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Study of Grass-Legume Intercropping System in Terms of Competition Indices and Monetary Advantage Index under Acid Lateritic Soil of India

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Research Article

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ABSTRACT

Association of sabai grass (Eulaliopsis binata) and blackgram (Vigna mungo) was studied under three intercropping ratios viz., 1:1, 1:2 and 3:5 for two years under acid lateritic soil. Both sabai grass and blackgram were grown as sole crop for comparison. It was found that leaf yield of sabai grass was significantly higher in intercropping than in monoculture system with the maximum value under 1:2 ratio. Higher land equivalent ratio (up to 2.01) and monetary advantage index (as high as US $ 207.0) was recorded under 1:2 intercropping ratio. The growth and yield of blackgram were affected when intercropped with sabai grass as compared to sole crop. Intercropped blackgram recorded up to 68.7% decrease in grain yield when compared with sole blackgram.

Keywords: [Eulaliopsis binata; Vigna mungo; Intercropping; Lateritic soil;]

1. INTRODUCTION

Sabai grass (*Eulaliopsis binata* (Retz.) C. E. Hubb) is a fibre producing perennial plant (Huang et al., 2004). Cellulosic material of the leaves to the extent of 32% makes it an excellent raw material, second only to bamboo, for paper industries (Chauhan, 1994; Mohapatra et al., 2001). At tender stage the leaves are used for fodder purposes. It is distributed in many Asian countries like China, India, Pakistan, Nepal, Bhutan, Mayanmar, Thailand, Malaysia and Phillipines (Sial, 1994; Yong, 1994). In India it is cultivated in the states of West Bengal, Bihar, Jharkhand, Orissa, Punjab, Haryana, Jammu and Kashmir, Himachal Pradesh, Madhya Pradesh and Uttar Pradesh (Gupta, 1994). The flexibility, luster and strength properties of the leaves make it useful for making ropes and other rope based utility items (Mohapatra et al., 2001; Basu et al., 2006), for which sabai grass has an important role in tribal economics of many regions of India (Chauhan, 1994; Anonymous, 2002). Wide spacing (100 cm x 50 cm) and initial slow growth rate of sabai grass provides ample scope for intercropping in association with legumes (Mohapatra et al., 2001; Basu et al., 2006). Intercrop systems may improve yield stability, allowing more consistent yields (Willey, 1979; Horwith, 1985; Fukai and Trenbath, 1993), and efficient use of the resources as well as reductions

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in costly inputs (Keatings and Carberry, 1993). Since the legume utilizes its own fixed nitrogen and cereals use mineral nitrogen, such legume/non-legume mixtures may reduce competition for nitrogen (Rerkasem et al., 1988). Higher yield of sabai grass under intercropping systems in association with grain legumes like cowpea, greengram, blackgram and pigeon pea was also reported by Barik (1996).

The information regarding sabai grass-legume intercropping system is scanty. Therefore, the present investigation was conducted to find out the performance of sabai grass (*Eulaliopsis binata* (Retz.) C. E. Hubb) and blackgram (*Vigna mungo* L. Hepper) intercropping system under acid lateritic soils of India.

2. MATERIAL AND METHODS

2.1 EXPERIMENTAL SITE AND TREATMENTS: The field experiment was conducted for two years (2002-'03 and 2003-'04) at the Research Farm of Rural Development Centre, Indian Institute of Technology, Kharagpur, West Bengal, India (22º19´N latitude and 87º19´E longitude at an altitude of 44 m above mean sea level). The climate of this region is warm humid. The soil is well drained, acid lateritic (pH 5.4), haplustalf, having sandy loam texture with low organic carbon (0.32%), nitrogen (0.042%) and phosphorus (0.034%) content and medium in potassium (0.058%) content.

Blackgram (*Vigna mungo* L. Hepper.) (variety B-76) was grown as a companion crop with sabai grass (*Eulaliopsis binata* (Retz.) C. E. Hubb) (local variety). Three intercropping ratios along with two sole crop treatments (sabai grass (Sb) and blackgram (Bg) of each crop, i. e., all together five treatments were tested in a completely randomized block design (CRBD) with four replications. These were viz., 1. Sole sabai grass; 2. Sole blackgram; 3. Sabai grass with 100% plant population. (Spacing: 100 cm x 50 cm between rows and plants respectively). One row of blackgram between two rows of sabai grass, i. e., 1Sb:1Bg; 4. Sabai grass with 100% plant population. (Spacing: 100 cm x 50 cm between rows and plants respectively). Two rows blackgram between two rows of sabai grass, i. e., 1Sb:2Bg and 5. Sabai grass with 100% plant population (Spacing: 100 cm x 40 cm between rows and plants respectively). A strip of 2 m wide is left after every 3 rows of sabai grass to accommodate 5 rows of blackgram with standard spacing, i. e., 3Sb:5Bg.

The crops were sown/planted in the first week of July. As sabai grass is perennial in nature 15 seedlings per hill were planted once in the first year. A basal application of 30 kg N, 20 kg P_2O_5 and 20 kg K_2O ha^{-1} was applied to all the plots before planting. Sabai grass was harvested in November. Blackgram was harvested manually at 90 DAS and grain yield was recorded.

2.2 COMPETITION INDICES: The yield advantage of intercropping was determined by calculating land equivalent ratio (LER), competition ratio (CR) and monetary advantage index (MAI) according to the methods described by Willey and Rao (1980).

2.3 LAND EQUIVALENT RATIO (LER): It is defined as the amount of land required under monoculture to obtain the same dry matter yield as produced in the intercrop. It is calculated as follows:

$$LERab = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where, Yaa = sole crop yield of species 'a'; Ybb = sole crop yield of species 'b'; Yab = inter crop yield of species 'a' in combination with species 'b' and Yba = inter crop yield of species 'b' in combination with species 'a'. If LERab > 1, there is yield advantage.

2.4 COMPETITION RATIO (CR): It gives an assessment whether the association of the two component crops is advantageous or not. In other words it gives a clear idea about which crop is more competitive in association. It is calculated as follows:

For species ‘a’ $$CRa = \frac{LERa}{LERb} \times \frac{Zba}{Zab}$$;

For species ‘b’ $$CRb = \frac{LERb}{LERa} \times \frac{Zab}{Zba}$$.

Where Zab = proportion of species ‘a’ grown in association with species ‘b’; Zba = proportion of species ‘b’ grown in association with species ‘a’; If CRa > 1, crop 'a' is more competitive than crop 'b' and if the value is < 1, then crop 'a' is less competitive than crop 'b'. The reverse is true for CRb, i. e., for species ‘b’.

2.5 AGGRESSIVITY: Here we don't know whether there is yield advantage or not, we only see whether competitive effect is larger or lesser. Aggressivity is calculated as follows:

$$Aab = \frac{Yab}{Yaa \times Zab} - \frac{Yba}{Ybb \times Zba}$$

$$Aba = \frac{Yba}{Ybb \times Zba} - \frac{Yab}{Yaa \times Zab}$$

Species 'a' is main crop and species 'b' is intercrop. If Aab = 0, crops are equally competitive, if the value is positive, ‘a’ is dominant, if Aab is negative, ‘a’ is the dominated crop. The reverse is true for Aba.

2.6 MONETARY ADVANTAGE INDEX (MAI): The most important part of recommending a cropping pattern is the cost:benefit ratio more specifically total profit, because farmers are mostly interested in the monetary value of return. The yield of all the crops in different intercropping systems and also in sole cropping system and their economic return in terms of monetary value were evaluated to find out whether sabai grass yield and additional blackgram yield are profitable or not. This was calculated with monetary advantage index (MAI). It is expressed as

$$MAI = \left(Pab + Pba\right) \times \frac{\left(LER - 1\right)}{LER}$$;

Where, $Pab = Pa \times Yab$; $Pba = Pb \times Yba$; Pa = Price of species 'a' and Pb = Price of species 'b'. The higher the index value, the more profitable is the cropping system.

Statistical analysis: The recorded data were analyzed with the help of analysis of variance (ANOVA). Least significant differences (LSD) were conducted at a 5% level of probability, where significance was indicated by F-test (Gomez and Gomez, 1984).

3. RESULTS AND DISCUSSION

3.1 YIELD: It is apparent from Table 1 that leaf yield of sabai grass was higher under intercropping system as compared to monocropping system. On an average, intercropped sabai grass produced 19.7% and 22.5% higher dry leaf yield as compared to sole cropping system in the first year and second year respectively. Higher leaf yield of sabai grass in association with blackgram was perhaps due to availability of extra nitrogen from the intercrop legume (Piper, 1994). The sabai grass-legumes intercropping system provides greater yield advantages as compared to sole cropping (Mohapatra et al., 2001, Basu, et al., 2006). As regards different intercropping ratios 1:2 ratio of sabai grass-blackgram association recorded maximum yield and 3:5 ratio showed the lowest yield in both the years. The yield differences were 28.9% and 24.4% system in the first year and second year respectively.

The performance of blackgram in terms of grain yield was superior in monocropping system as compared to intercropping with sabai grass in both the years (Table 1). On an average, intercropped blackgram recorded 55.7% and 68.6% lower grain yield as compared to monocropped one in the first year and second year respectively. Poor yield of blackgram was mainly due to the fact that at later stage of growth sabai grass suppressed growth of blackgram in terms of light and nutrients. Among three intercropping ratios 1:2 recorded maximum yield in both the years and it was followed by 3:5 and 1:1 ratios. Plant population variation under different intercropping ratios was partly responsible for difference in grain yield of blackgram.

Table 1: Leaf yield of sabai grass and grain yield of blackgram under sole cropping and different intercropping ratios

Treatments	Dry Leaf yield (kg ha^{-1})		Grain yield (kg ha^{-1})	
	2008	**2009**	**2008**	**2009**
Sole Sb[1]	692.30	1611.60	-	-
Sole Bg[2]	-	-	1243.8	1287.3
1Sb:1Bg	778.80	1947.50	391.7	311.4
1Sb:2Bg	961.10	2203.60	774.6	491.7
3Sb:5Bg	745.80	1771.80	487.4	411.9
LSD[3] (P<.05)	**55.40**	**82.60**	**81.2**	**62.6**

[1]Sabai grass; [2]Blackgram; [3]Least significant difference

Higher plant population and absence of inter-specific competition in the sole cropping system recorded higher yield (Ghosh, 2004). However, lower grain yield of blackgram was recorded in the second year as compared to first year and the reduction was 20.5%, 36.5% and 15.4% under 1:1, 1:2 and 3:5 intercropping ratio respectively. This was due to the fact that vigorous growth of sabai grass in the second year suppressed the growth of the intercrop. This suppressive effect was maximum in 1:2 ratio as both the rows of blackgram was shaded by canopy coverage of sabai grass.

3.2 COMPETITION INDICES: LER values greater than one in both the years indicated that sabai grass-blackgram intercropping system recorded yield advantage in all intercropping ratios. LER was maximum under 1:2 ratio of sabai grass-blackgram association (Table 2-3).

There was no significant difference between the LER in 1:1 and 3:5 ratios. Intercropping systems that constantly give LERs greater than one are considered to be more efficient systems from a land use point of view than monocrops (Willey 1979). Table 2-3 also reveal that the value of aggressivity of blackgram was negative in all three intercropping ratios in both the years and it was considered as the less-dominant crop in the system. But the positive values of aggressivity for sabai grass in intercropping system proved it to be more dominant than blackgram in both the years. The value of competition ratio of sabai grass-blackgram intercropping system was less than one for blackgram in both the years, so it can be grown with sabai grass as an intercrop. This was due to the fact that sabai grass created shading effect on blackgram and thus affected the growth and yield. According to Willey and Rao (1980), a better measure of competitive ability of the crops can be obtained from CR, which is also an advantageous index over relative crowding coefficient and aggressivity.

Table 2: Assessment of yield advantage under different intercropping ratios in 2008

Treatments	LER[1]	Competition Ratio		Aggressivity		MAI[4]
		Sb[2]	Bg[3]	Sb	Bg	
Sole Sb[1]	-	-	-	-	-	-
Sole Bg[2]	-	-	-	-	-	-
1Sb:1Bg	1.44	3.57	0.28	1.62	-1.62	3226.64
1Sb:2Bg	2.01	4.46	0.22	3.23	-3.23	9627.51
3Sb:5Bg	1.47	4.58	0.22	2.25	-2.25	3982.95
LSD[5] (P<.05)	**0.12**	**0.08**	**0.009**	**0.38**		**412.51**

[1]Land equivalent ratio; [2] Sabai grass; [3]Blackgram; [4]Monetary advantage index; [5]Least significant difference (Unit price (Rs. kg^{-1}) of sabai grass and grains of blackgram represent 3/- and 21/- respectively; US$1=Rs. 46.50/- as on 26.07.09)

Table 3: Assessment of yield advantage under different intercropping ratios in 2009

Treatments	LER[1]	Competition Ratio		Aggressivity		MAI[4]
		Sb[2]	Bg[3]	Sb	Bg	
Sole Sb[1]	-	-	-	-	-	-
Sole Bg[2]	-	-	-	-	-	-
1Sb:1Bg	1.45	5.00	0.20	1.93	-1.93	3844.59
1Sb:2Bg	1.75	7.16	0.14	3.53	-3.53	7254.62
3Sb:5Bg	1.42	5.73	0.17	2.42	-2.42	4126.26
LSD[5] (P<.05)	**0.17**	**0.32**	**0.008**	**0.24**		**525.32**

[1]Land equivalent ratio; [2] Sabai grass; [3]Blackgram; [4]Monetary advantage index; [5]Least significant difference (Unit price (Rs. kg^{-1}) of sabai grass and grains of blackgram represent 3/- and 21/- respectively; US$1=Rs. 46.50/- as on 26.07.06)

MONETARY ADVANTAGE INDEX (MAI)

The MAI was significantly higher under 1:2 sabai grass-blackgram association over all other intercropping ratios (Table 2-3), which might be due to higher LER value. The lowest monetary benefit was recorded in 1:1 sabai grass-blackgram association in both the years. However, the MAI under 1:1 and 3:5 intercropping ratio was statistically at par.

4. CONCLUSION

It is clear from the present study that sabai grass produced higher biomass in association with blackgram as compared to sole cropping system. Among three intercropping ratios the performance of sabai grass

was superior under 1:2 ratio as compared to others, which is also clear from LER, CR, aggressivity and MAI values.

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