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Influence of different rice (*Oryza sativa*)-legume associations on the performance of succeeding crops of linseed (*Linum usitatissimum*) and safflower (*Carthamus tinctorius*)

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ABSTRACT

In a field investigation during the dry seasons of 1991-93 two oilseed crops, namely, linseed (*Linum usitatissimum* L.) and safflower (*Carthamus tinctorius* L.), were tested under a typical rainfed upland condition which were preceded by different rice-legume associations comprising greengram (*Phaseolus radiatus* L.), blackgram (*P. mungo* L.) and pigeonpea [*Cajanus cajan* (L.) Millsp.]. The total water (consumptive use) was recorded to be the highest with the plots which succeeded rice+blackgram intercropping system at a higher level of fertility during 1991-92, but during 1992-93, the highest values of total water use were recorded with the plots, where previously rice + pigeonpea was practised at a higher level of fertility. Both the crops were found extracting greater percentage of moisture from the top 15 cm soil depth during both the years of experimentation. The total number of branches/plant, number of capsules/heads/plant and 1,000-seed weight of the crops were higher in the plots, where previously rice + blackgram intercropping system was adopted at a higher level of fertility, and the final seed yield of both the crops showed the same trend during both the years of experimentation.

Key words **:** Rice-legume association, Linseed, Safflower, Moisture extraction pattern

Legumes when grown in association with cereals in the intercropping system, bring about an improvement of N-status of the soil and conserving soil moisture. This association also helps in taking the second crop. The oilseeds in view of their capability to withstand soil moisture stress to a greater extent, can successfully be grown during the dry season under such a situation. Hence the present investigation was undertaken to study the effect of different rice-based inter- and mixed cropping systems on the performance of the succeeding oilseed crops under a typical rainfed upland condition.

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MATERIALS AND METHODS

A field experiment was conducted during the wet seasons of 1991 and 1992 at Kalyani, West Bengal, on a well drained upland sandy loam soil, pH 7.4, organic carbon 0.67%, total N 0.07%, available P 13.8 kg/ha and K 149.4 kg/ha. The experiment was laid out in randomized complete block design with 12 treatments replicated thrice and the plot size was 10.5 m × 4 m. The details of the treatment were as follows : T_1, Sole crop rice (cv. 'IR 36') 20 cm apart with 60 : 13.1 : 25 (N, P and K kg/ha); T_2, Sole crop of pigeonpea (cv. 'UPAS 120') 30 cm apart with 20 : 17.5 : 0 (N, P and K kg/ha); T_3, Sole crop of greengram (cv. 'B 105') 30 CM apart with 20 : 17.5 : 0 (N, P and K kg/ha);T_4 sole crop of black gram 30cm apart with 20 : 17.5 : 0 (N, P and k kg/ha); T_5, Rice + pigeonpea (3 : 2), rice on wide bed furrows (60 cm) and pigeonpea on raised beds (60 cm) with fertilizer dose as in T_1; T_6, Same as T_5 with fertilizer dose as in T_2; T_7, Rice + greengram) (3 : 2), rice on wide bed furrows (60 cm) and greengram on raised beds (60 cm) fertilizer dose as in T_1; T_8, Same as T_7 with fertilizer dose as in T_2; T_9, Rice + blackgram (3:2), rice on wide bed furrows (60 cm) and blackgram on raised beds (60 cm) with fertilizer dose as in T_1; T_{10}, Same as T_9 with fertilizer dose as in T_2; T_{11}, Rice and pigeonpea mixed cropping with fertilizer dose as in T_1; T_{12}, Same as T_{11} with fertilizer dose as in T_2.

After the wet season experiment, the present investigation during the dry season was started by dividing each plot into 2 subplots (length wise). The plot size was 5 m × 4 m. The succeeding crops of linseed (cv. 'Sweta') and safflower (cv. 'A 300') were tested in each plot with 20 cm and 40 cm spacings respectively. The fertilizer dose was 40:8.8:16.6 (N, P and K kg/ha) for the crops of linseed and safflower.

The water balance method was used for calculating total water use on each plot. Then, the percentage of contribution by each soil depth out of the total water use was worked out for determining the pattern of soil moisture extraction.

RESULTS AND DISCUSSION

Total water use and moisture extraction pattern

It was found that the total water use values were reorded to be higher from the plots previously treated with rice + blackgram intercropping system at a higher level of fer-

Table 1. Effect of different rice-legume associations on the total water use of succeeding crop of linseed and safflower

Treatment	Total wateruse (mm)			
	Linseed		Saflower	
	1991-92	1992-93	1991-92	1992-93
T_1	213	198	249	227
T_2	216	206	254	239
T_3	211	188	244	209
T_4	221	212	266	219
T_5	225	208	259	247
T_6	216	208	249	244
T_7	225	199	267	230
T_8	218	194	260	225
T_9	229	205	273	229
T_{11}	216	206	253	236
T_{12}	212	204	247	228

Details of treatments are given under Materials and Methods tility (T_9) in both linseed and safflower during 1991-92, whereas during 1992-93 the highest values were obtained from the plots which were previously treated with rice + pigeonpea intercropping system at a higher level of fertility (T_5). The higher values of total water use indicated less depletion of soil moisture from the top layer which resulted in better establishment of the plants on those plots as amount of total water utilized by the plants depended on the soil mosture status as well as plant growth. Singh and Das (1985) reported that the optimum soil moisture in the seeding zone played the key role in attaining optimum plant population per unit area for different oilseed crops under rainfed situation. Further, it was also found that the total water use values in both linseed and safflower were lower with the plots, where greengram was tested as sole crop (T_3) during both the years of experimentation. As the sole cropped plots of greengram were vacated sufficient time ahead of sowing of succeeding linseed and safflower due to the early harvest of greengram, resulted in greater depletion of soil moisture from the top layer of the soil which ultimately reduced the initial growth of both the crops of linseed and safflower on those plots. Further, it was found that the total water use was higher during 1991-92 as compared to 1992-93 with both the crops of linseed and safflower. This was mainly due to better residual soil moisture status during 1991-92 as there was oc-

Table 2. Effect of different rice-legume associations on the moisture extraction pattern (percentage) of succeeding crop of linseed

Treatment	Depth of Soil (cm)									
	0-15		15-30		30-45		45-60		60-75	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
T_1	27.7	25.1	23.3	20.7	18.3	19.6	17.1	1.9	14.6	16.6
T_2	27.1	26.6	24.7	22.4	19.3	20.2	15.6	16.8	13.4	14.1
T_3	26.5	24.8	19.7	20.5	18.9	19.8	18.8	18.0	16.2	17.1
T_4	26.9	25.6	21.1	21.1	18.8	20.4	18.1	18.9	15.2	14.0
T_5	28.1	27.0	24.2	22.6	19.7	19.5	16.9	18.4	11.1	12.6
T_6	27.7	26.4	24.3	21.8	19.8	20.3	17.9	17.6	10.2	13.9
T_7	27.3	25.8	21.9	20.4	18.7	18.8	17.4	17.8	14.8	17.3
T_8	26.8	25.5	22.5	21.1	20.3	20.6	16.9	16.8	13.5	16.0
T_9	27.6	26.0	23.2	20.8	20.4	19.4	15.1	18.8	13.7	15.0
T_{10}	27.3	25.2	23.0	21.4	19.6	19.6	17.3	17.2	12.9	16.5
T_{11}	27.8	26.6	21.9	22.8	20.4	19.4	17.2	17.7	15.0	15.6
T_{12}	27.4	26.2	21.5	21.6	18.5	18.6	16.3	16.8	14.0	14.8

Details of treatments are given under Materials and Methods

Table 3. Effect of different rice-legume associations on the moisture extraction pattern (percentage) of succeeding crop of safflower

Treatment	Depth of soil (cm)									
	0-15		15-30		30-45		45-60		60-75	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
T_1	23.5	21.7	18.8	18.4	20.5	20.1	21.6	21.4	15.6	18.4
T_2	23.8	22.9	18.1	18.8	20.4	19.6	22.2	20.8	15.5	17.9
T_3	24.4	20.4	20.6	19.1	19.4	20.7	19.2	21.4	16.4	18.4
T_4	24.7	22.5	19.1	19.1	20.5	20.2	20.3	20.2	15.4	18.0
T_5	25.2	23.9	20.4	18.5	20.2	20.1	19.0	20.8	15.2	16.8
T_6	24.9	23.5	21.0	18.4	19.8	20.3	19.6	19.0	14.8	18.9
T_7	24.0	21.2	17.6	18.5	21.1	20.2	19.7	21.6	17.6	18.5
T_8	23.4	20.8	18.4	19.5	20.3	20.6	19.0	20.6	18.9	18.5
T_9	24.2	22.3	18.8	18.7	21.0	20.6	19.3	19.3	17.2	19.2
T_{11}	24.2	22.7	19.8	16.9	21.1	19.0	20.7	21.5	14.2	20.0
T_{12}	24.6	23.1	20.6	17.8	20.3	19.0	19.2	20.2	15.4	19.9

Table 4. Yield components and seed yield of succeeding crop of linseed

Treatment	No. of branches/plant		No. of capsules/plant		1,000-seed weight (g)		Seed yield (q/ha)	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
T_1	11	8	178	117	5.2	5.4	11.1	8.1
T_2	11	7	201	108	5.3	5.0	11.8	7.5
T_3	10	7	171	107	5.1	4.9	11.1	7.1
T_4	12	.10	220	150	5.5	5.5	12.7	9.0
T_5	12	9	226	132	5.5	5.0	12.7	9.0
T_6	11	9	191	124	5.2	5.12	11.6	8.4
T_7	13	10	229	144	5.6	5.3	112.9	9.8
T_8	13	9	207	135	5.3	5.2	2.0	8.9
T_9	13	11	245	173	5.6	5.4	13.3	10.5
T_{10}	11	11	216	157	5.4	5.3	12.3	10.0
T_{11}	11	8	193	132	5.3	5.1	11.6	8.5
T_{12}	10	8	170	116	5.2	5.0	11.1	7.4
CD (P = 0.05)	NS	1.0	NS	20.1	NS	0.3	NS	1.6

currence of few showers during the growing season of the crops which resulted in better establishment of the crops with more efficient utilization of soil moisture during 1991-92. Again, the values of total water use were always higher in safflower as compared to linseed in the respective plots during both the years of experimentation which indicated the capability of safflower for extracting soil moisture even from a deeper layer of the soil under rainfed condition. Hodgson and Chan (1984) also showed the ability of safflower to extract soil moisture up to a depth of 145 cm in fallowed plots.

While considering the moisture extraction pattern, linseed showed greater utilization of moisture from the top 15 cm soil layer in different plots. The extraction of soil moisture was reduced with the increase in depth of soil and it was lowest at 61-75 cm soil layer. This indicated that the major portion of the plant roots of linseed were concentrated in the top soil layer and decreased with the increase in depth of the soil. However, in safflower, the extraction of the soil moisture was greater at the top 15 cm soil layer and was found to be reduced at deeper layers. It was further increased from 31-60 cm soil layer and a considerable amount of moisture was extracted from 31-60 cm soil depth. This was clearly indicated that safflower was capable of extracting soil moisture from a greater depth under moisture stress situation (Table 3).

Yield attributing characters and seed yield

In linseed and safflower, the number of

Table 5. Yield components and seed yield of succeding crop of safflower

Treatment	No. of branches/plant		No. of capsules/plant		1,000-seed weight (g)		Seed yield (q/ha)	
	1991 92	1992 93	1991 92	1992 93	1991 92	1992 93	1991 92	1992 93
T_1	13	10	56	37	333.0	344.8	17.6	11.7
T_2	14	8	57	40	338.7	341.1	18.0	12.1
T_3	11	8	53	34	327.0	330.3	16.6	10.9
T_4	15	11	63	45	360.3	362.7	19.8	14.2
T_5	13	9	59	40	342.6	354.0	18.6	12.6
T_6	13	9	55	39	331.9	343.6	17.2	12.1
T_7	15	10	62	43	358.9	355.8	19.5	13.3
T_8	14	10	60	40	347.7	347.1	18.9	12.9
T_9	15	11	64	47	364.1	364.3	19.8	14.8
T_{10}	14	11	61	43	350.7	354.8	19.0	13.9
T_{11}	14	10	58	38	339.8	344.1	18.3	12.0
T_{12}	13	8	54	36	330.6	343.8	17.2	11.3
CD (P = 0.05)	NS	1.0	NS	20.1	NS	0.3	NS	1.6

total branches/plant, number of capsules/ heads/plant and 1,000-seed weight were always found to be higher from the plots where previously rice + blackgram was practised at a higher level of fertility (T_9) during both the years, which ultimately reflected on the yield performance of both the crops. Both linseed and saffower showed higher seed yield from the same plots of T_9 (Tables 4 and 5). Again, the lower yield of both the crops of linseed and safflower was recorded from the plots which were preceeded by the sole crop of greengram (T_3). Here early harvest of greengram accelerated the depletion of soil moisture from the top layer of soil due to direct exposure to sunlight. But this problem did not arise with mid-maturing blackgram or late-maturing pigeonpea due to their better canopy coverage at the surface soil. This depletion of soil moisture resulted in poor establishment of the crops at the early stage which ultimately reduced the final yield of the crop. Due to the same reason of moisture availability as reflected from the higher values of total water use of the crops during 1991-92, the seed yield of both linseed and safflower was higher during 1991-92 as compared to 1992-93. Salvador *et al.* (1988) also obtained significantly higher yield of saffower at higher (30-45% available soil moisture over lower 15% level) moisture status. From the above discussion, it was clear that both the crops of linseed and safflower were responded well to available soil moisture and nutrient status of the soil even under rainfed condition. Bramn *et al.* (1990) also found a significant reduction in seed yield of linseed due to moisture stress.

Thus, it can be concluded that the different rice-legume associations played an important role in influencing the yield performance of succeding crops of linseed and safflower by putting their impact on nutrient status and moisture retentive capacity of the soil could be improved by adopting appropriate rice-legume association during *kharif* season under rainfed situtation.

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