J. Agronomy & Crop Science 191, 195—201 (2005)

Crop Forage/ Soil Management/ Grassland Utilisation

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Deferred Seeding of Blackgram (*Phaseolus mungo* L.) in Rice (*Oryza sativa* L.) Field on Yield Advantages and Smothering of Weeds

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Received January 30, 2004; accepted May 29, 2004

Abstract

Field experiments were conducted at Agricultural Experimental Farm, Giridih, Jharkhand, during the kharif (wet) seasons of consecutive four years (1998–2001) to study the effect of staggered seeding of blackgram (*Phaseolus mungo* L.) in rice field as a cereal–legume intercropping system and to minimize the degree of competition between the crop species to avoid yield damage, and at the same time to create a high level of competition by the intercrops to suppress the weeds. Intercropping systems were assessed on the basis of land equivalent ratio, relative crowding coefficient, aggressivity, actual yield loss, monetary advantage, etc. Intercropping reduced the yield of component crops when compared with respective pure stands. However, deferred seeding of blackgram in rice (30 cm) after one weeding was most remunerative system and registered maximum rice-equivalent yield (2711 kg ha^{-1}). Rice–blackgram (20 cm) intercropping system was very effective for weed smothering among unweeded intercropping treatments. In conclusion, deferred seeding of blackgram in rice field (30 cm) with one weeding may be recommended for better yield, weed suppression and better economics in the eastern plateau region of India.

Key words: actual yield loss — blackgram — cereal–legume intercropping — deferred seeding — monetary advantage — weed suppression

Introduction

Cereal–legume intercropping is becoming an integral part of cropping system where sustainable agriculture is emphasized. Legumes when intercropped with cereals fix considerable amount of atmospheric nitrogen, which is either available to the current companion crop or the succeeding crop (Ofori and Stern 1987). Legumes reduce external input requirement and improve the quality and quantity of the internal resources. In degraded soils of the eastern plateau, where crop failure due to erratic rainfall is a common feature, intercropping of cereals with legumes either simultaneously or as deferred seedings gives stability of production. Cereal–legume intercropping system in this tract has been recommended for maintaining soil fertility and to augment yield (Banik and Bagchi 1993, Banik et al. 2000, Rauber et al. 2001, Singh and Rathi 2003). Upland rice is heavily infested with weeds, which causes drastic reduction in yield. It has been estimated globally that yield losses of rice were 24 % with sedges and broadleaf weeds, and 86 % with grassy weeds (De Dutta 1979). However, almost similar grain yield may be obtained under upland rice when compared with transplanted lowland rice, provided that the weeds are effectively controlled. Weed management in intercropping system has hardly been studied to date (Moody and Shetty 1979, Altieri and Liebman 1986, Hong et al. 2004). Intercropping can suppress the growth of weeds more than sole cropping (Yih 1982). Cost of manual weeding may be to some extent mitigated through sound crop husbandry considering intercropping as a component of integrated weed management. This experiment was conducted to study the suitability of deferred seeding of blackgram in rice field as a cereal–legume intercropping system in terms of advantages and economics in the sub-tropical uplands of the eastern plateau region of India. A secondary objective of the experiment was to minimize the degree of competition between the crop species to avoid yield damage, and at the same time to create a high level of competition by the intercrops to suppress the weeds.

Materials and Methods

Experiments were conducted during the kharif (wet) seasons of four consecutive years (1998–2001) at the Agricultural Experimental Farm, Indian Statistical Institute, Giridih, on a sandy-loam soil with pH 5.8–6.3, organic carbon 0.36–0.43 %, available P 17–19 kg ha^{-1} and available K 98–110 kg ha^{-1}. Rice cv. 'Culture-1' was sown as sole crop with one hand weeding and without weeding at 20 and 30 cm spacings. Blackgram cv. 'T-9' *(Phaseolus mungo* L.) was sown as sole crop at 20 and 30 cm spacings. A single row of blackgram was intercropped within two rows of rice as deferred seeding in an additive series. Intercropping treatments were rice + blackgram at 20 and 30 cm spacings with and without weeding. Thus there were 10 treatments:

- T_1 Sole rice at 20 cm spacing without weeding
- T_2 Sole rice at 30 cm spacing without weeding
- T_3 Sole rice at 20 cm spacing with one hand weeding
- T_4 Sole rice at 30 cm spacing with one hand weeding
- T_5 Sole blackgram at 20 cm spacing without weeding
- T_6 Sole blackgram at 30 cm spacing without weeding
- T_7 Rice + blackgram at 20 cm spacing without weeding
- T_8 Rice + blackgram at 30 cm spacing without weeding
- T_9 Rice + blackgram at 20 cm spacing with one hand weeding
- T_{10} Rice + blackgram at 30 cm spacing with one hand weeding.

Treatments were laid out in a randomized complete block design with three replications.

Weekly rainfall and potential evapotranspiration during the growth periods of the crops are summarized in Table 1. Seed rate of sole rice and sole blackgram was 70 and 14 kg ha^{-1} respectively. Blackgram was sown within two rows of rice as deferred seeding at 20 days after sowing (DAS) of rice. Rice was sown at its 100 % sole population and blackgram at its 97 % of sole population under intercropping situation. Fertilizers were applied to both sole and intercropped plots at 60 kg N, 13.1 kg P, 25 kg K ha^{-1} along the rice rows at sowing time and in intercropped plots an additional dose of 20 kg N, 13.1 kg P and 25 kg K ha^{-1} was applied after weeding (20 DAS). Rice and blackgram were sown on 7 June, 12 June, 15 June and 4 June under sole condition and blackgram was intercropped with rice on 27 June, 2 July, 5 July and 24 June, respectively, during four consecutive years (1998–2001). Crops were grown as rainfed. Yield data were taken leaving border rows. Weed population and dry weight were taken at harvest. Land equivalent ratio (LER) and monetary advantage were calculated following Willey (1979), relative crowding coefficient (RCC) following De Wit (1960), aggressivity following McGilchrist (1965) and rice-equivalent yield following Chetty and Reddy (1987). Actual yield loss (AYL) was calculated following Banik (1996). Analysis of variance (ANOVA) of the data was performed using normal procedure (Gomez and Gomez 1984). Combined (Pooled) analyses of the data were performed to identify the temporal effect on the treatments as advocated by Gomez and Gomez (1984).

Table 1: Weekly rainfall and potential evapotranspiration during the experimental period

Week no.	Rainfall (mm)				Potential evapotranspiration (mm)			
	1998	1999	2000	2001	1998	1999	2000	2001
26	51.4	63.6	15.0	9.2	13.4	15.0	23.5	24.6
27	118.4	130.2	33.4	32.2	20.6	14.2	17.0	9.6
28	107.8	77.2	107.4	38.4	16.4	16.8	16.4	13.2
29	0.0	155.4	71.6	24.0	23.0	16.8	13.2	20.0
30	89.6	16.6	13.8	38.8	21.6	18.6	29.8	13.4
31	85.8	30.2	59.4	0.0	27.6	15.6	21.0	20.6
32	98.2	72.2	0.0	31.8	18.5	16.4	18.4	14.8
33	2.0	29.2	6.4	28.0	21.2	13.8	15.9	19.3
34	44.0	33.4	38.2	67.6	19.0	14.4	22.8	10.9
35	36.8	21.0	8.4	57.6	15.0	18.8	15.4	15.2
36	105.0	98.4	24.2	10.6	18.4	18.8	22.0	16.6
37	4.3	45.1	195.4	123.0	21.7	19.5	21.0	22.6
38	18.6	176.8	2.0	5.0	15.2	14.0	17.0	20.1
39	224.0	98.6	6.6	117.0	12.4	15.0	17.6	19.6
40	32.2	4.0	5.0	62.6	5.4	17.6	21.7	17.2
41	25.4	132.0	0.0	0.0	11.4	9.0	20.4	14.4
42	13.0	3.6	0.0	0.0	17.0	18.6	19.2	16.8
43	17.6	20.8	2.0	0.0	13.4	13.4	16.1	15.2
44	0.0	0.0	0.0	0.0	9.0	14.8	19.0	15.8
45	8.4	0.0	0.0	0.0	12.6	14.8	21.6	15.5
46	0.4	0.0	0.0	0.0	10.8	11.3	21.4	13.6
47	0.0	0.0	0.0	0.0	12.6	10.4	14.0	10.0
Total	1082.9	1208.3	588.8	645.8	356.2	337.6	424.4	359.0

Results and Discussion

Yield and rice equivalent yield

Higher grain yield of rice and blackgram was obtained under sole cropping treatment than in mixture in all the 4 years. The pure stand crops maintained their supremacy in terms of grain yield, which may be due to less disturbance of the habitat in homogeneous environment of sole cropping system (Grime 1977). Maximum rice yields of 1583, 1610, 985 and 1236 kg ha^{-1} were recorded under sole crop treatment, grown at 30 cm spacing with one weeding in 1998, 1999, 2000 and 2001 respectively (Table 2). Year-wise variation in yield

Table 2: Grain yield (kg ha^{-1}) of rice and blackgram as affected by intercropping system

Treatments	1998		1999		2000		2001		Pooled	
	Rice	Blackgram	Rice	Blackgram	Rice	Blackgram	Rice	Blackgram	Rice	Blackgram
T_1	805	–	835	–	656	–	820	–	779.00	–
T_2	996	–	1066	–	605	–	905	–	893.00	–
T_3	1430	–	1520	–	945	–	1154	–	1262.25	–
T_4	1583	–	1610	–	985	–	1236	–	1353.50	–
T_5	–	897	–	940	–	710	–	896	–	860.75
T_6	–	1001	–	1008	–	872	–	925	–	951.50
T_7	588	669	696	780	440	640	511	624	558.75	678.25
T_8	694	776	801	860	454	678	723	701	668.00	753.75
T_9	1250	729	1248	750	698	580	1006	735	1050.50	698.50
T_{10}	1375	746	1417	848	723	695	1063	722	1144.50	752.75
S.E.(±)	25.4	8.120	38.04	7.72	23.97	7.15	24.33	4.75	42.220	3.880
CD ($P = 0.05$)	54.49	18.10	81.59	17.21	51.41	15.93	52.20	10.58	87.56	8.28

For a detailed description of treatments in this and the following tables, refer Materials and Methods.

was due to the variation in weather, particularly rainfall. In 2000, less grain yield was recorded due to scanty and erratic rainfall (588.8 mm) whereas rainfall received in 1998, 1999 and 2001 was 1082.9, 1208.3 and 645.0 mm respectively (Table 1). Although rice intercropped with blackgram at 20 cm spacing yielded 72 and 83 % of sole crop rice with no weeding and one weeding treatment, respectively, that at 30 cm spacing yielded 75 and 85 % (mean of 4 years data) respectively. The yield of intercropped blackgram compared with their sole crop decreased by 21 and 19 % with no-weeding treatment at 20 and 30 cm spacings, respectively, and 21 % with one weeding treatment. Relative yield losses of rice under no-weeding treatments of rice + blackgram (20 cm) and rice + blackgram (30 cm) were 28.27 and 25.2 % respectively. On the contrary, under weeded conditions, relative yield loss of blackgram was more when compared with rice (Table 3). This indicates that the relative yield loss of rice is more when infested with weed which may be due to better smothering ability of legumes on weeds when compared with rice (Sheaffer et al. 2002). Maximum rice-equivalent yield (2711 kg ha^{-1}) was recorded under rice + blackgram (30 cm) with one weeding treatment followed by rice + blackgram (20 cm) with one weeding (Table 6).

Land equivalent ratio, competitive ratio, crowding coefficient and aggressivity

The LER values (Table 3) under all the intercropping systems were more than unity, indicating yield advantages due to intercropping. Maximum LER was recorded under rice + blackgram (20 cm) with one weeding treatment (1.644) followed by rice + blackgram (30 cm) with one weeding (1.637). This indicates that 64.4 and 63.7 % more area will be required by sole cropping system to get the equal amount of yield of intercropping system. Intercropped blackgram had more competitive ratios under no-weeding situation when compared with rice indicating that blackgram is more competitive than rice when weeds are dominant in the field. However, under weeding conditions the competitive ratio of rice was more when compared with blackgram indicating the dominance of rice under crop mixture. In the presence of weeds, rice might be considered dominant in a crop mixture situation, whereas under weeding treatment rice maintained its supremacy over blackgram. However, a reverse trend was observed in blackgram. The similar change was observed in RCC indicating blackgram as the dominant component under weed-stress situation with rice dominating where weeds were controlled (Table 3). The results of aggressivity were also in conformity with the results of competitive ratio and RCC.

Actual yield loss and monetary advantage

The mean data of partial AYL of rice and blackgram indicated that the values of partial AYL of both the components were negative indicating yield loss due to intercropping when per plant yield is considered (Table 3). It also revealed that in all the treatments rice was a dominant

Table 3: Different competition functions of rice + blackgram intercropping systems (mean of 4 years)

Treatments	Land equivalent ratio			Competitive ratio		Aggressivity	Crowding coefficient			Relative yield loss		MA	Actual yield loss	
	LERa	LERb	LER	CRa	CRb	Aba	Kab	Kba	K	RYLa	RYLb		AYLa	AYLb
T_7	0.717	0.788	1.505	0.883	1.133	−0.000951	2.461	3.831	9.428	28.27	21.20	2661.51	−0.283	−0.188
T_8	0.748	0.792	1.540	0.916	1.092	−0.000686	2.880	3.930	11.316	25.20	20.78	3157.12	−0.252	−0.183
T_9	0.832	0.812	1.644	0.995	1.005	−0.000044	4.812	4.438	21.358	16.78	18.85	3946.96	−0.168	−0.163
T_{10}	0.846	0.791	1.637	1.037	0.965	0.000299	5.312	3.905	20.740	15.44	20.89	4244.52	−0.154	−0.184

Aba, aggressivity; MA, monetary advantage.

species whereas blackgram was dominant because partial AYLa value of rice was greater than that of blackgram, particularly when grown under unweeded situation. The AYL index gave more precise information about the nature of competition and the behaviour of each species in the intercropping system (Banik 1996). Monetary advantage values were positive revealing definite yield advantages under all intercropping treatments. However, the highest monetary advantage was achieved under rice + blackgram (30 cm) with one weeding treatment (Table 3).

Effect on weed flora

The major weed flora of the experimental site comprised *Echinochloa colonum*, *Digitaria sanguinalis*, *Setaria glauca*, *Physalis minima* and *Digera alternifolia*. The proportion of grassy weeds was more when compared with broadleaved weeds. Maximum dry matter of weeds (137.5 g m^{-2}) was recorded under sole rice (30 and 20 cm) without weeding (Table 4). Sole blackgram at both the planting geometry (20 and 30 cm) recorded less dry matter of weeds when compared with sole rice, which might be due to the better weed-smothering efficacy of the pulse crop (Sheaffer et al. 2002). All intercropping treatments significantly reduced weed biomass when compared with sole cropping, which indicated the better biological efficiency of crop mixture in respect of weed management. Although the least dry matter production (52.2 g m^{-2}) by weeds was recorded under rice + blackgram (20 cm) with one weeding, the same combination without weeding reduced the total biomass of weeds more effectively when compared with the sole treatments of both the crops. This treatment reduced 50.8 % weed biomass when compared with sole rice (20 cm) without weeding. Year-wise data (Table 4) also indicated that there was temporal variation in biomass production by weeds (for both grassy and broad leaf) due to the erratic distribution of rainfall that produced differential flushes of weeds.

Weed population

Mean data on weed population revealed that sole rice at 30 cm spacing without weeding was heavily infested with weeds (156 m^{-2}). The population of grassy weeds was more when compared with broadleaved weeds, irrespective of all treatments (Table 5). There was a significant reduction in weed

Table 4: Weed biomass (g m^{-2}) as affected by deferred seeding of blackgram

	Weed biomass (g m^{-2})										
	1998		1999		2000		2001		Mean		
Treatments	N	B	N	B	N	B	N	B	N	B	Total
T_1	16.6	116.7	18.2	115.6	18.3	109.5	14.5	106.6	16.9	112.1	129.0
T_2	22.4	123.8	24.2	117.8	20.4	119.8	16.8	104.8	21.0	116.6	137.5
T_3	19.8	68.9	13.6	83.6	21.9	72.5	9.7	47.2	16.3	68.1	84.3
T_4	28.7	68.3	18.6	92.3	34.6	73.6	28.9	40.6	27.7	68.7	96.4
T_5	14.3	88.6	15.2	81.4	10.5	63.7	7.8	41.7	12.0	68.9	80.8
T_6	21.6	50.6	14.7	79.3	12.3	70.1	8.4	48.6	14.3	62.2	76.4
T_7	9.6	36.8	8.9	77.3	3.5	66.7	3.7	47.5	6.4	57.1	63.5
T_8	11.2	48.3	13.8	87.3	8.7	63.8	7.8	41.5	10.4	60.2	70.6
T_9	6.4	42.6	5.4	77.9	4.9	36.4	5.5	29.7	5.6	46.7	52.2
T_{10}	6.9	40.9	8.3	91.3	7.6	43.6	4.2	32.4	6.7	52.1	58.8
S.E.(±)	3.05	7.68	2.15	5.79	3.00	6.49	2.06	4.85	4.9	2.35	2.58
CD ($P = 0.05$)	6.42	16.15	4.52	12.17	6.31	13.63	4.34	10.19	10.06	4.83	5.42

N, grassy weeds; B, broadleaved weeds.

Table 5: Weed population (per m^2) as affected by deferred seeding of blackgram

	Weed population (per m^2)										
	1998		1999		2000		2001		Mean		
Treatments	N	B	N	B	N	B	N	B	N	B	Total
T_1	88	52	91	54	74	45	67	41	80	48	128
T_2	98	70	101	75	96	64	69	51	91	65	156
T_3	70	38	68	57	62	38	56	19	64	38	102
T_4	81	29	92	56	54	35	61	20	72	35	107
T_5	62	43	78	41	62	25	38	19	60	32	92
T_6	72	14	74	29	46	23	32	14	56	20	76
T_7	42	8	54	20	26	12	18	8	35	12	47
T_8	48	14	56	31	38	17	26	10	42	18	60
T_9	17	8	29	13	14	5	4	2	16	7	23
T_{10}	18	9	44	19	16	7	10	5	22	10	32
S.E.(±)	4.75	3.26	3.21	6.36	5.39	6.76	2.84	4.85	3.62	0.93	1.63
CD ($P = 0.05$)	9.98	6.85	6.74	13.37	11.32	14.21	5.97	10.19	7.42	1.90	3.42

N, grassy weeds; B, broadleaved weeds.

population (both grassy and broadleaved weeds) under all intercropping systems when compared with the pure stand. The population of weed flora was not static over the years of study (Table 5). Increase or decrease in weed flushes in any year was due to erratic distribution of rainfall. More rainfall encouraged more weed flush. Rice + blackgram (20 cm) with one weeding recorded least population of both the weeds (23 m^{-2}). Among the unweeded intercropping treatments, rice + blackgram (20 cm) registered less number of weeds. Uncontrolled weeds caused 38.3 % reduction in grain yield of sole rice at 20 cm spacing. However, in terms of reduction in weed population, deferred seeding of blackgram in rice field was effective for weed control.

Economic feasibility

The monetary advantages (Table 6) obtained over sole and intercropping systems indicated a definite gain from intercropping. The highest gross return (Rs 12 310.89 ha^{-1}) and net return (Rs 5810.89 ha^{-1}) were secured by rice + blackgram

Table 6: Economics of rice + blackgram intercropping systems (mean of 4 years)

Treatments	Rice-equivalent yield (kg ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})
T_1	779	3450	4045.48	595.48
T_2	893	3300	4644.33	1344.33
T_3	1262	4850	6409.55	1559.55
T_4	1354	4700	6779.85	2079.85
T_5	1791	3500	7628.78	4128.78
T_6	1980	3300	8493.81	5193.81
T_7	1970	5350	8769.31	3419.31
T_8	2236	5200	9911.36	4711.36
T_9	2504	6650	11408.20	4758.20
T_{10}	2711	6500	12310.89	5810.89
S.E.(±)	32.39	–	215.50	98.65
CD (P = 0.05)	66.47	–	452.77	207.26

Average procurement price per kg of rice grain = Rs 4.02; rice straw = Rs 0.70; blackgram grain = Rs 8.37; blackgram dry stalk = Rs 0.35; US\$1 = Rs 46.00.

(30 cm) with one weeding, and sole rice (20 cm) without weeding treatment recorded the least economic return among all the treatments. Sole cropping of blackgram in both planting geometry was better than sole rice in terms of economics. The results indicate that sole cropping of rice is less remunerative under the upland condition of the eastern plateau.

Conclusion

The ultimate consideration for selecting the best system is the advantages and economics of production. Thus on the basis of the results of this experiment, the staggered seeding of blackgram under different planting geometry on rice field may be recommended in the eastern plateau region of India. Intercropping systems were advantageous over sole cropping in terms of competition and economics. Furthermore weed population and biomass production were significantly reduced due to staggered seeding of blackgram in the rice field when compared with sole cropping systems. In the light of the experimental finding it may be concluded that rice + blackgram (30 cm) with one weeding is the most remunerative system when compared with sole cropping of the respective crops.

Acknowledgements

The authors are grateful to the learned referees of the *Journal of Agronomy and Crop Science* for their valuable comments to improve the manuscript.

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