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PRODUCTION POTENTIAL OF FORAGE SORGHUM (*SORGHUM BICOLOR* L.) UNDER DIFFERENT INTERCROPPING SYSTEMS

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ABSTRACT

Field experiment was conducted at GB Pant University of Agriculture and Technology, Pantnagar during *kharif* season 2011 to find out the optimum seed rate of legumes grown as an intercrop with sorghum. It was found that intercropping of sorghum + cowpea (50% seed rate) had higher green fodder yield, sorghum equivalent yield, net returns and land equivalent ratio, it was comparable with intercropping of sorghum + cowpea (25% seed rate) that had higher digestible dry matter yield and protein yield. In general, the intercropping systems reduced green forage, dry fodder, crude protein yield and crude protein content but enhanced the digestible dry matter yield and unaffected the digestible dry matter content of intercrops, cowpea and rice bean. Therefore it is concluded that intercropping of sorghum (recommended seed rate) + cowpea (50% seed rate) may be grown for higher green fodder yield protein yield and net returns.

Keywords:
Intercropping
Sorghum
Cowpea
Sorghum equivalent yield
Crude protein yield

INTRODUCTION

Intercropping of cereals with legumes is a paramount significance in Indian agriculture mainly because of it is not only risk free system under stress conditions but also improves soil fertility by fixing atmospheric nitrogen. Sorghum is poor in quality due to low protein content and presence of hydrocyanic acid (Hingra *et al.*, 1995), so legumes like cowpea, rice bean, guar etc are grown as an intercrops with sorghum to improve the forage quality. The cowpea being a deep rooted and slow growing in early growth stage, during which the more rapidly growing crop like sorghum and maize being shallow rooted and a wide spaced crop can be conveniently intercropped to utilize the natural resources more efficiently (Willey *et al.*, 1981). Cowpea (*Vigna sinensis*) enhances the fodder productivity, improves nutritive value of fodder.

Rice-bean (*Vigna umbellate* L.) is another forage legume, intercropped with sorghum, a promising multi-purpose legume with a good potential to be used as food, fodder, green manure, cover crop and its dry herbage meet scarcity of green forage during lean periods. Since, 40% green forages are available from various sources to feed livestock which shows higher gap between supply and demand for fodder. Hence, efforts should be made to intensify forage production per unit area and time to achieve maximum yield. Poor planting pattern as practiced in most farmers fields, can lead to low plant growth due to reduced light, mineral elements, as well as other growth factors either as a result of insufficient plants or too many plants per unit area leading to plant-to-plant or species-to-species competition, thus, low yield (Van Erk *et al.*, 1997; Hauggaard *et al.*, 2006). Therefore, the optimum seed rates of intercrops are of great significance for ensuring optimum growth and development both of intercrops. Keeping this in view, the present field experiment was conducted to find out optimum seed rate of intercrops under forage sorghum based intercropping systems.

MATERIALS AND METHODS

Field experiment was conducted at G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand, India during *kharif* season 2011. The soil of the experimental field was high in organic carbon (8.48 g/kg), medium in available nitrogen (278.48 kg/ha), available phosphorus (27.70 kg/ha) and available potassium (232.8 kg/ha) with neutral in reaction (pH: 7.6). The experiment was laid out in Randomized Block Design consisting of 11 treatments (sole sorghum, sole cowpea, sole rice bean, sorghum + cowpea and rice bean intercropping each with 25, 50, 75 and 100 % seed rates)

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The recommended application of fertilizers (N and P_2O_5) was 120 and 60 kg/ha for sole sorghum, 20 and 60 kg/ha for sole legumes and 80 and 60 kg/ha for intercropping system, respectively. In sole sorghum, 2/3rd nitrogen along with all phosphorus were applied as basal and the remaining 1/3rd nitrogen was top dressed at 30 DAS. In legume crops, whole nitrogen along with phosphorus was applied as basal. The source of nitrogen and phosphorus were urea and single super phosphate (SSP). Sole and intercrops were sown on June 08, 2011 and harvested at 112 days after sowing stages. The N content of fodder on dry weight basis was estimated by Micro-Kjeldhal method (Jackson, 1973) and crude protein was calculated from N content values. The dry matter digestibility was determined in vitro by nylon bag method given by Lowery (1969). The sorghum equivalents yield, land equivalent ratio and B:C ratio were calculated by applying standard methods to compare the benefits of intercropping systems.

RESULTS AND DISCUSSION

Green fodder yield

The higher green fodder yield of sorghum (Table 1) was observed in sorghum + cowpea (50%) remained significantly at par with sorghum + cowpea (25%) intercropping system. This might be due to the fact that 25% seed rate of cowpea under sorghum intercropping system had more favorable conditions for growth and development of both the crops. The results indicated that green forage yield of sorghum grown in association with legumes was lower than the sole crop of sorghum which was probably the effect of plant competition for the nutrients, mutual shading effect due to close spaces among the plants and suppressive allele-pathic effect of legume intercrops (Angadi *et al.,* 2004). Singh and Jadhav (2003) have also reported suppressive effect of legume intercrops on the forage yield of sorghum. The taller cereal sorghum reduced biological N-fixation and yields of the associated legumes (Fujita *et al.,* 1992) due to shading effect and on production of legumes as well as vigorous growth of main crops sorghum (Barik *et al.,* 1996).

Dry fodder yield

Sole sorghum produced significantly higher dry forage yield that was statistically at par with sorghum + cowpea (25%) intercropping system (Table 1). Among the intercropping systems, significantly higher dry fodder yield was recorded under sorghum + cowpea (25%) that remained non significant with all other intercropping systems except sorghum + rice bean (100%) system. The results also showed that sorghum + rice bean (50%) had more dry fodder yield than sorghum + rice bean (25%) system mainly due to more plant population and erect growth. Both intercrops grown with 100% recommended seed rates with sorghum had poor growth and lower dry fodder yield resulted lower yield of the intercropping systems mainly due to greater competition. In general, fodder yield of both main and intercrops reduced under intercropping systems mainly due to competition (Fujita *et al.,* 1992 Shankaranaryanan *et al.,* 2005; Singh *et al.,* 2014).

Digestible dry matter yield

Sole sorghum had significantly highest digestible dry matter production. The digestible dry matter yield of cowpea was recorded significantly highest under sorghum + cowpea (100%) followed by sole cowpea. Similarly sorghum + rice bean (100%) had significantly higher value that was statistically at par with sole rice bean. Among the intercropping systems, sorghum + cowpea (25%), gave significantly higher digestible dry matter yield that remained significantly equal to all other intercropping systems. Cereal-legume inter-cropping systems improved both quantity and quality of the fodder and supported by Verma *et al.* (1997) by concluding that digestible dry matter yield increased significantly in sorghum + cowpea paired row intercropping.

Crude protein content

The crude protein content of sorghum improved under intercropping systems but the crude protein of cowpea fodder reduced under intercropping systems, while rice bean had variable crude protein in different systems. However, the crude protein content of sorghum under sorghum + rice bean (75%), cowpea under sorghum + cowpea (25%) and rice bean in sorghum + rice bean (50%) intercropping had significantly higher crude protein content than other systems. The crude protein of sole cowpea reduced significantly under inter-cropping systems. The higher crude protein content of mixture over the sorghum alone is due to higher protein content of the legume crop. It is in conformity with finding of Eskandari and Ghanbari (2009) that the sole cowpea had higher crude protein content than intercropped cow pea. Thus, the forage quality of cowpea was decreased by intercropping. Angadi *et al.* (2004) mentioned that rice-bean sown alone produced significantly higher crude protein content and sorghum sown alone produced significantly lower protein content.

Crude protein yield

The intercropping systems sorghum + cowpea (25%), sorghum + cowpea (75%), sorghum + cowpea (100%), sorghum + rice bean (50%), had significantly higher crude protein yield than sole sorghum that also had significantly equal value with other intercropping systems. Sole cowpea and rice bean gave significantly lower crude protein yield than sole sorghum. Crude protein yield is a function of dry matter yield and crude protein content. High values of dry matter yield and crude protein content enhanced the crude protein yield under sorghum + cowpea (25%) treatment. Reduction in dry matter yield due to intercropping reduced crude protein yield of the system. Higher crude protein

content was attributed to the contribution of nitrogen by legumes, may have enhanced nitrogen uptake which converted in to protein leading to higher crude protein content (Singh, 2009; Mishra *et al.*, 1997; Singh *et al*., 2013).

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

Treatment	Green Fodder Yield (q/ha)				Dry Fodder Yield (q/ha)			
	Sorghum	Cowpea	Rice bean	Total	Sorghum	Cowpea	Rice bean	Total
Sole Sorghum	407.4	-	-	407.4	148.7	-	-	148.7
Sole Cowpea	-	228.5	-	228.5	-	44.7	-	44.7
Sole Rice bean	-	-	268.8	268.8	-	-	55.4	55.4
Sorghum + Cowpea 25%	237.6	170.5	-	408.1	91.5	34.3	-	125.9
Sorghum + Cowpea 50%	243.8	184.5	-	428.3	73.8	36.5	-	110.2
Sorghum + Cowpea 75%	189.7	161.5	-	351.2	80.8	35.9	-	116.7
Sorghum + Cowpea 100%	187.5	179.3	-	366.8	61.6	57.7	-	119.3
Sorghum + Rice bean 25%	147.9	-	192.7	340.6	54.1	-	48.3	102.4
Sorghum + Rice bean 50%	178.2	-	188.6	366.8	71.9	-	46.5	118.4
Sorghum + Rice bean 75%	118.8	-	211.5	330.2	43.7	-	56.8	100.5
Sorghum + Rice bean 100%	98.0	-	245.8	343.8	43.8	-	57.2	101.0
CD (*P*= 0.05)	83.1	45.0	38.8	74.9	31.6	12	NS	27.2

Table 2. Effect of intercropping systems on digestible dry matter, crude protein content and crude protein production

Treatment	Digestible dry matter yield (q/ha)				Crude protein content			Crude protein yield (kg/ha)			
	Sorghum	Cowpea	Rice bean	Total	Sorghum	Cowpea	Rice bean	Sorghum	Cowpea	Rice bean	Total
Sole Sorghum	69.7	-	-	69.7	6.58	-	-	9.77	-	-	9.77
Sole Cowpea	-	28.1	-	28.1	-	11.11	-	-	4.97	-	4.97
Sole Rice bean	-	-	35.9	35.9	-	-	9.51	-	-	5.27	5.27
Sorghum + Cowpea 25%	44.4	21.6	-	66.1	7.39	9.00	-	6.81	3.08	-	9.90
Sorghum + Cowpea 50%	32.8	23.4	-	56.2	7.83	8.76	-	5.77	3.20	-	8.97
Sorghum + Cowpea 75%	37.4	23.3	-	60.7	8.24	8.93	-	6.64	3.22	-	9.86
Sorghum + Cowpea 100%	29.1	36.9	-	66.0	8.69	8.89	-	5.34	5.11	-	10.45
Sorghum + Rice bean 25%	23.4	-	30.9	54.5	8.98	-	9.68	4.92	-	4.68	9.60
Sorghum + Rice bean 50%	32.9	-	29.8	62.6	8.60	-	9.76	6.19	-	4.50	10.69
Sorghum + Rice bean 75%	20.1	-	36.1	56.2	9.03	-	8.23	3.97	-	4.67	8.65
Sorghum + Rice bean 100%	20.8	-	37.1	57.9	8.85	-	8.75	3.86	-	5.01	8.87
CD (*P*=0.05)	16.78	7.13	6.95	24.17	0.81	0.80	0.62	2.67	1.11	NS	3.13

Sorghum Equivalent Yield

Among the sole cropping, sole sorghum had significantly higher sorghum equivalent yield that was significantly equal to sole rice bean. Similarly, among intercropping systems, sorghum + cowpea (50%) gave significantly higher sorghum equivalent yield that was statistically equal to sorghum + rice bean (25%) and sorghum + rice bean (75%) intercropping systems. The total productivity of system remained higher in terms of quantity, quality and monetary return, though the productivity of individual crop reduced in intercropping. The higher fodder price of rice bean and cowpea than sorghum might be a factor for improving sorghum equivalent yield. This result is in conformity with the finding of Wanjari *et al.* (1994) reported higher sorghum equivalent yield in sorghum + soybean intercropping system and Amedie *et al.* (2004) reported higher sorghum equivalent yield in sorghum + French bean intercropping system followed by sorghum + soybean intercropping system.

Land Equivalent Ratio (LER)

Sorghum + cowpea (50%) had the highest LER followed by sorghum + cowpea (25%), sorghum + cowpea (100%) and sorghum + rice bean (100%) intercropping

systems. The higher LER is attributed to higher green fodder yield of both crops under intercropping systems. This result was in conformity with the finding of Hussain *et al.* (1999) who reported maximum land equivalent ratio (LER) in sorghum + cowpea intercropping system. Also, higher LER was due to intercropping of fodder sorghum with pigeonpea (Verma *et al.*, 2005) and sorghum + mudgaparni as well as sorghum + phillipesara (Singh, 2009).

Table 3: Effect of intercropping systems on sorghum equivalent yield, net returns and LER

Treatment	SEY (q/ha)	Net Return (`)	LER
Sole Sorghum	407.4	10407	1.00
Sole Cowpea	304.7	4744	1.00
Sole Rice bean	358.4	8118	1.00
Sorghum + Cowpea 25%	464.9	14822	1.33
Sorghum + Cowpea 50%	489.8	15314	1.41
Sorghum + Cowpea 75%	405.0	9955	1.17
Sorghum + Cowpea 100%	426.6	10995	1.24
Sorghum + Rice bean 25%	404.8	10516	1.08
Sorghum + Rice bean 50%	427.0	11806	1.14
Sorghum + Rice bean 75%	400.8	9824	1.08
Sorghum + Rice bean 100%	446.5	11095	1.15
CD (P=0.05)	58.7	-	-

LER (Land equivalent ratio) was calculated on the basis of green forage yield at harvest; SEY Sorghum equivalent yield; *Data of LER was analyzed for intercropping system only considering 8 treatments; Note: Price of green forage legumes ` 80.00/q and sorghum ` 60.00/q.

Net return

The highest net returns were noticed in sorghum + cowpea (50%) followed by sorghum + cowpea (25%) and sorghum + rice bean (50%) intercropping systems. The higher net return is the result of greater sorghum equivalent yields of the systems. These findings are in conformity with the report of Mishra *et al.* (1997) who recommended intercropping of fodder sorghum with cowpea due to higher net return and B: C ratio than sole sorghum. Angadi *et al.* (2004) recorded the highest net monetary returns and B: C ratio in sorghum + pigeonpea intercropping and Patel and Rajgopal (2003) recorded maximum net returns in sorghum + cowpea in 4:2 row proportions.

CONCLUSION

On the basis of the present investigation, it is concluded that intercropping of forage sorghum (recommended seed rate) may be grown with cowpea (50% seed rate) for higher green fodder yield, protein yield, net returns and land equivalent ratio.

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