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Research Paper

Impact of agro-input use in integrated rice (*Oryza sativa* L.) farming system

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ABSTRACT

A field experiment was carried out at farmer's holdings of Sathamangalam village, Cuddalore District, Tamil Nadu during *Samba* season 2018 and 2019 with 'BPT (5204)' rice (*Oryza sativa* L.), to optimize the agro input use in integrated rice farming system and to study the impact of component technologies on integral enterprizes of fish and poultry and vice-versa. The treatments comprised 4 different combinations of agro-input use, viz. inorganic fertiliser + chemical pest control, inorganic fertilizer + organic pest control, organic manuring + chemical pest control and organic manuring + organic pest control, under 2 different systems, viz. sole cropping of rice and integrated rice + fish + poultry farming system. The results indicated that, integrating fish culture and poultry rearing offered a sustainable option in rice farming interms of enhanced returns, manurial addition, diversified farm produces and reduced pest incidence. The results also indicate the use of organic manures and organic pest control for sustainability. However inorganic inputs for rice crop were also shown to be compatible in this integrated farming system (IFS) without much deleterious effects.

Key words: Agro-input use, Fish culture, Integrated farming system, Poultry rearing, Rice

The population in almost all the tropical nations is increasing by leaps and bounds, warranting more food production from the limited cultivated lands. About 80% of India's population live in rural areas at subsistence or near-subsistence level. Though small and marginal farmers constitute 86.2% of the total farming community, they own only 47.3 per cent of the total cultivated area (Agricultural Census, 2015). Small and marginal farmers depend only on agriculture and that too subjected to a high degree of risk and uncertainty providing only seasonal, irregular and uncertain income and employment (Dev, 2017).

There is little scope for increasing the farm size because of steady explosion of population with shrinkage of cultivated land due to intense industrialization and urbanization. Accordingly, horizontal expansion of land for production of food, feed and fibre is impossible leaving vertical expansion alone possible. This could be achieved by integrating appropriate farming components ensuring periodic income to the farmers. The integrated farming system therefore assumes greater importance, for sound management of farm resources to enhance the farm productivity, to minimize environmental degradation, to add quality to resources of poor famers and beyond all to maintain sustainability.

Diversification of agricultural activities which links farm-based enterprizes with rice cultivation would help the farmers to get more income and generate an additional employment (Kathiresan, 2010). Fish culture could pay a share strongly towards solving these problems and the integration of fish and poultry as in Annamalai rice + fish + poultry farming is possible in lowland rice, as rice is grown with standing water throughout the crop duration, that enhances livelihoods and nutritional standards in smallholder farms (Kathiresan *et al.,* 2020).

Combining fish culture with poultry in rice is reported to be highly beneficial. The voiding of poultry could be recycled as fish feed and this could increase the biological productivity of water and fish culture is also safe even under inorganic plant-protection measures. Foliar spray of monocrotophos (Nuvacron 40 EC) applied @ 1.25 kg/ha effectively controlled the pest in rice-fish farming system without any apparent toxic effect on fish (Deka *et al*., 1994). Herbicides were also shown to be safe without causing fish mortality, when sprayed 10 days before releasing fish fingerlings (Kathiresan *et al*., 2001; Kathiresan, 2009). Fishes also contributed to biological pest and weed control and reduced pest incidence in the absences of chemical pest control (Kathiresan, 2007).

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Poultry manure which is one of the efficient organic manures in combination with fertilizers could increase the production in an integrated farming system. But intensive use of inorganic inputs is often quoted as the major constraint. So a comparison of integrated farming system with exclusive organic inputs, exclusive inorganic inputs and in combinations is proposed with the objectives of studying the computability and impact on integrated rice + fish + poultry farming system in comparison with sole cropping of rice and to optimize the use of agro inputs for rice in integrated farming system.

MATERIALS AND METHODS

Annamalai rice + fish + poultry (Kathiresan *et al*., 2020) was studied on Farmer's holdings at Sathamangalam village, Cuddalore District, Tamil Nadu during (*Samba*) season of 2018 and 2019 with rice ' BPT (5204)'. The soil was clayey loam with a *p*H of 8.0.

The treatments comprised of 4 different combinations of agro-input use, viz. inorganic fertilizer + chemical pest control, inorganic fertilizer + organic pest control, organic manuring + chemical pest control and organic manuring + organic pest control, tried under 2 different situations, viz. sole cropping of rice and Annamalai integrated rice + fish + poultry farming system (Kathiresan *et al.,* 2020). These were compared as 8 different treatments under randomized block design with 3 replications, in plots of size 200 m^2. In treatments under integrated farming system trenches on one side of the plot with a dimension of 20 m × 10 m × 1 m were excavated and fingerlings of catla, rohu, mrigal, silver carp, common carp and grass carp were released @ 100/trench in composite culture 10 days after transplanting of rice crop. Poultry cages of dimension 1.8 m × 1.2 m × 0.9 m made up of wood with the basement and sides comprising iron wire mesh of size 2.5 mm were installed at a height of 1.5 m using 4 concrete poles buried deep in the field to support the cage. The poultry broiler breed Vencob was released in the cage @ 20 birds/cage and were sold for meat at the age of 45 days. Three such rearings were carried out. In the treatments involving inorganic fertilizer, the nutrient requirements were fulfilled through urea, superphosphate and muriate of potash with recommended dose (150 : 50 : 50 kgs N, P_2O_5 and K_2O/ha) of application, viz. 100% N, P_2O_5 and K_2O basal in treatments under integrated farming systems, and for remaining treatments under sole cropping N was applied in 2 equal splits on 20 days after transplanting (DAT) and 40 DAT. Chemical pest control in respective treatments was done through a blanket application of monocrotophos @ 1.0 kg/ha on day 20 sprayed over the crop canopy excluding fish trenches.

In the treatments involving organic manuring, nutrient requirements were satisfied with farmyard manure (FYM) (12.5 t/ha), *Azolla* (1 t/ha) and *Azospirillum* (2 kg/ha). The FYM and *Azospirillum* were applied basal and *Azolla* was inoculated 1 week after transplanting. Organic pest control was done through application of nimbicidin @ 1.25 *l*/ha, applied on day 20 in respective treatments. The observations were recorded on rice growth and yield characters, pest incidence, fish-mortality rate, manurial output and meat output from poultry. Economics of production for the farming systems were also computed and recorded. The cost of permanent installations like poultry cage were divided for 5 years as the cages continue to serve for 5 years and 1 year cost is added for working out the cost cultivation. The experimental data were statistically analyzed following analysis of variance and least significant difference was worked out at 5% probability level.

RESULTS AND DISCUSSION

Among the treatments, integrated rice + fish + poultry supplemented with inorganic fertilizer and chemical pest control showed significantly higher crop-growth attributes of plant height tillers /clump leaf-area indices and crop dry-matter production during 2018 and 2019, (Table 1). This treatment also recorded the significantly highest yield attributes of highest panicle number/clump filled grains/panicle and grain yield during 2018 and 2019 (Table 2).

In both the years, integrating fish and poultry along with rice increased the growth and yield performance of rice compared to the sole cropping of rice. This is evident from the fact that all the 4 different agro-input combinations tried under integrated farming system registered higher values of plant height, leaf-area index, crop dry-matter, panicle number, filled grains/panicle and grain yield when compared with that of respective treatments under sole cropping of rice.

As regards the Rice-equivalent yield (Table 2), the treatment comprising rice+fish+poultry reinforced with organic manuring and organic pest control for rice recorded the highest of 64.89 t/ha and 64.78 t/ha during 2018 and 2019, respectively. However, all the integrated rice+fish+poultry farming treatments were comparable considering the rice-equivalent yield. This is because of the fish meat and poultry meat output in the integrated farming systems, that fetched higher returns in these treatments.

This could be attributed to a tangible expression of multifarious benefits, resulting from integrating fish and poultry in rice, viz. nutrient supplement, complementary pest control and enhanced fertility and productivity status of system. Fishes feed on weeds and pest, whereas the addition of poultry manure in a slow and sustained manner increased the biological productivity of the system in total. This lead to a substantial increase in the grain and straw yield of rice. Even after losing ten per cent of the area to

accommodate fish trenches, rice in these integrated farming treatments yielded higher than that under sole cropping of rice. These observations support the reports of Pandiarajan (1995) and Pushpa and Netaji (1999).

Impact of integrated farming system on pest incidence

Among the treatments, both organic and inorganic pest-control measures were equally effective under integrated farming system of rice + fish + poultry. In rice crop, both brown plant hopper ((*Nilaparvata lugens* Stal.) and leaf folder (*Cnaphalocrosis medinalis* Guen.) (Fig. 1) were effectively controlled under treatment comprising rice + fish poultry with organic manuring + chemical pest control wherein the incidence was the least. This was comparable with organic pest control against both the pests in 2018 and during 2019, although the attack of insects was not too high; same trend of results were obtained.

The results on pest incidence as influenced by the treatments, reveal that integrating fish and poultry as component enterprizes along with rice, reduced the incidence of insect pests, viz. leaf folder and brown plant hopper (Fig. 1). Feeding habits of carnivorous and omnivorous fish fingerlings like catla, rogu and grass carp on the egg-masses and larvae and young growth stages of these pests, reduced soil *p*H and *p*H of water and higher degree of tolerance of the crop as imparted by better biochemical constitution

Table 1. Effect of integrating other farm enterprizes, viz. fish and poultry on plant height, tillers/clump, leaf-area index (LAI) and crop dry-matter production

Treatment	Plant height on 60 DAT (cm)		Tillers/clump		Leaf-area index on 60 DAT		DMP t/ha	
	2018	2019	2018	2019	2018	2019	2018	2019
Rice (inorganic fertilizers + chemical pest control)	70.8	73.9	10.6	10.5	5.77	5.72	10.97	10.78
Rice (inorganic fertilizers + organic pest control)	69.2	72.7	11.5	11.2	5.63	5.61	10.69	10.35
Rice (organic manuring + chemical pest control)	65.1	70.6	12.5	11.0	5.25	5.48	9.61	9.74
Rice (organic manuring + organic pest control)	63.5	70.5	12.4	11.9	5.17	5.43	9.37	9.67
Rice (inorganic fertilizers + chemical pest control) + fish + poultry	82.4	80.9	15.7	15.1	7.15	7.06	14.20	13.33
Rice (inorganic fertilizers + organic pest control) + fish + poultry	81.2	79.3	14.3	14.3	6.96	6.95	13.04	12.96
Rice (organic manuring + chemical pest control) + fish + poultry	77.0	78.6	14.2	14.6	6.55	6.87	12.54	12.38
Rice (organic manuring + organic pest control) + fish + poultry	75.8	77.7	14.8	14.5	6.27	6.76	12.07	12.20
SEm±	2.11	2.17	0.39	0.37	0.17	0.18	0.33	0.33
CD (p=0.05)	6.48	6.66	1.19	1.15	0.54	0.55	1.03	1.02

DMP, Dry-matter production; DAT, days after transplanting

Table 2. Effect of integrating other farm enterprizes, viz. fish and poultry on yield attributes, yield of rice and rice-equivalent yield

Treatment	Panicles/ clump		Filled grains/ panicle		Grain yield (t/ha)		Rice-equivalent yield(t/ha)	
	2018	2019	2018	2019	2018	2019	2018	2019
Rice (inorganic fertilizers + chemical pest control)	9.5	9.6	70.8	67.3	5.4	5.5	–	–
Rice (inorganic fertilizers + organic pest control)	10.4	10.6	68.0	65.1	5.2	5.3	–	–
Rice (organic manuring + chemical pest control)	10.0	10.5	60.2	60.7	4.7	5.3	–	–
Rice (organic manuring + organic pest control)	9.8	10.4	58.3	59.5	4.5	5.1	–	–
Rice (inorganic fertilizers + chemical pest control) + fish + poultry	12.5	12.4	94.9	88.1	6.7	6.6	64.8	64.2
Rice (inorganic fertilizers + organic pest control) + fish + poultry	11.3	11.4	91.1	84.2	6.7	6.4	64.8	64.7
Rice (organic manuring + chemical pest control) + fish + poultry	11.1	11.3	83.5	83.6	6.0	6.2	64.4	64.6
Rice (organic manuring + organic pest control) + fish + poultry	11.9	12.2	79.3	81.7	6.2	6.1	64.9	64.8
SEm±	0.19	0.20	2.23	2.15	0.16	0.16	–	–
CD (p=0.05)	0.58	0.60	6.83	6.60	0.50	0.51	–	–

DMP, Dry-matter production; DAT, days after transplanting

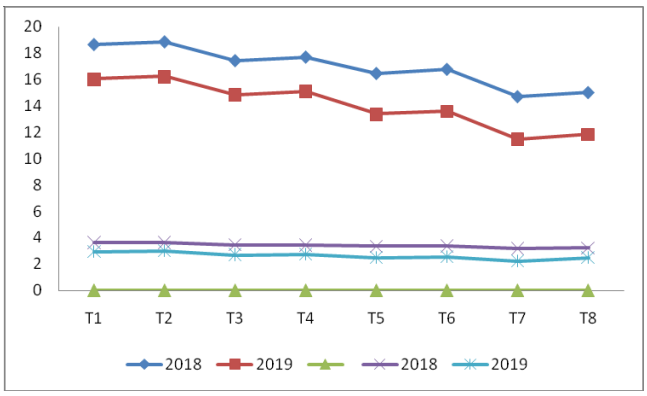

Fig. 1. Impact of integrated farming system on pest incidence (% leaf damage and BPH-*Nilaparvata lugens* Stoal)

[T_1, Rice (inorganic fertilisers + chemical pest control); T_2, rice (inorganic fertilizers + organic pest control); T_3, rice (organic manuring + chemical pest control); T_4, rice (organic manuring + organic pest control); T_5, rice + fish + poultry (T_1); T_6, rice + fish + poultry (T_2); T_7, rice + fish + poultry (T_3); T_8, rice + fish + poultry (T4)]

owing to organic nutrient supplement might have contributed for the lesser pest incidence in these treatments. Our results support the reports on reduced pest incidence with integrated farming systems by Kathiresan (2007).

Economics of rice farming as influenced by integrated farming system approach

All the economic indices, *viz*. gross income were higher in treatments under IFS compared to that under sole cropping of rice in both the seasons (Table 5). This is owing to enhanced rice yields, additional returns from boiler meat and fish yield. Though there is a considerable increase in the cost of production, it could not be construed as a serious impediment as it involves cost incurred with permanent installations that may continuously contribute returns for several seasons in future. Further substantial increase in the net income will commensurate with the higher cost of production. The benefit: cost ratio was also higher with differing treatments under IFS (2.34 and 2.35 for 2018 and 2019, respectively) as compared to that under sole rice cropping. Our results confirm the findings of Rangasamy (1996) and Patro *et al*. (1999) for increased economic returns from integrated farming systems.

Among the treatments comprising pattern of agroinput use fish mortality was highest with 37 and 41 percent in 2018 and 2019, respectively, with inorganic fertilizers and chemical pest control. This was higher than all other treatments, because of the application of fertilizers in the rice field that contributed a greater share besides a lesser magnitude of impact due to drift of the pesticides sprayed over the cropped field to the fish trenches. Accordingly, the fish-meat yield also was the least of 848 kg/ha and 722 kg/ha during 2018 and 2019 (Table 4), respectively. The fish mortality was the least, being 20% and 24% with organic

Table 3. Manurial output from poultry bird/day (g)

Age of birds (days)	Average quantity of dropping voided by a bird/day (g)								Mean	
	Rice (inorganic fertilizers + chemical pest control) + fish + poultry		Rice (inorganic fertilizers + organic pest control) + fish + poultry		Rice (organic manuring + chemical pest control) + fish + poultry		Rice (organic manuring + organic pest control) + fish + poultry		2018	2019
	2018	2019	2018	2019	2018	2019	2018	2019		
15	38.5	39.7	39.7	39.9	39.2	39.7	38.3	39.9	39.0	39.8
30	72.0	73.0	72.3	72.8	72.2	73.1	72.3	73.1	72.0	73.0
45	77.8	78.9	78.0	79.2	78.8	79.1	79.0	79.2	78.4	79.1

DMP, Dry-matter production; DAT, days after transplanting

Table 4. Fish mortality (%) at harvest, fish meat output (kg/ha) and poultry meat output (kg/ha)

Treatment	Fish mortality (%) at harvest		Fish meat output (Kg/ha)		Poultry meat output (Kg/ha)	
	2018	2019	2018	2019	2018	2019
Rice (inorganic fertilizers + chemical pest control)	–	–	–	–	–	–
Rice (inorganic fertilizers + organic pest control)	–	–	–	–	–	–
Rice (organic manuring + chemical pest control)	–	–	–	–	–	–
Rice (organic manuring + organic pest control)	–	–	–	–	–	–
Rice (inorganic fertilizers + chemical pest control) + fish + poultry	37.0	41.0	848	722	6,376	6,379
Rice (inorganic fertilizers + organic pest control) + fish + poultry	33.0	34.0	865	902	6,378	6,380
Rice (organic manuring + chemical pest control) + fish + poultry	27.0	30.0	940	952	6,374	6,375
Rice (organic manuring + organic pest control) + fish + poultry	20.0	24.0	1,025	1,018	6,378	6,379

DMP, Dry-matter production; DAT, days after transplanting

Table 5. Economics of integrated rice farming system

Treatments	Cost of cultivation (×10³₹/ha)		Gross income (×10³₹/ha)		Net income (×10³₹/ha)		Return per rupee invested (₹/ps)	
	2018	2019	2018	2019	2018	2019	2018	2019
Rice (inorganic fertilizers + chemical pest control)	56.8	58.5	77.0	70.8	20.1	12.3	1.35	1.21
Rice (inorganic fertilizers + organic pest control)	56.3	58.2	74.2	76.0	17.8	17.7	1.32	1.30
Rice (organic manuring + chemical pest control)	56.8	57.7	73.2	75.4	16.3	17.6	1.29	1.31
Rice (organic manuring + organic pest control)	55.8	567.4	70.6	73.0	14.7	16.2	1.26	1.29
Rice (inorganic fertilizers + chemical pest control) + fish + poultry	417.8	442.8	963.3	963.7	545.5	520.8	2.31	2.18
Rice (inorganic fertilizers + organic pest control) + fish + poultry	425.4	420.4	972.7	970.3	547.3	549.9	2.29	2.31
Rice (organic manuring + chemical pest control) + fish + poultry	431.9	426.9	966.2	969.5	534.3	542.5	2.24	2.27
Rice (organic manuring + organic pest control) + fish + poultry	416.9	413.5	974.0	971.6	557.1	558.1	2.34	2.35

DMP, Dry-matter production; DAT, days after transplanting

manuring + organic pest-control during 2018 and 2019, respectively, that could be attributed to natural mortality under field conditions. Thus organic manuring and organic pest control recorded the highest fish meat output of ₹1,025 kg/ha and ₹1,018 kg/ha during 2018 and 2019, respectively. However, the poultry meat output did not show much of a difference, as the birds remained above the crop canopy without any interaction with the agroinputs used for the crop. These factors contributed for the highest net return of ₹557,190 and ₹558,170 and the highest return/rupee invested of 2.34 and 2.35 during 2018 and 2019, respectively, in treatment with rice + fish + poultry where in organic manuring and organic pest control were taken up for rice.

Based on the results of the present study, it could be concluded that integrated rice + fish + poultry farming system using organic manures along with organic pest-control in rice may be recommended as a sustainable and profitable approach in rice farming. Because the same maintains crop productivity, improves soil-fertility status, offers the benefits of increased economic returns and reduced fertilizer and pesticide use. However, inorganic inputs were also shown to be compatible in the integrated farming system (IFS) without much of deleterious effects.

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