cent RDF (₹ 52058).Since, green fodder yield increased with increase in fertility levels in proportion to cost of cultivation. Similar observation was also recorded by Meena et al. (2017).

4. Conclusion

Single-cut fodder sorghum genotype SPV 2445 fertilized with 125% recommended dose of fertilizer proved statistically better in HCN%, chlorophyll content, quality traits, nutrient (content & uptake) and yield (green & dry fodder) as well as found economically profitable with respect to net returns.

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