Microbial biomass and soil health as influenced by INM practices in rice - cotton cropping system

S. Ramesh and S. Manimaran

Assistant professor, Department of Agronomy, Faculty of Agriculture,
Annamalai University, Annamalainagar – 608 002.

ABSTRACT

Field investigations were carried out in rice - cotton cropping system at the Annamalai University, Experimental Farm, Faculty of Agriculture, Annamalai Nagar during September 2006 to June 2007 to study the microbial biomass and soil health as influenced by INM practices in rice - cotton cropping system. The whole research consist of two experiments, first experiment include rice and second experiment was raised with cotton. First experiment (rice) comprised of eight treatments with recommended dose of nitrogen and graded dose of nitrogen along with different organic manures. The experiment laid out in a randomized block design (RBD) and replicated thrice. With regard second experiment (cotton), all the main plots of rice (experiment-I) were divided in to three equal sub plots in which rice fallow cotton was raised without and with fertilizer at different levels (0, 75 per cent and 100 per cent RDF). Performance of the cropping system as a whole was reflected by available soil nitrogen, phosphorus and potassium and microbial population and organic carbon status in rice cotton cropping system. From the results of field trails in rice - cotton cropping system, available soil nitrogen, phosphorus and potassium and microbial population and organic carbon status gain at end of the experiment were significantly influenced by 100% RDN + vermicompost @ 5 t ha^{-1} applied to rice followed by 100% RDF to cotton.

Keywords: Rice, cotton, available soil nitrogen, phosphorus and potassium and microbial population and organic carbon

Introduction

United Nation General Assembly (UNGA) declared 2004 as International Year of Rice (IYR). The theme of IYR was “Rice is life”. This is because rice is the staple food of over half of the world’s population and more than 70 per cent of people, s energy is obtained from rice (Godhawale *et al*., 2007). Above 90 per cent of the world’s rice is grown and consumed in Asia, where 60 per cent of the people on the earth live. In India, rice being grown over an area of 44 million hectare with a production of 87.80 million tonnes (Directorate of Economics and Statistics, 2005). Rice often surprises us with phenomenal adjustments to its environment perhaps that is the reason why it has become one of the world’s prime food crops. To feed the exploding population by 2025 AD, it is obligatory to produce around 140 million tonnes, which can be made only possible by increasing the production by over 2.0 million tonnes per year for the coming years (Subbiah, 2006). In contrast, recent slow down (or) stagnation of yields in low land rice was noticed as a result of eroding of soil fertility and decline in productivity level. The low yield of rice is due to several factors. Among these, poor fertility is the major factor for low yield of rice. Cotton is a vital cash crop of India, grown by 4 million farmers on an estimated 7.4 million hectare of cultivated land. Cotton contributes to 80 per cent of the raw material to the textile industry and provides employment to nearly 60 million people. India ranks first in area and second in global cotton production. In canal irrigated deltaic area of southern India, recently this crop is recognized as a best substitute for the existing rice fallow crops like pulse and gingelly under assured water supply. Even though the yield of rice fallow cotton fetches higher monetary returns than other crops, the average yield was much lower than the potential yield of the crop. Lower cotton productivity could be attributed to highly varying factors and management practices mainly low soil fertility status. A treadmill has set in for use of more and more fertilizers and pesticides, and this has now reduced crop yields in relation to increased cost of cultivation. It has led to serious thought to safeguard the environment and the quality of natural resources for sustainability. Thus, more and more emphasis is being given towards returning to nature and adoption of organic farming or Integrated nutrient management system. INM practices are a holistic management system, which promotes sustainable agriculture and enhances agro-ecosystem health. Vermicompost is a rich source of enzymes, antibiotics, immobilised micro flora and growth hormones like gibberellins which regulate the growth of plants and microbes. Green manure is considered as good source of nitrogen and it increases the availability of P, K and secondary and trace elements in the soil. Agro industrial wastes are pressmud from sugar industries. It has a greater potential in supplying higher quantity of nitrogen, phosphorus and potassium besides secondary and micronutrients and can be used as best organic manure (Raman *et al.*, 1999). Although research work on INM practices on rice and cotton crop individually are in plenty, integrated nutrient management practices in rice - cotton cropping system as a whole is almost very meager. Therefore, the present investigation was study the microbial biomass and soil health as influenced by INM practices in rice - cotton cropping system under tail end area of Cauvery Deltaic Zone of Tamil Nadu (India).

Materials and methods

Field experiments were carried at the experimental farm, Faculty of Agriculture, Annamalai University during September 2006 - June 2007 study the microbial biomass and soil health as influenced by INM practices in rice - cotton cropping system under tail end area of Cauvery Deltaic Zone of Tamil Nadu (India). The average annual rainfall of Annamalainagar is 1250 mm, distributed over 51 rainy days. The mean maximum and minimum temperature are 30.8°C and 24.7°C respectively. The soil of the experimental field was having a pH of 7.1 and EC of 0.32 dSm^{-1}. Taxonomically the soil is classified as Udic chromustert, low in available nitrogen (201 kg ha^{-1}), medium in available phosphorus (20.9 kg ha^{-1}) and high in available potassium (277 kg ha^{-1}). The whole research consist of two experiments, first experiment include rice followed second experiment raised with cotton. The first experiment (rice) comprised of eight treatments. It was laid out in a randomized block design (RBD) and replicated thrice. In respect of cotton, All the main plots of rice (experiment I) were divided in to three equal sub plots in which rice fallow cotton was raised without and with fertilizer at different levels (0, 75 per cent and 100 per cent RDF). It was conducted in a split plot design and replicated thrice.

Treatment details:

Rice (experiment-I) : T_1 - Control (No fertilizer and no organic manure), T_2 - 100% RDN (Recommended dose of nitrogen), T_3 - T_2 + Green manure @ 6.25 t ha^{-1} , T_4 - 75% RDN + Green manure @ 6.25 t ha^{-1} , T_5 - T_2 + Vermicompost @ 5 t ha^{-1} , T_6 - 75% RDN + Vermicompost @ 5 t ha^{-1} , T_7 - T_2 + Pressmud @ 10 t ha^{-1} , T_8 - 75% RDN + Pressmud @ 10 t ha^{-1} .

Cotton (experiment- II) : Main plot treatments: Residual effect of INM practices of rice (experiment I) on rice fallow cotton. : T_1 - Control (No fertilizer and no organic manure), T_2 - 100% RDN (Recommended dose of nitrogen), T_3 - T_2 + Green manure @ 6.25 t ha^{-1} , T_4 - 75% RDN + Green manure @ 6.25 t ha^{-1} , T_5 - T_2 + Vermicompost @ 5 t ha^{-1} , T_6 - 75% RDN + Vermicompost @ 5 t ha^{-1} , T_7 - T_2 + Pressmud @ 10 t ha^{-1} , T_8 - 75% RDN + Pressmud @ 10 t ha^{-1} . **Sub plot treatments**: NPK fertilizer to rice fallow cotton. S_1 - 0% RDF (No fertilizer), S_2 - 75% RDF, S_3 - 100% RDF

Rice cultivar CO 43 was used as test cultivar. Twenty eight days old rice seedlings were transplanted with a spacing of 20 cm x 10 cm. For rice, recommended dose of 150:50:50 kg ha^{-1} of N, P_2O_5 and K_2O was applied. The following organic manures were used in the study ***viz.,*** vermicompost, pressmud and green manure**.** All the organic manures were obtained from the Experimental Farm, Annamalai University and the same were applied as per treatment schedule basally one week before transplanting of rice. For cotton, Acid delinted cotton seeds of LRA 5166 @ 7.5 kg ha^{-1} were dibbled in rice stubbles immediately after harvest of rice. Two seeds $hill^{-1}$ were dibbled at a depth of 3 cm at waxy condition of the soil and adopting a spacing of

60 x 30 cm. Recommended dose of 60:30:30 kg ha^{-1} of N, P_2O_5 and K_2O was applied. All other improved recommended package of practices were followed to rice and rice fallow cotton, as per the Crop Production Guide.

Soil analysis

The post harvest composite soil samples were collected after the harvest of cotton and analysed for post harvest available nutrients. Analytical methods employed for soil/manure were as under

Particulars	**Author(s)**	**Method**
Organic carbon	Walkley and Black (1934)	Chromic acid wet digestion method
Available N	Subbiah and Asija (1956)	Alkaline permanganate method
Available P	Olsen *et al.* (1954)	Colorimeter method
Available K	Stanford and English (1949)	Flame photometric method

Soil microbial Analysis

Soil samples were taken from individual plots at the end of experiments, dried and powdered. Soil water extract of respective treatments was cultured to assess the soil microbial population. For bacterial counts, the soil extract at a concentration of 10^{-5} and 10^{-6} was inoculated in Nutrient Glucose Agar medium and observed on 3rd day. For assessing the fungal population, the extract was inoculated at a concentration of 10^{-3} and 10^{-4} in Rose Bengal Agar medium and the counts were taken on 4th day. For actinomycetes, the soil water extract was inoculated in Ken Knight's Agar medium at a concentration of 10^{-4} and 10^{-5} and count was taken on 11th day. The population of microorganisms was expressed in ten thousands. Fungi and actinomycetes were identified based on morphology. Bacteria were identified through Hewlett Packard microbial identification system.

The data on various studies recorded during the investigation were subjected to statistical scrutiny as suggested by Gomez and Gomez (1984).

RESULTT AND DISCUSSION

Post harvest soil nutrient status

Organic carbon

Among the main plot treatments (residual effect), T_5 (100% RDN + vermicompost @ 5 t ha^{-1} applied to rice) registered significantly maximum organic carbon content of 0.65 per cent . It was on par with T_6 (75% RDN + vermicompost @ 5 t ha^{-1} applied to rice). This might be due to the build up of humus and higher microbial population by vermicompost and crop residue. This concurs with the views of Patro *et al.* (2005). The least organic carbon content of 0.49 per cent was registered under T_1 (No fertilizer and no organic manure. Among the sub plot treatments (direct effect), S_3 (100% RDF to cotton) registered significantly higher organic carbon content of 0.61 per cent. However, it was on par with S_2 (75% RDF to cotton). This might be due to increasing the quantity of organic and inorganic fertilizer applied to rice and inorganic fertilizer to succeeding crop which resulted in substantial increase in the organic carbon at end of experimentation when compared to initial status. This is possible due to increase in the quantum of residues added. Similar findings was reported by Singh and Verma (1999) and Charjan and Gaikwad (2005). The least organic carbon content of 0.52 per cent recorded under S_1 (0% RDF to cotton). The interaction effect was not significant.

Soil available nitrogen

Among the main plot treatments(residual effect), T_5 (100% RDN + vermicompost @ 5 t ha^{-1} applied in rice) recorded significantly higher soil available N of 208.41 kg ha^{-1} under rice - cotton cropping system. It was followed by T_6. The least soil available N of 193.87 kg ha^{-1} registered under T_1 (No fertilizer and no organic manure). Among the sub plot treatments(direct effect), S_3 (100% RDF to cotton) registered significantly maximum soil available N of 210.62 kg ha^{-1}. It was followed by S_2 (75% RDF to cotton). S_1 (0% RDF to cotton) recorded the least soil available N of 190.06 kg ha^{-1}. The interaction effect was significant. The treatment combination of, T_5S_3 (100% RDN + vermicompost @ 5 t ha^{-1} applied in rice followed by 100% RDF to cotton) registered significantly higher soil available N of 215.72 kg ha^{-1}.

Soil available phosphorus

Among the main plot treatments(residual effect), T_7 (100% RDN + pressmud @ 10 t ha^{-1} applied in rice) significantly recorded higher soil available P of 23.54 kg ha^{-1}. The next best in order was T8 (75% RDN + pressmud @ 10 t ha^{-1} applied in rice). The least soil available P of 19.45 kg ha^{-1} was registered under T_1 (No fertilizer and no organic manure). Among the sub plot treatments, (direct effect), S_3 (100% RDF to cotton) registered significantly maximum soil available P of 23.61 kg ha^{-1} . This was followed by S2 (75% RDF to cotton). S_1 (0% RDF to cotton) recorded the least soil available of P 21.06 kg ha^{-1}. The interaction effect was not significant.

Soil available potassium

Among the main plot treatments (residual effect), T_5 (100% RDN + vermicompost @ 5 t ha^{-1} applied in rice) significantly registered higher soil available K of 281.53 kg ha^{-1}. The least soil available K of 264.81 kg ha^{-1} was recorded under T_1 (No fertilizer and no organic manure). Among the sub plot treatments (direct effect), S_3 (100% RDF to cotton) registered significantly higher available K of 283.64 kg ha^{-1}. It was followed by S_2 (75% RDF to cotton). The least soil available K of 261.00 kg ha^{-1} was recorded under S_1 (0% RDF to cotton). The interaction effect was not significant.

Among INM treatments, T_5 (100% RDN + vermicompost @ 5 t ha^{-1} applied in rice) recorded the higher available N and K. This might be due to the continuous and slow release of nutrients from vermicompost involving higher availability of N and K. Application of 100% RDN + pressmud @ 10 t ha^{-1}applied in rice (T_7) registered higher values of P. This might be due to slow release nature of nutrients from organics. It has the capacity to form phospho – humic complex with anions replacement of the phosphate by humate ion and the coating of sesquioxide by humus to form a protective cover and thus reducing the phosphate fixing capacity of soil. These results of the present study corroborate with earlier report of Gaikwad *et al.* (1996). In respect of direct effect of fertilizer, S_3 (100% RDF to cotton) registered higher available NPK. This might be due to organic manure and inorganic fertilizer applied to rice and further application of inorganic fertilizer to succeeding crop, which reflected on increased availability of NPK in soil (Aruna and Shaik Mohammad, 2005).

Soil microbial status in rice - cotton cropping system

Soil Bacteria, fungai and actinomycetes

Among the main plot treatments(residual effect), T_5 (100% RDN + vermicompost @ 5 t ha^{-1} applied in rice) registered significantly maximum bacterial count of 48.75, fungal count of 15.77 and actinomycetes count of 5.54 in rice - cotton cropping system. This might be due to addition of organics, which might have regulated soil temperature and available soil moisture and the humus content of soil. This might have created favourable soil environment for sustenance, rapid multiplication and their activity on nutrient availability (Woods and Schuman, 1986). This was followed by T_6 (75% RDN + vermicompost @ 5 t ha^{-1} applied in rice). The least bacterial count of 34.40, fungal count of 11.01 and actinomycetes count of 3.87 was registered under T_1 (No fertilizer and no organic manure).

In respect of sub plot treatments(direct effect), S_3 (100% RDF to cotton) registered significantly higher bacterial count of 49.68, fungal count of 16.07 and actinomycetes count of 5.65. Vermicompost along with inorganic fertilizer applied to preceding crop followed by fertilizer application to succeeding crop increased the humus content in soil, which could be due to the organic waste and addition of residues by both crops. These sources inturn supply food and energy requirements of microbes. This might be the reason for higher microbial count in respective plots. However, it was on par with S_2 (75% RDF to cotton). The least bacterial count of 25.91, fungal count of 8.38 and actinomycetes count of 2.95 recorded under S_1 (0% RDF to cotton). The interaction effect was not significant.

Table 1. Effect of INM practices and graded doses of fertilizer on post harvest soil nutrient status in rice - cotton cropping system

Treatments	Available-N				Available-P				Available-K				Organic carbon content (%)			
	S_1 0% RDF	S_2 75% RDF	S_3 100% RDF	Mean	S_1 0% RDF	S_2 75% RDF	S_3 100% RDF	Mean	S_1 0% RDF	S_2 75% RDF	S_3 100% RDF	Mean	S_1 0% RDF	S_2 75% RDF	S_3 100% RDF	Mean
T_1	179.89	198.93	202.78	193.87	17.64	19.42	21.29	19.45	249.57	270.13	274.73	264.81	0.41	0.44	0.46	0.44
T_2	185.75	203.64	206.52	198.64	18.19	21.15	22.38	20.57	255.23	275.67	278.82	269.91	0.42	0.45	0.48	0.45
T_3	192.26	210.09	212.37	204.91	21.54	23.06	23.62	22.74	261.49	281.36	283.43	275.43	0.47	0.55	0.56	0.53
T_4	191.63	209.38	211.82	204.28	21.23	22.53	23.21	22.32	260.38	280.29	282.32	274.33	0.46	0.53	0.55	0.51
T_5	195.70	213.81	215.72	208.41	22.21	23.98	24.43	23.54	267.53	287.48	289.57	281.53	0.51	0.59	0.60	0.57
T_6	195.09	213.22	215.14	207.82	21.86	23.47	23.98	23.10	266.36	286.09	288.12	280.19	0.49	0.58	0.59	0.55
T_7	190.37	208.19	210.67	203.08	22.93	24.68	25.18	24.26	264.27	284.78	286.92	278.66	0.45	0.52	0.55	0.51
T_8	189.78	207.57	209.93	202.43	22.56	24.31	24.79	23.89	263.18	283.11	285.18	277.16	0.45	0.51	0.53	0.50
Mean	190.06	208.10	210.62		21.06	22.83	23.61		261.00	281.11	283.64		0.46	0.52	0.54	

	Main	Sub	M at S	S at M	Main	Sub	M at S	S at M	Main	Sub	M at S	S at M	Main	Sub	M at S	S at M
$S.E_D$	0.24	0.31	0.46	0.59	0.14	0.18	58	0.69	0.37	0.46	1.41	1.91	0.005	0.01	0.021	0.045
CD (p =0.05)	0.47	0.62	0.91	1.19	0.28	0.36	NS	NS	0.76	0.92	NS	NS	0.01	0.02	NS	NS

Table 2. Effect of INM practices and graded doses of fertilizer on microbial status in rice - cotton cropping system

Treatments	Bacteria (10^{-6})				Fungi (10^{-4})				Actinomycetes (10^{-5})			
	S_1 0% RDF	S_2 75% RDF	S_3 100% RDF	Mean	S_1 0% RDF	S_2 75% RDF	S_3 100% RDF	Mean	S_1 0% RDF	S_2 75% RDF	S_3 100% RDF	Mean
T_1	17.88	42.13	43.20	34.40	5.78	13.28	13.98	11.01	2.03	4.67	4.91	3.87
T_2	20.32	43.93	45.19	36.48	6.58	13.89	14.62	11.69	2.31	4.88	5.14	4.11
T_3	27.87	49.69	50.23	42.59	9.02	15.93	16.25	13.73	3.17	5.60	5.71	4.83
T_4	26.66	48.74	49.21	41.53	8.62	15.60	15.92	13.38	3.03	5.48	5.60	4.70
T_5	32.35	56.74	57.18	48.75	10.47	18.36	18.50	15.77	3.68	6.45	6.50	5.54
T_6	31.21	55.66	56.16	47.68	10.10	18.01	18.17	15.43	3.55	6.26	6.39	5.40
T_7	26.04	47.71	48.69	40.81	8.42	15.44	15.75	13.20	2.96	5.43	5.54	4.64
T_8	24.95	46.64	47.60	39.73	8.07	15.09	15.40	12.85	2.84	5.30	5.41	4.52
Mean	25.91	48.91	49.68		8.38	15.70	16.07		2.95	5.51	5.65	

	Main	Sub	M at S	S at M	Main	Sub	M at S	S at M	Main	Sub	M at S	S at M
$S.E_D$	0.31	0.42	1.34	1.75	0.14	0.25	0.86	1.04	0.05	0.08	0.25	0.51
CD (p =0.05)	0.63	0.84	NS	N.S	0.28	0.51	NS	NS	0.10	0.16	NS	NS

REFERENCES

Aruna, E. and Shaik Mohammad. 2005. Influence of conjunctive use of organic and inorganic source of nutrients in rice (*Oryza sativa*) on crop growth, yield components, yield and soil fertility in rice-sunflower (*Helianthus annuus*) sequence. **Indian J. Agron., 50**(4): 265-268.

Charjan, Y.D. and C.B. Gaikwad. 2005. Integrated nutrient management in cotton - wheat sequence on vertisol. **Indian J. Agron., 50**(3): 176-180.

Directorate of Economics and Statistics. 2005. Agricultural statistics at glance, Ministry of Agriculture, pp. 14.

Gaikwad, S.S., R.B.Puranik and S.D.Deshmukh. 1996. Dynamics of soil microbial population and nutrient availability as influenced by application of pressmud cake in an entisol. **J. Soils and Crops. 6**: 82-85.

Godhawale, G.V., R.V.Dahiphale, O.M. Yadav and G.N. Phad. 2007. Production and economic efficiency of rice as influenced by organic nutrition under upland drilled condition. **Int. J. Tropical Agric., 25**(2): 209-212.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research. A Willey Inter Science Publication, New York, pp.76-83.

Olsen.S.R., C.V.Cole, F.S.Watnabe and L.A.Dean.1954. Estimation of available phosphorus by extraction with sodium carbonate. U.S.Dept.Agric., 939:1-19.

Patro, H., B.S.Mahapatra, G.L.Sharma and Ajay Kumar. 2005. Total productivity, nitrogen, phosphorus and potassium removal and economics of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system with integrated nitrogen management in rice. **Indian J. Agron., 50**(2): 94-97.

Raman, S., R.G. Patil and N.M. Zalawadia. 1999. Pressmud as a potential source of nutrient and amendment. **Fert. News, 44**(11): 25-26, 29-31.

Singh, N.B. and K.K. Verma. 1999. Integrated nutrient management in rice - wheat crop sequences, **Oryza, 36**(2): 171 -172.

Stanford, S. and L.English. 1949. Use of flame photometer for rapid soil test for K and Ca. Agron. J., 41: 446-447.

Subbiah, B.V. and G.Asija.1956. A rapid procedure for estimation of available nitrogen in soils. Curr. Sci., 25:259-260.

Subbiah, S.V. 2006. Rice-Several options being taped. The Hindu ,Survey of Indian Agriculture, 2006. pp.50-54.

Walkley, A. and I.A. Black. 1934. An estimation of digestion method for determining soil organic matter and a proposed modification of the chromic and titration method. **Soil sci., 37**: 29-38

Woods, L.E. and G.E.Schuman. 1986. Influence on soil organic matter concentration on carbon and nitrogen activity. **Soil Sci. Soc. Am. J., 50**(5):1241-1245.