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Enhancing root traits and quality of sorghum and guar through mixed cropping and nutrient management

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ABSTRACT

A field experiment was conducted at ICAR- National Dairy Research Institute, Karnal during 2018–19 to study the effect of mixed cropping and nutrient management on root traits, nutritional quality and yield of sorghum and guar fodder crops. Experiment was laid out in factorial randomized complete block design with four seed rate combinations in different ratios of sorghum and guar along with six nutrient management treatments in three replications. Results showed that the root traits, viz. root length, volume and dry weight were higher under mixed cropping in comparison to sole crops however the difference was not significant, whereas the significant difference were observed in root traits under different nutrient management practices. Statistically higher green fodder yield was reported under sole sorghum but it was at par with 75% sorghum + 25% guar. Nutritionally enriched fodder with higher macro and micronutrients was also obtained under 75% sorghum + 25% guar treatment. Under mixed cropping nutrient uptake and soil nutrient status at crop harvest were higher in comparison to sole crops. Results pertaining to nutrient management practices revealed that higher supply of nutrients under 100% RDF, 100% RDF +PGPR, 100% RDF +seaweed extract and 75% RDF +seaweed extract treatments helped the crops to take up more nutrients besides leaving substantial balance in the soil at harvest. It was concluded that 75% sorghum + 25% guar mixed cropping with 75% RDF + seaweed extract was best combination to get higher and nutritionally enriched fodder and enriched soil at harvest.

Key words: Fodder yield, Guar, Mixed cropping, Nutrient uptake, Sorghum

India is home for 535.8 million livestock population contributing to 187.7 million tonnes of milk production during 2018-19 (Basic Animal Husbandry Statistics 2019). Despite this highest population and milk production in world, the milk productivity of Indian cattle is lower than global average. One of the prime reason behind that is unavailability of quality feed in sufficient quantity (Hindoriya *et al*. 2019). Green fodders are mainly maintainer of animal health as they meet wholesome nutrient requirement of animals and thus proper selection of crops is important. Crops should be capable of supplying qualitative biomass as per need of the animal. Inclusion of protein rich leguminous crops with sorghum crop may improve the feed quality and subsequently the potential of animals (Sankaranarayanan 2005). In addition to the cereal-legume association may also be beneficial for improving the fertility status of the soil. Legumes as an intercrop also have a complimentary effect on cereals crops by fixing the atmospheric nitrogen for availability to the crop plants in the production system (Ram and Singh 2001). The enhancement in yield have been attributed most exclusively to the above-ground growth interactions between intercropped species such as greater sunlight interception or more efficient conversion of the intercepted radiation. However, the yield advantages of intercropping systems are due to both the above and below ground interactions between intercropped species (Li *et al.* 2006) due to efficient nutrient and water uptake, *etc.* For supplementing the biologically fixed nitrogen by legume crop in the cropping system along with fertilizers there is a need to explore newer organic sources like sea weed extract, plant growth promoting rhizobacteria (PGPR) etc. Limited studies had been carried out in intercropping and mixed cropping of cereal and legume crops especially incorporating guar with sorghum in the field of fodder production. Therefore, present research was undertaken to explore the effect of agronomic management practices like seed ratios and nutrient management in mixed cropping of sorghum with guar to increase the nutritional composition of fodder with higher production.

MATERIALS AND METHODS

A field experiment was conducted at Research Farm of ICAR-National Dairy Research Institute, Karnal (located at 29º45' N latitude, 76º58' E longitude) having sub-tropical

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climate to examine the influence of seed rate ratios and nutrient management in mixed cropping of sorghum and guar on the nutritional composition of fodder during *kharif* 2018. According to the average meteorological data of 2018 (August to September), the highest rainfall and relative humidity (25.89 mm and 95.57%) was recorded in 39th standard week (24–30 September), and there was no rainfall in 37th, 40th and 41st standard weeks during the crop period. The evaporation rate (5.77 mm/day) and maximum temperature (33.57°C) were highest in 31st standard week during the crop period. The soil of the experimental field was clay loam in texture, neutral to alkaline in reaction with low available nitrogen, medium organic carbon, available phosphorus and available potassium. The experiment was laid out in factorial randomized complete block design (FRBD) with four seed rate combinations in four ratios of sorghum and guar, viz. S_1: sole sorghum, S_2: sole guar, S_3: 75% sorghum + 25% guar and S_4: 60% sorghum + 40% guar along with six nutrient management practices, viz. N_1: 100% RDF, N_2:100% RDF + PGPR, N_3: 100% RDF + seaweed extract, N_4 :75% RDF + PGPR, N_5:75% RDF + seaweed extract and N_6: 50% RDF + PGPR + seaweed extract in three replications. Sorghum was seeded at 30 kg/ha and guar @ 40 kg/ ha. The recommended dose of fertilizers (RDF) was 60 kg N/ha, 40 kg P_2O_5/ha and 40 kg K_2O/ha for sorghum and 20 kg N/ha, 60 kg P_2O_5/ha and 40 kg K_2O/ ha for guar; and it was supplied through urea, DAP and MOP. Half dose of N and full dose of P_2O_5 and K_2O was applied as based and rest of half N was top dressed at 30 DAS. PGPR was used as seed treatment. 50 ml of its liquid culture diluted with 1 litre of water and used for seed required for one acre of land. As a source of seaweed extract, *Sagarika* (a commercial product) was used which was sprayed @ 1-2 ml/ l of water in early morning hours after the dew has evaporated. All recommended agronomic practices were followed during the cultivation of crops. Net plot area was harvested separately from each plot, weighed as kg/plot and then converted into q/ha to record the final green fodder yield. For root studies five plants from the net plot area were randomly uprooted and followed the standard procedure given by Schuurman and Goedewaagen (1965). The harvested plant samples were oven dried (70°C) and ground in a Wiley mill to pass through two mm sieve. The sieved samples were used for determining nitrogen (Jackson 1967), phosphorus (Olsen and Sommers 1982), potassium (Richards 1954), calcium (Hanlon 1998), magnesium (Hanlon 1998) and micronutrient concentration (Tandon 2001) by using appropriate instrument. Nitrogen, phosphorous and potassium in randomly collected soil samples (of 0-15 cm depth) was estimated by using alkaline permanganate (Subbiah and Asija 1956), sodium bicarbonate (Olsen *et al*. 1954) and ammonium acetate method (Stanford and English 1949), respectively. Data were processed in Microsoft excel 2010 and analyzed by using SPSS 19.0 Version. The least significant difference test was used to compare among different treatments at 5%

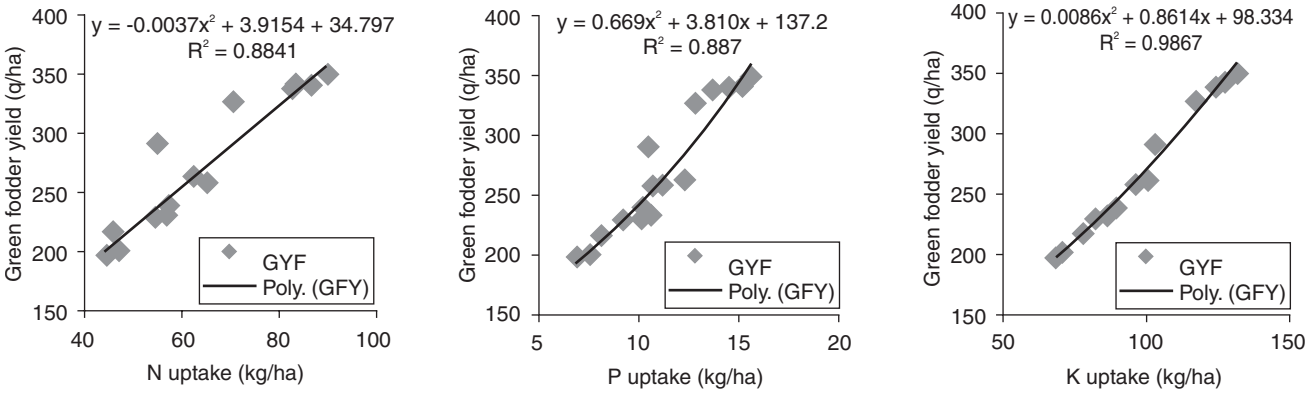

Fig 1 Relationship between nutrient uptake and green fodder yield of sorghum.

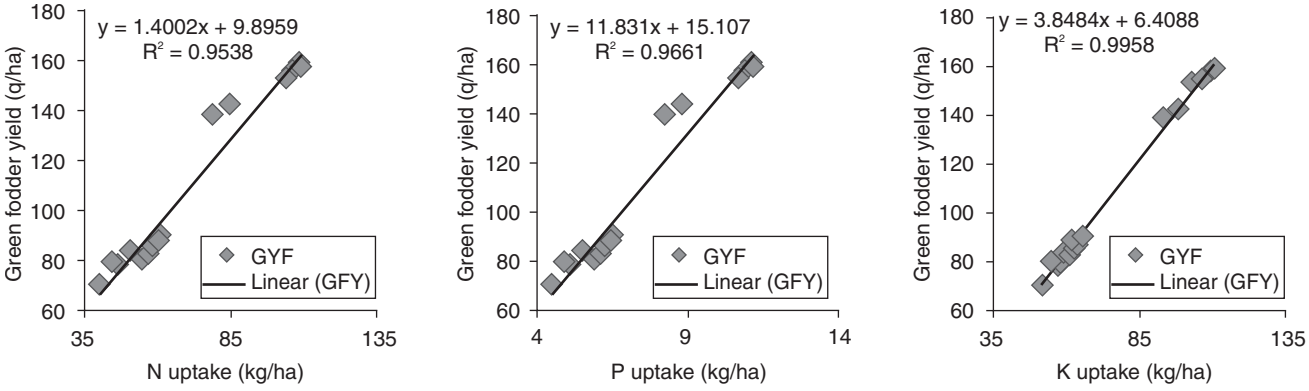

Fig 2 Relationship between nutrient uptake and green fodder yield of guar.

Table 1 Effect of seed rate in different seed ratio and nutrient management practices on growth, nutrient uptake, soil nutrient status after harvesting and yield of sorghum and guar crops

Treatment	Root length (cm)		Root volume (cm^3)		Root dry weight (g)		Shoot dry weight (g)		Total nutrient uptake (kg/ha)			Soil nutrient status (kg/ha)			Green fodder yield (q ha^{-1})		
	Sor.	Guar	Sor.	Guar	Sor.	Guar	Sor.	Guar	N	P	K	N	P	K	Sor.	Guar	Total
Seed rates																	
S_1	989.67	-	9.03	-	11.23	-	64.19	-	78.11	13.71	120.66	189.62	17.35	179.81	331.45	-	331.45
S_2	-	25.69	-	1.09	-	0.35	-	9.19	98.11	11.25	37.42	190.19	16.77	187.82	-	150.96	150.96
S_3	1031.18	25.91	9.92	1.19	11.90	0.35	50.48	8.94	111.62	16.21	111.49	177.10	15.45	174.02	247.98	80.83	328.81
S_4	996.75	25.66	9.60	1.08	11.38	0.34	44.46	8.80	109.02	15.46	101.12	176.97	15.06	175.79	222.55	87.24	309.79
SEm±	20.74	0.49	0.28	0.03	0.23	0.01	1.45	0.16	1.36	0.34	1.02	1.79	0.21	1.86	2.32	1.82	2.78
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	4.17	NS	3.87	0.97	2.90	5.09	0.59	5.30	6.66	5.24	7.90
Nutrient management practices																	
N_1	1041.18	26.64	10.99	1.15	11.99	0.36	58.95	9.24	107.15	15.42	98.32	187.18	14.84	179.59	278.92	109.51	291.32
N_2	1037.63	26.96	10.56	1.31	12.02	0.38	61.52	9.59	108.29	15.57	98.24	189.53	15.20	184.13	279.23	112.21	293.58
N_3	1049.25	26.85	11.51	1.26	12.35	0.37	61.85	9.58	109.08	16.11	100.13	188.29	14.78	183.71	281.97	111.48	295.09
N_4	947.41	23.88	7.29	0.92	10.73	0.31	40.51	8.39	88.57	12.83	85.79	177.40	17.16	176.47	252.82	101.47	265.71
N_5	1034.27	26.44	9.97	1.17	11.77	0.38	59.86	9.14	105.14	13.86	94.64	183.44	17.14	178.69	275.37	107.11	286.86
N_6	925.46	23.76	6.77	0.92	10.14	0.28	35.55	7.92	77.05	11.15	78.91	174.99	17.84	173.58	235.64	96.27	248.93
SEm±	29.34	0.69	0.39	0.05	0.33	0.01	2.05	0.23	1.67	0.42	1.25	2.19	0.25	2.28	3.28	2.58	3.40
LSD(P=0.05)	84.32	1.99	1.13	0.14	0.94	0.03	5.89	0.66	4.74	1.18	3.55	6.23	0.73	6.50	9.42	7.42	9.68

Sor., Sorghum; S_1: Sole Sorghum; S_2, Sole Guar; S^3,75% Sorghum + 25% Guar; S^4, 60% Sorghum + 40% Guar; N_1, 100% RDF; N_2, 100% RDF+PGPR; N_3, 100% RDF+Seaweed Extract; N_4,75% RDF+PGPR; N_5,75% RDF+Seaweed Extract; N_6, 50% RDF + PGPR + Seaweed Extract. Initial soil nutrient status for nitrogen, phosphorous and potassium was 200.31, 15.90 and 197.12 kg/ ha, respectively.

Table 2 Effect of seed rate in different seed ratio and nutrient management practices on nutrient content of sorghum and guar fodder

Treatment	N (%)		P (%)		K (%)		Ca (%)		Mg (%)		Fe (ppm)		Mn (ppm)		Cu (ppm)		Zn (ppm)	
	Sor.	Guar	Sor.	Guar	Sor.	Guar	Sor.	Guar	Sor.	Guar	Sor.	Guar	Sor.	Guar	Sor.	Guar	Sor.	Guar
Seed rates																		
S_1	1.12	-	0.20	-	1.73	-	0.40	-	0.20	-	363.3	-	74.6	-	12.4	-	41.1	-
S_2	-	3.06	-	0.35	-	1.17	-	0.70	-	0.33	-	417.2	-	53.4	-	16.3	-	60.1
S_3	1.14	3.05	0.20	0.32	1.76	1.15	0.41	0.67	0.22	0.32	369.5	411.1	74.7	52.9	12.6	15.7	41.1	58.9
S_4	1.12	3.05	0.19	0.34	1.71	1.13	0.40	0.69	0.21	0.33	367.2	413.5	76.6	51.0	12.5	16.2	40.7	59.6
SEm±	0.005	0.011	0.004	0.006	0.016	0.012	0.002	0.011	0.004	0.009	2.79	1.73	0.79	0.61	0.03	0.34	0.15	0.62
LSD (P=0.05)	0.014	NS	NS	0.018	NS	NS	0.005	NS	NS	NS	NS	NS	NS	1.76	0.07	NS	NS	NS
Nutrient management practices																		
N_1	1.17	3.22	0.22	0.35	1.78	1.18	0.42	0.72	0.22	0.34	416.7	423.1	81.3	52.8	14.2	16.8	44.2	62.1
N_2	1.18	3.23	0.20	0.37	1.77	1.19	0.42	0.74	0.22	0.36	410.7	427.1	81.7	55.1	13.7	17.4	44.5	63.1
N_3	1.18	3.23	0.22	0.37	1.80	1.18	0.42	0.73	0.22	0.35	418.3	428.9	82.1	54.9	13.9	17.9	44.5	64.3
N_4	1.08	2.79	0.18	0.33	1.68	1.13	0.40	0.68	0.20	0.32	319.7	398.4	73.8	51.6	11.4	14.7	38.9	57.3
N_5	1.17	3.22	0.20	0.32	1.74	1.14	0.4	0.68	0.21	0.32	409.0	422.2	79.0	51.3	11.9	16.6	38.5	58.6
N_6	0.98	2.62	0.17	0.30	1.65	1.09	0.38	0.55	0.19	0.30	225.7	383.8	53.9	48.7	9.8	12.9	35.2	51.9
SEm±	0.007	0.015	0.006	0.009	0.023	0.017	0.003	0.015	0.006	0.012	3.94	2.44	1.12	0.87	0.04	0.48	0.21	0.87
LSD (P=0.05)	0.020	0.043	0.017	0.026	0.067	0.049	0.007	0.043	0.018	0.036	11.34	7.02	3.20	2.49	0.10	1.37	0.62	2.51

level of significance (P<0.05).

RESULTS AND DISCUSSION

Yield attributes and yield: Different root parameters of sorghum and guar, viz. root length, root volume and root dry weight were not influenced significantly by the seed rate treatments however, higher growth were recorded by 75% sorghum + 25% guar treatment in both crops. Shoot dry weight was reported higher in case of sole crops but the influence was not significant for guar crop (Table 1). Green fodder yield of sole sorghum as well as guar depicted a decreasing trend with decreasing seed rate in the mixed cropping in comparison to their sole crops (Table 1). However, higher total green fodder yield was recorded with sole sorghum (331.45 q/ha) which was at par with seed rate in ratio of 75% sorghum + 25% guar (328.81 q/ha) cropping which might be due to the efficient utilization of all resources like water, space, nutrients and light and also complementary effect of legume on cereal fodder. While comparing the effect of nutrient management practices, higher root growth, shoot dry weight and green fodder yield was reported significantly superior under the application of 100% RDF + seaweed extract but were at par with 100% RDF + PGPR, 100% RDF and 75% RDF + seaweed extract in case of sorghum. However, in guar significantly higher growth and fodder yield was recorded under the application of 100% RDF + PGPR which was statistically at par with 100% RDF + seaweed extract, 100% RDF and 75% RDF + seaweed extract. Hence growth and green fodder yield followed the increasing trend with the increasing dose of RDF. Such results were reported due to the fact that higher supply of all nutrients (macro and micro) resulted in higher uptake which stimulated the rate of different yield contributing factors and thus green fodder yield (Fig 1, 2). Present findings are in line with that of Saritha *et al.* (2013), Kumar *et al.* (2015a), Sultana *et al.* (2016) and Ginwal *et al.* (2019).

Nutrient concentration: Higher nutrient concentrations, viz. nitrogen, phosphorous, potassium, calcium, magnesium, iron, manganese, copper and zinc in sorghum were reported under mixed cropping treatment, 75% sorghum + 25% guar whereas in guar higher values were recorded under sole guar. However, the influence was significant only for nitrogen, calcium and copper concentration in sorghum and phosphorous and manganese concentration in guar (Table 2). These results might be due to the fact that guar crop association enhanced availability of nutrients to sorghum whereas for guar vice versa results might be due to the competing ability of sorghum. With accretion in application dose of nutrients in integrated manner the nutrients concentration increased in sorghum and guar. Hence significantly higher content of nutrients in the dry matter was reported under 100% RDF + seaweed extract in sorghum and 100% RDF + PGPR in guar. However, values were at par with N_2 and N_3 in sorghum and N_1 and N_3 in guar and also closely related to or at par with N_5. Similar results were reported by Kumhar *et al.* (2013), Kumar *et al.* (2015b), Miri *et al.* (2016) and Tamta *et al.* (2019).

Nutrient uptake and soil nutrient status: Total nitrogen and phosphorous uptake was higher in mixed cropping treatments, viz. 75% sorghum + 25% guar and 60% sorghum + 40% guar (Table 1) but potassium uptake was maximum with sole sorghum, probably this might be due to more monovalent cation uptake capacity of sorghum with respect to guar crop. Higher the nutrient application rate in an integrated manner, higher will be the nutrient uptake in crops. Hence significantly higher N, P and K uptake was noticed in 100% RDF + seaweed extract treatment which was at par with 100% RDF + PGPR and 100% RDF over the treatments N_4, N_5 and N_6 for P and K but N_4 and N_6 for N. Results corroborate with earlier findings of Kumar *et al.* (2005) and Ginwal *et al.* (2019).

Significantly higher N and K content in soil was reported under sole guar but value for N was at par with sole sorghum whereas higher P content was reported under sole sorghum and was at par with sole guar (Table 1). So, the post-harvest status of nutrients in soil revealed that higher amount of nutrients were remained in soil after harvest of sole crop in comparison to mixed crop which might be due to the fact that mixed cropping treatments proved to be more exhaustive because of higher nutrient uptake by both crops in combination from soil nutrient pool. In comparison of nutrient management practices, it was noticed that application of 100% RDF + PGPR showed significantly higher available N and K status of soil after crop harvest, being statistically non-significant with N_3, N_1 and N_5 over rest of the treatments. Whereas higher available P was confirmed by employing the 50% RDF + PGPR + seaweed extract which remained at par with 75% RDF + PGPR and 75% RDF + seaweed extract as compared to all of the remaining treatments. Similar results were reported by Dutta *et al.* (2019), Hindoriya *et al*. (2019) and Tamta *et al.* (2019).

It was concluded that growing of 75% sorghum + 25% guar mixed cropping with 75% RDF + seaweed extract produced most nutritionally enriched fodder in highest quantity and enriched the soil. Besides, this combination was economically profitable also (Bhakar *et al.* 2020). Thus a portion of recommended dose of fertilizer could be substituted by organic sources of nutrients like PGPR and seaweed extract which had positive influence on root growth, yield and nutritional composition of both the fodder crops.

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