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Influence of pre-season crops on productivity of rice (*Oryza sativa*)—sunflower (*Helianthus annuus*) sequences and soil-fertility status

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ABSTRACT

A field experiment was conducted during 1989–90 and 1990–91 at Bangalore. Fodder maize (*Zea mays* L.) and green-manure crops, viz. *Sesbania rostrata*, sunnhemp (*Crotalaria juncea* L.) and soybean [*Glycine max* (L.) Mill.]; were grown as sole crops and as intercrops, viz. maize + sunnhemp, maize + *S. rostrata* and maize + soybean in 1 : 1 proportion, preceding rainy-season rice (*Oryza sativa* L.). There was a preceding fallow treatment. Green-manures were incorporated into the soil before planting rainy-season rice. Their effects on yield of rice, sunflower and soil-fertility status was studied. Pre-season green-manure crops, viz. *S. rostrata* and sunnhemp, improved the nitrogen, phosphorus and potash contents of the soil under rice–sunflower sequence. The biomass yield and the total productivity of rice and sunflower was maximum with *S. rostrata* green-manure, followed by sunnhemp green-manure. Incorporation of the green-manure crops grown as intercrop with maize + sunnhemp, maize + *S. rostrata* and maize + soybean or sole soybean did not improve the yield significantly. The organic carbon, available N, P and K contents of the soil improved on inclusion of sunnhemp or *S. rostrata* in the sequence. Biomass yield and economic yield of rice and sunflower were highest with 100 kg N/ha.

The main thrust of the present-day systems of farming is to maximize productivity per unit area per unit time. This can be accomplished by efficient utilization of scarce resources like land, water, inputs and labour. The nutrient demand of an intensive cropping system is greater than of a monocropping system. Hence the present study was undertaken to found out a suitable green-manure crop in the early rainy season (*kharif*) and to introduce sunflower (*Helianthus annuus* L.) in rice fallows. Besides, effect of crop sequence on the fertility status of the soil was studied in the Eastern Dry Zone of Karnataka.

MATERIALS AND METHODS

The field experiment was conducted during—seasons of 1989 at the Main Research Station, Bangalore. Pre-season fodder maize (*Zea mays* L.), soybean [*Glycine max* (L.) Merr.], *Sesbania rostrata*, sunnhemp (*Crotalaria juncea* L.), and maize + sunnhemp, maize + *S. rostrata* and maize + soybean and a pre-season fallow (no crop before rainy-season rice) were the 8 main treatments for rainy-season rice. Maize was grown for fodder, while the rest of the crops were chopped off at flowering stage and incorporated into the soil. These

Table 1. Biomass and economic yields of pre-season crops,, rice and sunflower

Treatment (pre-season crop)	Biomass yield (tonnes/ha)						Economic yield (tonnes/ha)			
	Pre-season crops (fresh weight)		Rice dry weight		Sunflower (dry weight)		Rice		Sunflower	
	A	B	A	B	A	B	A	B	A	B
Crop										
Maize	12.40	9.47	7.07	8.06	1.81	1.04	3.45	3.65	0.51	0.35
Soybean	4.60	4.08	8.25	10.39	2.52	1.51	3.92	4.35	0.73	0.49
Sesbania rostrata	17.20	20.82	9.72	11.80	2.91	1.84	4.38	4.55	0.93	0.64
Sunnhemp	17.70	25.93	9.36	11.33	2.73	1.70	4.27	4.46	0.87	0.56
Maize + sunnhemp	10.34 (4.54 + 5.80)	12.02 (6.74 + 5.28)	8.05	9.64	2.42	1.43	3.78	4.14	0.83	0.47
Maize + *S. rostrata*	11.16 (5.06 + 6.10)	11.71 (4.94 + 6.77)	8.38	9.89	2.44	1.47	3.87	4.22	0.78	0.49
Maize + soybean	8.61 (5.51 + 3.10)	9.50 (7.00 + 2.50)	7.46	9.26	2.27	1.32	3.67	3.89	0.74	0.42
Fallow (without pre-season crop)			7.41	8.52	2.04	1.14	3.55	3.70	0.57	0.38
CD (P = 0.05)			0.47	0.58	0.13	0.11	0.15	0.28	0.08	0.07
N (kg/ha)										
50			7.67	9.24	2.30	1.36	3.66	3.94	0.71	0.45
100			8.75	10.48	2.48	1.50	4.06	4.20	0.78	0.49
CD (P = 0.05)			0.19	0.22	0.04	0.02	0.06	0.05	0.03	0.009

A, 1989–90; B, 1990–91

Figures in the parentheses indicate biomass yield of maize and green-manure crops

crops occupied the land from the last week of May to the third week of July. Plot size was 6.9 m x 4.5 m. 'Mangala' ('MR 272') rice was transplanted during the middle of August. Twentyone-day-old seedlings were used. The spacing adopted was 15 cm and 10 cm. There were 2 levels of N for rice, viz. 50 and 100 kg N/ha, constituting 2 subplot treatments. Thus for rice and sunflower split-plot design was followed with 3 replications. Each main plot was subdivided into 2 subplots of size 4.5 m x 3.3 m to accommodate subplot treatments, forming a bund of 0.3 m at the centre. A common dose of 50 kg P_2O_5/ha and 50 kg K_2O/ha was applied to rice. The residual effect of these treatments on the performance of the second crop of sunflower was studied without fertilizer N. A common dose of 75 kg P_2O_5/ha and 62.5 kg K_2O/ha was given as a basal dose.

The biomass yield of green-manure on fresh-weight basis and biomass and grain yields of rice and sunflower on dry-weight basis were recorded. The soil samples before sowing pre-season crops, before planting rice and sunflower and after harvest of sunflower were taken and analysed for organic carbon, nitrogen, phosphorus and potassium (Jackson, 1973). The plant samples were also analysed for NPK content as described by Jackson (1973) and the total uptake of NPK was computed. The expected and actual balance of NPK in the soil was calculated. The biomass yield and organic carbon content of the soil were statistically analysed.

RESULTS AND DISCUSSION

Biomass and economic yield of crops grown in sequence

The fresh-biomass yield of sunnhemp was maximum during both the years. The next best was *S. rostrata* (Table 1). Among the intercropping treatments, viz. maize + *S. rostrata*, maize + sunnhemp and maize + soybean, the former 2 gave higher biomass yield than the maize + soybean intercropping system. Beri *et al.* (1989) and Salam *et al.* (1989) also reported higher biomass production with *Sesbania* sp. and sunnhemp. The biomass yield of rice was significantly highest during both the years with the main-plot effect of *S. rostrata* green-manuring, followed by sunnhemp. Similarly, sunflower gave more biomass yield with the main-plot residual effects of *S. rostrata* and sunnhemp. The grain yield of rice was significantly superior with *S. rostrata*, followed by sunnhemp. Rinaudo *et al.* (1988) and Singh *et al.* (1988) attributed highest yield of rice to green-manuring with *S. rostrata*. The grain yield of the succeeding crop of sunflower was higher with *S. rostrata* green-manuring, followed by sunnhemp. Sharma and Mittra (1988) opined increased yield of wheat and gram when succeeded rice crop green-

Table 2. Organic carbon (%) content of the soil after harvest of third crop in the sequence

Treatment (pre-season crop)	Initial	After harvest of III crop during 1989–90	After harvest of III crop during 1990–91
Maize	0.44	0.55	0.70
Soybean	0.44	0.77	1.11
Sesbania rostrata	0.44	0.91	1.24
Sunnhemp	0.44	0.83	1.16
Maize + sunnhemp	0.44	0.74	1.07
Maize + *S. rostrata*	0.44	0.73	0.98
Fallow (without pre-season crop)	0.44	0.63	0.86
CD (P = 0.05)		0.06	0.14

Table 3. Nitrogen, phosphorus and potassium balance (kg/ha) as influenced by the sequence of crops

Treatments (pre-season crop)	Initial + added NPK		NPK uptake by crops		*Actual balance of NPK		Expected balance		Difference	
									Actual	Expected
	1989–90	1990–91	1989–90	1990–91	1989–90	1990–91	1989–90	1990–91	1989–90	1990–91
					Nitrogen					
Maize	315	273	217	202	198	209	98	71	+ 100	+ 138
Soybean	357	321	193	199	209	263	122	122	+ 87	+ 141
Sesbania rostrata	476	501	225	224	231	285	251	277	— 20	+ 8
Sunnhemp	472	547	195	217	242	274	277	330	— 35	— 56
Maize + sunnhemp	367	328	201	224	209	242	166	104	+ 43	+ 138
Maize + *S. rostrata*	375	331	215	231	198	274	160	100	+ 38	+ 174
Maize + soybean	347	272	198	202	165	242	149	70	+ 16	+ 172
Fallow	315	306	163	161	231	245	152	145	+ 29	+ 100
					Phosphorus					
Maize	181	174	53	61	49	50	143	113	— 94	— 63
Soybean	189	207	51	57	75	80	138	150	— 63	— 70
Sesbania rostrata	197	232	55	66	87	99	142	166	— 55	— 67
Sunnhemp	197	233	52	59	84	86	145	174	— 61	— 88
Maize + sunnhemp	187	201	50	63	70	77	137	138	— 67	— 61
Maize + *S. rostrata*	187	201	54	67	71	65	133	134	— 62	— 69
Maize + soybean	186	200	51	60	71	62	135	140	— 64	— 78
Fallow	181	189	44	50	64	51	137	139	— 73	— 88
					Potassium					
Maize	331	345	168	178	232	434	163	167	+ 69	+ 267
Soybean	349	431	144	162	300	551	205	269	+ 95	+ 282
Sesbania rostrata	407	579	164	192	374	591	243	387	+ 131	+ 204
Sunnhemp	385	541	167	159	348	561	218	382	+ 130	+ 179
Maize + sunnhemp	349	451	151	184	317	527	198	267	+ 119	+ 260
Maize + *S. rostrata*	354	458	157	189	322	531	197	269	+ 125	+ 262
Maize + soybean	345	424	150	170	300	522	195	254	+ 105	+ 268
Fallow	331	367	135	123	254	448	196	244	458	+ 204

* Initial + added NPK—NPK uptake by crops

manured with sunnhemp and *dhaincha* [*Sesbania cannabina* (Retz.) Pers.]. The grain yield of rice and the residual crop of sunflower was minimum when maize was introduced as a pre-season crop.

The biomass and economic yields of both rice and sunflower were significantly higher with 100 kg N/ha during both the years compared with 50 kg N/ha. The interaction effects of pre-season crop and nitrogen levels on the grain yield of rice differed significantly during 1989—90. *Sesbania rostrata* green-manure with 100 kg N/ha recorded significantly highest grain yield (4.50 tonnes/ha), which was on a par with sunnhemp with 100 kg N/ha (4.41 tonnes/ha). The seed yield of sunflower due to the interaction of effects of the residual effects of green-manures and nitrogen levels did not differ significantly.

Organic carbon

The organic carbon content of the soil improved significantly after harvest of the third crop in sequence during both the years (Table 2). Organic carbon content of the soil was higher in the second year than in the first year. This may be attributed to the build up of organic matter content in the soil, as the studies were conducted in the same site during both the years. The slow mineralization rate of organic matter under submerged condition during the rainy season may be another reason for higher organic carbon content of the soil. Among the treatments the organic carbon was significantly higher with the incorporation of *S. rostrata*, followed by sunnhemp. Swarup (1987) also reported improvement in organic carbon content of the soil owing to green-manuring. The organic carbon content of the soil was the lowest in treatments with pre-season maize or fallow, followed by rice—sunflower sequence. However, there was increase in organic carbon in maize and pre-season fallow treatments. This may be attributed to the addition of roots and stubbles of maize, rice and sunflower in the cropping system used in our study.

Balance sheet of NPK

The total N,P and K contents of the soil including of the initial and added NPK were 315, 181 and 331 kg/ha respectively. Considering the NPK added through green-manures and NPK removed by rice the actual balance of available N was maximum with sunnhemp green-manuring, and P_2O_5 and K_2O were higher with *S. rostrata* (Tables 2, 3). Swarup (1987) also reported higher available NPK status of the soil owing to incorporation of *S. aculeata* green-manure. The difference between the expected and actual balance of N was 20 kg with *S. rostrata* green-manure and 35 kg with sunnhemp green-manure. The actual balance of P_2O_5 in the soil was lesser than the expected balance to an extent of 55—94 kg/ha. Both the actual and expected balances of P_2O_5 in the soil were highest with *S. rostrata* and sunnhemp green-manures. Actual K_2O in the soil was higher than the expected K_2O to an extent of 58—131 kg/ha. The soils were depleted of NPK by pre-season maize, pre-season fallow or maize + soybean system. The results further reveal that the soil tests under-estimated the available P_2O_5 and over-estimated the available K_2O content in the soil.

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