Direct and residual effect of organic and inorganic nutrients on total economic produce, per day productivity and rice equivalent yield in rice - cotton cropping system

S. Ramesh

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, which represents the tail end area of Cauvery Deltaic Zone of Tamil Nadu, India, during September 2005 to June 2007 to study the Direct and residual effect of organic and inorganic nutrients on total economic produce, per day productivity and rice equivalent yield in rice - cotton cropping system. The whole research consist of two phases each phase contain two experiments, first experiment include rice followed by second experiment with cotton. First experiment (Rice) comprised of eight treatments with recommended dose of nitrogen and graded dose of nitrogen along with different organic manures. It was laid out in a randomized block design (RBD) and replicated thrice. With regard to 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 total economic produce, total biomass production, per day productivity and Rice yield equivalent (RYE) by the two component crops of the cropping system was taken in to account to work out the aforesaid parameters of the cropping system. In rice - cotton cropping system higher values of total economic produce, total biomass production, per day productivity of economic produce and Rice yield equivalent (RYE) were significantly registered by 100% RDN + vermicompost @ 5 t ha^{-1} applied to rice followed by 100% RDF to cotton.

Keywords: Rice, Cotton, cropping system, total economic produce, total biomass production, per day productivity of economic produce and Rice yield equivalent

Introduction

Rice is the most important and staple food crop for more than two third of population of India. The slogan “RICE IS LIFE” is most appropriate for India as this crop plays vital role in our national food security and a mean of live hood for millions of rural households. India is the second largest rice producing country in the world after China. India produces 96.43 million tonnes of rice in an area of 43.77 million hectares with a productivity of 2.2 t/ha (Siddique, 2000). 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 based cropping system was noticed as a result of eroding of soil fertility and decline in productivity level (IRCN, 2001).

Cotton (Gossypium hirsutum L.) is a principal source of raw material for the world's textile industry and its dominant position has been seriously eroded by synthetic fibers (Aiken, 2006). The English word Cotton *(Gossypium hirsutum L.)* comes from the Arabic word quttin or Kutun. The time when the cotton fibre was first utilized by man is not known but from the prehistoric time this crop enjoys the status of the most important cash and individual crop of India till today. Cotton is popularly called as “White Gold” and is considered as “King of

fiber crops". It is the most important commercial crop of India cultivated in an area of 12.65 million ha with a production of 40 million bales of lint. 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. The productivity of cotton in India is significantly lower (518 kg ha^{-1}) as compared to the other major cotton growing countries.

Lower productivity of rice and cotton 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. Organic manures like green mnaure, pressmud and vermicompost deserves priority for sustained production and better utilization in intensive cropping system. Vermicompost is a rich source of enzymes, antibiotics, immobilised micro flora and growth hormones like gibberellins which regulate the growth of plants and microbes (Banik and Ranjita Bejbaruah, 2004). 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. Incorporation of *Sesbania* green manuring over the years before transplanting of rice helps in improving DTPA-extractable micronutrient cations of the soil (Nayyar and Chhibba, 2000). Recycling of industrial wastes is one way of disposal mechanism and another way of resource management. One among the agro industrial wastes is 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). Rice based cropping system is a predominant cropping system in coastal Tamil nadu. Complementary use of organic sources of plant nutrients along with chemical fertilizer is great importance for the maintenance of soil health and productivity, especially under intensive cropping system. There is immense need to exploit the best source of nutrients from organic manures *viz.*, pressmud, vermicompost and green manure to sustain the productivity, soil health and soil fertility with more environment friendly nutrient management system.

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 direct and residual effect of organic and inorganic nutrients on total economic produce, per day productivity and rice equivalent yield in rice - cotton cropping system under tail end area of Cauvery Deltaic Zone of Tamil Nadu (India).

Materials and methods

Field experiments were carried out in farmlands of Faculty of Agriculture, Annamalai University during September 2005 - June 2006 (Phase I) and September 2006 - June 2007 (Phase - II) in rice - cotton cropping system. 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 (each phase) consist of two experiments, first experiment include rice followed second experiment 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.

Experiments details

Details	Phase I (September 2005 to January 2006)		Phase II (September 2006 to January 2007)	
	Experiment-I	Experiment-II	Experiment-I	Experiment-II
Crop	Rice	Cotton	Rice	Cotton
Design	RBD	Split plot design	RBD	Split plot design

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. The data on various studies recorded during the investigation were subjected to statistical scrutiny as suggested by Gomez and Gomez (1984). The following parameters were worked out *viz.,* total economic produce, total biomass production and per day productivity of economic produce and Rice yield equivalent (RYE) by the two component crops of the cropping system was taken in to account to work out the below mentioned parameters of the cropping system.

Production potential of cropping system

Total economic produce

The grain yields of rice and seed cotton were recorded from the net plot area and the recorded rice grain yield was added to the seed cotton yield to obtain total economic produce and expressed in kg ha^{-1}.

Total biomass production

Rice straw and stalk yield of cotton from net plot were sun dried and recorded. These recorded yields were added to the economic produce to obtain total biomass production and expressed in kg ha^{-1}.

Per day productivity of economic produce

The total economic produce from rice - cotton cropping system was divided by the total duration of the system and the per day productivity of economic produce of cropping system was arrived and expressed in kg ha^{-1} day^{-1}.

Rice yield equivalent (RYE)

In rice - cotton cropping system, the yield equivalents of rice due to different treatments are calculated as below.

$$RYE = \frac{\text{Yield of component crop (kg ha}^{-1}\text{)} \times \text{Price of component crop (Rs. kg}^{-1}\text{)}}{\text{Price of rice (Rs. kg}^{-1}\text{)}}$$

The RYE of component crop is added to the yield of rice to obtain the RYE of cropping system (De *et al*., 1978).

RESULT AND DISCUSSION

Total economic produce, biomass production and per day productivity of economic produce by the two component crops of the cropping system was taken in to account to work out the aforesaid parameters of the cropping system.

Among the main plot treatments, T_5 (100% RDN + vermicompost @ 5 t ha^{-1} applied to rice) recorded significantly maximum economic produce of 7519 and 7932 kg ha^{-1} , total biomass production of 18739 and 19878 kg ha^{-1} , per day productivity of economic produce of 25.93 and 27.35 kg ha^{-1} day^{-1} during phase I and phase II, respectively. Maximum direct effect in terms of improving yield and yield attributes was observed when vermicompost along with the application of inorganic fertilizer which could be attributed to higher availability of nutrients to first crop of rice, residual nutrient availability for rice fallow cotton and subsequent better uptake might have resulted in higher dry matter accumulation, yield attributes and yield. All these factors might have contributed for maximizing the total economic produce, biomass and per day productivity of total economic produce. These results are in agreement with the findings of Bhoite (2005) and Mahala *et al*. (2006). It was followed by. T_6 (75% RDN + vermicompost @ 5 t ha^{-1} applied to rice). The least economic produce of 3265 and 3379 kg ha^{-1}, total biomass production of 9052 and 9429 kg ha^{-1} and per day productivity of economic produce of 11.26 and 11.65 kg ha^{-1} during phase I and phase II, respectively registered under T_1 (No fertilizer and no organic manure). Among the sub plot treatments, S_3 (100% RDF to cotton) registered significantly higher total economic produce of 6141 and 6496 kg ha^{-1} , total biomass production of 15994 and 17034 kg ha^{-1} and per day productivity of economic produce of 21.18 and 22.40 kg ha^{-1} day^{-1} during phase I and phase II, respectively. The greater availability of nutrients through inorganic fertilizer to cotton and INM treatments to rice induced all growth parameters of both crops, which inturn facilitated higher translocation of photosynthates to the reproductive organs might be the reason for higher yield of rice and cotton. It directly reflected on higher values of total economic produce, biomass of rice and cotton and per day productivity of total economic produce (Charjan, 2005 and Patro *et al*., 2005). The lowest total economic produce of 5294 and 5563 kg ha^{-1} , total biomass production of 13028 and 13769 kg ha^{-1} and per day productivity of economic produce of 17.44 and 18.37 kg ha^{-1} during phase I and phase II, respectively recorded under S_1 (0% RDF to cotton). The interaction effect between main plots and sub plots 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 maximum total economic produce of 7827 and 8262 kg ha^{-1} , total biomass production of 19918 and 21141 kg ha^{-1} and per day^{-1} productivity of economic produce of 26.99 and 28.49 kg ha^{-1} during phase I and phase II, respectively.

Rice yield equivalent (RYE)

All the treatments significantly influenced on the rice yield equivalent under rice - cotton cropping system. Among the main plot treatments, T_5 (100% RDN + vermicompost @ 5 t ha^{-1} applied to rice) significantly recorded higher RYE of 11761 and 12491 kg ha^{-1} in phase I and phase II, respectively under rice - cotton cropping system. It was followed by T_6 (75% RDN + vermicompost @ 5 t ha^{-1} applied to rice). Slow

nutrients release with combined use of organic manures along with inorganic fertilizer provides stable supply of nutrients and thus supported for maximal yields. Its significant residual effect also contributed to supply nutrients to the succeeding crop. These facts directly reflected on productivity of succeeding cotton crop. This might be reason for getting higher RYE value. Similar reports was reported by Singh *et al.* (2006) and Aruna and Shaik Mohammad (2005).The least RYE under rice - cotton cropping system of 6114 and 6406 kg ha^{-1} in phase I and phase II, respectively recorded in T_1 (No fertilizer and no organic manure).

Among the sub plot treatments, S_3 (100% RDF to cotton) registered significantly higher RYE of 10419 and 11141 kg ha^{-1} in phase I and phase II, respectively under rice - cotton cropping system. This might be due to better nutrient uptake and efficient assimilation of applied nutrients by both the crops resulting in higher values of RYE. This finding is in conformity with those results of Singh and Ghosh (1999) Singh *et al.* (2000). It was followed by S_2 (75% RDF to cotton). The interaction effect between main plots and sub plots was significant. The treatment combination , T_5S_3 (100% RDN + vermicompost @ 5 t ha^{-1} applied in rice followed by 100% RDF to cotton) registered maximum RYE of 12804 and 13609 kg ha^{-1} in phase I and phase II, respectively.

Table 1. Direct and residual effect of organic and inorganic fertilizer on total economic produce and total biomass production per day productivity of economic produce and Rice yield equivalent in rice - cotton cropping system

Treatments	Total economic produce (kg ha^{-1})		Total biomass production (kg ha^{-1})		Per day productivity of economic produce (kg ha^{-1} day^{-1})		Rice yield equivalent (kg ha^{-1})	
	Phase -I	Phase -II	Phase -I	Phase -II	Phase -I	Phase -II	Phase -I	Phase -II
Main treatments								
T_1	3265	3379	9052	9429	11.26	11.65	6114	6406
T_2	4744	4993	12362	13128	16.36	17.22	7783	8315
T_3	6432	6789	16148	17154	22.18	23.41	10061	10721
T_4	6093	6443	15417	16423	21.01	22.22	9605	10267
T_5	7519	7932	18739	19878	25.93	27.35	11761	12491
T_6	7166	7570	17985	19084	24.71	26.10	11331	12028
T_7	5867	6199	14996	15947	20.23	21.38	9343	9966
T_8	5554	5887	14280	15238	19.15	20.30	8924	9551
$S.E_D$	78	87	207	162	0.49	0.55	6114	6406
CD (p =0.05)	156	174	415	325	0.97	1.09	7783	8315
Sub treatments								
S_1- 0% RDF	5294	5563	13028	13769	17.44	18.37	7551	7986
S_2 - 75% RDF	6055	6388	15596	16553	19.88	21.09	10126	10776
S_3-100% RDF	6141	6496	15994	17034	20.13	21.44	10419	11141
$S.E_D$	68	76	162	186	0.31	0.38	187	204
CD (p =0.05)	136	152	325	373	0.62	0.76	375	409

Table 2. Interaction effect between direct and residual nutrients on total economic produce, biomass production, per day productivity of economic produce and Rice yield equivalent in rice - cotton cropping system

Treatments	Total economic produce (kg ha^{-1})		Total biomass production (kg ha^{-1})		Per day productivity of economic produce (kg ha^{-1} day^{-1})		Rice yield equivalent (kg ha^{-1})	
	Phase -I	Phase -II	Phase -I	Phase -II	Phase -I	Phase -II	Phase -I	Phase -II
T_1S_1	2716	2811	7174	7486	9.37	9.69	4257	4483
T_1S_2	3432	3523	9614	9908	11.83	12.15	6679	6892
T_1S_3	3647	3804	10367	10892	12.58	13.12	7407	7844
T_2S_1	4211	4397	10543	11095	14.52	15.16	5977	6298
T_2S_2	4931	5210	12989	13860	17.00	17.96	8414	9049
T_2S_3	5092	5372	13553	14428	17.56	18.52	8959	9598
T_3S_1	5924	6233	14409	15247	20.43	21.49	8343	8839
T_3S_2	6648	7024	16840	17908	22.92	24.22	10792	11517
T_3S_3	6724	7110	17196	18306	23.18	24.52	11048	11807
T_4S_1	5593	5885	13703	14508	19.29	20.29	7913	8378
T_4S_2	6308	6675	16107	17167	21.75	23.02	10332	11050
T_4S_3	6378	6770	16441	17595	21.99	23.34	10569	11371
T_5S_1	6921	7289	16655	17636	23.86	25.13	9737	10313
T_5S_2	7809	8245	19646	20857	26.93	28.43	12743	13551
T_5S_3	7827	8262	19918	21141	26.99	28.49	12804	13609
T_6S_1	6564	6924	15885	16832	22.63	23.88	9292	9842
T_6S_2	7462	7883	18914	20065	25.73	27.18	12332	13088
T_6S_3	7473	7902	19157	20354	25.77	27.25	12368	13154
T_7S_1	5367	5641	13278	14030	18.51	19.45	7648	8076
T_7S_2	6083	6428	15690	16681	20.98	22.17	10073	10739
T_7S_3	6152	6529	16020	17131	21.22	22.51	10307	11082
T_8S_1	5056	5328	12572	13318	17.44	18.37	7241	7661
T_8S_2	5766	6115	14966	15974	19.88	21.09	9644	10324
T_8S_3	5838	6217	15303	16422	20.13	21.44	9888	10667
$S.E_D$	68	76	162	186	0.31	0.38	187	204
CD (p =0.05)	136	152	325	373	0.62	0.76	375	409

REFERENCES

Aiken, C. S. 2006. The cotton plantation south. Transportation Information Service of Germany, Gesamtverband der Deutschen Versicherungswirtschaft e.V. (GDV), Berlin, http://www./tis_e/baumwoll/baumwoll.htm, 2002-2006.

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.

Banik, P and Ranjita Bejbaruah. 2004. Effect of vermicompost on rice yield and soil fertility status of rainfed humid sub-tropics. Indian J. Agric. Sci., 74(9): 488-491.

Bhoite, S.V. 2005. Integrated nutrient management in basmati rice-wheat cropping system. **Indian J. Agron., 50**(2): 98-101.

Charjan, Y.D. 2005. Fertilizer economy and energy utilization of cotton-wheat sequence under integrated nutrient management system. **Ad. Plant Sci., 18**(1): 195-200.

De,R., R.S.Gupta, S.P. Singh, M. Pal, S.N. Singh, R.N. Sharma and S.K. Kaushik. 1978. Intercropping maize, sorghum and pearl millet with short duration grain legumes. **Indian J. Agric. Sci., 48(9)**: 132- 137.

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

IRCN, 2001. Expert consultation on yield gap and productivity decline in rice production. Conclusion and recommendations. **Int. rice Com. Newsletter, 50**: 73-83.

Mahala, H.L., M.S.Saktawat and R.K.Shivran. 2006. Direct and residual effect of sources and levels of phosphorus and farmyard manure in maize-mustard cropping sequence. **Indian J. Agron., 51** (1): 10-13.

Nayyar, V.K. and Chhibba, I.M. 2000. Effect of green manuring on micronutrient availability in rice-wheat cropping system of northwest India. Page 68-72 (In): *Long-term Soil Fertility Experiments in Rice-Wheat Cropping Systems* (Abrol, I.P. and Brown, K.F.). Rice-Wheat Consortium Paper Series 6. New Delhi, India.

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.

Siddique, E.A. 2000. Rice-yawning productivity gaps. The Hindu survey of Indian Agriculture, pp.39-44.
Singh, R.B. 2000. Environmental consequences of agricultural development : a case study for the green revolution state of Haryana, India.Agr. Ecosys. Environ., 82: 97- 103.

Singh, A.K., L.P.Amgain and S.K.Sharma. 2000. Root characteristics, soil physical properties and yield of rice (*Oryza sativa*) as influenced by integrated nutrient management in rice - wheat (*Triticum aestivum*) system. **Indian J. Agron., 45**(2): 217-222.

Singh, G., O.P. Singh, R.G. Singh, R.K. Mehta, V.Kumar and R.P.Singh. 2006. Effect of integrated nutrient management on yield and nutrient uptake of rice - wheat cropping system in lowlands of eastern Uttar Pradesh. **Indian J. Agron., 51**(2): 85-88.

Singh, S.K. and B.C .Ghosh. 1999. Direct and residual effect of fertilizers on yield and nutrient uptake of jute and rice grown in a cropping sequence in rainfed low lands. **Indian J. Agron., 44**(3): 473-476.

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