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PERFORMANCE OF SINGLE CUT FORAGE SORGHUM [*SORGHUM BICOLOR* (L.) MOENCH] GENOTYPES UNDER GRADED LEVELS OF NPK FERTILIZERS

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SUMMARY

Field experiment was made to assess the impact four graded levels of recommended fertilizer doses (RDF 0, 50, 100 and 150% with 75.0-13.2-24.9 kg N-P-K/ha as RDF) on fodder productivity, quality and economics of six single cut forage sorghum [*Sorghum bicolor* (L.) Moench] genotypes (SPV 2584, SPV 2587, SPV 2593, CSV 21F, CSV 30F and SH 1519) at Hisar (Haryana), India during *kharif* season of 2020 using Split plot design with two replications. Results revealed that 'SPV 2584' 'SPV 2593' and 'SH 1519' with identical green and dry fodder yields *i.e.* 51.74 and 12.75 t/ha (mean) have excelled both checks CSV 21F and CSV 30F by 8 & 8 and 11 & 13 per cent, respectively and are promising from crude protein, digestible dry matter yield and net income wise also. Check cultivar "CSV 30F' that fared very badly for both fodder quality and net income generation point of view; however, was most efficient from dry fodder yields/ kg N-P-K uptake. CSV 21F has lowest HCN content (54 µg/g) while SPV 2584, the highest (89.8 µg/g). High fodder producing genotypes (SPV 2584, SPV 2593 and SH 1519) are more depletive of soil nutrients. Among RDF levels, significant improvement was seen in leaf area index values only with 150% RDF application over RDF and thus RDF was best for realizing the fodder yield and also for economics. Fertilizers (RDF) have contributed to 20.2, 40.3 and 49.9% green, dry fodder yield and net income enhancements at the test site as compared to 0% RDF *i.e.* unfertilized control (42.26, 8.26 t/ha and ₹ 19,528). Inherent soil fertility (0% RDF) has contributed to 105.3-9.94-92.0 kg/ha N-P-K uptake of forage sorghum crop producing highest dry fodder/kg NPK uptake (78.4-831.0-89.8 kg fodder / kg N-P-K) and uptake got 2.08-2.88-1.89 times more with RDF use. Application of 150% RDF has not only reduced the soil NP uptake over RDF but also produced highest dry fodder/kg NPK application (61.8-458.0-78.1 kg fodder/kg N-P-K). HCN content increased from 60 to 96 µg/g as RDF increased from 0 to 150% RDF. It is concluded that single cut forage sorghum genotypes SPV 2584, SPV 2593 and SH 1519 are promising and application of 100% RDF (75.0-13.2-24.9 kg/ha N-P-K) was recommended for higher fodder yield, quality and income.

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

Sorghum [*Sorghum bicolor* (L.) Moench] is the widely grown cereal forage crop of the country (2.6 m ha) and single cut sorghums account for 23.1% of this (PrabhakarBabu, 2018). Short duration (60 days) with its ability to produce high biomass (Satpal *et al.,* 2020) under wide edapho-climatic situations across the country including Andaman & Nicobar Islands (Gangaiah and Kundu, 2020) and saline conditions (Devi *et al.,* 2021) during *kharif* season. Efforts are being made to improve not only the fodder productivity but also its quality under All India Coordinated Sorghum Improvement Project (AICSIP) continuously. For this, promising new genotypes of breeding program (AVT-II) are tested for agronomic performance also against the check cultivars (CSV 21 F and CSV 30F). High productivity of forage sorghums results in removal of huge quantity of primary nutrients (NPK) that is evident from the fact

that a silage producing sorghum crop was estimated to remove 13-4.6-15 kg N-P_2O_5-K_2O per tonne of biomass produced (Nathan *et al.,* 2020). Such high nutrient removal by fodder crops calls for adequate supply both through native soil fertility and fertilizer and manure application. Indian soils are already deficit in primary nutrients. Data of 500 districts (Muralidharudu *et al.,* 2011) indicated that 51 & 40% and 9 & 42% district are low & medium for available P and K, respectively. This fertility is further declining under intensive cultivation. These declines in macronutrient availability coupled with declines in soil organic matter and degradation in physical soil structure in the Indo-Gangetic Plains is leading to crop yield declines (Bhandari *et al.,* 2002). In Haryana, the situation is still precarious as 99, 24.8 and 10% of the 1.4 million soil samples analyzed for soil health card purpose, are very low for available N, P and K while 31.7 and 19.0% of samples are low for available P and K. Thus 99-56.5-29% samples are deficit for soil fertility and can't support high levels of production without fertilizers. In this context, there is need to revise recommended fertilization schedules to various crops keeping in view the increasing crop requirements and depleting soil supplies and reduced fertilizer use. Selection of high yielding but low fertilizer requiring crop cultivars also needs due attention. It is in this context the present study was made to assess the response of new single-cut forage sorghum genotypes (including the checks) to graded levels of primary nutrients (NPK) fertilization.

MATERIALS AND METHODS

A field experiment was conducted during rainy (*kharif*) season of 2020 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. A rainfall of 225.3 mm was received during crop duration. Weekly weather parameters *i.e.* temperature (°C), relative humidity (%) and rainfall (mm) during the crop duration are given Fig 1. The experimental sandy loam soil samples drawn from plough layer at the start of study with pH 7.7 was

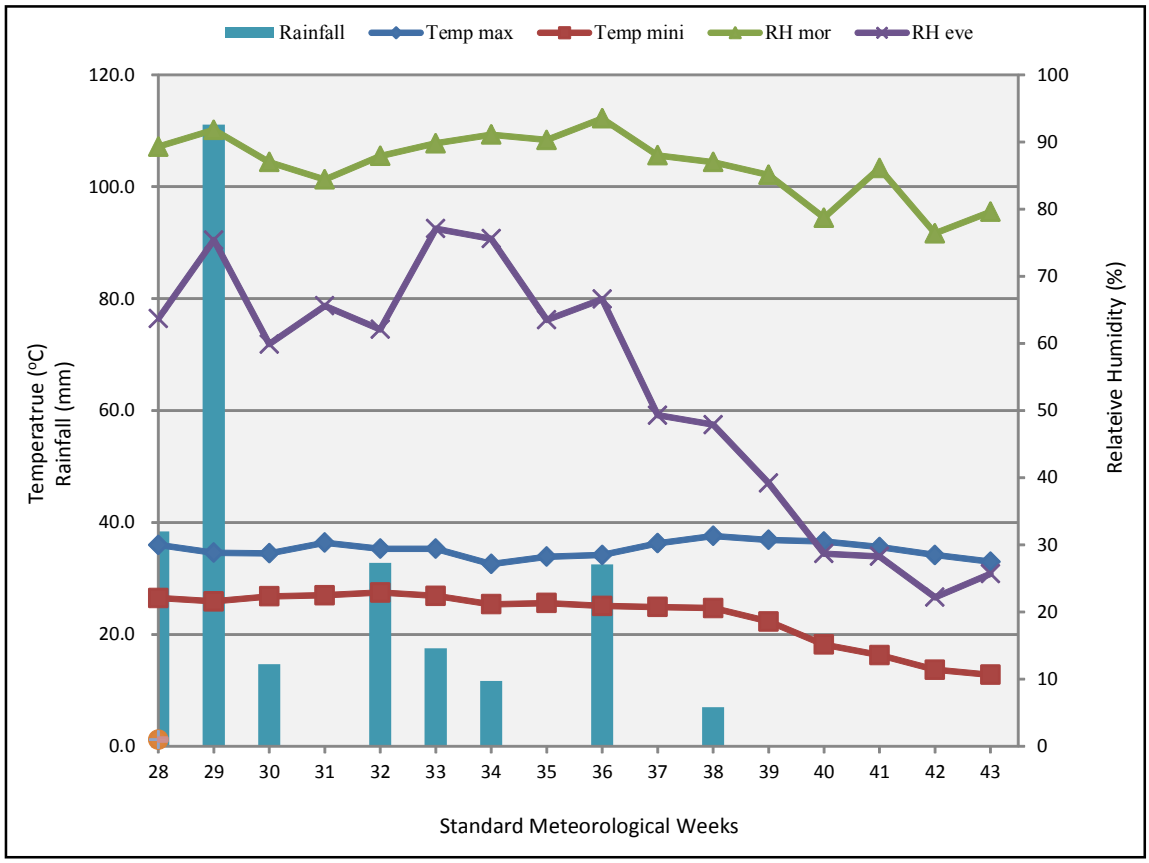

Fig. 1. Weekly weather data during the crop period kharif 2020.

rated as low for organic carbon (0.48%), available N (166.5 kg/ha), and medium for available P and K (12.5 and 266.4 kg/ha). Twenty-four treatments formed by combination of six single-cut forage sorghum genotypes (SPV 2584, SPV 2587, SPV 2593, CSV 21F, CSV 30F and SH 1519) and four recommended dose of fertilizer (RDF, 75-16.7-20.3 kg/ha N-P-K) levels (control, 50 % RDF 75% RDF, 100% RDF and 150% RDF) were evaluated in split plot design with two replications, keeping RDF levels in main plot and genotypes in sub plot. Entire P and K along with $^{2}/_{3}$ N was applied basal at the time of sowing in last ploughing and remaining N was top dressed at 30 days after sowing (DAS). Crop was sown manually on July 18, 2020 in solid rows at 25 cm apart and were harvested at 50 per cent flowering stage. All the other package of practices for *kharif* crops of CCS Haryana Agricultural University, Hisar, were followed for forage sorghum culture (Anonymous, 2017). 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 estimated as per Hogg and Ahlgren (1942). Nitrogen content (AOAC, 1995) and in vitro dry matter digestibility (IVDMD) (Barnes *et al.,*1971) were estimated for 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. Crude protein and digestible dry matter yield (t/ha) were calculated by multiplication of CPC and IVDMD with dry matter yield (t/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) reveals significant differences in days to 50% flowering (DFF). None of the single cut forage sorghum (SCFS) genotypes have at par DFF as early check CSV-21F (82.1 days) while SPV 2587 and SPV 2593 have at par DFF as late check CSV 30F (96.3) and SPV-2584 and SH-1519 being at par with each other, stood in between two checks for DFF (>CSV-21F and < CSV 30F). Plant height and leaf area index (LAI) of all SCFS genotypes were identical with the exception that SH 1519 (252.6 cm) being at a par with SPV 2584 and CSV 30F have markedly taller plants than other three genotypes while SPV 2593 (5.53) being at par with SPV 2584 have

TABLE 1
Performance of single cut sorghum genotypes to different fertilizer levels

Treatments	Days to 50% flowering	Plant height (cm)	LS ratio	Leaf area index	Green fodder yield (t/ha)	Dry fodder yield (t/ha)	Per day productivity of GFY (kg/ha)	Per day productivity of GFY (kg/ha)
Fertilizer level (F)								
0% RDF	88.9	213.5	0.26	3.02	42.26	8.26	477.5	93.2
50% RDF	89.9	234.4	0.29	4.90	49.40	12.00	551.7	134.2
100% RDF	90.3	248.2	0.30	6.28	52.96	13.83	589.1	153.9
150% RDF	90.8	253.2	0.32	6.66	54.21	14.46	599.8	160.1
CD (P=0.05)	1.2	18.12	0.03	0.29	1.57	1.04	13.2	12.8
Genotype (G)								
SPV 2584	86.1	239.2	0.32	5.39	52.23	12.87	606.0	148.9
SPV 2587	94.5	230.6	0.28	5.18	48.32	11.50	511.0	121.5
SPV 2593	94.8	227.9	0.33	5.53	51.59	12.58	544.5	132.7
CSV 21F (early check)	82.1	234.7	0.26	5.12	48.10	11.81	585.5	143.7
CSV 30F (late check)	96.3	239.0	0.27	5.00	46.61	11.27	484.1	117.0
SH 1519	86.3	252.6	0.29	5.06	51.39	12.80	596.1	148.3
CD (P=0.05)	1.8	15.17	0.01	0.26	3.22	0.99	40.9	11.8
Factor G at same level of F								
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Factor F at same level of G								
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
CV%	1.85	6.09	-	4.78	6.56	7.91	7.03	8.32

excelled other 3 genotypes for LAI values. For leaf: stem (LS) ratio too, SPV 2593 (0.33) superseded all other genotypes except SPV 2584 (0.32). Both green and dry fodder yields of SPV-2584 and SH-1519 were markedly higher than both the checks while SPV-2593 showed its superiority over checks for GFY only and SPV-2587 has at par GFY and DFY as the checks. Tall stature of plants (SH-1519) and high LAI and LS values of SPV-2584 and SPV-2593 are the reasons for their yield superiority. Poor performance of both the checks and SPV-2587 was ascribed to low LAI and LS values. Per day green and dry fodder productivity too, CSV-30F and SPV-2587 fared badly with the at par and least values. However, none of the genotypes could fare better than CSV-21F though SPV-2584 and SH-1519 have at par values. Superior per day productivity of CSV-21F was ascribed to its shortest duration (82.1 days). Despite of best fodder yields, SPV-2584 and SH-1519 stood at par with CSV-21F owing to their longer duration for flowering / harvest stage (94.8 & 86.3 days). The differential values of SCFS genotypes could be ascribed to their genetic makeup (Meena *et al*., 2012).

Quality parameters data was presented in Table 2. Genotypes differed for HCN contents and they remained below critical limit (200 µg/g at 30 days). CSV-21F has the least HCN content, while SH-1519 and SPV-2593 (<78 µg/g) and SPV-2587, CSV-30F and SPV-2584 (>85 to <90 µg/g) stood at a high and very levels of HCN. Yield superiority of SPV 2593 and SPV 2584 continued for crude protein (CP) content, CP yield, *In-vitro* dry matter digestibility (IVDMD, %) and digestible dry matter yield (DDMY) also over all other genotypes. *In-vitro* dry matter digestibility was markedly lower in SH 1519 (being at par with CSV 30F) than other four genotypes. However, on account of higher fodder yield despite of lower CP (%) and IVDMD (%), SH 1519 reached at par CPY and DDMY as SPV 2593 and SPV 2584. For quality traits, CSV 21F fared poor among all genotypes.

Recommended Dose of Fertilizers (RDF)

Perusal of the data of fertilizer levels (Table 1) shows that except leaf area index, no other growth parameter and thus productivity were improved significantly due to enhanced fertilizer levels over RDF. On the contrary, reduction in RDF to 50% and to 0% RDF (un-fertilized control) proved detrimental to crop growth and yields as well. Unfertilized crop was markedly quicker to reach 50% flowering stage and has leaf production as evident from markedly lower LS ratio than 50% RDF and RDF. However, for plant height and LAI both 0 and 50% RDF could bring marked reductions in their values over their respective

TABLE 2
Quality of single cut sorghum genotypes to different fertilizer levels

Treatments	HCN (µg/g) on fresh wt. basis	Crude protein (%)	IVDMD (%)	Crude protein yield (t/ha)	Digestible dry matter yield (t/ha)
Fertilizer Level (F)					
0% RDF	60.00	7.95	49.18	0.66	4.07
50% RDF	75.80	9.04	51.95	1.09	6.24
100% RDF	82.20	9.91	53.88	1.38	7.45
150% RDF	96.03	10.08	54.09	1.46	7.82
CD (P=0.05)	3.08	0.18	2.34	0.08	0.78
Genotype (G)					
SPV 2584	89.79	9.56	52.58	1.25	6.82
SPV 2587	85.68	9.17	52.35	1.07	6.05
SPV 2593	77.84	9.66	53.38	1.24	6.77
CSV 21F	53.99	9.11	52.71	1.09	6.26
CSV 30F	86.54	8.95	51.63	1.02	5.85
SH 1519	77.22	9.02	50.99	1.20	6.61
CD (P=0.05)	3.65	0.30	1.34	0.11	0.49
Factor G at same level of F					
CD (P=0.05)	7.64	NS	NS	NS	NS
Factor F at same level of G					
CD (P=0.05)	7.27	NS	NS	NS	NS
CV%	4.42	3.08	2.44	10.01	7.17

TABLE 3
Interaction effect of fertilizer levels and genotypes on HCN content

	SPV 2584	SPV 2587	SPV 2593	CSV 21F	CSV 30F	SH 1519	Mean of fertilizer levels
0% RDF	67.59	67.91	53.62	44.15	66.38	60.35	60.00
50% RDF	87.52	90.54	80.52	51.60	74.01	70.61	75.80
100% RDF	94.54	86.57	83.51	54.45	90.76	83.41	82.20
150% RDF	109.51	97.71	93.73	65.77	115.01	94.49	96.03
Mean of genotypes	89.79	85.68	77.84	53.99	86.54	77.22	

succeeding level of RDF i.e. 50%RDF and RDF. Green fodder and dry matter yields realized with RDF use (52.96 and 13.83 t/ha) were reduced by 6.7 and 13.2% with 50% RDF that got further reduced by 14.5 and 31.2% with 0% RDF as compared to 50% RDF. Thus the data infers that fertilizers (RDF) have contributed to 20.2 and 40.3% of green and dry fodder yields realized at the test site. Yield reduction reported in this study due to reduced RDF are close to those reported Satpal *et al*. (2020).

Fodder quality was markedly impacted by fertilizers (Table 2). Enhanced RDF (150% RDF) has brought significant increases in HCN contents (96.03 µg/g). On positive side, 150%RDF could bring marked increases in crude protein yield and over RDF. However, a reduction from RDF has proved quality inhibitive. Crude protein content, crude protein yield, IVDMD and DDMY got significantly reduced with 0 and 50% RDF over 50% RDF and RDF, respectively and the only exception is the reduction in IVDMD with 50%RDF over RDF was not significant. The decrease in CP and IVDMD content with increase in fertilizers levels were ascribed to decreases in L:S ratio. Similar impacts of N fertilization on crude protein and IVDMD were reported by Joshi *et al*. (2009). HCN content also got decreased markedly with reduced RDF from RDF to 0% RDF. Enhanced HCN contents of forage sorghum due to higher levels of fertilizers of the present study were corroborated by findings of Khatri *et al*. (1997) and Aziz-Abdel and Abdel-Gwad (2008).

TABLE 4
Nutrient content in dry fodder and nutrient uptake of single-cut sorghum genotypes as influenced by different fertilizer levels

Treatments	Nutrient content (%)			Nutrient uptake (kg/ha)			Nutrient balance (Uptake-Application)*		
	N	P	K	N	P	K	N	P	K
Fertilizer level (F)									
0% RDF	1.27	0.169	1.11	105.3	9.9	92.0	-	-	-
50% RDF	1.45	0.120	1.19	174.0	20.4	143.3	136.5	13.8	130.9
100% RDF	1.59	0.206	1.26	219.4	28.6	173.6	144.4	15.4	148.7
150% RDF	1.61	0.218	1.28	233.8	31.6	185.2	121.3	11.8	147.9
CD (P=0.05)	0.03	0.009	0.03	11.44	2.34	14.37	-	-	-
Genotype (G)									
SPV 2584	1.53	0.186	1.23	200.4	25.0	159.1	144.2	15.1	140.4
SPV 2587	1.47	0.171	1.20	170.9	20.4	138.8	114.7	10.5	120.1
SPV 2593	1.55	0.190	1.23	197.9	24.9	156.0	141.7	15.0	137.3
CSV 21F	1.46	0.174	1.19	174.7	21.3	142.3	118.5	11.4	123.6
CSV 30F	1.43	0.166	1.19	163.7	19.3	135.5	107.5	9.4	116.8
SH 1519	1.44	0.181	1.22	191.3	24.8	159.5	135.1	14.9	140.8
CD (P=0.05)	0.05	0.012	0.03	18.20	2.74	12.35	-	-	-
G at same level of F									
CD (P=0.05)	NS	NS	NS	NS	NS	NS	-	-	-
F at same level of G									
CD (P=0.05)	NS	NS	NS	NS	NS	NS	-	-	-
CV%	3.02	-	2.61	9.46	11.52	7.92	-	-	-

*Mean N-P-K applied for genotypes: 56.3-9.9-18.7 kg/ha.

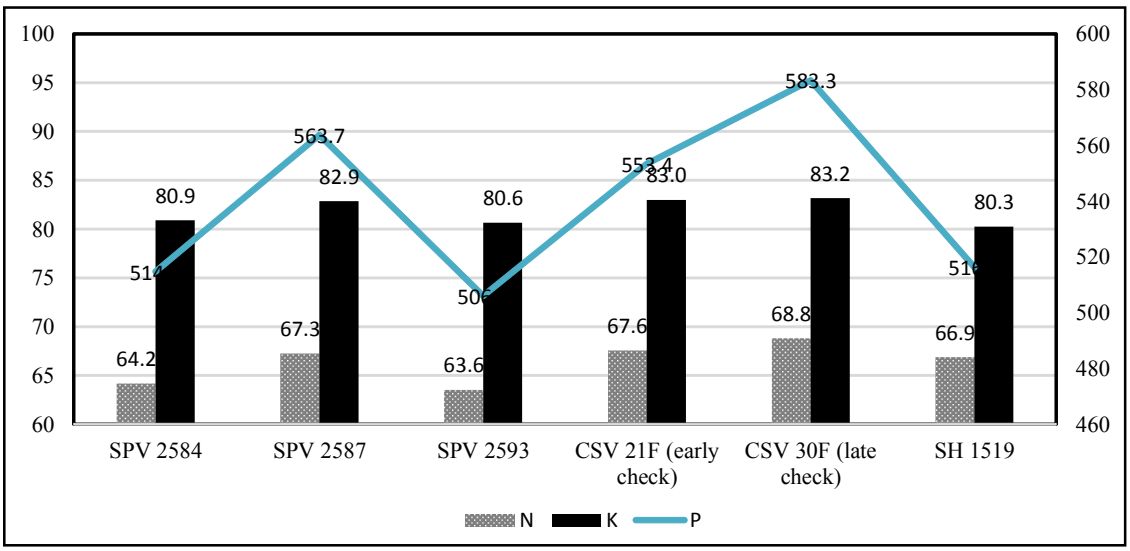

Fig. 2. Dry fodder yields/kg nutrient uptake.

Nutrient content, uptake and apparent soil depletion

Perusal of the nutrient content data (Table 4) shows that SPV 2593, SPV 2584 has more N, P and K content (SH 1519 higher PK contents) in their biomass and thus has significantly higher uptakes than CSV 30F, CSV 21 and SPV 2587. Nutrient concentration (NP) in fodder and their uptake were significantly increased with 150% RDF over RDF. Reduced fertilizer level impacts were more discernible than that of enhanced RDFs on NPK nutrient content and uptake. Inherent soil fertility has contributed to 105.3-9.94-90.2 kg/ha N-P-K uptake and application of RDF has resulted in 2.08-2.88-1.89 times more N-P-K uptake. Application of 150% and 50% RDF have enhanced the NPK uptake by 6.6-10.4-6.7% and reduced by 20.7-28.8-17.5 over RDF. At RDF, 63.0-483.6-79.7 kg dry fodder was produced /kg N-P-K uptake. More fodder is produced per kg N-P-K uptake at 50% RDF (69.0-589.7-83.7) while less with 150% RDF (61.8-458.0-78.1). Lower fodder production per kg nutrient uptake at 150% RDF indicates their luxury consumption as the fodder yield increases were insignificant. On native soil fertility highest dry fodder is produced / unit NPK uptake (78.4-831.0-89.8 kg fodder / kg N-P-K). Mean data of genotypes (Fig. 2) shows that 66.4-539.6-81.8 kg dry fodder is produced per kg N-P-K uptake. Fodder sorghum CSV 30F (check) proves to be most efficient while SPV-2593 the inefficient from their highest and lowest dry fodder yields/ kg N-P-K uptake. Apparent nutrient balance (Uptake-application through fertilizers) indicates that 150% RDF has reduced the N and P depletion of soil over RDF while CSV 30F, SPV 2587 and CSV 21F are less depletive of soil nutrients than other three genotypes.

TABLE 5
Economics of single cut sorghum genotypes as influenced by different fertilizer levels

Treatments	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit :cost (BC ratio)
Fertilizer Level (F)				
0% RDF	33569	52827	19258	1.57
50% RDF	35448	61750	26302	1.73
100% RDF	36969	66201	29233	1.79
150% RDF	38493	67758	29266	1.76
CD (P=0.05)	-		1962	0.05
Genotype (G)				
SPV 2584	36119	65292	29172	1.81
SPV 2587	36119	60396	24277	1.67
SPV 2593	36119	64490	28370	1.78
CSV 21F	36119	60127	24008	1.66
CSV 30F	36119	58261	22141	1.61
SH 1519	36119	64240	28120	1.77
CD (P=0.05)	-		4029	0.11

ECONOMICS

Perusal of the data (Table 5) of net returns and BC ratio shows that SPV 2584, SPV 2593 and SH-1519 are equally promising while CSV-30F (being at par with CSV-21F and SPV-2587) is least promising. Among fertilizer levels, recommended dose of fertilizers (RDF) is the best for net returns (₹ 29, 233) and benefit cost ratio (1.79).

CONCLUSION

It is concluded from the study that single cut forage sorghum genotypes, SPV-2584, SPV-2593 and SH-1519 are promising from fodder, crude protein, digestible dry matter yields and economics point of view over the checks (CSV-21F and CSV-30F). However, for per day productivity, CSV 21F proved as equally promising as SPV 2584 and SH 1519. For dry fodder yields/ kg N-P-K uptake, CSV-30F was most efficient while SPV-2593 most inefficient. Among fertilizer levels, no significant gains in fodder yields and profits were seen due to 150% RDF application and thus RDF (75-16.7-20.3 kg/ha N-P-K) is the best.

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