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Evaluation of productivity and quality of forage sorghum and legumes crops under varying intercropping combinations

DEVENDRA SINGH GINWAL[1], RAKESH KUMAR[1]✉, HARDEV RAM[1], R K MEENA[1], M R YADAV[2], GOVIND MAKARANA[3], AVINASH CHAUHAN[1], MANJUNATH S K[1] and UTTAM KUMAR[1]

ICAR-National Dairy Research Institute, Karnal, Haryana 132 001 India

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ABSTRACT

The present study was conducted during *kharif* season of 2017 with objective to study the influence of different intercropping combinations of forage sorghum and legumes (cowpea and guar) on forage productivity and quality. The experiment was laid out in randomized complete block design (RCBD) with 7 treatments consisting of three different forage crops, viz. sorghum, cowpea and guar sown in sole treatment as well as in 1:1 and 2:1 intercropping combinations of forage sorghum with legume crop components. Results revealed that the highest total green fodder yield (434.61 q/ha) and total dry matter yield (90.65 q/ha) were obtained with sorghum+cowpea (2:1) and sorghum+guar (2:1) intercropping combinations, respectively. Forage sorghum recorded significantly higher CP content (8.92%) in sorghum+guar (1:1) intercropping combination. Significantly higher ether extract of sorghum (2.03%), cowpea (2.60%) and guar (2.61%) were found in their (1:1) intercropping row proportion. The maximum total CP yield and total EE yield (10.35 and 1.93 q/ha), respectively were reported in sorghum+guar (1:1) ratio, while total ash yield (9.18 q/ha) was recorded in sorghum+guar (2:1) intercropping ratio. The sorghum planted under 1:1 intercropping row ratios of sorghum with cowpea/ guar crops recorded significantly lowest value of NDF (61.12–61.14%) and ADF (30.12–30.15%) and ADL (4.24–4.26%) over 2:1 row ratio intercropping of sorghum with cowpea/ guar and its sole stand. The minimum value of NDICP on DM% and ADICP DM% basis and NDICP on CP% and ADICP CP% basis were reported in 1:1 intercropping proportion. Therefore, considering overall results of our study, it can be concluded that to realize higher production and quality of forage sorghum its cultivation in 1:1 and 2:1 row ratio with legumes (Guar/cowpea) can be recommended**.**

Keywords: Fodder, Intercropping combinations, Legumes, Quality, Sorghum

With rapid increase in population and less chance of bringing new land area under cultivation of fodder crops, intercropping seems to be the only way to increase the productivity and intensity of land use. This situation requires developing an appropriate technology of growing quality fodder in association with legumes without too much intercrops interference and competition. To meet the increasing demand of forage for livestock, there is a necessity to use the suitable fodder crop having higher yield potential. Efforts have been made to identify suitable intercropping combination in sorghum with different legumes for various agro-climatic zones. Accessibility of green fodder with improved quality to animals is the key to success of dairy enterprises and it is difficult to sustain the health and milk production of the livestock without supply of the quality green fodder. Intercropping of sorghum with legumes is a recognized practice for increasing the productivity, quality, palatability, yield increment, high crude protein percentage, protein yield and profitability per unit area and time. Intercropping of sorghum with legume proved to be more remunerative than growing sorghum crop alone. However, sorghum, even having good palatability, is poor in quality due to low protein content and presence of hydrocyanic acid. Loss of animal production occurs when toxic constituents like prussic acid and nitrate nitrogen are present in forage sorghum, which is why sorghum is generally harvested after initiation of flowering. The digestibility of forage sorghum is mainly dependent on the concentration and availability of cellulose portion which is affected by the degree of lignification and silicification. Forage legume, cowpea, is commonly grown with sorghum. Being deep rooted crop and slow growing in early growth stage, during which the more rapidly growing wide spaced crops like forage sorghum for fodder can be conveniently intercropped to utilize the natural resources more efficiently. Cowpea enhances the fodder productivity and improves nutritive value of fodder. Guar another forage legume, intercropped with wide spaced row crops, is a promising multipurpose legume with a good potential to be used as

Present address: [1]National Dairy Research Institute, Karnal, Haryana. [2]Rajasthan Agricultural Research Institute, Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan. ✉Corresponding author e-mail: drdudi_rk@rediffmail.com.

food, fodder, green manure and cover crop and its dry herbage meets scarcity of green forage during lean periods. Only 40% green forages are available from various sources to feed livestock which shows higher gap between supply and demand for fodder. Hence, efforts need to be made to intensify forage productivity and production per unit area and time to achieve maximum qualitative yield.

MATERIALS AND METHODS

The present study was conducted at ICAR-National Dairy Research Institute, Karnal during *kharif* 2017. The study location situated at an elevation of 245 meters above mean sea level with latitude of 29°43' N and longitude of 76°58' E in the sub-tropical zone. It has semi-arid climate characterized by hot and dry summer, and severe cold during winter. The average maximum temperature is as high as 47°C during summer and minimum temperature near to 1°C accompanied by frost in peak winter months. The annual rainfall of the area is 650 mm with the mean annual evaporation of 850 mm, over 70% of which occurs during the main rainy season (June to September). The soil of experimental site was clay loam in texture with pH (7.2) (Jackson 1973), organic carbon (0.62%) (Walkley and Black 1934), EC (0.32 dS/m), available N (170 kg/ha) (Subbiah and Asija 1956), available phosphorus (22.5 kg/ha) (Olsen *et al*. 1954), and 1 N NH_4OAC extractable K (270 kg/ha) (Jackson 1973).

This experiment was laid out in randomized complete block design (RCBD) with 7 treatments consisting of three different forage crops, viz. sorghum, cowpea and guar sown in sole as well as in 1:1 (1 row of cereal and 1 row of legume) and 2 : 1 (2 row of cereal and 1 row of legume) intercropping combinations with forage sorghum in three replications. The plot size was 4.5 m × 3.5 m (15 rows of 3.5 m length, 30 cm apart). The experimental field was deep tilled and then levelled before starting of the experiment. The fodder sorghum (cultivar Haryana Chari), Cowpea (cultivar C-152) and Guar (cultivar HG-02) were sown with seed rate of 60 : 25 : 25 kg/ha respectively during 29th standard meteorological by keeping a row spacing of 30 cm. For accommodating component crops in intercropping treatments, replacement series was used. Forage crops were harvested manually at the age of 65 days and fresh forage yield were recorded. Subsamples were collected from each of the experimental plot and the DM content was estimated by putting the representative fodder samples in hot air oven at 70°C for 48 h. The dried samples were ground to pass through 1 mm sieve and used for chemical analysis. Finally milled sample were analyzed for DM, ash, ether extract and Kjeldahl Nitrogen (Licitra *et al.* 1996, AOAC 2005). Crude protein was determined by multiplying the N concentration by 6.25. Proximate principles (AOAC 2005) and fibre fractions (Van Soest *et al.* 1991) were determined in fodder samples. All data recorded for different parameters were analysed by using Fisher's analysis of variance technique and the least significant difference test at 5% probability level. The model followed in the analyses was described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of different intercropping combinations on fodder yields: Green fodder yield is one of the most important aspects to determine the efficacy of any agronomic practices. The total green fodder yield (Table 1) of the different forage crops was significantly influenced by the different intercropping ratios and highest (434.61 q/ha) was enumerated in (2:1) intercropping ratio of sorghum+ cowpea followed by sorghum+guar (2:1) row ratios. The intercropping combinations of different component crops also significantly affected total dry matter yield and significantly higher total dry matter yield was recorded in sorghum+guar (2:1) followed by sorghum+cowpea (2:1) intercropping treatments as compared to their respective sole as well as (1:1) ratio treatments (Table 1). The higher forage yields in intercropping combination of sorghum with cowpea and guar in (2:1) row ratio might be attributed to corresponding effect of legumes, which supplemented nitrogen to forage sorghum and the better exploitation of solar radiation, space along with nutrient contribution of leguminous fodder to sorghum intercropped components. The optimum availability of nitrogen and improvement in the overall soil health due to inclusion of legume associated with better crop growth of sorghum (in term of plant height, stem girth, leaf number and leaf area/plant) which ultimately leads to higher green fodder as well as dry matter yield. Our results of higher dry matter yield under intercropping

Table 1. Effect of intercropping combinations on green fodder and dry matter yield

Treatment	Green fodder yield (q/ha)			Total	Dry matter yield (q/ha)			Total
	Sorghum	Cowpea	Guar		Sorghum	Cowpea	Guar	
Sole sorghum	416.44	–	–	416.44	87.67	–	–	87.67
Sole cowpea	–	299.63	–	299.63	–	58.13	–	58.13
Sole guar	–	–	283.95	283.95	–	–	60.31	60.31
Sorghum + Cowpea (1 : 1)	253.37	164.70	–	418.07	53.44	31.85	–	85.30
Sorghum + Guar (1 : 1)	252.19	–	155.33	407.52	53.18	-	32.90	86.07
Sorghum + Cowpea (2 : 1)	310.47	124.15	–	434.61	65.46	24.04	–	89.50
Sorghum + Guar (2 : 1)	311.00	–	118.30	429.30	65.57	-	25.09	90.65
SEm±	2.11	1.73	1.76	2.48	0.39	0.29	0.36	0.43
CD (P=0.05)	4.86	4.81	4.89	5.40	0.90	0.82	1.00	0.93

of legume fodder with cereals were in close agreement with the outcome of Surve *et al.* (2007) and Barik *et al*. (2006).

Effect of different intercropping combinations on fodder quality parameters: Effect of intercropping ratio on forage quality parameters of sorghum (crude protein, ether extract and ash content) was found significant (Table 2 and Table 4). The crude protein was influenced significantly in intercropping combinations as compared to their respective sole crops. Both component crops of intercropping produce higher CP content in (1:1) intercropping row ratio over (2:1) intercropping row ratio of forage sorghum with cowpea/ guar crop. Forage sorghum recorded significantly higher CP content (8.92% and 8.90%) in sorghum+guar (1:1) and sorghum+cowpea (1:1) intercropping combination, respectively as compared to sorghum+guar (2:1), sorghum+cowpea (2:1) intercropping row ratio and sole sorghum. Intercropping combinations has significant effect on ether extract of different forage crops. Significantly higher ether extract of sorghum (2.03 and 2.02%), cowpea (2.60%) and guar (2.61%) were found in their (1:1) intercropping row proportion over their sole as well as (2:1) intercropping row proportion. Intercropping also significantly improved the ash content of sorghum and significantly higher ash content was recorded in 1:1 row ratio (9.71–9.73%) over sole sorghum (9.40%). The sorghum intercropped under 1:1 ratio with guar and cowpea recorded statistically similar ash content when intercropped with 2:1 ratio. Ash content was quite higher in legume component as compared to forage sorghum. The higher content of aforesaid forage quality parameters under the treatment which contain higher proportion of legumes (1:1) over 2:1 intercropping ratio and sole crop of sorghum might be due the fact that a legume has the ability to fix atmospheric N and recycle the soil P for the component crop. Besides, better soil health with higher proportion of legume in intercropping may promote the growth and dry matter accumulating capacity of the plants and enhance uptake of macro and micro nutrient thus nutrients play a critical role in enhancement of forage quality. Our results of improvement of forage quality of cereal component intercropped with legumes are in close agreement with the finding of Ibrahim *et al.* (2006) and Baghdadi *et al.* (2016). The total crude protein yield of different forage crops were recorded significantly higher in intercropping combinations (9.68–10.35 q/ha) as compared to sole crops (7.47–10.04 q/ha) (Table 3). Among the intercropping treatments (1:1 or 2:1 ratio) of different forage crops, sorghum intercropped under (1:1) row ratio with forage legumes recorded significantly higher total crude protein yield over 2:1 intercropping ratio. The total ether extract yield was also significantly influenced by intercropping combination of forage sorghum+legume crop and the highest values of ether extract yield (1.93 and 1.91 q/ha) were observed in treatment sorghum+guar (1:1) intercropping row ratio and sorghum+cowpea (1:1) row ratio, respectively. The total ether yield of different forage crops was recorded significantly higher in intercropping combinations (1.81–1.93 q/ha) as compared to sole crops (1.35–1.51 q/ha).

Table 2. Effect of different intercropping combinations on crude protein and ether extract

Treatment	Crude protein %			Ether extract %		
	Sorghum	Cowpea	Guar	Sorghum	Cowpea	Guar
Sole sorghum	8.52	–	–	1.73	–	–
Sole cowpea	–	16.24	–	–	2.33	–
Sole guar	–	–	16.81	–	–	2.38
Sorghum + Cowpea (1 : 1)	8.90	16.61	–	2.03	2.60	–
Sorghum + Guar (1 : 1)	8.92	–	17.06	2.02	–	2.61
Sorghum + Cowpea (2 : 1)	8.71	16.53	–	1.87	2.46	–
Sorghum + Guar (2 : 1)	8.72	–	16.93	1.87	–	2.48
SEm±	0.05	0.08	0.05	0.04	0.07	0.04
CD (P=0.05)	0.14	0.21	NS	0.11	0.19	0.10

Table 3. Effect of intercropping combinations on crude protein (CP) and ether extract (EE) yield

Treatment	CP yield (q/ha)			Total	EE yield (q/ha)			Total
	Sorghum	Cowpea	Guar		Sorghum	Cowpea	Guar	
Sole sorghum	7.47	–	–	7.47	1.51	–	–	1.51
Sole cowpea	–	9.44	–	9.44	–	1.35	–	1.35
Sole guar	–	–	10.04	10.04	–	–	1.44	1.44
Sorghum + Cowpea (1:1)	4.76	5.29	–	10.05	1.08	0.83	–	1.91
Sorghum + Guar (1:1)	4.74	–	5.61	10.35	1.08	–	0.86	1.93
Sorghum + Cowpea (2:1)	5.7	3.97	–	9.68	1.22	0.59	–	1.81
Sorghum + Guar (2:1)	5.72	–	4.25	9.96	1.23	–	0.62	1.85
SEm±	0.05	0.05	0.07	0.06	0.04	0.03	0.02	0.04
CD (P=0.05)	0.11	0.13	0.2	0.13	0.08	0.09	0.05	0.09

Table 4. Effect of different intercropping combinations on ash% and ash yield (q/ha)

Treatment	Ash content			Ash yield			Total
	Sorghum	Cowpea	Guar	Sorghum	Cowpea	Guar	
Sole sorghum	9.4	–	–	8.24	–	–	8.24
Sole cowpea	–	11.12	–	–	6.47	–	6.47
Sole guar	–	–	11.82	–	–	7.13	7.13
Sorghum + Cowpea (1:1)	9.73	10.94	–	5.2	3.48	–	8.68
Sorghum + Guar (1:1)	9.71	–	11.68	5.16	–	3.84	9.01
Sorghum + Cowpea (2:1)	9.6	10.84	–	6.28	2.61	–	8.89
Sorghum + Guar (2:1)	9.58	–	11.54	6.28	–	2.9	9.18
SEm±	0.08	0.03	0.06	0.08	0.03	0.05	0.08
CD (P=0.05)	0.19	NS	NS	0.18	0.07	0.15	0.17

Likewise, intercropping significantly improved the total ash yield and significantly higher ash yield were recorded in 2:1 row ratio with respect to 1:1 intercropping ratio and sole stand of crops. Among sole stands, the significantly maximum ash yield was recorded with sorghum while lowest with cowpea (Table 4). The higher nutrient yields (Crude protien and ether yield) 1:1 intercropping ratio may be attributed due to higher proportion legume over cereal. As the nutrient yields is a function of dry matter yield and nutrient content in fodder and inclusion of legumes have favorable effect on cereal component which improve the growth and total dry matter yield ultimately leads to higher yields over 2:1 intercropping ratio and their sole stand. The legume intercropped cereals were able to grow better, exerted greater amount of soil N and its transformation in the form of proteins which further ads in enhancement of nutrient yields. These results are in line with findings of Kumar and Venkateswarlu (2013).

The sorghum planted under 1:1 intercropping row ratios of sorghum with cowpea/ guar crops recorded significantly lowest value of NDF (61.12–61.14% vs 61.36–62%) and ADF (30.12–30.15% vs 30.41–31.01%) and ADL (4.24–4.26% vs 4.45–4.70%) over 2:1 row ratio intercropping of sorghum with cowpea/ guar and its sole stand (Table 5 and Table 6). However, cowpea and guar sown under 2:1 ratio (sorghum:cowpea/guar) recorded significantly lowest value of NDF, ADF and ADL over 1:1 row ratio intercropping of sorghum with cowpea/ guar and its sole stand. The intercropping systems did not produced significant effect on hemicellulose content of cowpea and sorghum

Table 5. Effect of intercropping combinations on NDF and ADF content (%)

Treatment	NDF			ADF		
	Sorghum	Cowpea	Guar	Sorghum	Cowpea	Guar
Sole sorghum	62.01	–	–	31.01	–	–
Sole cowpea	–	46.97	–	–	30.85	–
Sole guar	–	–	44.52	–	–	30.66
Sorghum + Cowpea (1:1)	61.14	46.53	–	30.12	30.47	–
Sorghum + Guar (1:1)	61.12	–	43.34	30.15	–	30.32
Sorghum + Cowpea (2:1)	61.38	45.97	–	30.41	30.05	–
Sorghum + Guar (2:1)	61.36	–	42.22	30.42	–	30.06
SEm±	0.06	0.05	0.09	0.06	0.04	0.12
CD (P=0.05)	0.14	0.15	0.24	0.14	0.11	NS

Table 6. Effect of different intercropping combinations on hemicellulose and ADL content (%)

Treatment	Hemicellulose			ADL		
	Sorghum	Cowpea	Guar	Sorghum	Cowpea	Guar
Sole sorghum	31	–	–	4.7	–	–
Sole cowpea	–	16.11	–	–	8.99	–
Sole guar	–	–	13.86	–	–	9.36
Sorghum + Cowpea (1:1)	31.02	16.06	–	4.24	8.8	–
Sorghum + Guar (1:1)	30.97	–	13.03	4.26	-	9.21
Sorghum + Cowpea (2:1)	30.98	15.93	–	4.45	8.68	–
Sorghum + Guar (2:1)	30.94	–	12.16	4.46	-	9.05
SEm±	0.08	0.07	0.21	0.04	0.03	0.04
CD (P=0.05)	NS	NS	0.57	0.08	0.07	0.12

(Table 6). In case of guar crop intercropping combination, hemicellulose content was significantly affected and minimum value (12.16%) was recorded in (2:1) row ratio compared to 1:1 ratio (13.03%) and sole stand (13.86%). The lowest values of various fibre fractions in intercropped treatments might be due the fact of higher availability of nutrients and improved soil condition due to inclusion of legumes with cereal which enhance the growth and reduced the fibre fractions. Further, the higher nitrogen availability to the cereal component under legume intercropping resulted in higher protein synthesis and lowered the soluble carbohydrates which could be responsible for lower content of NDF, ADF and ADL in fodder. Similar results were also reported by Khan *et al.* (2013).

There intercropping combinations had significant effect on NDICP and ADICP (DM and CP % basis) of different forage crops (Table 7 and Table 8). The minimum value of NDICP on DM% and ADICP DM% basis of sorghum crop was found in 1:1 intercropping proportion (3.22–3.23% and 1.76–1.78%) with respect to 2:1 and sole stand of sorghum, respectively. While in case of legume component (cowpea or guar) the lowest significant value of NDICP on DM% and ADICP on DM% were found in 2:1 row ratio followed by 1:1 and highest under sole stand. Intercropping combination of different forage crops had significant effect on NDICP and ADICP content on the CP% basis of fodder crops (Table 7 and Table 8). The minimum value of NDICP on CP% and ADICP CP% basis of sorghum crop was found in 1:1 intercropping proportion (36.14–36.19% and 19.81–19.93%) compared to 2:1 (37.62–37.71% and 20.67–20.73%) and sole stand of sorghum (39.45% and 22.09%), respectively. While in case of legume component (cowpea or guar) the lowest significant value of NDICP on CP% and ADICP on CP% were found in 2:1 row ratio followed by 1:1 and highest under sole stand. The lowest values of aforesaid parameters under intercropped treatments might be due the fact of lower fibre fraction of different forage crops due to the inclusion of legumes with cereal. Further, the enhanced N availability to the cereal component under legume intercropping resulted in more leafy growth with higher protein synthesis which could be responsible for lower fibre content in the forage. Similar results were also reported by Khan *et al.* (2013), Ginwal *et al*. (2019a) and Ginwal *et al.* (2019b).

Our study demonstrated that the growing of forage sorghum in 1:1 row ratio with legumes (Guar/cowpea) can improve the fodder yields and its quality (protein content, palatability and digestibility). Therefore, considering overall results of our study, it can be concluded that to realize higher production and quality of forage sorghum its cultivation in 1:1 and 2:1 row ratio with legumes (Guar/cowpea) can be recommended which will further strengthen and sustain the performance of livestock in terms of health and milk production**.**

Table 7. Effect of different intercropping combinations on NDICP DM % and NDICP CP %

Treatment	NDICP DM basis			NDICP CP basis		
	Sorghum	Cowpea	Guar	Sorghum	Cowpea	Guar
Sole sorghum	3.36	–	–	39.45		–
Sole cowpea	–	7.82	–	–	48.16	–
Sole guar	–	–	7.92	–		47.09
Sorghum + Cowpea (1:1)	3.22	7.74	–	36.14	46.61	–
Sorghum + Guar (1:1)	3.23	–	7.87	36.19	–	46.14
Sorghum + Cowpea (2:1)	3.28	7.68	–	37.62	46.44	–
Sorghum + Guar (2:1)	3.29	–	7.78	37.71	–	45.97
SEm±	0.04	0.02	0.04	0.45	0.10	0.24
CD (P=0.05)	0.07	0.06	NS	0.67	0.27	NS

Table 8. Effect of different intercropping combinations on ADICP DM % and ADICP CP %

Treatment	ADICP DM basis			ADICP CP basis		
	Sorghum	Cowpea	Guar	Sorghum	Cowpea	Guar
Sole sorghum	1.88	–	–	22.09	–	–
Sole cowpea	–	2.62	–	–	16.15	–
Sole guar	–	–	2.75	–	–	16.34
Sorghum + Cowpea (1:1)	1.76	2.54	–	19.81	15.27	–
Sorghum + Guar (1:1)	1.78	–	2.66	19.93	–	15.58
Sorghum + Cowpea (2:1)	1.80	2.48	–	20.67	15.02	–
Sorghum + Guar (2:1)	1.81	–	2.59	20.73	–	15.28
SEm±	0.03	0.03	0.03	0.38	0.13	0.17
CD (P=0.05)	0.07	0.08	NS	0.99	0.37	0.46

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