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Effect of cotton crop-residue management practices and levels of nitrogen and potassium on rice (*Oryza sativa*) and succeeding blackgram (*Phaseolus mungo*) in rice–blackgram cropping system

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ABSTRACT

A field experiment was carried out at Agricultural College and Research Institute, Madurai, during the winter (*rabi*) seasons of 2000 and 2001, to study the effect of cotton (*Gossypium* sp.) crop residue management practices and levels of inorganic fertilizer N and K on rice (*Oryza sativa* L.) and succeeding blackgram (*Phaseolus mungo* L.) in rice–blackgram cropping system. Incorporation of cotton stalks @ 5 tonnes/ha with *Trichoderma viride* in rice crop significantly improved the growth parameters, yield attributes and yield of rice. Maximum residual effect was observed with the incorporation of cotton stalks @ 5 tonnes/ha + *Trichoderma viride*, that resulted in the marked improvement in the growth, yield attributes and yield of succeeding blackgram. Similar yield trend was seen by increasing levels of N and K fertilizers in rice and blackgram.

Key words : Cotton crop residue incorporation, Fertilizer levels, Rice, Blackgram

In sourthern districts of Tamil Nadu, winter (*rabi*) rice is grown after summer cotton. Similarly in Thanjavur district, rice is grown after rice fallow cotton. Disposal of cotton residues is a major problem in these areas. Cotton stalks of about 10–15 tonnes/ha after the final picking, are normally uprooted and used as fuel. About 15 tonnes/ha of cotton stalks can supply 180 kg N/ha (Budhar and Palaniappan, 1994). Though *G. hirsutum* cotton stalks have sufficient nutrient value, either goes waste or used as fuel, in spite of poor calorific value of stalks. Burning results in huge wastage of plant nutrients and creates environmental pollution. The nutrients present in organic materials (cotton residue) can be recycled into field either by direct incorporation or by composting with some bio-inoculants. It is an easy way to utilize the cotton stalks efficiently by integrating with biological sources. Integrated plant nutrient approach to crops by the combination of organics, bio-inoculants along with synthetic fertilizers have numerous apparent agronomical and environmental benefits over inorganic fertilizers alone. Hence a field trial was conducted to study the effect of cotton crop residues management practices and levels of inorganic fertilizer N in rice and succeeding blackgram in rice-blackgram sequence.

MATERIALS AND METHODS

A field experiment was carried out at Agricultural College and Research Institute, Madurai, during winter (*rabi*) seasons of 2000 and 2001. The experimental soil was sandy clay loam with pH of 8.05, which was medium in organic carbon (0.52%), low in available nitrogen (186.3 kg/ha), medium in phosphorus (17.80 kg/ha) and high in potassium (285.80 kg/ha). The experiment was laid out in split-plot design with 3 replications. The experiment in main plots consisted of 5 treatment combinations on incorporation of cotton stalks @ 5 tonnes/ha alone or with bio-inoculants, *viz.* control: without cotton stalks incorporation (M_1), cotton stalk incorporation @ 5 tonnes/ha (M_2), cotton stalk incorporation @ 5 tonnes/ha + *Trichoderma viride* (M_3), cotton stalk incorporation @ 5 tonnes/ha + *Pleurotus sajor-caju* (M_4) and cotton stalks incorporation @ 5 tonnes/ha + *Trichoderma viride* + *Pleurotus sajor-caju* (M_5). In subplots, 4 (S_1, S_2, S_3 and S_4) inorganic fertilizers levels, i.e. 50, 75, 100 and 125% of the recommended dose of inorganic fertilizer N and K, were kept respectively. The full dose of phosphorus fertilizer was applied basal and the inorganic fertilizers N and K were applied in 3 splits, viz. at basal, active tillering and flowering stages, of rice crop. Five tonnes of cotton stalk/

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ha was incorporated manually in the concerned treatments. Rice 'CO 43' was sown in the first week of September in wetland area and rice fallow blackgram 'T9' was raised during January–March. Other management practices were adopted as per recommendations of the crops. The total rainfall received in the winter season was 538 and 547 mm during 2000 and 2001 respectively.

RESULTS AND DISCUSSION

Effect of cotton stalk management on rice

Growth attributes of rice: Incorporation of cotton stalks @ 5 tonnes/ha with *Trichoderma viride* recorded maximum tillers/hill and higher leaf-area index at flowering stage and dry matter at harvest stage and it was on a par with incorporation of cotton stalks @ 5 tonnes/ha with *Trichoderma viride* and *Pleurotus sajor-caju* (Table 1). Higher nutrient content of cotton stalks and its rapid decomposition rate by bio-inoculants and nutrient uptake might have reflected in higher leaf-area index and dry matter compared to the control, which promoted high tiller number, size and number of leaves/plant, contributing higher dry matter. Similar result was reported by Gururajan *et al.* (2001).

Total weed population and weed dry matter: An incorporation of cotton stalks @ 5 tonnes/ha with *Trichoderma viride* (M_3) significantly reduced the total weed population and total weed dry matter production at harvest stage of rice crop and also it was on a par with cotton stalks incorporation @ 5 tonnes/ha with *Trichoderma viride* and *Pleurotus sajor-caju* (M_5) than the other treatments (Table 1). This might be due to well establishment of rice crop in these treatments which might have suppressed the weed growth (Gururajan *et al.*, 2001).

Yields attributes and yield of rice : Among the different cotton stalk management, incorporation of cotton stalks @ 5 tonnes/ha with *Trichoderma viride* recorded the highest panicle number/m² (Table 1). Similarly, the increase in grains/panicle owing to the incorporation of cotton stalks along with or without bio-inoculants in rice ranged from 117.14 to 135.72. It confirm the findings of Babou *et al.* (2001). The increase in grain yield in treatment receiving cotton stalks incorporation @ 5 tonnes/ha

Table 1. Growth and yield-attributing characters, total weed population and dry-matter production and yield of rice as influenced by different organic and bio-inoculants and inorganic fertilizers (pooled data of 2 years)

Treatment	Tillers/ hill	LAI at flowering	Dry matter at harvest (kg/ha)	Panicles/ m²	Total grains/ panicle	Total weed (at harvest) Population/ m²	Total weed (at harvest) Dry matter production (kg/ha)	Grain yield (q/ha)	Straw yield (q/ha)
Organic and bio-inoculant									
M_1	16.02	5.22	11,359	355	106.92	56.58 (7.55)	101.41 (10.09)	44.25	68.10
M_2	17.11	5.86	12,732	371	117.14	26.66 (5.20)	22.83 (4.82)	57.45	77.75
M_3	19.72	6.95	13,716	425	135.72	21.75 (4.71)	19.16 (4.42)	63.92	84.60
M_4	18.02	6.25	13,122	385	124.63	25.66 (5.11)	21.16 (4.64)	58.85	79.80
M_5	19.37	6.67	13,635	419	131.62	21.78 (4.73)	19.66 (4.48)	63.18	84.00
CD (P=0.05)	0.46	0.31	93.31	11.20	6.00	0.063	0.132	89.38	2.05
Inorganic fertilizer									
S_1	20.20	6.94	13,267	414	138.13	30.20 (5.54)	26.41 (5.18)	59.23	84.40
S_2	19.02	6.62	13,191	412	132.33	29.88 (5.51)	26.17 (5.16)	58.09	82.60
S_3	18.02	6.28	13,093	410	126.63	29.56 (5.48)	25.91 (5.14)	5,730	82.10
S_4	17.25	5.60	12,100	328	118.93	30.33 (5.45)	34.66 (5.11)	55.48	80.10
CD (P=0.05)	0.58	0.36	102.31	5.80	6.30	NS	NS	1.19	2.15
Interaction	N.S	NS	Sig.	Sig.	NS			Sig.	

Details of treatments are given under materials and Methods
Figures in parentheses are $\sqrt{X + 0.05}$ transformed value
LAI, Leaf-area index

+ *Trichoderma viride* and cotton stalk incorporation @ 5 tonnes/ha + *Trichoderma viride* + *Pleurotus sajor-caju* was 19.67 and 18.93 q/ha, respectively, resulting in 44.45 and 42.78% over no cotton stalk incorporation treatments, and straw yield of rice was also highest owing to incorporation of cotton stalks (Table 1). Gururajan *et al.* (2001) also reported similar results.

Nutrient uptake and availability : Significantly higher N, P and K uptake and availability was observed with incorporation of cotton stalks @ 5 tonnes/ha along with *Trichoderma viride* (M_3) than the other treatments. The organic carbon content of the soil after harvest of rice was higher with incorporation of cotton stalks @ 5 tonnes/ha with *Trichoderma viride* (M_3) (Table 3). Budhar and Palaniappan (1994) opined that the relatively higher nutrient content in cotton stalks resulted in higher availability which in turn increased the uptake of nutrients.

Residual effect of cotton stalk management on succeeding blackgram

Growth attributes: The higher residual effect was realised in blackgram with incorporation of cotton stalks @ 5 tonnes/ha + *Trichoderma viride* and incorporation of cotton stalks @ 5 tonnes/ha + *Trichoderma viride* + *Pluerotus sajor-caju* in preceding rice crop (Table 2). This may be owing to the increased available nutrients after rice leading to higher uptake of nutrients, which increased the blackgram growth components, viz. plant height, leaf-area

Table 2. Residual effect of cotton crop residue management practices and levels of inorganic fertilizer N and K applied in rice crop on growth and yield attributes and yield of succeeding blackgram (pooled data of 2 years)

Treatment	Growth attributes			Yield attributes			Seed yield (q/ha)	Haulm yield (q/ha)
	Plant height (cm)	Leaf-area index	DMP (kg/ha)	Pods/ plant	Seeds/ pod	1,000-seed weight (g)		
Organic and bio-inoculant								
M_1	32.70	2.61	1,671	24.0	4.81	3.47	4.21	13.70
M_2	37.62	2.99	1,970	27.6	5.39	3.52	5.22	16.01
M_3	41.30	3.45	2,152	36.2	6.03	3.56	5.85	17.53
M_4	38.90	3.17	2,038	30.8	5.64	3.53	5.45	16.61
M_5	40.29	3.36	2,103	34.0	5.89	3.55	5.70	17.16
CD (P=0.05)	1.28	0.12	54	2.8	0.19	NS	18	44
Inorganic fertilizer								
S_1	42.70	3.47	2,080	37.2	6.20	3.57	5.51	17.02
S_2	40.70	3.31	2002	35.2	5.95	3.55	5.27	16.42
S_3	38.90	3.16	1,927	32.7	5.72	3.52	5.05	15.84
S_4	33.00	2.68	1,824	23.8	5.5	3.49	4.72	14.42
CD (P=0.05)	2.11	0.18	84	2.9	0.30	NS	28	0.68

Details of treatments are given under Materials and Methods; DMP; dry matter production

Table 3. Effect cotton crop residue management practices and levels of inorganic fertilizer N and K applied in rice crop on N, P and K uptake of rice and soil available N, P, K and organic carbon% after harvest of rice (pooled data of 2 years)

Treatment	Nutrients uptake (kg/ha)			Post-harvest nutrient status of soil (kg/ha)			
	Nitrogen	Phosphorus	Potassium	N	P	K	Organic carbon (%)
Organic and bio-inoculant							
M_1	76.3	24.1	100.2	176.1	14.8	226	0.572
M_2	80.7	26.4	104.8	190.1	16.4	234	0.651
M_3	90.2	30.5	115.7	220.7	19.5	248	0.768
M_4	83.4	28.0	108.9	200.6	17.8	238	0.696
M_5	87.5	29.5	112.9	212.1	18.8	244	0.738
CD (P=0.05)	3.2	1.1	3.3	9.8	0.8	4.4	0.038
Inorganic fertilizer							
S_1	92.2	31.70	118.8	225.2	19.4	251	0.756
S_2	89.3	31.35	115.0	213.7	18.8	247	0.736
S_3	86.5	30.90	111.4	202.1	18.2	242	0.717
S_4	82.5	29.30	106.2	187.1	16.8	235	0.650
CD (P=0.05)	3.4	0.46	4.3	12.5	0.7	5.6	0.024

Details of treatments are given under Materials and Methods

index and dry matter. The results are in conformity with those of Gururajan *et al.* (2001).

Yields attributes and yield : The yield attributes (pods/plant, seeds/pod and 1,000-seeds weight), seed and haulm yields of blackgram were markedly increased owing to the residual effect of incorporation of cotton stalks to rice crop (Table 2). The increase in seed yield of blackgram in treatment receiving cotton staks @ 5 tonnes/ha + *Trichoderma viride* and cotton stalk incorporation @ 5 tonnes/ha + *Trichoderma viride* + *Pleurotus sajor-caju* was 164 and 149 kg/ha, respectively, resulting in 38.95 and 35.39% over no-cotton stalk incorporation treatment (Table 2). This was possibly owing to the substantial improvement in the soil nutrient status after the harvest of rice crop. Jayanthi Chinnusamy (1997) also reported similar results.

Nutrient uptake and availability : Highest nutrient uptake and availability after succeeding blackgram were observed with residual effect of cotton stalk incorporation @ 5 tonnes/ha + *Trichoderma viride* than the other treatments. The improvement in organic carbon content of soil at the end of succeeding blackgram was noticed due to the incorporation of cotton stalks (Table 4). More nutrient uptake and availability under higher N and K levels of application proved effective by greater absorption of nutrients by crop at all stages due to synergistic effect between N and K. Similar findings were obtained by Son and Ramaswami (1997).

Responce to levels of inorganic fertilizers N and K

Rice : Higher fertility level (125% of the recommended dose of N and K) enhanced the growth, yield attributes and yield of rice over the lower dose (50% of the recommended dose of N and K) and it was on a par with application of 100% of the recommended dose of inorganic N and K (Table 1). The results are in conformity with those of Gururajan *et al.* (2001). The total weed population and total weed dry matter production remained the same at lower as well as higher N and K levels at harvest stage of rice crop. Our results confirm those of Gururajan *et al.* (2001).

Nutrient uptake and availability : In the present study, among the levels of inorganic fertilizer, 125% of recommended dose of inorganic N and K (S_1) recorded the highest nutrient uptake and availability (Table 3) and it was on a par with 100% of recommended dose of inorganic N and K (S_2). More nutrient uptake and availability under higher N and K levels of application proved effective by greater absorption of nutrients by rice crop at all stages due to synergistic effect between N and K. Similar findings were obtained by Balasubramaniyan (2004).

Responce to levels of inorganic fertilizer N and K

Succeeding blackgram : Higher levels of inorganic fertilizers N and K applied to the rice crop had a great residual effect on growth and yield attributes of blackgram and seed yield was increased with 125% of the recommended dose of N and K fertilizer (S_1) applied to preceding rice crops as compared with 50% of the recommended dose of N and K (S_4) and it was on a par with application of 100% of the recommended dose of inorganic N and K (Table 2). This increase in seed yield may be owing to increased availability of N, P, K and organic

Table 4. Residual effect of cotton crop residue management practices and levels of inorganic fertilizer N and K applied in rice crop on nutrients uptake (kg/ha) by succeeding blackgram and soil-available N, P, K and organic carbon (%) status after harvest of blackgram (pooled data of 2 years)

Treatment	Nutrients uptake (kg/ha)			Post-harvest nutrient status of soil (kg/ha)			
	Nitrogen	Phosphorus	Potassium	Available N	Available P	Available K	Organic carbon (%)
Organic and bio-inoculant							
M_1	28.41	3.32	18.73	165.2	13.2	212	0.651
M_2	34.04	3.94	22.33	194.6	15.8	225	0.785
M_3	38.98	4.92	24.92	227.8	18.8	243	0.823
M_4	36.05	4.32	23.24	207.8	17.0	231	0.799
M_5	37.95	4.67	24.14	219.7	18.2	238	0.813
CD (P=0.05)	1.42	0.3	0.84	10.8	0.8	5.5	0.011
Inorganic fertilizer							
S_1	37.02	4.42	24.02	235.8	18.9	246	0.801
S_2	36.00	4.30	23.42	223.6	18.3	240	0.794
S_3	35.02	4.18	22.87	210.6	17.7	235	0.787
S_4	33.19	3.96	21.97	191.6	15.3	225	0.710
CD (P=0.05)	1.20	0.16	0.70	15.36	0.7	6.9	0.008

Details of treatments are given under Materials and Methods

carbon after the harvest of rice. Son and Ramaswami (1997) also reported similar results.

Nutrient uptake and availability: Highest nutrient uptake and availability after succeeding blackgram were observed with residual effect of high levels of inorganic fertilizer, 125% of recommended dose of inorganic N and K (S1) (Table 4) and it was on a par with 100% of recommended dose of inorganic N and K (S_2). More nutrient uptake and availability under higher N and K levels of application proved effective by greater absorption of nutrients by crop at all stages due to synergistic effect between N and K. Similar findings were obtained by Son and Ramaswami (1997).

Interaction effect of organics and inorganic fertilizes on rice

The interaction effect between organic and levels of inorganic fertilizes was prominent in growth characters like dry matter at harvest, yield attributes, panicles/m^2 and grain yield of rice (Table 1). Among the nutrient management, incorporation of cotton stalks @ 5 tonnes/ha with *Trichoderma viride* + 125% of recommended dose of inorganic N and K (M_3S_1) recorded the highest panicles/m^2, dry matter at harvest and grain yield and it was on a par with cotton stalks incorporation @ 5 tonnes/ha with *Trichoderma viride* + 100% of recommended dose of inorganic N and K (M_2S_2). This might be due to the presence of lignin content in cotton stalks, which was decomposed by microbes and mineralized at slower rate and thereby it acted as slow release fertilizer and maintained ammoniacal N in the soil during most of the crop-growth period and provided the required quantity of N at sustained rates to the crop at critical stages (Budhar and Palaniappan, 1994).

Thus incorporation of cotton stalks @ 5 tonnes/ha along with bio-inoculants in combination with 100% of the recommended dose of N and K level to winter rice is the best nutrient management for increasing the rice and succeeding blackgram yields in rice–blackgram cropping system.

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