Effect of organic manures and inorganic fertilizers on productivity and economics of 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 effect of organic manures and inorganic fertilizers on productivity and economics of rice - cotton cropping system. The whole research consist of two phases each phase contain two experiments, first experiment include rice and 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, cost of cultivation, gross return and net return and return per rupee invested (Benefit cost ratio) by the two component crops of the cropping system was taken in to account to work out the aforesaid parameters of the cropping system. From the results of field trials, it may be inferred that combined application of 100% RDN + vermicompost @ 5 t ha^{-1} to rice and 75% RDF to cotton under rice - cotton cropping system may be an eco-friendly, economically viable and biologically active system that can be advocated to the farmers of tail end area of Cauvery Deltaic Zone of Tamil Nadu. In case of non availability of vermicompost, traditional practice of green manuring with @ 6.25 t ha^{-1} + 100% RDN to rice and 100% RDF to cotton under rice - cotton cropping system, may be a good alternative to augment rice and cotton yields, besides helping in the maintenance of soil health.

.

Keywords: Rice, Cotton, cropping system, total economic produce, **g**ross **r**eturn, **n**et **r**eturn and **r**eturn per rupee invested

Introduction

Rice (*Oryza sativa L.*) is one of the most important stable food crops in the world. It is the major source of calories for 40 percent of the world population. Currently, the world population is increasing at alarming rate but there is no scope to increase the net cultivable land for crop production. Exploiting the production potential of high yielding rice varieties through agronomic management is one of the alternatives to feed the ever rising population.

Cotton is the king of fibre crops, a crop of prosperity, is an industrial commodity of global importance. In fact, no agricultural commodity in the world has exercised such a considerate influence on men and matter. Cotton is a vital cash crop of India, grown by 4 million farmers on an estimated 7.4 million hectare of cultivated land. 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 (Rammohan, 1997). Although 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. The use of inorganic fertilizer to sustain cropping was found to increase yield only for some few years but on long-term, it has not be effective and leads to soil degradation (Satyanarayana *et al.*, 2002). Sustainable production of a crop can not be maintained by using the chemical fertilizer alone and similarly it is not possible to obtain high yield by using only organic manure (Bair, 1990). Kumar and Goh (2000) reported that no single manure management practice is superior under all conditions. Similarly, continuous application of organic manures alone on crop field resulting low yield of crop (Javier *et al.*, 2004).

This implies that the need of integrated nutrient management for both rice and cotton production. Therefore the combined use of organic manures and inorganic fertilizers help in maintaining yield stability through correction of marginal deficiencies of secondary and micronutrients, enhancing efficiency of applied nutrients and providing favorable soil physical conditions. Integrating nutrient management (INM) aims for efficient and judicious use of all the major sources of plant nutrients in an integrated manner (Farouque and Takeya, 2007). INM practices are a holistic management system, which promotes sustainable agriculture and enhances agro-ecosystem health. Organic manures like green manure, pressmud and vermicompost deserves priority for sustained production and better utilization in intensive cropping system. The existing system of fertilizer management in cropping system is based on the nutrient requirement of individual crop ignoring the carry over effect of manure or fertilizer applied to the preceding crop. Indications are also available of saving some fertilizer, if fertilizer management is done for the cropping system as a whole. Residual effect of nutrients may be more pronounced for organic sources of nutrients applied to the preceding crop, benefiting the succeeding crop to a greater extent (Hegde, 1998) and the system productivity becomes sustainable through integrated use of organic and inorganic sources of nutrients (Singh and Yadav, 1992).

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 effect of organic manures and inorganic fertilizers on productivity and economics of 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 following parameters were worked out *viz.*, total economic produce, cost of cultivation, gross return and net return and return per rupee invested (Benefit cost ratio) 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.

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}.

Economics of rice - cotton cropping system

The economics of cropping system was worked out based on the cost of inputs and outputs prevailed during the period of experimentation and the relative merits of rice - cotton cropping system were evaluated.

Cost of cultivation

It is supplementary index to indicate the amount of capital resources needed to adopt a rice- cotton cropping system. This was computed with the expenditure incurred on different items such as labour, seeds, fertilizer, herbicides, pesticides and animal power and expressed in Rs. ha^{-1}.

Gross Return

The gross return of all rice - cotton cropping system was worked out by multiplying the economic produce and by-produce (straw and stalks) by respective sale prices and expressed in Rs. ha^{-1}.

Net Return

The net return of rice - cotton cropping system was worked out by subtracting the total cost of cultivation from the total gross return of the system and expressed in Rs. ha^{-1}.

Return per rupee invested (Benefit cost ratio)

This was worked out by dividing the gross return by the total cost of cultivation.

Cost of cultivation, Gross Return and Net Return and Return per rupee invested (Benefit cost ratio)

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

RESULT AND DISCUSSION

Total 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. The INM practices on rice and its residual effect on cotton significantly influenced the economic produce of rice- cotton cropping system.

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} 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. These results are in agreement with the findings of Reddy *et al.* (2004) and Chakravorti and Samantaray (2006). Besides, 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 under rice and cotton cropping system (Charjan, 2005 and Patro *et al.*, 2005).

Economic analysis on rice - cotton cropping system

Different economic parameters worked out for the rice - cotton cropping system as a whole was presented in this section.

Gross return

The maximum gross return (Rs. 81360.92 and 86546.75 during phase I and phase II, respectively) was recorded in T_5S_3 (100% RDN + vermicompost @ 5 t ha^{-1} imposed to rice followed by 100% RDF to cotton). This was followed by T_5S_2 (100% RDN + vermicompost @ 5 t ha^{-1} imposed to rice followed by 75% RDF to cotton) which registered a gross return of Rs. 80937.32 and Rs. 86140.96 during phase I and phase II, respectively. The lowest gross return was noticed in T_1S_1 (No fertilizer and no organic manure in rice followed by 0% RDF to cotton) with Rs. 27158.38 and Rs. 28635.62 in phase I and phase II, respectively.

Net return

The maximum net return (Rs 44866.32 and Rs. 50012.96 in phase I and phase II, respectively) was recorded in T_5S_2 (100% RDN + vermicompost @ 5 t ha^{-1} imposed to rice followed by 75% RDF to cotton). This was followed by T_5S_3 (100% RDN + vermicompost @ 5 t ha^{-1} imposed to rice followed by 100% RDF to cotton) which registered a net return of Rs. 44784.92 and Rs. 49932.75 in phase I and phase II, respectively.

The lowest net return was noticed in T_1S_1 (No fertilizer and no organic manure in rice followed by 0% RDF to cotton) with Rs. 3526.38 and Rs. 4965.62 in phase I and phase II, respectively.

Return per rupee invested

The maximum return per rupee invested of Rs. 2.24 and Rs. 2.38 was recorded in phase I and phase II, respectively under T_5S_2 (100% RDN + vermicompost @ 5 t ha^{-1} imposed to rice followed by 75% RDF to cotton). This was followed by T_5S_3 (100% RDN + vermicompost @ 5 t ha^{-1} imposed to rice followed by 100% RDF to cotton) with a return per rupee invested of Rs. 2.22 and Rs. 2.36 in phase I and phase II, respectively. The lowest return per rupee invested was noticed under T_1S_1 (No fertilizer and no organic manure in rice followed by 0% RDF to cotton) with Rs.1.15 and Rs. 1.21 in phase I and phase II, respectively. Inorganic fertilizer along with vermicompost applied in rice significantly influenced the growth and yield attributes of rice and its residual effect on cotton also significantly influenced growth and yield attributes of cotton. The growth attributes are directly reflected on increased the yields of rice and cotton. In addition aforesaid treatments offered favourable neutro physiological conditions and enhanced the soil fertility. These might be the reason for increased profitability in the rice based cropping system (Jeyabal and Kuppuswamy, 2001 and Sudhakar and Kuppuswamy, 2007).

In the light of economic analysis it may be inferred that combined application of 100% RDN + vermicompost @ 5 t ha^{-1} to rice and 75% RDF to cotton under rice - cotton cropping system may be an eco-friendly, economically viable and biologically active system that can be advocated to the farmers of tail end area of Cauvery Deltaic Zone of Tamil Nadu. In case of non availability of vermicompost, traditional practice of green manuring with @ 6.25 t ha^{-1} + 100% RDN to rice and 100% RDF to cotton under rice - cotton cropping system, may be a good alternative to augment rice and cotton yields, besides helping in the maintenance of soil health.

Table 1. Effect of INM practices and graded doses of fertilizer on total economic produce and economics in rice - cotton cropping system in Phase I

Treatments	Total economic produce (kg ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net income (Rs ha^{-1})	Return/Re. invested
T_1S_1	2811	23632.00	27158.38	3526.38	1.15
T_1S_2	3523	24937.00	43071.80	18134.80	1.73
T_1S_3	3804	25442.00	47857.77	22415.77	1.88
T_2S_1	4397	27082.00	37776.43	10694.43	1.39
T_2S_2	5210	28387.00	53789.03	25402.03	1.89
T_2S_3	5372	28892.00	57373.50	28481.50	1.99
T_3S_1	6233	31547.00	52507.22	20960.22	1.66
T_3S_2	7024	32852.00	68597.18	35745.18	2.09
T_3S_3	7110	33357.00	70288.35	36931.35	2.11
T_4S_1	5885	31012.00	49857.23	18845.23	1.61
T_4S_2	6675	32317.00	65747.36	33430.36	2.03
T_4S_3	6770	32822.00	67318.09	34496.09	2.05
T_5S_1	7289	34766.00	61186.68	26420.68	1.76
T_5S_2	8245	36071.00	80937.32	44866.32	2.24
T_5S_3	8262	36576.00	81360.92	44784.92	2.22
T_6S_1	6924	34231.00	58446.62	24215.62	1.71

T_6S_2	7883	35536.00	78420.14	42884.14	2.21
T_6S_3	7902	36041.00	78680.96	42639.96	2.18
T_7S_1	5641	30207.00	48263.29	18056.29	1.60
T_7S_2	6428	31512.00	64193.63	32681.63	2.04
T_7S_3	6529	32017.00	65744.26	33727.26	2.05
T_8S_1	5328	29672.00	45731.41	16059.41	1.54
T_8S_2	6115	30977.00	61521.98	30544.98	1.99
T_8S_3	6217	31482.00	63132.47	31650.47	2.01

Not analysed

Table 2. Effect of INM practices and graded doses of fertilizer on total economic produce and economics in rice - cotton cropping system in Phase II

Treatments	Total economic produce (kg ha $^{-1}$)	Cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net income (Rs ha^{-1})	Return/Re. invested
T_1S_1	2716	23670.00	28635.62	4965.62	1.21
T_1S_2	3432	24994.00	44470.61	19476.61	1.78
T_1S_3	3647	25480.00	50722.86	25242.86	1.99
T_2S_1	4211	27120.00	39854.44	12734.44	1.47
T_2S_2	4931	28444.00	57931.72	29487.72	2.04
T_2S_3	5092	28930.00	61540.00	32610.00	2.13
T_3S_1	5924	31585.00	55681.19	24096.19	1.76
T_3S_2	6648	32909.00	73279.58	40370.58	2.23
T_3S_3	6724	33395.00	75193.13	41798.13	2.25
T_4S_1	5593	31050.00	52841.22	21791.22	1.70
T_4S_2	6308	32374.00	70398.70	38024.70	2.17
T_4S_3	6378	32860.00	72518.99	39658.99	2.21
T_5S_1	6921	34804.00	64871.97	30067.97	1.86
T_5S_2	7809	36128.00	86140.96	50012.96	2.38
T_5S_3	7827	36614.00	86546.75	49932.75	2.36
T_6S_1	6564	34269.00	61956.57	27687.57	1.81
T_6S_2	7462	35593.00	83278.30	47685.30	2.34
T_6S_3	7473	36079.00	83734.86	47655.86	2.32
T_7S_1	5367	30245.00	51007.29	20762.29	1.69
T_7S_2	6083	31569.00	68502.93	36933.93	2.17
T_7S_3	6152	32055.00	70767.96	38712.96	2.21
T_8S_1	5056	29710.00	48426.39	18716.39	1.63
T_8S_2	5766	31034.00	65922.47	34888.47	2.12

T_8S_3	5838	31520.00	68187.28	36667.28	2.16

Not analysed

REFERENCES

Bair, W. 1990. Characterization of the environment for sustainable agriculture in Semi-Arid Tropics. In: Sustainable Agriculture: Issue, Perspective and prospects in Semi Arid Tropics (Ed. Singh RP), Hyderabad, India. *Indian Soci. Agron.* **1**: 90-128.

Chakravorti, S.P. and Samantaray, R.N. 2006. Annual Report. CRRI, Cuttack

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.

Farouque M., Takeya H. 2007. Farmers' Perception of Integrated Soil Fertility and Nutrient Management for Sustainable Crop Production: A Study of Rural Areas in Bangladesh. Journal of agricultural education 48:111-122.

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

Hegde, D.M. 1998. Long term sustainability of productivity in rice (*Oryza sativa*) - Wheat (*Triticum aestivum*) system in sub humid ecosystem through integrated nutrient supply. **Indian J. Agron., 43**(2): 189-198.

Javier E.F, Marquez J.M, Grospe F.S, Mamucod H. F. and Tabien R.E. 2004. Three-Year Effect of Organic Fertilizer Use on Paddy Rice. Philippine Journal of Crop Sciences. 27(2): 11-15.

Jeyabal, A. and G.Kuppuswamy. 2001. Recycling of organic wastes for the production of vermicompost and its response in rice-legume cropping system and soil fertility, **European. J. Agron., 15**: 153-170

Kumar, K. and K. M. Goh. 2000. Crop residue management: Effects on soil quality, soil nitrogen dynamics, crop yield and nitrogen recovery. *Adv. Agron.* **68**: 197-319.

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.

Rammohan, J. 1997. Evaluation of suitable cropping system for single rice based low lands of karaikal region of union territory of Pondicherry. **Ph.D., Thesis**, Tamil Nadu Agricultural Univ., Coimbatore, Tamil Nadu, India.

Reddy, M.D., Rama Lakshmi, Ch.S., Rao, C.N., Rao K.V., Sitaramayya M., Padmaja, G. and Raja Lakshmi T. 2004. Effect of long term integrated nutrient supply to rice-rice cropping system on soil chemical properties, nutrient uptake and yield of rice. Indian Journal of Fertilizers 52: 36-40.

Satyanarayana V., Murthy V. R. K., Vara Prasad P. V. and Boote K. J.2002. Influence of Integrated Use of Farmyard Manure and Inorganic Fertilizers on Yield and Yield Components of Irrigated Lowland Rice. Journal of Plant Nutrition. Vol. 25, No.10, pp. 2081-2090.

Singh, G. B. and D. V. Yadav. 1992. Integrated nutrient supply system (INSS) in sugarcane based cropping system. Fertilizer News. **37**(4): 15-22.

Sudhakar, P. and G.Kuppuswamy . 2007. Evaluation of Different organic manures in rice and their impact on succeeding crops. **Plant Archives, 7**(1): 439-441.