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Ensuring Nutritional Security of Animals by Mixed Cropping of Sorghum and Guar under Varying Nutrient Management

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ABSTRACT

An experiment was carried out to analyse productivity and quality of fodder sorghum and guar as influenced by nutrient management under mixed cropping and in *kharif* season of 2018 tested in factorial randomized complete block design with four seed rate combinations of sorghum and guar along with six nutrient management treatments in three replications. The productivity of crops was evaluated in terms of fodder yield and quality in form of dry matter, organic matter, ash, crude protein, ether extract, total carbohydrates, fibre fractions (NDF, ADF, ADL and hemicellulose), total digestible nutrients, dry matter intake and dry matter digestibility. Results revealed that total green fodder and dry matter yield was higher in sole sorghum but it was at par with 75% sorghum + 25% guar. Mixed cropping treatments performed better in comparison to sole crops for different quality parameters in both crops. Among nutrient management, treatments 100% RDF, 100% RDF+ PGPR and 100% RDF+ seaweed extract recorded higher fodder production as well as fodder quality in both crops which was not statistically different from75% RDF + seaweed extract treatment. The results revealed that seed rate of 75% sorghum + 25% guar in mixed cropping with the application of 75% RDF + seaweed extract produced higher quality fodder for animals.

Key words: Fodder yield and quality, Guar,, Mixed cropping, Nutrient management, Seed rate, Sorghum

INTRODUCTION

Agriculture and its allied sectors are the backbone of Indian economy. Farmers along with crop production follow livestock rearing practice as it provides employment to the farmer's family during lean periods and act as a buffer in case of crisis like crop failure, *etc.* India is a home for 535.78 million livestock (20th livestock census). Despite India's huge livestock production and its first rank in milk production, the productivity of Indian animals is too low (due to improper and inadequate nutrition, breeding and adaptability problem, *etc.*) and this factor increases the cost of milk production. The cost of feeding alone constitutes about 60-70% of the gross expenses of livestock production which is the most dominant reason behind the low productivity. The demand for feed is increasing with the growing livestock population and will extend till 1012 mt of green fodder and 631 mt of dry forage by the year 2050. With present rate of growth in forage resources, there will be 18.4 % deficit in green fodder and 13.2% deficit in dry fodder in the year 2050 (IGFRI Vision, 2050). Hence, to achieve the higher productivity there is a need to bridge the gap between demand and supply of feed resources for farm animals. Among different feeds, green forages are the most important as these show immediate result and supply all the essential nutrients including water to the animals. Animal may get green forage through forest, pasture or grazing land but the cultivated fodders are most important. Different fodder crops can be grown in *kharif* (sorghum, maize, cowpea, guar, *etc.*), *rabi* (berseem, lucerne, oats, chinese mustard, *etc.*) and *zaid* season to ensure the year round green fodder supply for the animals. Feeding cereals and grasses as sole may cause protein deficiency and a legume alone causes bloat in animals. So, feeding a mixture of cereals and legumes by growing them in mixed cropping may help to overcome the problem of protein deficiency as well as bloating to maintain better health and productivity of animals.

Mixed cropping is the sowing of two or more crops at a time span in the field without any definite row

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pattern and sowing is done after mixing the seeds in an optimum ratio. In mixed cropping selection of crops is most important. Sorghum (*Sorghum bicolor* L. Moench), annual cereal fodder crop occupying largest area among different fodder crops grown in India can be taken as a main crop in mixed cropping. It is used in the form of green fodder, hay and silage as the stalks are of sweet juicy nature and hence liked by the animals. It has around 28.1% DM, 8.2% CP, 57.9% NDF, 35% ADF, 3.3% lignin, 1.9% EE and 9.1% ash (feedipedia.org). To enrich the fodder with protein clusterbean (*Cyamopsis tetragonoloba L.*), an important short duration annual fodder legume herb (popularly known as Guar) can be selected as a component crop with sorghum in mixed cropping. Being a leguminous crop it improves the fertility status of soil by nitrogen fixation and reduces the nitrogen requirement of companion or succeeding crop in rotation. Guar fodder (on dry matter basis) contain 25.2% crude protein, 0.9% ether extract, 48.9% NDF, 33.3% ADF, 43.6% NFE, 16.5% ash and 1.8 M cal/kg ME (NDDB, 2012).

Quality or nutritional composition of the fodder crop directly depends upon the nutrient uptake by the fodder crop from soil. Hence, balanced nutrient management taking care of nutritional requirement of plant and animal is of utmost importance. Although incorporation of legume component in mixed cropping helps to achieve nutrient economy by its ability of fixing atmospheric nitrogen, but supplementation from external nutrient sources is required. Also the depleting soil fertility is demanding organic source of nutrients (Manures, Bio-fertilizers, seaweeds *etc.*) alongwith the chemical fertilizers due to their ability to sustain the soil physical and chemical properties. Knowing the need, the availability of new organic sources like seaweed and plant growth promoting rhizobacteria (PGPR) is increasing in the market but their role in fodder crop production in not yet tested. Seaweeds are the macroscopic multicellular marine alga (brown, red or green) often colonizing in the coastal parts of the world oceans and are rich source of mineral elements like N, P, K, Ca, Mg, Fe, Mn, Zn and Cu and also of many vitamins and enzymes. Plant growth promoting rhizobacteria are tailor made consortia which can be utilised to solubilise and mineralise the native pool of nutrients in soil. keeping all these in mind, the above field experiment was carried out to assess the nutritional quality of fodders grown under different nutrient management under mixed cropping of sorghum and guar in irrigated condition.

MATERIALS AND METHODS

The experiment was conducted at research farm of Agronomy Section, ICAR-National Dairy Research Institute, Karnal (during *kharif* season of 2018) located at 29º45' N latitude, 76º58' E longitude and at an altitude of 245 m above mean sea level (MSL). Having sub-tropical climate zone the place receives rainfall from both southwest and northeast monsoons and faces extremes of both high and low temperature. According to the average meteorological data of 2018 (August to September), the highest rainfall of 25.89 mm was recorded in 39th standard week (24thSeptember-30th September), and there was no rainfall in 37th, 40th and 41st standard weeks during the crop period. The highest and lowest relative humidity were recorded in 39th standard week (95.57%, 24th-30th September) and 42nd standard week (33.57%, 15th-21stOctober), respectively. The evaporation rate (5.77 mm/day) and maximum temperature (33.57ºC) 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 and low in available nitrogen, medium in organic carbon, available phosphorus and available potassium. The experiment was laid out in factorial randomized complete block design (FRBD) with four seed rate combinations of sorghum and guar (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 treatments (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. Seed rate used for sorghum was 30 kg ha^{-1} and guar was 40 kg ha^{-1}. RDF for sorghum and guar were 60 kg N ha^{-1},

20 kg N ha^{-1} (half dose as basal), 40 kg P_2O_5 ha^{-1}, 60 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} (full dose as basal) for sorghum and guar, respectively which were supplied though urea, DAP and MOP, respectively. PGPR liquid culture was used for seed treatment @ 50 ml diluted with 1 lit. water for application on seeds required for one acre of field. As a source of seaweed extract, *Sagarika* (a commercial product) was used which was sprayed in early morning hours after the dew has evaporated at the rate of 1-2 ml $lit.^{-1}$ of water. All recommended agronomic practices were followed during the cultivation of crops.

To eliminate border effect two rows on both sides were discarded and the net plot area was harvested separately from each plot to record the final green fodder yield. Fresh weight of the sorghum and guar fodder was recorded per plot from the harvested plants. The harvested green forage yield was weighed in kg $plot^{-1}$and then converted into qha^{-1}.The sorghum and guar fodder samples were dried at 60°C and grounded (Wiley mill) to pass through one mm screen for analysis of quality parameters. The quantitative analysis of different macronutrients in feeds and fodder was done by Weende or proximate analysis and for analysis of cell wall constituents (Van Soest *et al.,* 1991). Computation of TDN, DMI and DMD was done according to Lithourgidis *et al.* 2006 method and SPSS 19.0 Version was used to analyze the experimental data for its test of significance.

RESULTS AND DISCUSSION

Agronomic practices especially seed rate and nutrient management play a vital role in the yield of fodder crops (Fig. 1 and Fig. 2). Green fodder yield and dry matter yield of sorghum as well as guar crop depicted decreasing trend with decreasing seed rate under the seed rate treatments of mixed cropping. However significantly higher total green fodder yield and dry matter yield (331.45 $qha^{-1}$and 69.50 q/ha) were

Table 1. Effect of different seed ratio and nutrient management on DM, OM and Ash content of sorghum and guar fodder

Treatments	DM (%)		OM (%)		Ash content (%)	
	Sorghum	Guar	Sorghum	Guar	Sorghum	Guar
Seed rates						
S1	20.98	-	90.67	-	9.33	-
S2	-	21.17	-	88.64	-	11.36
S3	21.00	21.10	90.57	88.90	9.43	11.10
S4	21.04	21.13	90.38	88.79	9.62	11.21
SEm±	0.04	0.06	0.06	0.03	0.06	0.03
CD (p=0.05)	NS	NS	0.16	0.09	0.16	0.09
Nutrient sources						
N1	20.91	21.01	90.43	88.66	9.57	11.34
N2	20.89	20.85	90.42	88.62	9.58	11.38
N3	20.88	20.92	90.41	88.64	9.59	11.36
N4	21.17	21.43	90.69	88.93	9.31	11.07
N5	20.93	21.06	90.45	88.72	9.55	11.28
N6	21.26	21.52	90.85	89.09	9.15	10.91
SEm±	0.05	0.08	0.08	0.05	0.08	0.05
CD (p=0.05)	0.15	0.24	0.23	0.13	0.23	0.13

Note: S1 = Sole Sorghum, S2 = Sole Guar, S3 =75% Sorghum + 25% Guar, S4 = 60% Sorghum + 40% Guar, N1 = 100% RDF, N2 = 100% RDF+PGPR, N3 = 100% RDF+Seaweed Extract, N4 = 75% RDF+PGPR, N5 = 75% RDF+Seaweed Extract, N6 = 50% RDF + PGPR + Seaweed Extract, DM = Dry matter and OM = Organic matter

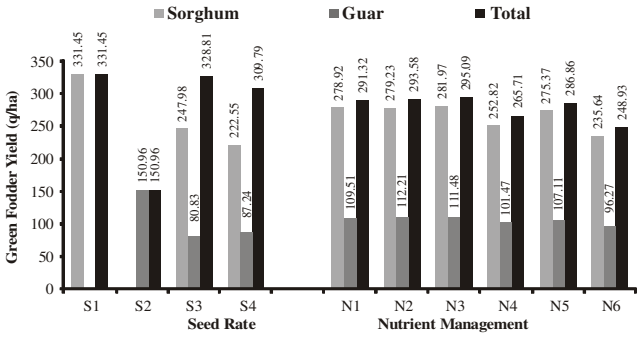

Fig. 1: Effect of different seed ratio and nutrient management on green fodder yield (q/ha) of sorghum and guar fodder

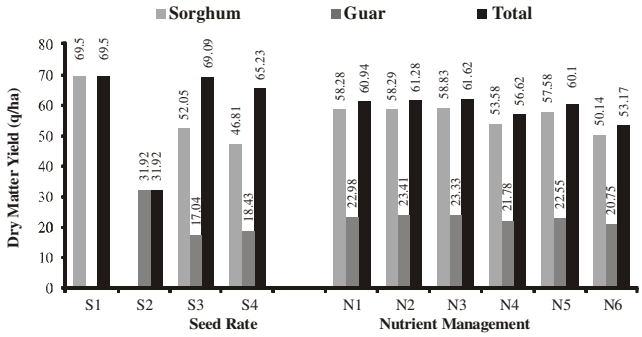

Fig. 2: Effect of different seed ratio and nutrient management on dry matter yield (q/ha) of sorghum and guar fodder

recorded with sole sorghum over rest of the treatments except treatment with seed rate in ratio of 75% sorghum + 25% guar (328.81 qha^{-1} and 69.09 q/ha). Nutrient management treatments depicted an increasing trend in fodder yield with the increasing dose of RDF and thus significantly higher yields were recorded by employing 100% RDF + seaweed extract (295.09 q/ha and 61.62 q/ha) over the treatments N_4 and N_6, but remained at par with 100% RDF + PGPR (293.58 q/ha and 61.28 q/ha), 100% RDF(291.32 q/ha and 60.94 q/ha) and 75% RDF + seaweed extract (286.86 q/ha and 60.10 q/ha). Surve *et al.* (2007), Yadav *et al.* (2007), Agarwal *et al.* (2014) and Htet *et al.* (2016) also reported similar results.

Table 2. Effect of different seed ratio and nutrient management on CP, EE and Total CHO of sorghum and guar fodder

Treatments	CP (%)		EE (%)		Total CHO (%)	
	Sorghum	Guar	Sorghum	Guar	Sorghum	Guar
Seed rates						
S1	6.99	-	1.80	-	81.88	-
S2	-	19.15	-	1.25	-	68.24
S3	7.11	19.07	1.87	1.31	81.60	68.52
S4	7.02	19.04	1.86	1.37	81.49	68.38
SEm±	0.03	0.07	0.04	0.07	0.08	0.09
CD (p=0.05)	0.09	NS	NS	NS	0.23	NS
Nutrient sources						
N1	7.34	20.15	1.93	1.41	81.17	67.09
N2	7.35	20.22	1.97	1.48	81.10	66.93
N3	7.37	20.19	1.98	1.43	81.06	67.02
N4	6.76	17.44	1.74	1.14	82.19	70.35
N5	7.32	20.13	1.86	1.39	81.28	67.19
N6	6.10	16.37	1.61	1.01	83.14	71.71
SEm±	0.04	0.09	0.06	0.09	0.11	0.12
CD (p=0.05)	0.13	0.27	0.18	0.27	0.33	0.35

Note: S1 = Sole Sorghum, S2 = Sole Guar, S3 =75% Sorghum + 25% Guar, S4 = 60% Sorghum + 40% Guar, N1 = 100% RDF, N2 = 100% RDF+PGPR, N3 = 100% RDF+Seaweed Extract, N4 = 75% RDF+PGPR, N5 = 75% RDF+Seaweed Extract, N6 = 50% RDF + PGPR + Seaweed Extract, CP = Crude Protein, EE = Ether Extract and CHO = Carbohydrates

Results of the experiment revealed that quality parameters of sorghum and guar were influenced by seed rate. A critical examination of data presented in table 1, indicated that dry matter content in sorghum increased with mixed cropping whereas in guar it decreased and the dry matter content of sorghum and guar was reported higher in 60 % sorghum + 40% guar and sole guar treatment respectively, but the results were non-significant. Such behavior was due to change in succulency as reported by Ginwal *et al.* (2019) and Tamta *et al.* (2019). Significantly lower organic matter content was reported under 60 % sorghum + 40% guar in sorghum and under sole guar in case of guar. However contrasting results were reported for total ash content as it is negatively correlated with organic matter (Table 5 and 6). These results are in conformity with the findings of Bakhashwain (2010). In sorghum the crude protein (CP) content increased with mixed cropping had reported significantly higher in 75 % sorghum + 25% guar which was at par with 60 % sorghum + 40% guar but in guar sole guar recorded higher CP content. This might be due to presence of higher protein content in leguminous plant as reported by Contreras-Govea *et al.* (2009) and Bakhashwain (2010).The treatment of 75 % sorghum + 25% guar and 60 % sorghum + 40% guar reported higher EE content in sorghum and guar respectively, but the results were non- significant. Increasing ether extract content increases the availability of fat soluble vitamins *viz.* A, D, E and K. These results are comparable to the findings of Ibrahim *et al.* (2012) in maize legume mixtures. Total carbohydrates content in sorghum was significantly superior under sole sorghum whereas in guar it was higher under mixed cropping but the influence was not significant. Significantly higher total CP yield and total ash yield was reported under 75 % sorghum + 25% guar but results were at par with 60 % sorghum + 40% guar for total CP yield. Total EE yield was significantly higher in sole sorghum and at par with 75 % sorghum + 25% guar. These yield results are in

Table 3. Effect of different seed ratio and nutrient management total CP yield, total EE yield and total ash content yield (q/ha)

Treatments	Total CP Yield (qha^{-1})	Total EE Yield (qha^{-1})	Total Ash Yield (qha^{-1})
Seed rates			
S1	4.88	1.26	6.49
S2	6.13	0.40	3.63
S3	6.98	1.20	6.81
S4	6.81	1.13	6.58
SEm±	0.09	0.03	0.07
CD (p=0.05)	0.24	0.08	0.19
Nutrient sources			
N1	6.70	1.08	6.14
N2	6.77	1.11	6.19
N3	6.82	1.12	6.21
N4	5.54	0.88	5.55
N5	6.57	1.04	6.04
N6	4.82	0.76	5.13
SEm±	0.10	0.03	0.08
CD (p=0.05)	0.30	0.10	0.23

Note: S1 = Sole Sorghum, S2 = Sole Guar, S3 =75% Sorghum + 25% Guar, S4 = 60% Sorghum + 40% Guar, N1 = 100% RDF, N2 = 100% RDF+PGPR, N3 = 100% RDF+Seaweed Extract, N4 = 75% RDF+PGPR, N5 = 75% RDF+Seaweed Extract, N6 = 50% RDF + PGPR + Seaweed Extract, CP = Crude Protein and EE = Ether Extract

Table 4. Effect of different seed ratio and nutrient management on NDF, ADF and ADL content (%) of sorghum and guar fodder

Treatments	NDF		ADF		ADL		Hemicellulose	
	Sorghum	Guar	Sorghum	Guar	Sorghum	Guar	Sorghum	Guar
Seed rates								
S1	67.62	-	36.51	-	4.78	-	31.11	-
S2	-	45.34	-	33.11	-	5.00	-	12.23
S3	66.95	43.91	35.96	32.16	4.60	4.75	30.99	11.75
S4	66.83	44.16	35.89	32.26	4.57	4.80	30.94	11.90
SEm±	0.04	0.03	0.03	0.04	0.02	0.02	0.05	0.05
CD (p=0.05)	0.12	0.10	0.10	0.11	0.04	0.05	NS	0.13
Nutrient sources								
N1	66.79	44.02	35.81	32.14	4.60	4.80	30.98	11.88
N2	66.77	43.99	35.80	32.13	4.59	4.78	30.97	11.85
N3	66.76	44.01	35.79	32.14	4.58	4.79	30.97	11.88
N4	67.64	44.85	36.46	32.77	4.72	4.88	31.17	12.08
N5	66.89	44.10	35.87	32.19	4.64	4.82	31.02	11.92
N6	67.94	45.84	36.97	33.69	4.79	5.03	30.97	12.14
SEm±	0.06	0.05	0.05	0.05	0.02	0.02	0.07	0.06
CD (p=0.05)	0.16	0.13	0.14	0.15	0.06	0.06	NS	0.19

Note: S1 = Sole Sorghum, S2 = Sole Guar, S3 =75% Sorghum + 25% Guar, S4 = 60% Sorghum + 40% Guar, N1 = 100% RDF, N2 = 100% RDF+PGPR, N3 = 100% RDF+Seaweed Extract, N4 = 75% RDF+PGPR, N5 = 75% RDF+Seaweed Extract, N6 = 50% RDF + PGPR + Seaweed Extract, NDF = Neutral detergent fibre, ADF = Acid detergent fibre and ADL = Acid detergent fibre

line with the agreement of Tiwana *et al.* (2008) and Ginwal *et al.* (2019).

Plant cell wall is composed of various fibre fractions to support and protect plant against various biotic and abiotic agents and also provides strength to plant against lodging. Results revealed that these fibre

Table 5. Correlation coefficient (r) between yield and different quality parameters of sorghum fodder

	GFY	DM	OM	Ash	CP	EE	CHO	NDF	ADF	ADL	HC
GFY	1.00										
DM	-0.38	1.00									
OM	0.18	0.59**	1.00								
Ash	-0.18	-0.59**	-1.00**	1.00							
CP	0.26	-0.93**	-0.71**	0.71**	1.00						
EE	0.14	-0.77**	-0.83**	0.83**	0.82**	1.00					
CHO	-0.14	0.88**	0.85**	-0.85**	-0.97**	-0.91**	1.00				
NDF	0.27	0.56*	0.88**	-0.88**	-0.64**	-0.83**	0.78**	1.00			
ADF	0.20	0.60**	0.85**	-0.85**	-0.70**	-0.84**	0.81**	0.90**	1.00		
ADL	0.50*	0.42	0.83**	-0.83**	-0.56*	-0.72**	0.69**	0.95**	0.88**	1.00	
HC	0.21	0.01	0.21	-0.21	0.02	-0.13	0.07	0.39	-0.05	0.32	1.00

Note: GFY = Green fodder yield, DM = Dry matter, OM = Organic matter, CP = Crude protein, EE = Ether extract, CHO = Carbohydrates, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, ADL = Acid detergent lignin, HC = Hemicellulose, * = correlation significant at 5% level and ** = correlation significant at 1% level

Table 6. Correlation coefficient (r) between yield and different quality parameters of guar fodder

	GFY	DM	OM	Ash	CP	EE	CHO	NDF	ADF	ADL	HC
GFY	1.00										
DM	-0.08	1.00									
OM	-0.62**	0.76**	1.00								
Ash	0.62**	-0.76**	-1.00**	1.00							
CP	0.20	-0.93**	-0.82**	0.82**	1.00						
EE	-0.06	-0.79**	-0.63**	0.63**	0.78**	1.00					
CHO	-0.22	0.94**	0.85**	-0.85**	-1.00**	-0.82**	1.00				
NDF	0.54*	0.72**	0.26	-0.26	-0.69**	-0.71**	0.68**	1.00			
ADF	0.45	0.76**	0.35	-0.35	-0.75**	-0.73**	0.73**	0.99**	1.00		
ADL	0.65**	0.60**	0.08	-0.08	-0.56*	-0.59**	0.53*	0.97**	0.94**	1.00	
HC	0.71**	0.50*	-0.06	0.06	-0.43	-0.53*	0.40	0.89**	0.80**	0.89**	1.00

Note: GFY = Green fodder yield, DM = Dry matter, OM = Organic matter, CP = Crude protein, EE = Ether extract, CHO = Carbohydrates, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, ADL = Acid detergent lignin, HC = Hemicellulose, * = correlation significant at 5% level and ** = correlation significant at 1% level

fractions (NDF, ADF, ADL and hemicelluloses) decreased with the mixed cropping. Significantly lower fibre fractions (NDF, ADF, ADL and hemicelluloses) in sorghum were reported under 60% sorghum + 40% guar treatment which were at par with 75% sorghum + 25% guar. However, in guar 75% sorghum + 25% guar

Table 7. Effect of seed rate in different seed ratio and nutrient management on TDN, DMI and DMD of sorghum and guar fodder

Treatments	TDN (%)		DMI (g kg/bw)		DMD (%)	
	Sorghum	Guar	Sorghum	Guar	Sorghum	Guar
Seed rates						
S1	54.22	-	1.775	-	60.46	-
S2	-	58.60	-	2.647	-	63.10
S3	54.93	59.84	1.793	2.734	60.89	63.85
S4	55.02	59.70	1.796	2.718	60.94	63.77
SEm±	0.04	0.05	0.001	0.002	0.03	0.03
CD (p=0.05)	0.13	0.14	0.003	0.006	0.08	0.08
Nutrient sources						
N1	55.11	59.85	1.797	2.727	61.00	63.86
N2	55.13	59.87	1.797	2.729	61.01	63.87
N3	55.14	59.86	1.798	2.727	61.02	63.87
N4	54.28	59.05	1.774	2.676	60.50	63.38
N5	55.04	59.80	1.794	2.722	60.96	63.83
N6	53.63	57.85	1.766	2.618	60.10	62.65
SEm±	0.06	0.07	0.002	0.003	0.04	0.04
CD (p=0.05)	0.18	0.20	0.004	0.008	0.11	0.12

Note: S1 = Sole Sorghum, S2 = Sole Guar, S3 =75% Sorghum + 25% Guar, S4 = 60% Sorghum + 40% Guar, N1 = 100% RDF, N2 = 100% RDF+PGPR, N3 = 100% RDF+Seaweed Extract, N4 = 75% RDF+PGPR, N5 = 75% RDF+Seaweed Extract, N6 = 50% RDF + PGPR + Seaweed Extract, TDN = Total digestible nutrients, DMI = Dry matter intake and DMD = Dry matter digestibility

treatment recorded significantly lower fibre fractions (NDF, ADF, ADL and hemicelluloses) gives better quality but the results for ADF and ADL were at par with 60% sorghum + 40% guar. These results might be due to increase in the succulence and result had close conformity with the findings of Htet *et al.* (2016) and Mut *et al.* (2017). An appraisal of data presented in Table 7 revealed that total digestible nutrients (TDN), dry matter intake (DMI) and dry matter digestibility (DMD) of sorghum and guar increased with the mixed cropping. In sorghum significantly higher TDN, DMI and DMD were reported under 60% sorghum + 40% guar treatment which were at par with 75% sorghum + 25% guar. Whereas in guar 75% sorghum + 25% guar recorded significantly higher TDN, DMI and DMD but the results for TDN and DMD were at par with 60% sorghum + 40% guar. Cumulative influence of both crops under mixed cropping might be the reason behind the results.

Critical examination of experimental data revealed that nutrient management treatments influenced the quality parameters of sorghum and guar fodder (Table 1, 2, 3, 4 and 7). In sorghum, significantly lower DM, OM, total carbohydrates and fibre fractions (NDF, ADF and ADL) and significantly higher ash, CP, EE, total ash, CP, EE yield, TDN, DMI and DMD were reported under 100% RDF + seaweed extract which were at par with 100% RDF + PGPR, 100% RDF and 75% RDF + seaweed extract. Whereas in guar such results for above mentioned parameters were reported under 100% RDF + PGPR which were at par with 100% RDF + seaweed extract, 100% RDF and 75% RDF + seaweed extract. Trend in quality parameters of crop might be due to the reason that uptake of nutrients in higher amount minerals concentration in plant sap increases due to mainly of nitrogen which helped the plant to increase the amino acid formation and succulency. Similarly, trend reported for quality parameters were highly correlated as depicted in table 5 and 6 by correlation coefficient (r). The results are in tune with similar findings of Ayub *et al.* (2012), Chattha *et al.* (2017), Dutta *et al.* (2019) and Kushwaha *et al.* (2019).

CONCLUSION

Mixed cropping has tremendous scope in improving productivity and quality of fodder crops. Thus, seed rate 75% sorghum + 25% guar with application of 75% RDF + seaweed extract in mixed cropping can be used to ensure supply of quality fodders for animals. For future line of work, in lieu of sorghum and guar, different cereal and legume fodder crops integration can be explored by conducting location specific trials with optimum dose and source of nutrients for better productivity and quality.

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