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Effect of intercropping on growth, yield and profitability of sorghum, pearl millet and cowpea

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Abstract
Green forage availability is very important to maintain livestock health and productivity and this is particularly essential in dairy entrepreneurship where consistent and regular supply of green fodder is imperative to sustain the milk production. Green herbage in addition to energy also provides vitamins, minerals with better dry matter digestibility (Surve *et al*., 2012). The field experiment was conducted at research farm, Bihar Agricultural University, Sabour, Bhagalpur, Bihar during *kharif* season of the year 2019 to study the effects of cereal fodder based cowpea intercropping. The soil of the experimental field was loamy in nature and medium in organic carbon (0.54 %), low in available nitrogen (172.84 kg/ha), available phosphorus (28.56 kg/ha) and available potassium (161.34 kg/ha) and neutral reaction. The experiment was laid out in a Randomized Block Design (RBD) design consisting of 11 treatments *viz.* T_1- sole sorghum, T_2- sole pearl millet, T_3- sole cowpea, T_4- sorghum + cowpea (1:1), T_5- sorghum + cowpea (1:2), T_6- sorghum + cowpea (2:1), T_7- sorghum + cowpea (2:2), T_8- Pearlmillet + Cowpea (1:1), T_9- Pearlmillet + Cowpea (1:2), T_{10}- Pearlmillet + Cowpea (2:1) and T_{11}- Pearlmillet + Cowpea (2:2) row ratio. Within various treatments of intercropping, it was found that intercropping of sorghum with cowpea (2:1 row ratio) had higher green fodder (490.0 qh^{-1}) and dry fodder yield (103.3 qh^{-1}), sorghum equivalent yield, net returns (Rs. 55,597 ha^{-1}) and benefit cost ratio (BC ratio) (2.30). Intercropping of sorghum and cowpea with 2:1 row ratio was found economically viable with higher green fodder yield and net returns.

Keywords: Intercropping, sorghum, pearl millet, cowpea, green fodder yield, and B: C ratio

Introduction
India's livestock sector is one of the largest in the world. According to 20th livestock census, 2019, the livestock population is around 536.7 million. At present, the country faces a net deficit of 35.6% green fodder, 10.95% dry crop residue and 44% concentrate feed ingredients. The demand of green and dry fodder will reach to 1012 and 631 million tonnes of by the year 2050 (Vision document-2050, ICAR-IGFRI, Jhansi). At the current level 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. The lack of sufficient quantity of green fodder throughout the year seems to be a major constraint in the growth of animal husbandry in India. This situation can be improved, if animals are fed with balance and adequate quantity and quality of feed and fodder (Singh and Singh, 2002). The major part of livestock forage resources in the state is met either from by-product (rice straw/crop residues) or from the less nutritious grasses leading to low production and productivity of livestock. Therefore, there is a need to boost the production of green and dry fodder from the available resources. Cowpea (*Vigna unguiculata* L.) is commonly grown with sorghum and maize. Fodder cowpea being deep rooted crop and slow growing in early growth stage, during which the more rapidly growing wide spaced crops like- sorghum and pearl millet for fodder, can be conveniently intercropped to utilize the natural resources more efficiently. Cowpea enhances the fodder productivity and improves nutritive value of fodder. Ricebean (*Vigna umbellata* L.) is a fodder legume, intercropped with wide spaced row crops, and a promising multipurpose legume with a good potential to be used as food, fodder, green manure and cover crop (Ayub *et al*., 2004) [11].

Intercropping of cereals with legumes is not only a risk free system under stress conditions but also improves soil fertility by fixing atmospheric nitrogen. Sorghum having low protein content and presence of hydrocyanic acid, makes it poor in quality (Hingra *et al*., 1995) [12], so legumes like cowpea, soybean, guar etc are grown as intercrops with sorghum and pearl millet to improve the forage quality. Cereal-legume intercropping plays an important role in subsistence food production in both developed and developing countries (Tsubo *et al*., 2005). Cowpea being a deep rooted and slow growing in early growth stage, during which the more rapidly growing crop like sorghum, pearl millet and maize being shallow rooted, a wide spaced crop can be conveniently intercropped to utilize the natural resources more efficiently (Willey *et al.,* 1981) [13]. When sorghum was grown in mixture with cowpea, maximum fresh weight per plant, total green fodder yield, dry matter percentage and protein content were.

produced (Abbas, 2005) [14]. The main objective of intercropping has been to maximize the use of resources such as space, light and nutrients (Li *et al.*, 2003) [15] as well as to improve crop quality and quantity (Mpairwe *et al.*, 2002) [16]. In general, beneficial effects of legumes intercropped in cereals like sorghum and maize have been observed under low fertility condition because legumes fix atmospheric nitrogen besides their own N requirements. This eventually helps in meeting the N needs of cereals partially (Ibrar *et al.,* 2002) [17].

Materials and Methods

Experimental site

Field experiment was conducted at research farm Bihar agricultural university, Sabour during *kharif* season 2019. It is located at 25° 23' N, 78° 07' E and 37.19 meters above the mean sea level. The soil of the experimental field was loamy in nature with medium in organic carbon (0.57 %), low in available nitrogen (172.84 kg/ha), available phosphorus (28.56 kg/ha) and available potassium (161.34 kg/ha) with almost neutral in reaction (pH: 7.4). The experiment was laid out in Randomized Block Design consisting of 11 treatments (sole sorghum, sole pearl millet, sole cowpea, sorghum + cowpea and pearl millet +cowpea intercropping each with 1:1, 1:2, 2:1, 2:2 row ratio). It has three replications and a net plot size is 6 m × 3.6 m with 12 rows in each plot. The seed rate of sorghum, pearl millet and cowpea was 18, 8 and 30 kg/ha respectively. The variety of sorghum, pearl millet and cowpea was SSG- 998, Giant bajra and Bundel Lobia-1 respectively. The recommended application of fertilizers (N, P_2O_5 and K_2O) was 80, 60 and 40 kg/ha for sole sorghum and pearl millet whereas 20, 60 and 40 kg/ha for sole legumes but in intercropping system 50 kg N was applied in 1:1 and 2:2 row ratio while 40 and 60 kg N was applied in 1:2 and 2:1 row ratio respectively whereas dose of phosphorus and potash was same. In sole sorghum and pearl millet, 2/3rd nitrogen along with all phosphorus and potash were applied as basal and the remaining 1/3rd nitrogen was top dressed at 30 DAS but in case of cowpea, whole nitrogen along with phosphorus and potash was applied as basal. The source of nitrogen, phosphorus and potash were urea and DAP and MOP. Field was cultivated with cultivator 3 - 4 times and then planking was done to make the soil feasible for sowing. Sole and intercrops were sown on August 2019 and harvested at fifty percent flowering stage (55-60 days after sowing). The sorghum equivalent yield, land equivalent ratio and B: C ratios were calculated by applying standard methods to compare the benefits of intercropping systems.

Results and Discussion

Growth attributes

Plant height: Data regarding plant height (cm.) is given in table- 1 indicating that the plant height of sorghum, pearl millet and cowpea were affected by intercropping patterns. The intercropping pattern of 1:2 was superior for plant heights of sorghum (293.16 cm) and pearl millet (201.72 cm). This result may be because in the intercropping pattern of 1:2, each crop was able to complement each other in growth integration due to higher light interception, soil moisture and reduce intra-specific competition between sorghum or pearl millet and cowpea plants than other intercropping patterns. Similar results were obtained by Shafy (2002) and Sharawy *et al.* (2011) [20]. Intercropping pattern of 1:2 resulted in higher plant population of cowpea reducing the weed infestation (Reda *et al*. 2005) [5].

Number of leaves: Nutritional importance of leaves is greater than stems as animals mostly like to eat leaves of crops rather than stems. Besides other factors which contribute in the final yield, leaf area is one of those factors which affect the yield of crop. Data presented in table 1 indicates the number of leaves per plant in sorghum, pearl millet and cowpea. The intercropping pattern 1:2 depicted maximum number of leaves per plant in sorghum and pearl millet because of better utilization of environmental factors, low inter-row competition and higher plant population of cowpea. Higher plant population of cowpea enhances the N uptake in cereal fodder which improves the growth and yield of fodder. Chundawat (1997) [9] also reported higher number of leaves plant^{-1} of sorghum when grown in mixture with cluster bean. However, in intercropping, the number of leaves in cowpea was reduced due to the shading effect and antagonistic effect of sorghum, pearl millet than sole cowpea crop. Previously, it has been reported that cereals-cluster bean intercropping reduced the proportionate share of component crops for available nutrients, which reduced the number of branches per plant of legumes. Comparatively, fewer branches produced less number of leaves per plant, which ultimately decreased leaf area per plant in comparison with sole cropping (Agegnehu *et al*. 2006) [21].

Leaf area index (LAI): Leaf area is equal to the product of length and width of leaf. It can be influenced due to difference in the fertility of soil and due to prevailing environmental conditions. It is depends upon the leaf area and number of leaves per plant. Data of the leaf area index of plants is given in table 1 and it shows significant effect of intercropping on leaf area of sorghum and pearl millet. The value of leaf area index is higher in sole crop than intercrops. Sole cowpea is having maximum LAI followed by sole sorghum. Islam *et al*. (2018) also reported that sole crop had higher leaf area index than intercrop.

Fresh weight and dry matter accumulation: Data presented in table 2 indicates the fresh and dry weight (g/plant) of sorghum, pearl millet and cowpea were affected by intercropping patterns. The intercropping pattern 1:2 showed maximum fresh and dry weight per plant due to lower population of cereal fodder and higher population of legume crop which enhanced the nutrient uptake as there were sufficient of resources, less inter-row competition. Iqbal *et al.* 2006 [3]; Geren *et al*. 2008 [6] similar result was found and stated that better agronomic growth of component crops led to the increase the fresh and dry biomass in intercropping.

Yield attributes

Green and dry fodder yield: Data presented in table- 3 indicates that the green and dry fodder yield of sorghum, pearl millet and cowpea were affected by intercropping patterns.

The maximum total green and dry biomass production were obtained from the treatment T_6 (intercropping of sorghum and cowpea with 2:1 row ratio) at 490.99 q ha^{-1} and 103.3 q ha^{-1} respectively, while sole sorghum yielded 460.83 q/ha of green biomass and 100.81 q/ha of dry biomass which is statistically at par with intercropping of sorghum and cowpea with 2:1 row ratio (T6). This result indicates the complementary and non competitive effects of these intercrops due to differences in the temporal and spatial characteristics of the crops (Girase *et al*., 2007). The improved performance of the intercropping system was attributed to better utilization of resources, particularly soil moisture and nutrients (Gare *et al*. 2009) [10]. Similar result was found by Sapna *et al*. (2017) where they stated that among the intercropping treatments, intercropping of maize with cowpea in 2:1 row ratio yielded significantly higher green fodder biomass and yield. Same result was also reported by sorghum-cowpea and sorghum-cluster bean intercropping in a 2:1 row proportion which resulted in the higher fresh and dry biomass than other spatial arrangements (Iqbal *et al*. 2018).

Sorghum Equivalent Yield (SEY): Among the all treatments sorghum and cowpea intercropping 2:1 row ratio having maximum sorghum equivalent yield followed by 1:1 and 2:2 row ratio of sorghum and cowpea intercropping. The data of SEY is presented in table- 4 which shows the effect of intercropping on sorghum equivalent yield. The higher fodder price of cowpea than sorghum, pearl millet and higher green biomass production might be a factor for improving sorghum equivalent yield. This result is in conformity with the findings of Pal *et al.* (2014) [2] who reported higher sorghum equivalent yield in sorghum + cowpea and sorghum + ricebean intercropping system and Amedie *et al.* (2004) [11] who also reported higher sorghum equivalent yield in sorghum + french bean intercropping system followed by sorghum + soybean intercropping system.

Land equivalent ratio (LER): Sorghum and cowpea 2:1 row ratio had maximum LER followed by 1:1 and 2:2 sorghum and cowpea intercropping. The higher LER is attributed to higher green fodder yield of both crops under intercropping systems (Table-4). This result was in conformity with the findings of Pal *et al*. (2014) [2] who reported maximum land equivalent ratio (LER) in sorghum + cowpea intercropping system. Similar result was also found by Oseni *et al*. (2010) [4] and reported that an intercropping of sorghum and cowpea under different row ratio showed that 2:1 row ratio gave a better land equivalent ratio (LER) as compared to other planting patterns.

Economics: The data presented in table- 5 shows the net returns, B: C ratio and net profitability. Among the treatments the intercropping of sorghum and cowpea in 2:1 row ratio showed maximum net returns and B: C ratio of Rs. 55,597 ha^{-1} and 2.30 respectively with maximum net profitability followed by 1:1 row ratio of sorghum and cowpea. The difference in net returns and benefit cost ratio might be due to variation in yield. Similar result was found by Sapna *et al.* (2017).

Table 1: Effect of intercropping on growth and yield parameters of sorghum, pearl millet and cowpea at harvest.

Treatments	Plant height (cm)			Number of leaves (plant^{-1})			LAI	Fresh weight (g. plant^{-1})			Dry matter (g. plant^{-1})			Green fodder yield (q ha^{-1})				Dry fodder yield (q ha^{-1})			
	S	PM	CP	S	PM	CP		S	PM	CP	S	PM	CP	S	PM	CP	Total	S	PM	CP	Total
Sorghum (sole)	285.3	-	-	12.4	-	-	4.87	336.5	-	-	40.9	-	-	460.8	-	-	460.8	100.8	-	-	100.8
Pearl millet (sole)	-	195.3	-	-	12.5	-	4.55	-	284.9	-	-	32.4	-	-	366.7	-	366.7	-	80.7	-	80.7
Cowpea (sole)	-	-	194.1	-	-	53.00	4.91	-	-	173.0	-	-	24.1	-	-	247.7	247.7	-	-	54.6	54.6
Sorghum + Cowpea (1:1)	290.8	-	178.9	13.5	-	44.67	4.52	384.9	-	144.1	46.4	-	20.2	293.6	-	161.8	455.4	64.5	-	34.1	98.7
Sorghum + Cowpea (1:2)	293.1	-	174.9	14.1	-	42.33	4.68	391.8	-	124.5	49.7	-	16.5	179.9	-	213.8	393.7	34.2	-	42.2	76.3
Sorghum + Cowpea (2:1)	287.7	-	186.8	12.9	-	49.33	4.09	345.8	-	167.9	41.5	-	22.0	369.3	-	121.6	490.9	77.9	-	25.4	103.3
Sorghum + Cowpea (2:2)	289.3	-	178.9	13.4	-	42.67	4.21	384.6	-	145.9	46.3	-	19.7	292.4	-	158.6	451.0	62.2	-	34.1	96.3
Pearlmillet + Cowpea (1:1)	-	198.2	182.4	-	14.8	44.33	4.10	-	343.2	144.7	-	35.9	19.2	-	230.3	158.3	388.6	-	50.4	33.3	83.7
Pearlmillet + Cowpea (1:2)	-	201.7	177.4	-	15.9	44.67	4.37	-	347.6	122.5	-	37.6	17.4	-	145.3	212.8	358.1	-	37.9	44.7	82.7
Pearlmillet + Cowpea (2:1)	-	196.3	188.8	-	13.6	50.00	4.00	-	297.0	167.9	-	32.7	21.9	-	288.8	121.4	410.2	-	60.1	24.1	84.2
Pearlmillet + Cowpea (2:2)	-	197.3	182.8	-	14.8	44.33	4.09	-	342.7	145.4	-	35.6	18.9	-	226.6	160.0	386.6	-	50.3	33.4	83.7
SEm ±	-	-	-	-	-	-	0.19	-	-	-	-	-	-	--	--	--	11.88	--	--	--	1.97
CD (P=0.05)	-	-	-	-	-	-	0.56	-	-	-	-	-	-	--	--	--	35.06	--	--	--	5.80

S=Sorchum, PM= Pearl Millet, CP=Chickpea

Table 2: Effect of intercropping on sorghum equivalent yield (SEY), land equivalent ratio (LER) and profitability of sorghum, pearl millet and cowpea

Treatments	Sorghum Equivalent Yield (SEY) q ha^{-1}	LER	Net returns (Rs. ha^{-1})	Net profitability (Rs. ha^{-1}day^{-1})	B:C Ratio
Sorghum (sole)	460.83	1.00	45311	742.80	1.90
Pearl millet (sole)	366.74	1.00	32069	525.71	1.40
Cowpea (sole)	330.22	1.00	24758	405.87	1.00
Sorghum + Cowpea (1:1)	509.34	1.29	52106	854.20	2.14
Sorghum + Cowpea (1:2)	464.98	1.26	45293	742.51	1.85
Sorghum + Cowpea (2:1)	531.54	1.30	55597	911.42	2.30

Sorghum + Cowpea (2:2)	503.92	1.28	51293	840.87	2.11
Pearlmillet + Cowpea (1:1)	441.37	1.27	42347	694.21	1.77
Pearlmillet + Cowpea (1:2)	429.04	1.26	40193	658.90	1.66
Pearlmillet + Cowpea (2:1)	450.64	1.28	44043	722.01	1.87
Pearlmillet + Cowpea (2:2)	439.95	1.27	42134	690.71	1.77
SEm ±	12.86	0.03	1930	31.63	0.08
CD (P=0.05)	37.95	0.10	5692	93.31	0.24

Conclusion

The above mentioned findings clearly reflect the advantages of intercropping of cereal and legume crop. Hence it may be concluded that intercropping of forage sorghum with cowpea in 2:1 row ratio gives the maximum green fodder yield, net returns, LER and B: C ratio. The economic advantage per unit area of land was higher when cowpea proportion in the inter-cropping was increased.

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