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Response of Intercropping System, Nutrient Management and Tree Leaf Extract Sprays on Cotton Rhizosphere Microbial Population and Seed Cotton Yield

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Field investigation was carried out at Agricultural College and Research Institute, Madurai during summer 2006 and winter 2006-2007 to elicit information on the effect of intercropping system, inorganic fertilizers, biofertilizers and leaf extract spray on microbial population of cotton rhizosphere and seed cotton yield. The experiments were laid out in a split plot design with three replications. Intercropping system *viz*., C_1 – Cotton sole, C_2 – Cotton + Blackgram, C_3 – Cotton + Greengram and C_4 – Cotton + Cluster bean were allotted to mainplot. The intercrops residues were incorporated at 65 DAS. The subplot consisted of six nutrient management and botanicals spray treatments *viz*., N_1 - 100 % RDF (Recommended Dose of fertilizer – 80:40:40 kg NPK/ha), N_2 – 75 % RDF, N_3 - 75 % RDF + biofertilizers, N_4 -75 % RDF + 5 % Morinda leaf extract spray at 60 and 80 DAS, N_5 - 75 % RDF + 5 % Vilvam leaf extract spray at 60 and 80 DAS, N_6 - 75 % RDF + 5 % Annona leaf extract spray at 60 and 80 DAS. The biofertilizers include *azospirillum* + Phosphobacteria + silicate solubilizing bacteria each at 2.6 kg/ha. The results revealed that cotton + blackgram intercropping has produced higher microbial count with more seed cotton yield. Among the nutrient management treatments application of 75 % RDF + combined application of *azospirillum*, phosphobacteria and silica solubilizing bacteria recorded higher microbial population and seed cotton yield.

Key words: Intercropping, nutrient management, biofertilizers, leaf extract spray

Cotton, an important commercial crop, plays a key role in Indian economy. It has immense potentiality to share foreign exchange of 38 per cent of total export from India besides providing employment to 60 million people (Kairon and Venugopalan, 2000). The present thrust should be to increase the productivity to meet the demand of textile industries. Chemical fertilizers increase cotton productivity, but at the same time it leads to deterioration of soil health and increase in buildup of new pest and diseases. Taking these aspects into consideration, field investigations were carried out with the objectives to study the effect of nutrient management through application of biofertilizers, inorganic fertilizers and *in situ* incorporation of intercrop residues on microbial dynamics of cotton rhizosphere and seed cotton yield.

Materials and Methods

Response of intercropping system, inorganic fertilizers, biofertilizers, intercrop residues and leaf extract spray on microbial population of cotton rhizosphere and seed cotton yield were evaluated by conducting field experiments at Agricultural College and Research Institute, Madurai during summer 2006 and winter 2006-2007. The soil of the experimental site was vylogam series, a member of fine loamy kaolinite, iso-megathermic family of Typic Rhodustalfs with a pH of 8.1 and 6.9 and an EC of 0.31 dSm^{-1} and 0.42 dSm^{-1} in field number D_5 and C_{42}, respectively. Cotton variety SVPR 2 with duration of 150 -165 days was chosen for this study. Blackgram (*Vigna mungo*) variety VBN (Bg) 4, greengram (*Vigna radiata*) cultivar Pusa bold and cluster bean (*Cyamopsis tetragonaloba* (L) Taub.) cultivar Pusa Navbahar were chosen as intercrops. The experiments were laid out in a split plot design with three replications. Intercropping system *viz*., C_1 – Cotton sole, C_2 – Cotton + Blackgram, C_3 – Cotton + Greengram and C_4 – Cotton + Cluster bean were allotted to mainplot. The intercrops after few harvests were incorporated as green manure at 65 DAS. The subplot consisted of six nutrient management and botanicals spray treatments *viz*., N_1 - 100 % RDF (Recommended Dose of fertilizer – 80:40:40 kg N,P,K/ha), N_2 - 75 % RDF, N_3 - 75 % RDF + biofertilizers, N_4 -75 % RDF + 5 % Morinda leaf extract spray at 60 and 80 DAS, N_5 - 75 % RDF + 5 % Vilvam leaf extract spray at 60 and 80 DAS, N_6 - 75 % RDF + 5 % Annona leaf extract spray at 60 and 80 DAS. The biofertilizers include *azospirillum* + phosphobacteria + silicate solubilizing bacteria each at 2.6 kg/ha. Post-harvest soil sample around the rhizosphere region were collected. One gram of soil sample was weighed and transferred to 10 ml sterile

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water blank and a serial dilution upto 10^{-6} was prepared. From each dilution one ml was used for plotting and counting different micro organisms and population was expressed on dry weight basis. Observations on seed cotton yield and rhizosphere microbial population were recorded and statistically analysed.

Result and Discussion

Rhizosphere Microbial Population

Intercropping, *in situ* incorporation of intercrop residue, nutrient management and botanicals spray have significantly enhanced the microbial population of cotton rhizosphere.

Bacterial population

The data pertaining to rhizosphere bacterial population is statistically significant. Intercropping, nutrient management, leaf extracts spray and *insitu* incorporation of intercrop residue had marked influence on the population of rhizosphere bacteria (Table 1). Bacterial population of about 192 and 199 x 10^6 CFU g^{-1} dry soil was observed under clusterbean intercropping (C_4) and its residue incorporation which was significantly higher than other treatments during summer 2006 and winter 2006-07 respectively. The increase might be due to greater availability of organic carbon and mineralized nutrients for their proliferation and development (Suresh and Surya Prabha, 2005). Among the nutrient management treatment, application of 75% RDF + biofertilizers (N_3) have recorded highest bacterial population of 204 and 211x 10^6 CFU g^{-1} dry soil during summer 2006 and winter 2006-07 respectively. This was followed by the treatment receiving 100 % RDF (N1) (185 and 189 x 10^6 CFU g^{-1} dry soil). Very low bacterial population of 174 and 177 x 10^6 CFU g^{-1} dry soil was recorded under the treatment plot receiving 75 % RDF (N_2) alone and it was on par with other three treatments (N_4 -75 % RDF + 5 % Morinda leaf extract spray at 60 and 80 DAS, N_5 - 75 % RDF + 5 % Vilvam leaf extract spray at 60 and 80 DAS, N_6 - 75 % RDF + 5 % Annona leaf extract spray at 60 and 80 DAS) during summer 2006 and winter 2006-07 respectively. Combination of clusterbean intercrop residue and 75 % RDF along with biofertilizers have registered significantly higher bacterial population of 210 and 227 x 10^6 CFU g^{-1} dry soil which is statistically significant during summer 2006 and winter 2006-07, respectively.

Table 1. Response of intercropping system, nutrient management and tree leaf extract sprays on bacterial population (x 10^6 CFU g^{-1} soil) in the rhizosphere of cotton

	Summer 2006						Winter 2006-07				
Treatment	C_1	C_2	C_3	C_4	Mean	Treatment	C_1	C_2	C_3	C_4	Mean
N_1	164	192	190	194	185	N_1	170	194	192	199	189
N_2	156	180	174	185	174	N_2	158	182	177	191	177
N_3	198	205	202	210	204	N_3	200	210	206	227	211
N_4	157	180	175	186	175	N_4	159	185	178	192	179
N_5	158	181	175	188	176	N_5	161	185	179	190	179
N_6	159	181	176	190	177	N_6	161	185	179	192	179
Mean	165	187	182	192		Mean	168	190	185	199	
For	C	N	C at N	N at C		For	C	N	C at N	N at C	
S.Ed	1.0	1.6	3.1	3.2		S.Ed	0.5	1.3	2.4	2.6	
CD(P=0.05)	2.5	3.2	6.4	6.4		CD(P=0.05)	1.3	2.6	4.9	5.2	

Fungi population

Maximum population of fungi (23.43 and 25.30 x 10^6 CFU g^{-1} dry soil during summer 2006 and winter 2006-07 respectively) were recorded with *insitu* incorporation of clusterbean residues (Table 2). This was closely followed by *insitu* incorporation of blackgram residue which recorded 22.52 and 25.28 x 10^6 CFU g^{-1} dry soil. Addition of clusterbean residue has increased the carbon substrate for microbial growth (Thiyageshwari and Selvi, 2005). Lowest population of 19.43 and 21.28 x 10^6 CFU g^{-1} dry soil was recorded under sole (C_1) cotton rhizosphere during summer 2006 and winter 2006-07 respectively. Application of 75 % RDF along with biofertilizers (N_3) recorded the highest fungal population of 25.05 and 27.00 x 10^3 CFU g^{-1} dry soil. Very low population of 20.68 and 22.85 x 10^3 CFU g^{-1} dry soil was noticed under the treatment plot receiving 75% RDF (N_2) alone. Among the combinations *in situ* incorporation of residue and application of 75% RDF along with biofertilizers recorded higher fungal population of 26.60 and 28.20 x 10^3 CFU g^{-1} dry soil during summer 2006 and winter 2006-07 respectively.

Actinomycetes population

Actinomycetes population (Table 3) in rhizosphere environment of cotton was greatly influenced by intercropping, nutrient management and leaf extracts spray. Highest population of actinomycetes (26.7 and 28.2 x 10^3 CFU g^{-1} dry soil) was observed in the rhizosphere soil of cotton + clusterbean (C_4) intercropped plot. This was closely followed by *insitu* blackgram intercropping (C_2) which recorded 26.3 and

Table 2. Response of intercropping system, nutrient management and tree leaf extract sprays on fungi population (x 10^3 CFU g^{-1} soil) in the rhizosphere of cotton

Treatment	Summer 2006					Treatment	Winter 2006-07				
	C_1	C_2	C_3	C_4	Mean		C_1	C_2	C_3	C_4	Mean
N_1	19.20	23.00	23.00	24.00	22.30	N_1	21.90	26.00	25.90	26.20	25.00
N_2	18.20	21.50	21.00	22.00	20.68	N_2	19.80	24.50	23.10	24.00	22.85
N_3	24.00	25.60	24.00	26.60	25.05	N_3	25.40	27.40	27.00	28.20	27.00
N_4	18.40	21.50	21.00	22.50	20.85	N_4	20.00	24.50	23.20	24.00	22.93
N_5	18.40	21.50	21.00	22.50	20.85	N_5	20.20	24.60	23.20	24.70	23.18
N_6	18.40	22.00	21.00	23.00	21.10	N_6	20.40	24.70	23.40	24.70	23.30
Mean	19.43	22.52	21.83	23.43		Mean	21.28	25.28	24.30	25.30	
For	C	N	C at N	N at C		For	C	N	C at N	N at C	
S.Ed	0.26	0.24	0.50	0.47		S.Ed	0.13	0.21	0.41	0.42	
CD(P=0.05)	0.64	0.48	1.08	0.95		CD(P=0.05)	0.33	0.42	0.84	0.85	

27.4 x 10^3 CFU g^{-1} dry soil during summer 2006 and winter 2006-07 respectively. The clusterbean intercropping adds high amount of organic matter hence highest population of microorganism were observed. Similar results of higher microbial population under high organic matter added was observed by Mukherjee *et al*. (1999). Tiwari *et al*. (2000) also observed maximum population of total bacteria, fungi and actinomycetes due to green manure incorporation. The Actinomycetes population was low in the rhizosphere soil of sole cotton (C_1).

Application of 75 % RDF along with biofertilizers (N_3) has recorded highest population of actinomycetes (27.1 and 30.7 x 10^3 CFU g^{-1} dry soil) and this was followed by application of 100 % RDF (N_1) (25.8 and 27.1 x 10^3 CFU g^{-1} dry soil) during summer 2006 and winter 2006-07. Least population of 23.8 and 25.2 x 10^3 CFU g^{-1} dry soil was recorded

Table 3. Response of intercropping system, nutrient management and tree leaf extract sprays on actinomycetes population (x 10^3 CFU g^{-1} soil) in the rhizosphere of cotton

Treatment	Summer 2006					Treatment	Winter 2006-07				
	C_1	C_2	C_3	C_4	Mean		C_1	C_2	C_3	C_4	Mean
N_1	21.9	27.0	26.9	27.2	25.8	N_1	23.4	28.2	28.0	28.7	27.1
N_2	20.4	25.2	24.2	25.5	23.8	N_2	22.1	26.1	25.3	27.1	25.2
N_3	20.9	29.3	28.2	30.1	27.1	N_3	30.0	30.9	30.6	31.4	30.7
N_4	20.7	25.3	24.7	25.6	24.1	N_4	22.4	26.4	25.7	27.2	25.4
N_5	20.8	25.4	24.8	25.7	24.2	N_5	22.4	26.5	25.7	27.4	25.5
N_6	21.0	25.4	24.9	25.8	24.3	N_6	22.5	26.5	25.8	27.5	25.6
Mean	21.0	26.3	25.6	26.7		Mean	23.8	27.4	26.9	28.2	
For	C	N	C at N	N at C		For	C	N	C at N	N at C	
S.Ed	0.30	0.27	0.57	0.53		S.Ed	0.08	0.18	0.34	0.37	
CD(P=0.05)	0.73	0.54	1.22	1.08		CD(P=0.05)	0.19	0.37	0.70	0.74	

from the treatment plot receiving 75 % RDF (N_2) alone during summer 2006 and winter 2006-07 respectively. Clusterbean residue incorporation and its interaction with 75 % RDF along with biofertilizers have resulted in higher actinomycetes population of 30.1 and 31.4 x 10^3 CFU g^{-1} dry soil. Sole cotton receiving 75 % RDF (N_2) alone has recorded least population of 20.4 and 22.1 x 10^3 CFU g^{-1} dry soil during both summer 2006 and winter 2006-07 respectively.

Seed cotton yield of cotton

Remarkable response in terms of seed cotton yield was observed under cropping system, nutrient management and botanicals treatment (Table 4). Higher seed cotton yield of 1619 and 1715 kg ha^{-1} was recorded under blackgram intercropping system during summer 2006 and winter 2006-07 respectively. The increase in seed cotton yield due to blackgram intercropping and *in situ* incorporation may be attributed to their complementary effect by way of lesser competition for nutrients and supply of nitrogen in view of better nodulation of legume intercrop and atmospheric N fixation. In addition the incorporated legume has released the nutrient at steady rate which was available to the crop at later stages. The results are in agreement with Chellamuthu and Ramaswami (2000). Cotton + clusterbean cropping system reduced the seed cotton yield significantly.

Among the nutrient management and botanicals spray treatment, application of 75 % RDF along with biofertilizers *viz*., *azospirillum*, phosphobacteria and silica solubilizing bacteria recorded higher seed cotton yield (1742 and 1852 kg ha^{-1}) during summer 2006 and winter 2006-07. The yield increase might be due to the growth, multiplication and unfailing

Table 4. Response of intercropping system, nutrient management and tree leaf extract sprays on seed cotton yield (kg ha^{-1})

	Summer 2006						Winter 2006-07				
Treatment	C_1	C_2	C_3	C_4	Mean	Treatment	C_1	C_2	C_3	C_4	Mean
N_1	1595	1723	1690	1565	1643	N_1	1675	1861	1803	1645	1746
N_2	1445	1480	1475	1290	1423	N_2	1525	1570	1560	1495	1538
N_3	1650	1910	1782	1625	1742	N_3	1732	1998	1954	1724	1852
N_4	1480	1525	1495	1295	1449	N_4	1560	1614	1585	1455	1554
N_5	1485	1535	1505	1310	1459	N_5	1564	1620	1601	1459	1561
N_6	1490	1540	1510	1315	1464	N_6	1580	1627	1604	1462	1568
Mean	1524	1619	1576	1400		Mean	1606	1715	1685	1540	
For	C	N	C at N	N at C		For	C	N	C at N	N at C	
S.Ed	49	71	138	142		S.Ed	45	55	110	110	
CD(P=0.05)	120	143	NS	NS		CD(P=0.05)	110	111	NS	NS	

colonization (Arulmozhiselvan, 1996) of biofertilizer around rhizosphere region, which supplied the nutrients continuously. The increase in bacteria, fungi and actinomycetes population at the end of this study indicate the intensive microbial activity in the rhizosphere region which might have increased the availability of major nutrients and its steady supply to cotton throughout cropping period resulting in higher seed cotton yield. Seed cotton yield was low from the treatment receiving 75% RDF alone. The low yield was due to reduction in growth and yield attributes. Low availability of nutrients reduced the growth and led to low N, P and K uptake which in turn finally resulted in poor yield.

Combination of intercropping, nutrient management and leaf extracts spray had no interaction effect on seed cotton yield during both summer and winter seasons.

The microbial population was high under cotton + clusterbean intercropping system with application of 75 % RDF + combined application of *azospirillum*, phosphobacteria and silica solubilizing bacteria. The study revealed that cotton + blackgram intercropping with application of 75 % RDF + combined application of *azospirillum*, phosphobacteria and silica solubilizing bacteria recorded higher seed cotton yield.

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