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Planting geometry and nitrogen management in rice (*Oryza sativa*) and soybean (*Glycine max*) intercropping

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ABSTRACT

A field experiment was conducted during rainy (*kharif*) season of 1993 and 1994 at Raipur, to identity level and schedule of nitrogen under different planting geometry of rice (*Oryza sativa* L.) and soybean [*Glycine max* (L.) Merr.] intercropping under rainfed upland conditions. Higher growth, yield and its attributes were recorded under sole crop of rice and soybean. However, among intercroppings rice : soybean under paired-row combinations (2:2) had higher values of these, followed by 1:1 and 1:2 row combinations. The yield and its attributes of soybean were higher with 40 kg N/ha applied in 2 equal splits at basal and panicle–initiation (PI) stages of rice, while in case of rice, it was higher with 60 kg N/ha applied in 3 splits–at basal, tillering and PI stage of rice–during both the years. The land-equivalent ratio was higher under paired-row combinations of rice : soybean compared with other combinations at the respective levels and scheduling of nitrogen.

Key words **:** Intercropping, Rice, Soybean, Planting geometry, Nitrogen management

Chhattisgarh region of Madhya Pradesh covers more than 30% of the total area under unbunded upland black soils where rainfed rice crop mainly being grown. Rice-based intercropping is useful in reducing the risks of monsoon and also in increasing productivity (Angadi and Chittapur, 1990). The competition between component under different row combinations in an intercropping system could be considerably reduce and the benefits from the systems increased by varying the planting geometry of component crops (Gupta and ÖToole, 1986). Nitrogen management in rice and soybean intercropping is very crucial for determining the efficiency of intercrop system. Afori and Stem (1986) reported strong competition for soil N by intercrop maize and cowpea.

The information on rice and soybean intercropping under different levels and scheduling of N, to improve their performance under rainfed upland conditions of Chhattisgarh plain region of

Madhya Pradesh is lacking. The investigation was, therefore, undertaken to study the possibility of increasing stability of production under different planting geometry and scheduling of N in rainfed upland by intercropping of rice and soybean.

MATERIALS AND METHODS

The field experiment was conducted during rainy (*kharif*) season of 1993 and 1994 at Raipur, under rainfed upland conditions. The trial was laid out in randomized block design with 15 treatments and replicated thrice. The soil was clayey loam with 7.2 pH, having available nitrogen 261.4 and 254.8 kg/ha, available phosphorus 24.3 and 21.8 kg/ha and available potash 344 and 320 kg/ha during 1993 and 1994 respectively at 0–15 cm depth. There were 15 treatments, comprising T_1, sole soybean 30 cm, N 30 kg/ha at basal; T_2, sole soybean 40 cm, N 30 at basal; T_3 sole rice 20 cm, N 40 as 20 at basal and 20 at panicle initiation (PI); T_4, sole rice 20 cm, N 60 as 30 at basal and 30 at PI; T_5, Sole rice 20 cm, N 80 as 20 at basal, 30 at tillering and 30 at PI; T_6, Sole rice 20 cm, N 100 as 40 at basal, 40 at tillering and 20 at PI; T_7, rice : soybean (1:1) 20 cm, N 60 as 20 at basal, 20 at tillering and 20 at PI; T_8, rice : soybean (1:1) 20 cm, N 40 as 20 at basal and 20 at tillering; T_9, rice : soybean (1:1) 20 cm, N 40 as 20 at basal and 20 at PI; T_{10}, rice : soybean (1:2) 20 cm, N 60 as per T_7; T_{11}, rice : soybean (1:2) 20 cm, N 40 as per T_8; T_{12}, rice : soybean (1:2) 20 cm, N 40 as per T_9: T_{13}, rice : soybean (2:2) paired 30:20 cm, N 60 as per T_7; T_{14}, rice : soybean (2:2) paired 30:20 cm, N 40 as per T_8; T_{15}, rice : soybean (2:2) paired 30:20 cm, N 40 as per T_9, during both the years. The test variety of rice was 'Annada' and of soybean was 'Gaurav'. Date of sowing was 30 June and 1 July during 1993 and 1994 respectively. Entire quantity of phosphorus and potassium was applied @ 60 kg and 30 kg/ha respectively, uniformly to all the plots, whereas N was given as per treatments separately to both the crops. The top-dressing of N in sole rice and intercropping was given at the close proximity line of rice only.

RESULTS AND DISCUSSION

Growth

Soybean: Significantly higher plant height, branches/plant and total dry-matter accumulation were recorded under pure crop than intercropping treatments (Table 1). Among sole crops, soybean placed at 40 cm spacing (T_2) had significantly higher plant height, branches/plant and total dry matter than 30 cm spacing, except during 1993 for plant height where it was higher at 30 cm spacing, because of the more space become available for grand growth and less competition for nutrient, moisture and light. Similar results were also reported by Singh *et al.* (1994) for chickpea. Among the intercroppings, higher plant height, branches/plant, total dry matter were recorded in rice : soybean (2:2) paired row because 30 cm space was maintained between 2 rows of soybean which provided better growth condition. Nitrogen application @ 60 kg/ha to rice crop resulted higher of these values than that of 40 kg N/ha. However, 20 kg N/ha applied either at tillering stage or at PI stage to rice had no significant response in any intercropping treatments.

Rice: Plant height, tillers/plant and dry matter were higher in sole rice crop and increased with increasing levels of N from 40 to 100 kg/ha (Table 1). However, rice : soybean in 2:2 ratio under paired row (T_{13} to T_{15}) had significantly higher plant height, number of tillers and dry matter, followed by rice : soybean in 1:2 and in 1:1 row combinations. Among all 3 individual intercropping treatments, higher plant height, branches/plant and dry matter were obtained when 60 kg N was applied in 3 equal splits at basal, tillering and PI stage. However, 20 kg N/ha at tillering stage or at PI stage under 40 kg/ha had not much influence on all above characters.

Yield and yield attributes

Soybean: Significantly higher pods/plant, seeds/pod, 100-seed weight and protein contents were noticed with sole crop of soybean planted at 40 cm apart, whereas seed and straw yields were

Table 1. Growth of rice and soybean at maturity as influenced by N scheduling and intercropping

Treatment	Rice						Soybean					
	Plant height (cm)		Tillers/ plant		Dry matter/ plant (g)		Plant height/ (cm)		Branches/ plant		Dry matter/ plant (g)	
	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
T_1							94.6	82.8	5.67	5.47	34.8	31.8
T_2							89.2	88.3	6.69	6.53	39.5	36.1
T_3	44.6	46.8	2.98	3.16	6.27	4.78						
T_4	45.2	51.9	3.30	3.30	6.55	5.24						
T_5	51.3	59.2	3.33	4.04	5.74	5.87						
T_6	54.2	62.9	3.98	4.43	7.06	6.21						
T_7	36.4	37.4	2.46	2.47	3.59	3.80	70.6	66.3	3.98	3.54	27.2	24.2
T_8	32.7	31.0	2.31	2.22	3.03	3.54	66.9	60.2	3.82	3.36	25.2	21.2
T_9	30.8	26.5	2.07	2.13	2.55	3.28	61.3	60.0	3.52	3.36	24.7	21.2
T_{10}	39.3	40.0	2.50	2.42	4.53	4.54	64.8	65.6	4.06	3.93	25.5	26.2
T_{11}	33.9	36.4	2.40	2.28	3.96	3.88	63.1	60.2	3.88	3.54	24.1	23.5
T_{12}	31.1	30.5	2.13	2.13	3.72	3.85	60.8	60.6	3.52	3.52	23.7	22.4
T_{13}	41.9	44.6	2.58	2.80	5.54	4.70	73.4	72.1	4.44	4.51	30.6	27.7
T_{14}	36.4	40.1	2.60	2.42	5.08	4.24	71.8	64.3	4.20	4.10	28.4	23.9
T_{15}	33.4	38.9	2.40	2.30	4.65	4.09	68.1	64.0	4.09	4.15	27.4	23.3
CD (P=0.05)	1.44	7.0	0.17	0.14	0.38	0.30	2.5	4.6	0.25	0.27	1.7	2.5

Details of treatments are given under Materials and Methods

Table 2. Yield and yield attributes of rice as influenced by N scheduling and intercropping

Treatment	Panicles/ hill	Panicle weight (g)	Grains/ panicle	1,000-grain weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Protein content (%)
				1993			
T_1							
T_2							
T_3	2.63	1.22	54.3	25.0	19.4	24.8	8.25
T_4	2.88	1.26	58.4	25.6	21.8	28.2	8.75
T_5	3.02	1.36	64.6	26.0	24.2	35.0	9.25
T_6	3.40	1.45	68.8	26.8	26.1	35.7	9.50
T_7	2.25	1.11	58.0	20.0	11.9	14.5	7.50
T_8	2.10	1.08	50.8	18.8	10.6	15.0	7.31
T_9	1.92	1.01	49.6	18.0	10.1	14.3	7.25
T_{10}	2.33	1.20	61.7	23.5	16.7	26.0	8.31
T_{11}	2.30	1.15	57.3	21.8	15.2	24.0	8.00
T_{12}	2.02	1.09	56.1	20.7	14.0	24.4	7.87
T_{13}	2.39	1.29	63.4	25.6	12.5	16.5	8.68
T_{14}	2.30	1.20	60.9	24.9	11.6	16.0	8.43
T_{15}	2.18	1.18	59.4	24.3	10.5	15.3	8.00
CD (P = 0.05)	0.14	0.08	2.3	1.7	2.1	3.8	0.20
				1994			
T_1							
T_2							
T_3	2.86	1.20	52.4	24.4	16.3	20.0	9.12
T_4	3.02	1.26	56.3	25.5	19.2	22.6	8.56
T_5	3.33	1.33	61.8	26.1	23.5	26.0	10.18
T_6	3.41	1.41	64.7	26.8	25.0	30.1	10.62
T_7	2.21	1.12	52.5	21.6	10.4	13.9	8.31
T_8	2.08	1.00	45.1	20.0	8.3	13.1	7.94
T_9	2.00	0.92	45.2	19.3	8.2	13.0	7.62
T_{10}	2.00	0.92	45.2	19.3	8.2	13.0	7.62
T_{11}	2.15	1.22	55.4	23.2	14.9	17.1	8.81
T_{12}	1.88	1.08	48.0	21.6	12.2	16.1	8.12
T_{13}	2.36	1.30	60.4	25.9	12.2	14.3	9.37
T_{14}	2.20	1.23	53.2	24.9	11.5	12.1	9.00
T_{15}	2.11	1.19	53.4	24.5	11.2	12.0	8.69
CD (P = 0.05)	0.20	0.12	2.6	1.5	1.8	2.6	1.22

Details of treatments are given under Materials and Methods

Table 3. Yield and yield attributes of soybean as influenced by N scheduling and intercropping

Treatment	Pods/ plant	Grains/ pod	100-grain weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Protein content (%)	LER
				1993			
T_1	62.4	2.60	13.2	25.50	35.5	39.6	1.00
T_2	67.6	2.73	13.7	22.69	33.1	41.8	1.00
T_3							
T_4							
T_5							
T_6							
T_7	49.1	2.17	11.6	18.67	30.5	28.7	1.28
T_8	50.8	2.15	10.9	18.00	30.2	38.6	1.16
T_9	52.1	2.30	11.9	20.69	29.9	37.8	1.25
T_{10}	45.1	1.96	10.6	14.58	22.2	38.6	1.30
T_{11}	42.1	1.92	10.4	14.20	22.0	37.9	1.22
T_{12}	46.2	2.06	11.5	15.77	21.7	37.5	1.23
T_{13}	58.1	2.41	12.5	19.88	32.6	39.2	1.32
T_{14}	56.0	2.16	12.2	19.02	29.9	38.7	1.25
T_{15}	59.2	2.56	12.9	21.46	30.7	38.3	1.30
CD (P = 0.05)	1.9	0.16	0.9	1.67	2.2	0.6	0.06
				1994			
T_1	60.2	2.55	12.8	24.05	36.10	42.0	1.00
T_2	68.3	2.78	13.5	22.64	26.91	42.8	1.00
T_3							
T_4							
T_5							
T_6							
T_7	51.8	2.40	11.4	15.02	36.82	39.1	1.19
T_8	46.7	2.27	10.6	14.84	35.09	38.5	1.15
T_9	55.8	2.55	12.0	17.00	25.21	38.1	1.23
T_{10}	43.1	2.08	10.8	12.88	20.56	38.6	1.33
T_{11}	40.6	1.90	10.1	11.28	18.95	38.1	1.22
T_{12}	48.7	2.31	11.3	13.24	13.79	37.6	1.31
T_{13}	55.3	2.50	12.0	17.20	39.97	39.6	1.38
T_{14}	51.7	2.43	11.2	14.39	30.92	39.2	1.32
T_{15}	57.4	2.60	12.3	19.60	34.76	38.6	1.53
CD (P = 0.05)	4.4	0.19	0.9	1.32	6.68	NS	0.13

Details of treatments are given under Materials and Methods

significantly higher in sole soybean placed at 30 cm spacing than when placed at 40 cm or intercropping treatment (Table 2). In general, narrow row spacing gave 12.4 and 6.6% more yield in 1993 and 1994 respectively than wider row spacing and it was attributed to increased number of plants/ha (more than 83,000) under this row spacing. The improvement in yield attributes under wider row spacing might be owing to better utilization of available soil moisture at later stages, whereas same might have become a limiting factor for more number of plant adjusted in narrow row spacing of 30 cm. Sarawgi and Singh (1989) also reported similar effect of population in chickpea. Among rice : soybean intercroppings, the 2:2 paired (T_{13} to T_{15}) had higher yield and yield attributes, followed by and 1:2 over each of the respective levels and scheduling of N. The highest seed yield of soybean in all the intercroppings was recorded with application of 40 kg N/ha to rice crop, applied in 2 equal splits at basal and PI stage. This might be due to the application of 20 kg N/ha at PI stage favoured more accumulation and translocation of N; because at this stage most of the nodules were degenerated. Application of 20 kg N/ha at tillering stage of rice had detrimental effect on nodulation and yield of soybean. Angadi and Chittapur (1990) also mentioned that yield of legumes was significantly influenced due to application of N at tillering stage. The protein content in grain varied from 37.6 to 42.8%. The highest land-equivalent ratio (LER) of 1.32 and 1.53 were noted with T_{13} and T_{15} treatments during 1993 and 1994 respectively, while the lowest LER with T_8.

Rice: All the yield and yield attributes, viz. panicles plant, panicle weight, grains/panicle and 1,000-grain weight, grain and straw yields and protein content in grain of rice were significantly higher in sole rice treatments over all intercropping treatments (Table 3). Further, all these characters increased with the increasing levels of N in sole rice crop and were found significantly higher with 100 N/ha applied in 3 splits (T_6) as 40 kg at basal, 40 kg at tillering and 20 kg at PI stage than 60 and 40 kg N/ha. Gupta and O,Toole (1986) also reported that application of higher dose of N in 3 splits gave significantly higher yield under upland conditions. Among intercroppings, rice : soybean (2:2) under paired row combination (T_{13} to T_{15}) had higher panicles/hill, panicle weight, grains/panicle, 1,000-grain weight and protein content, possibly owing to more favourable environment for growth and development of rice under paired-row combination. However, higher grain and straw yields of rice in rice : soybean in 1:2 ratio (T_{10} to T_{12}), placed 20 cm apart, was due to population effects only because 67% area was covered by rice and only 33% area under the soybean. The lowest grain and straw yields were found with rice : soybean in 1:1 ratio (T_7 to T_9) where rice suffered more competition for light, moisture and nutrients. In each of the intercropping, application of 60 kg N/ha in 3 equal splits, at basal, tillering and PI stage, resulted in higher yield and yield attributes of rice than the 40 kg N/ha applied in 2 equal splits at basal and tillering stage or at basal and PI stage. Application of 20 kg N at tillering stage of rice caused slight improvement in yield and yield attributes and protein content in grain than at PI stage. Ramamoorthy *et al.* (1977) reported that the highest rice grain- equivalent yield in rice + blackgram intercropping at 4:1 ratio, followed by rice + blackgram (3:1) riee + greengram (4:1) and rice + soybean (2:1)

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