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Correlation analysis of forage production of sorghum, cowpea and rice-bean under varying seed rates of intercrops

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ABSTRACT

A field experiment was conducted at Forage Agronomy Block of Instructional Dairy Farm at G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during *kharif* 2011 to find out the correlation between growth, yields and quality parameters of legumes (cowpea: *Vigna unguiculata* L. var. UPC-5286 and rice-bean: *Vigna umbellate* L. var. RB-1) and sorghum (*Sorgum bicolar* L. Moench, var. Pant chari-5) crops in intercrops. Overall, intercropping system reduced the growth parameters of crops than sole stand. The correlation studies indicated that association between growth parameters and yield as well as quality was positive and significant, except land equivalent ratio which negatively correlated with growth, yield and quality parameters.

Key words: Correlation, cowpea, growth parameters, intercropping, rice bean, sorghum

INTRODUCTION

Traditionally, intercropping is used by marginal farmers to increase the density of their produce and stability. However, with rapid increase in population and reduction in cultivated areas, intercropping plays crucial role in intensifying land use. The fodder legumes which are mostly removed for fodder at 55 days stage leave biologically fixed nitrogen available in the soil for the sorghum plant without further competing for light or for other resources. It is accounted for total N accumulation of 61-77% in cowpea (*Vigna unguiculata* L.) and 58-78% in soybean (*Glycine max*. L.), respectively (Ofori et al., 1987; Ahmad et al., 2008).

Among *kharif* cereal forage crops, sorghum possesses a wide range of ecological adaptability for its xerophytic characteristics. It is fed to almost every class of livestock. It has higher green forage yield (35-70 t ha^{-1}) and dry fodder yield (10.2 t ha^{-1}). However, the fodder is poor in quality due to low protein content (0.69 t ha^{-1}; Hingra et al., 1995). Legumes have long been recognized as important components of intercropping situations. Among the fodder legume crops, cowpea is commonly grown with maize and sorghum in *kharif*. Being deep rooted crop and slow growing in early growth stage, the rapidly growing crops like sorghum and maize due to their shallow roots utilize the natural resources more efficiently (Willey et al., 1981). Cowpea enhances fodder productivity (25-45 t ha^{-1} green forage yield), improves nutritive value of fodder (crude protein) more than 20% (Solaiman, 2007). Rice-bean (*Vigna umbellate* L.) is another forage legume crop intercropped with sorghum in rainy season. Rice-bean is reported to produce 3000 kg seed ha^{-1}, up to 0.8 t ha^{-1} (Mukherjee et al., 1980) dry herbage to meet scarcity of green forage during lean periods and can supply green fodder yield 15-30 t ha^{-1} (ICAR, 2011).

Increased intercrop competition from 1: 1 to 1: 2 ratio of fodder cowpea and fodder sorghum, plant height, green fodder yield and dry fodder yield of sorghum reduced owing to increased population

pressure of legume in the system (Gumaste, 1990). Intercropping system has an important role in profitability and sustainability in crop production for low-input agricultural systems especially in arid and semi-arid regions (Yildirim and Ekinci, 2017), efficient use of resources (Knudsen et al., 2004), reducing damage caused by pests, diseases and weeds and improvement of forage quality through complementary effects of two or more crops grown simultaneously on the same area of land (Bingol et al., 2007). Singh and Jadhav (2003) reported the higher values of plant height, leaf area and leaf area index under sole sorghum as compared to sorghum intercropped with groundnut, soybean and pigeon pea. The seed proportions of sorghum and rice-bean significantly affected the sorghum plant height, number of leaves of sorghum and rice-bean plants, green and dry matter yields (Ayub et al., 2004).

There has been little or no information on correlation analysis on intercrop of crops, although, Bello et al. (2010) reported the significant and positive correlation of green yield per ha with D50F tassel and PH l maize. A positive association between crude protein content, dry matter yield and protein yield has been found under intercropping of sorghum with cowpea (Ram and Singh, 2003a, b). Based on two years study, Singh (2009) concluded that sweet sorghum intercropped with phillipesara receiving nitrogen 50 per cent through inorganic fertilizer and 50 per cent through vermicompost sustain higher fodder and stalk equivalent yield, quality such as total crude protein, digestibility, and improves soil fertility. Significant positive correlation between yield and all growth parameters of sweet sorghum was noticed. Also there is a report of positive and significant effects on grain yield of rice in intercrop with cassava (Okonji et al., 2013).

MATERIALS AND METHODS

The experiment was conducted at Forage Agronomy block of Instructional Dairy Farm, Nagla of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India in *kharif* 2011. Soil of the experimental field was rich in organic carbon (8.48 g kg^{-1}), medium in available nitrogen (278.48 kg ha^{-1}), available phosphorus (27.70 kg ha^{-1}) and available potassium (232.8 kg ha^{-1}) 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 intercropped each with 25, 50, 75 and 100 % seed rates) with 4 replications. The recommended application of fertilizers (N and P_2O_5) was 120 and 60 kg ha^{-1} for sole sorghum, 20 and 60 kg ha^{-1} for sole legumes and 80 and 60 kg ha^{-1} for intercropping system, respectively. In sole sorghum, two third nitrogen and all phosphorus were applied as basal and remaining one third 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 8, 2011 and harvested at 112 days after sowing.

The statistical analysis of data were appropriate to randomized block design (Cochran and Cox, 1966). Correlation coefficient analysis (Dewey and Lu, 1959) was based on data collected randomly and was carried out to find out the association between plant growth, yield and quality characters using Pearson's correlation at $P = 0.05$.

RESULTS AND DISCUSSION

The simple correlation coefficient analysis carried out in this study for establishing the extent and cause of association between growth, yield and quality parameters of sorghum and legumes intercropped.

Correlation between growth parameters and green forage yield of sorghum

The correlation for sorghum growth parameters was found to have positive correlation among them and with green fodder yield of

sorghum, excluding land equivalent ratio (LER), which was negatively correlated with all the growth parameters and yield. The positive association between mentioned parameters was significant, except number of plants with total dry weight, in which their correlation was positive, but not significant (Table 1).

Cowpea

The linear correlation coefficient between cowpea growth parameters such as plant height, number of plants per meter row length, total dry weight, dry matter (DM) yield, crude protein (CP) content, land equivalent ratio and sorghum equivalent yield with green fodder yield was positive, except LER with fodder yield of cowpea. This, positive association between mentioned parameters was positively significant, excluding plant height with number of plant, total dry weight, DM yield, CP content and sorghum equivalent yield, number of plant with total dry weight and green fodder yield, total dry weight with DM yield, CP content, sorghum equivalent yield and green fodder yield, DM with green fodder yield and finally sorghum equivalent yield with green fodder yield which were positively associated but statistically there was no significant difference among them. The only exception was LER that was negatively correlated with all the other parameters (Table 1).

Rice-bean

The linear positive correlation between growth parameters and green fodder yield of rice bean were positive. These positive correlations were significant among plant height with number of plants, total DM accumulation, DM yield and sorghum equivalent yield; number of plants and sorghum equivalent yield; DM yield with CP content, sorghum equivalent yield and green fodder yield; CP content with green fodder yield (Table 1).

The correlation studies of sorghum, cowpea and rice bean growth parameters with their green forage yield in Table 1 found positive, but in case of sorghum, the growth parameters were significantly positive with CP content and yield. It might be attributed to the fact that increase in plant population, there will be increase in plant height and accumulation of more dry matter in plant parts, which enhance the total dry weight and ultimately green and DM yield would be improved. The positive correlation of plant growth parameters with CP content may be due to sorghum associated legumes which contribute biologically fixed nitrogen to sorghum and enhance nitrogen availability and uptake resulted in improvement of CP content in sorghum. The negative correlation of LER with all other parameters, could be attributed to reduction of yields in intercropping system compared to sole crops. It was in conformity with the findings of Singh (2009) who noticed that various growth parameters and nutrient content per uptake had positively correlated with DM accumulation and yield of sorghum stalk. The positive association between CP content, DM yield and protein yield of sorghum and cowpea was also noticed by Ram and Singh (2003b). Similarly, reports of positive and significant correlation between yield factors of cowpea to that of cowpea and maize (Maurice et al., 2010).

Correlation between yield and quality parameters of Sorghum

The correlations between CP yield, digestible DM, digestible DM yield, DM yield and green forage yield of sorghum were positively correlated. These positive associations were significant between CP yield and digestible DM yield, DM yield and green forage yield; digestible DM yield with DM yield and green forage yield, and DM yield with green forage yield, however, the correlation was not significant with the remaining parameters but maintained positive association (Table 2).

Table 1. Correlation coefficient between growth parameters and green fodder yield of sorghum, cowpea and ricebean plants grown in intercrop

Characters	PH (cm)	NP m RL^{-1}	TDW (g 0.5m RL^{-1})	DMY (q ha^{-1})	CPC (%)	LER	GFY(q ha^{-1})
Plant height (cm) (PH)	-	.850**	.755**	.9328**	.922**	-.534	.937**
Number of plants/m row length (NP mRL^{-1})	-	-	.478	.834**	.791**	-.853	.806**
Total dry weight (g 0.5^{-1} m row length) (TDWg 0.5 mRL^{-1})	-	-	-	.766**	.742**	-.254	.775**
Dry matter yield (q ha^{-1}) (DMY)	-	-	-	-	.988**	-.667	.969**
Crude protein content % (CPC)	-	-	-	-	-	-.607	.948**
Land equivalent ratio (LER)	-	-	-	-	-	-	-.623
Green fodder yield (q ha^{-1})	-	-	-	-	-	-	-

Correlation Coefficient between growth parameters and green fodder yield of cowpea

Characters	PH (cm)	NP mRL^{-1}	TDW (g 0.5 mRL^{-1})	DMY (q ha^{-1})	CPC %	LER	SEY (q ha^{-1})	GFY (q ha^{-1})
Plant height (cm) (PH)	-	0.505	0.510	0.168	0.316	-0.389	0.031	0.715**
Number of plants/m row length (NP mRL^{-1})	-	-	0.541	0.902**	0.893**	-0.410	0.791**	0.516
Total dry weight (g $0.5m^{-1}$ row length) (TDWg 0.5mRL^{-1})	-	-	-	0.591**	0.413	-0.168	0.464	0.157
Dry matter yield (q ha^{-1}) (DMY)	-	-	-	-	0.903**	-0.249	0.952**	0.282
Crude protein content (CPC)	-	-	-	-	-	-0.641	0.932**	0.636**
Land equivalent ratio (LER)	-	-	-	-	-	-	-0.397	-0.913
Sorghum Equivalent yield (q ha^{-1}) (SEY)	-	-	-	-	-	-	-	0.351
Green fodder yield (q ha^{-1}) (GFY)	-	-	-	-	-	-	-	-

Correlation Coefficient studies among growth parameters and with green fodder yield of rice-bean

Characters	PH (cm)	NP mRL^{-1}	TDW (g 0.5 mRL^{-1})	DMY (q ha^{-1})	CPC %	LER	SEY (q ha^{-1})	GFY (q ha^{-1})
Plant height (cm) (PH)	-	0.797**	0.683**	0.738**	0.545	-0.012	0.726**	0.543
Number of plants m^{-1} row length (NP mRL^{-1})	-	-	0.379	0.406	0.023	-0.551	0.803**	0.067
Total dry weight (g 0.5 m^{-1} row length) (TDW g 0.5 mRL^{-1})	-	-	-	0.180	0.511	-0.206	0.039	0.347

Dry matter yield (q ha^{-1}) (DMY)	-	-	-	-	0.648**	-0.338	0.739**	0.750**
Crude protein content % (CPC)	-	-	-	-	-	-0.820	0.298	0.975**
Land equivalent ratio (LER)	-	-	-	-	-	-	-0.203	-0.777
Sorghum equivalent yield (q ha^{-1}) (SEY)	-	-	-	-	-	-	-	0.441
Green fodder yield (q ha^{-1}) (GFY)	-	-	-	-	-	-	-	-

**Level of significant at n-2 degree of freedom at 5% in "r" table is 0.6215 for sorghum plants
** Table value of r = 0.5822, significant at 5% and (n-2 degree of freedom) for cowpea plants
** Table value of r = 0.5822, significant at 5% and (n-2 degree of freedom) for rice-bean plants

Table 2. Correlation coefficient between quality parameters and fodder yield of sorghum, cowpea and rice-bean plants grown in intercrop

Correlation coefficient between quality parameters and fodder yield of sorghum					
Characters	CPY	DDM	DDMY	DMY	GFY
Crude protein yield (CPY)	-	0.003	0.983**	0.988**	0.948**
Digestible dry matter (DDM)	-	-	0.107	0.046	0.062
Digestible dry matter yield (DDMY)	-	-	-	0.988**	0.961**
Dry matter yield (DMY)	-	-	-	-	0.969**
Green forage yield (GFY)	-	-	-	-	-
Correlation Coefficient between quality parameters and fodder yield of cowpea					
Characters	CPC	CPY	DDMY	DMY	GFY
Crude protein content (CPC)	-	0.565	0.119	0.155	0.916**
Crude protein yield (CPY)	-	-	0.886**	0.903**	0.636
Digestible dry matter yield (DDMY)	-	-	-	0.999**	0.246
Dry matter yield (DMY)	-	-	-	-	0.282
Green forage yield (GFY)	-	-	-	-	-
Correlation coefficient between quality parameters and fodder yield of rice-bean					
Characters	CPY	DDM	DDMY	DMY	GFY
Crude protein yield (CPY)	-	0.851	0.704	0.648	0.975**
Digestible dry matter (DDY)	-	-	0.445	0.365	0.822
Digestible dry matter yield (DDMY)	-	-	-	0.996**	0.796
Dry matter yield (DMY)	-	-	-	-	0.75
Green forage yield (GFY)	-	-	-	-	-

** Table value of r = 0.666, significant at 5% and (n-2 degree of freedom: 7) for sorghum plants
** Table value of r = 0.8782, significant at 5% and (n-2 degree of freedom: 3) for cowpea plants
** Table value of r = 0.8782, significant at 5% and (n-2 degree of freedom: 3) for rice-bean plants and Cowpea

The correlation between quality and yield of cowpea indicated the positive correlation between CP content, CP yield, digestible DM yield, DM yield and green forage yield. These positive correlations were significant between CP content and green forage yield; CP yield with digestible DM yield and DM yield, and digestible DM yield with DM yield, but maintained positive correlation with other parameters, though there were not significant correlation (Table 2).

Rice-bean

There was positive correlation between quality and yield of rice-bean parameters such as CP yield, digestible DM, digestible DM yield, DM yield and green forage yield. Among the parameters, CP yield with green forage yield and digestible DM yield with DM yield significantly correlated, whereas, the remaining parameters maintained positive association, although there were not significant associations (Table 2).

Generally, the positive correlation between quality and yield parameters of forage crops indicated that there are direct relationship between quality and yields. It was evident that increase in productivity of green forage yield caused in enhancing the DM yield, digestible DM, digestible DM yield and CP yield. The present findings are in conformity with the findings of Mittal and Moore (2009) who observed significant positive association between green and DM yield of cowpea. Maurice et al. (2010) reported that the positive and significant correlation existed between all the yield attributes of cowpea, as well as between cowpea and maize yields. Sanderson et al. (1994) found that *in vitro* digestibility and CP of sorghum were positively correlated, but the yield of forage sorghum was negatively associated with CP.

CONCLUSION

On the basis of the present investigation, the correlation studies indicated the positive and significant association between growth parameters with yield as well as yield with quality parameters of fodder crops, except for land equivalent ratio, which was negatively correlated with growth yield parameters.

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