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Integrated Nutrient Management in Rice-Gingelly-Maize Cropping System Yield and System Economics through Integrated Farming System

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A B S T R A C T

Field experiments were conducted at Wetland farm of Tamil Nadu Agricultural University, Coimbatore during 2014-2015 and 2015-2016 to study the effect of integrated nutrient management in rice-gingelly-maize cropping system. The field experiments were laid out in randomized block design with three replications and the same layout was maintained both the years. The experiment consisted of thirteen treatments comprising of three level of recommended dose of fertilizer (100, 75 and 50% RDF combination with various organic sources (turkey, quail and goat manure as pond silt and vermicompost) and 100% RDF along with FYM. In Rice-gingelly-cropping system during 2014-15 and 2015-2016, application of 100% RDF + vermicompost at 5 t/ha (T_1) recorded higher system yield of 15102 kg/ha and 15551 kg/ha. This was followed by application of 100% RDF + goat manure as pond silt at 5 t/ha (T_4), 100% RDF + FYM 12.5 t/ha (T_{13}) and 100% RDF + turkey manure as pond silt at 5 t/ha (T_2). The application of 50% RDF + quail manure as pond silt at 5 t/ha (T_{11}) recorded lesser system yield of 8876 kg/ha. In 2015-16 followed by application of 100% RDF + goat manure as pond silt at 5 t/ha (T_4), 100% RDF + turkey manure as pond silt at 5 t/ha (T_2), 100% RDF + FYM 12.5 t/ha (T_{13}), 75% RDF + vermicompost at 5 t/ha (T_5) and100% RDF + quail manure as pond silt at 5 t/ha (T_3). The application of 50% RDF + quail manure as pond silt at 5 t/ha (T_{11}) recorded lesser system yield of 9310 kg/ha. It was comparable with application 100% RDF + goat manure at 5 t/ha recorded higher gross return and net return and 75% RDF + vermicompost at 5 t/ha recorded higher B:C ratio of 2.69 and 2.78 during 2014-2015 and 2015-2016. Compare to conventional practices increased percentage of gross return (10.74 and 11.11) and net return (17.86 and 18.23) respectively during 2014-2015 and 2015-2016.

Introduction

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 based cropping system through agronomic management is one of the alternatives to feed the ever rising population. For this, fertilizers have

contributed substantially to the spectacular increase in rice yield. This concept of nutrient management assumed greater significance in recent years because of two reasons. First, the need for continued increase in agricultural production and productivity requires growing application of nutrients and the present level of fertilizer production in India is not enough to meet the entire plant nutrient requirement.

A typical rice based system in South Asia follows traditional cultivation techniques that involve wet ploughing (puddling), followed by transplanting rice seedlings grown in a seedbed in the summer (Hobbs *et al.,* 2008). Wheat or other crops in a rotation are grown in the winter using traditional desi plough or moldboard plough tillage. Improved management practices such as reduced or no tillage management, crop residue addition, crop rotation, and balanced nutrient application increases soil organic carbon (SOC) and improves agricultural sustainability (Six *et al.,* 2002; West and Post 2002; Vanden Bygaart *et al.,* 2003). Rice based cropping systems in South and Southeast Asia include irrigated continuous rice cropping, rice-wheat rotation and rainfed rice based mixed farming in upland areas which feed more than 1.5 billion people (Cassman, 1999). In South Asia, continuous rice cropping and rice-wheat rotation occupy approximately 26% of the cultivated land with additional 30% area under the rainfed mixed farming that includes upland rice production (FAO, 2001). Upland rice is produced in areas with low precipitation and limited opportunities for irrigation. There is a growing interest towards the use of conservation management systems, such as reduced tillage, no-tillage, crop residue addition, and improved nutrient management practices in rice and other crops in rotation for sustainably increasing food production in South Asia (Carter, 2002; Erenstein and Laxmi, 2008; Johnston *et al.,* 2009), productivity by 3 per cent/annum (Thiyagarajan and Selvaraju, 2001).

Rice cultivation requires large quantity of water and for producing one kg rice, about 3000-5000 litres of water depending on the different cultivation methods such as transplanted rice, direct sown rice (wet seeded), alternate wetting and drying method (AWD), aerobic rice and rice based cropping system.

Owing to increasing water scarcity, a shifting trend towards less water demanding crops against rice is noticed in most part of the India and this warrants alternate methods of rice cultivation that aims at higher water and crop productivity. There are evidences that cultivation of rice based cropping system can increase rice equivalent yields by two to three fold compared to current yield levels.

The impending demand-supply gap of about 10 million tonnes of plant nutrients is likely to widen further in view of steep hike in the prices of P&K fertilizers and raw materials. Second, a large number of experiments on INM, particularly long term experiments conducted in India or elsewhere reveal that neither the fertilizers nor the organic sources in isolation can achieve sustained production under intensive cropping.

Materials and Methods

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore during *rabi-summer-kharif* seasons (Sep-Oct, Feb-Mar, June-July, respectively) in 2014-15 and 2015-16 to study the effect of integrated nutrient management for rice-gingelly-maize cropping system. The details of the experimental materials used and the methods adopted during the course of investigations are presented in this chapter. Experiments were conducted in Field No. M-8 at wetland farm of the Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore. The experimental site is geographically situated in the western agro-climatic zone of

Tamil Nadu at 11ºN latitude and 77ºE longitude and at an altitude of 426.7 meters above mean sea level (MSL).

During 2014-15, the crop received 198.4 mm of rainfall. The maximum and minimum temperatures ranged from 27.6ºC to 36.2ºC and 18.1ºC to 25.5ºC, respectively. The mean relative humidity ranged from 65.8 to 93.1 per cent and 23.7 to 66.4 per cent during forenoon and afternoon, respectively. The mean bright sunshine hours ranged from 1.5 to 12.4 hours/day.

During 2015-16, the crop received 163.7 mm of rainfall. The maximum and minimum temperatures ranged from 27.3ºC to 37.9ºC and 16.7ºC to 26.0ºC, respectively. The mean relative humidity ranged from 76.9 to 89.4 per cent and 25.4 to 64.6 per cent in forenoon and afternoon, respectively. The mean bright sunshine hours ranged from 1.0 to 0.1 hours/day

Table.2 Details of treatments

T_1 - 100% RDF + vermicompost

T_2 - 100% RDF + turkey manure as pond silt

T_3 - 100% RDF + quail manure as pond silt

T_4 - 100% RDF + goat manure as pond silt

T_5 - 75% RDF + vermicompost

T_6 - 75% RDF + turkey manure as pond silt

T_7 - 75% RDF + quail manure as pond silt

T_8 - 75% RDF + goat manure as pond silt

T_9 - 50% RDF + vermicompost

T_{10} - 50% RDF + turkey manure as pond silt

T_{11} - 50% RDF + quail manure as pond silt

T_{12} - 50% RDF + goat manure as pond silt

T_{13} - 100% RDF + FYM at 12.5 t/ha

Note: RDF - As per the recommendation to the individual crop.

OM (turkey, quail, goat manures as pond silt and vermicompost) were applied to first crop (rice) only in the cropping system at 5 t/ha.

Preliminary trial

Experimental methods

Preliminary experiment

Quantification of fish pond silt fed with fresh manures

Pond I: Turky (20 Nos.)

Pond II: Quail (80 Nos.)

Pond III: Goat (5+1 Nos.)

The preliminary experiment was conducted 9 months in fish pond for pond silt and manure production.

The nutrient analysed pond silt and manure was utilized for main experiment (Table 3) but the pond silt and manure cost was taken by at the time of marketing price. Here not added for any special cost of cultivation for pond silt and manure production through integrated farming system. Fish pond fallow in 3 months.

Main field experiment

Crop management

Field preparation: After the harvest of gingelly crop, each plot was prepared with

ridges and furrows without disturbing layout plan then puddling to rice.

Manures and fertilizer application: Recommended dose of fertilizer of NPK in the form of urea (46% N), single super phosphate (16% P_2O_5) and muriate potash (60% K_2O) were applied. Nitrogen and was applied in quarter dose as basal, remaining in 45 DAS, respectively. The entire dose of phosphorus and Potassium was applied as basal depend on the crop.

Seeds and sowing: seeds were dibbled at the rate of one seed/hill adopting spacing within the row. A required seed rate of was adopted. Seeds were dibbled manually and transplanting.

Gap filling and thinning: Gap filling was done on seventh day after sowing and thinning on 15th day after sowing for all crops.

Irrigation: First irrigation was given immediately after sowing. Life irrigation was given on third day after sowing. Subsequent irrigations were given on need basis at an interval of 7-10 days.

Weed management: Application of pre-emergence herbicide atrazine 0.25 kg/ha was done on third day after sowing. Hand weeding was done on 30th DAS and necessary place.

Plant protection: Adequate need based plant protection measures were taken up periodically during the crop growth period as per recommendation of crop production guide (2012).

Two border rows on all four sides of each treatment plot were harvested first and then the net plots harvested separately. The harvested cobs were dried, dehisced, husk, shelled and cleaned separately. After cleaning, the grains were sun dried to 14 per cent moisture content. Grain weight of each treatment was recorded and expressed in kg/ha. Stover yield was also recorded and expressed in kg/ha.

Results and Discussion

System yield

Rice grain equivalent yield (System yield) was significant influence on system yield was observed during both the years of study and are presented in the Table 1. Mean system yield of two years revealed that, application of 100% RDF + vermicompost at 5 t/ha (T_1) recorded higher system yield of 15327 kg/ha. This was followed with application of 100% RDF + goat manure as pond silt at 5 t/ha (T_4), 100% RDF + FYM 12.5 t/ha (T_{13}) and 100% RDF + turkey manure as pond silt at 5 t/ha (T_2). The application of 50% RDF + quail manure as pond silt at 5 t/ha (T_{11}) recorded lesser system yield of 9093 kg/ha.

System economics

System economics and the viability of crop cultivation are mainly the outcome of the yield of crop (Table 2). Mean of two years data on recorded that system cost of cultivation higher system cost of cultivation and net returns of ₹ 83610 and ₹ 146287/ha were observed with application of 100% RDF + vermicompost at 5 t/ha (T_1). This was followed by application of 100% RDF + goat manure as pond silt at 5 t/ha (T_4) and 100% RDF + FYM 12.5 t/ha (T_{13}). The lower cost of cultivation and net return of ₹ 75740 and ₹ 60659/ha, respectively were recorded with application of 50% RDF + quail manure as pond silt at 5 t/ha (T_{11}).

System equivalent yield

System equivalent yield of rice-gingelly-maize cropping is influenced by integrated nutrient management (INM) practices (Fig. 1).

Table.1A Physico - chemical characteristics of the experimental field

S.No.	Particulars	Values	Methods used	Authors
I. Physical properties				
1.	Clay (%)	44.24	International pipette method	Piper (1966)
2.	Silt (%)	19.3		
3.	Coarse sand (%)	15.2		
4.	Fine sand (%)	21.3		
5.	Texture	clay loam		
II. Chemical properties				
1.	pH	8.4	1:2 soil: water suspension	Jackson (1973)
2.	EC (dS/m)	0.4	Conductometry (1:2 soil water suspension)	Jackson (1973)
3.	Organic carbon (%)	0.5	Wet chromic acid digestion	Walkley and Black (1934)
4.	Available nitrogen (kg/ha)	310	Alkaline permanganate	Subbiah and Asija (1956)
5.	Available phosphorus (kg/ha)	12.9	Colorimetry	Olsen *et al.,* (1954)
6.	Available potassium (kg/ha)	482	Neutral normal ammonium acetate	Stanford and English (1949)

Table.1B Effect of integrated nutrient management on system yield (kg/ha) of rice-gingelly-maize cropping system (mean of two years)

Treatment	Rice	REY of Gingelly	REY of Maize	System total
T_1 - 100% RDF + vermicompost	6188	3359	5780	15327
T_2 - 100% RDF + turkey manure as pond silt	5525	3025	5290	13840
T_3 - 100% RDF + quail manure as pond silt	5328	2919	5147	13394
T_4 - 100% RDF + goat manure as pond silt	5903	3232	5532	14666
T_5 - 75% RDF + vermicompost	5365	2800	5432	13596
T_6 - 75% RDF + turkey manure as pond silt	4798	2475	4874	12146
T_7 - 75% RDF + quail manure as pond silt	4475	2394	4549	11418
T_8 - 75% RDF + goat manure as pond silt	5115	2669	5072	12856
T_9 - 50% RDF + vermicompost	3980	2446	4826	11252
T_{10} - 50% RDF + turkey manure as pond silt	3263	2219	4165	9646
T_{11} - 50% RDF + quail manure as pond silt	3100	2101	3892	9093
T_{12} - 50% RDF + goat manure as pond silt	3535	2321	4564	10420
T_{13} - 100% RDF + FYM at 12. 5 t/ha	5685	2981	5211	13877

Data not statistically analysed

Table.2 Effect of integrated nutrient management on system economics of rice-gingelly-maize cropping system (mean of two years)

Treatment	Cost of cultivation (₹/ha)				Net return (₹/ha)			
	Rice	Gingelly	Maize	Total	Rice	Gingelly	Maize	Total
T_1 - 100% RDF + vermicompost	29840	22930	30840	83610	62973	27450	55864	146287
T_2 - 100% RDF + turkey manure as pond silt	29840	22930	30840	83610	53035	22445	48504	123984
T_3 - 100% RDF + quail manure as pond silt	29840	22930	30840	83610	50073	20850	46360	117283
T_4 - 100% RDF + goat manure as pond silt	29840	22930	30840	83610	58698	25553	52136	136387
T_5 - 75% RDF + vermicompost	28760	21880	29790	80430	51715	20113	51682	123510
T_6 - 75% RDF + turkey manure as pond silt	28760	21880	29790	80430	43203	15245	43314	101762
T_7 - 75% RDF + quail manure as pond silt	28760	21880	29790	80430	38365	14035	38450	90850
T_8 - 75% RDF + goat manure as pond silt	28760	21880	29790	80430	47965	18160	46290	112415
T_9 - 50% RDF + vermicompost	26590	21440	27710	75740	33110	15245	44674	93029
T_{10} - 50% RDF + turkey manure as pond silt	26590	21440	27710	75740	22348	11835	34754	68937
T_{11} - 50% RDF + quail manure as pond silt	26590	21440	27710	75740	19910	10075	30674	60659
T_{12} - 50% RDF + goat manure as pond silt	26590	21440	27710	75740	26435	13375	40754	80564
T_{13} - 100% RDF + FYM at 12.5 t/ha	29840	21440	30840	82120	55435	23275	47320	126030

Data not statistically analysed

Table.3 Nutrient analysis of the different manure components

S.No.	Manures	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potash (kg/ha)
1.	Vermicompost (5t)	60	30	40
2.	Turkey pond silt (5t)	30	15	20
3.	Quail pond silt (5t)	30	10	15
4.	Goat pond silt (5t)	40	20	25
5.	Farm Yard Manure (12 t)	35	15	20

Fingerlings for Integrated Farming System

Fingerlings ready for Integrated Farming System

Fingerlings releasing by chairperson

Fingerlings releasing by research scholar

Pond ready for Fish collection

Fish collection by fishnet

Collection of Fish from IFS pond

Silt manure ready for next cropping system from IFS

Fig.1 Integrated farming system via a fish weight 3.5 kg/9months

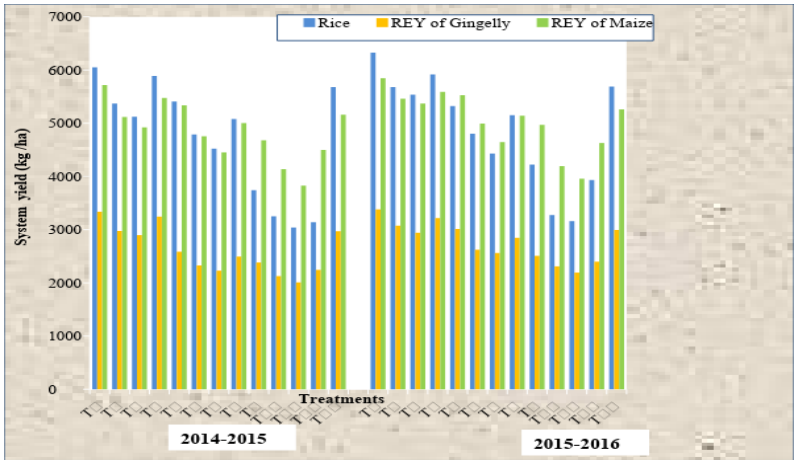
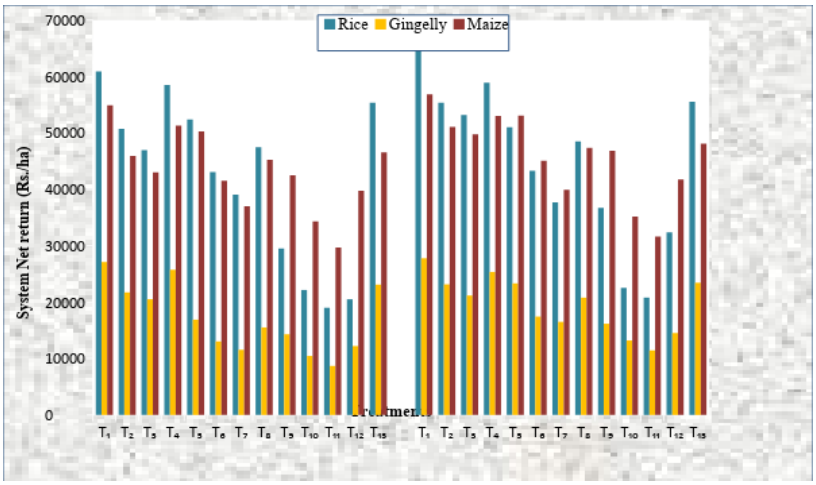


Fig.2 Influence of integrated nutrient management on system yield of rice-gingelly-maize cropping system



In both the years, mean system equivalent yield of two years revealed that, the application of 100% RDF + vermicompost recorded higher system equivalent yield (15,327 kg/ha/year) and it was followed by 100% RDF + 5 t/ha of goat manure (14,666 kg/ha/year). The higher system equivalent yield with these treatments might be due to integration of organic sources and inorganic fertilizers which enhanced the availability of nutrients for a shorter period as mineralization of nitrogen is more rapid and in turn the losses of inorganic nitrogen due to volatilization, denitrification and leaching etc., would be more. Sarwar *et al.,* (2008) and Ali *et al.,* (2012) also claimed increased system yields of rice with the use of organic manures alone or in combination with chemical fertilizers.

System economics

System economics of rice-gingelly-maize cropping system was influenced by integrated nutrient management (INM) practices during both the years of study (Fig. 2). Higher system cost of cultivation (₹ 83610/ha/year) and net returns (₹ 146287 ha/year)) were observed with application of 100% RDF + vermicompost at 5 t/ha and it was followed by application of 100% RDF + goat manure as pond silt at 5 t/ha with the cost of cultivation of ₹ 83610/ha/year and net return of ₹ 136387/ha/year of rice- gingelly- maize cropping system. This might be due to the crops low variable cost, higher growth and yield to more gross return was obtained from above treatment and many research work related to the integrated use of fertilizer have found high return to profitable. The similar findings reported by Haque *et al.,* (2001).

Lower cost of cultivation (₹ 75740) and net return (₹ 60659) were registered with application of 50% RDF + quail manure as pond silt at 5 t/ha. The lower system economics was recorded due to imbalanced application of nutrients gave lesser yield thus recording lower economics of the rice-gingelly-maize cropping system in both the years. The similar findings are confirmed by Islam *et al.,* (2013).

In conclusion, the mean data two years revealed that higher rice grain equivalent yield 15327 kg/ha/year in rice-gingelly-maize as was registered with application of 100% RDF + vermicompost at 5 t/ha. This was

followed by 100% RDF + goat manure as pond silt at 5 t/ha, 100% RDF + FYM at 12.5 t/ha and 100% RDF + turkey manure as pond silt at 5 t/ha. Mean data over two years stated that the highest cost of cultivation (83610/ha/year) and net returns of 146287/ha/year was recorded with application of 100% RDF + vermicompost at 5 t/ha in rice-gingelly-maize cropping system. This was followed with application of 100% RDF + goat manure as pond silt at 5 t/ha and 100% RDF + FYM at 12.5 t/ha.

Recommendations

In rice-gingelly-maize cropping system for rice and gingelly crops application of 100% recommended dose of fertilizer along with either 5 t/ha vermicompost (or) 5 t/ha of goat manure as pond silt and for maize crop 75% recommended dose of fertilizer along with 5 t/ha vermicompost can be recommended for better yield and economics.

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