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Analysis of diversified rice based cropping systems under organic management

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Abstract
Monocropping of rice has led to the heavy withdrawal of nutrients from the soil. The imbalanced and indiscriminate use of chemical fertilizers has reduced the yield and deteriorated the soil health. Diversification of the existing monocropping system especially under the organic condition is an alternative to sustain the yield besides ensuring the ecosystem balance and farm income. Therefore, present investigation was carried out during May 2015 to May 2017 at Department of Agronomy, College of Horticulture, Thrissur to enhance the farmer's income by diversifying the existing rice monocropping under organic management. The experiment was laid out in randomized block design and replicated thrice. Rice was grown under four different cropping systems with and without foliar spray of liquid organic manures (LOMs) along with traditional cropping system (rice-rice-fallow) keeping as control. The rotations followed were rice-rice-njavara rice, rice-rice-salad cucumber, rice-rice-vegetable cowpea, rice-rice-amaranthus and rice-rice-fallow. The management practices were followed as per the Package of Practices Recommendations: (*Ad hoc*) for organic farming: Crops of the Kerala Agricultural University. *Jeevamrutham, Panchagavya,* green leaf extract and *fish amino acid* were the liquid organic manures sprayed at 15 days intervals after planting/ transplanting. Rice-rice-salad cucumber with and without LOMs enhanced the system productivity by registering highest rice equivalent yield, system productivity, sustainability yield index, gross return and net return while rice-rice-vegetable cowpea with and without LOMs showed highest B:C ratio.

Keywords: Cropping systems, liquid organic manures, rice equivalent yield, system productivity, sustainability yield index and B:C ratio

Introduction
The low land cropping system of India is mainly dominated by the cropping sequences like rice-rice-rice and rice-rice- fallow. Monocropping has decreased crop productivity as well as soil fertility over a period of time. The intensive agriculture with imbalanced and indiscriminate use of fertilizers and pesticides has also resulted in deterioration of soil health (John *et al*. 2001). Diversification of rice based cropping system under organic management will help to enhance soil fertility, increase the crop yield, minimize the spread of diseases, control the weed growth, reduce the pests and diseases infestation, increase the resource use efficiency and reduce the risk of crop failure besides improving food and financial security. In addition to this, use of liquid organic manures is becoming popular among the farmers due to their beneficial effects on soil and crop. Fermented liquid organic formulations prepared from on-farm wastes such as *Panchagavya, Beejamrutham* and *Jeevamrutham* are rich in beneficial microflora and can be used as efficient plant growth promoters (Devakumar *et al*. 2014). They are mainly applied as foliar spray and through irrigation water which is meant to enhance soil health by improving biological activity, crop productivity and sustainability of the system. Hence, the present investigation was carried out to study the effect of diversification of the existing rice based cropping system on crop productivity under organic management.

Materials and Methods
The experiment was carried out during May 2015 to May 2017 at Department of Agronomy, College of Horticulture, Thrissur, Kerala. The soil of the experimental site was slightly acidic in nature (pH 5.83), low in available N (141.15 kg ha^{-1}), medium in phosphorus (37.47 kg ha^{-1}) and high in potassium (287.46 kg ha^{-1}). The experiment was conducted in randomized block design. The treatments were T_1: Rice-rice-njavara rice (*Ad hoc* POP), T_2: rice-rice-njavara rice (*Ad hoc* POP + foliar spray of LOMs), T_3: rice-rice-salad cucumber (*Ad hoc* POP), T_4: rice-rice-salad cucumber (*Ad hoc* POP + foliar spray of LOMs), T_5: rice-rice-vegetable cowpea (*Ad hoc* POP), T_6: rice-rice-vegetable cowpea (*Ad hoc* POP + foliar spray of LOMs), T_7: rice-rice-amaranthus (*Ad hoc* POP), T_8: rice-rice-amaranthus (*Ad hoc* POP + foliar spray of LOMs) and T_9: rice-rice-fallow (*Ad hoc* POP). *virippu* (kharif) and *mundakan* (rabi) seasons were

practiced with rice while *puncha* (summer) was diversified with medicinal rice, salad cucumber, vegetable cowpea and amaranthus. All the crops were grown as per the *Ad hoc* POP of Kerala Agricultural University for organic farming: Crops (KAU 2009) and the cultivation practices were followed as per Table 1. Liquid organic manures (LOMs) *viz*., *Jeevamrutham*, *Panchagavya*, Green leaf extract and *Fish amino acid* were sprayed sequentially at fifteen days interval.

The data on yield of each of the crop was recorded and subjected to statistical analysis by applying the technique of analysis of variance using the WASP 2.0 package and the significance among the treatments was estimated at 5 per cent of probability (Gomez and Gomez 1984) [2]. Cost of cultivation of each crop was worked out and income of crop yields calculated on prevailing market prices. The cost-benefit ratio of each cropping pattern was also calculated.

Table 1: Cultivation practices of all the crops

Particulars	**Crop- I**	**Crop- II**	**Crop-III**			
Crop	**Rice**	**Rice**	**Medicinal rice**	**Salad cucumber**	**Vegetable cowpea**	**Amaranthus**
Land preparation	Nursery was prepared to raise the seedlings (raised beds of 5-10 cm height, 1-1.5 m width and 2 m length)			Pits with a size 60 cm diameter and 30 cm depth were prepared	Ridges were made 45 cm apart	Shallow trenches of 30 cm width were prepared at 30 cm apart
Variety	Jyothi	Kanchana	Njavara	Pusa Uday	Anaswara	Arun
Seed rate (kg ha^{-1})	80		60	0.50 – 0.75	25	1.50
Seed treatment	*Pseudomonas fluorescens* @ 10 g kg^{-1}			1% *Pseudomonas fluorescens* and PGPR 1	1% PGPR 1	*Pseudomonas fluorescens* @ 10 g kg^{-1}
Spacing (cm)	20 X 15	15 X 10	15 X 10	200 X 150	45 X 30	30 X 20
Sowing	21 days old seedlings were transplanted in the main field		18 days old seedlings were transplanted in the main field	@ 4 seeds per pit	@ 3 seeds per pit at a depth of 5 cm	Seedlings were transplanted in trenches at a distance of 20 cm apart in two rows
Manuring	Vermi compost @ 2.5 t ha^{-1} and neem cake @ 400 kg ha^{-1} as basal application, Groundnut cake @ 400 kg ha^{-1} at active tillering stage			FYM @ 12 t ha^{-1} and vermi compost @ 4 t ha^{-1} as basal application, Cow dung slurry @ 50 kg ha^{-1} at 15 days interval (1 kg 10 L^{-1})	FYM @ 20 t ha^{-1}, vermi compost @ 2 t ha^{-1} and rock phosphate @ 110 kg ha^{-1} as basal application	Compost @ 25 t ha^{-1} as basal application, Top dressing of cow dung slurry @ 50 kg ha^{-1} at 7-10 days interval, Foliar spray of cow urine (1%) after each harvest
Weeding	20 and 40 DAS		15 and 30 DAT	15 and 30 DAS	20 and 40 DAS	
Irrigation	1.50 cm of water level was maintained during transplanting and gradually increased up to 5 cm until maximum tillering stage. Water was drained out 14 days before harvest			Daily during early period and later once in 3-4 days interval	Twice in a week until pod formation stage and later once in a week	Daily
Plant protection measurements	Trichocards (*Trichogramma japonicum* and *Trichogramma chilonis*) @ 5 cc ha^{-1}, Neem soap @ 10 g L^{-1}			Neem soap @ 10 g L^{-1}, *Beauveria bassiana* 10 g L^{-1}		

DAS- Days after sowing, DAT- Days after transplanting

Table 2: Rice equivalent yield, system productivity, sustainability yield index and economics of rice based cropping systems

Treatments	**Rice equivalent yield (t/ ha)**		**System productivity (kg/ ha/ day)**		**SYI**	**Cost of cultivation (≠/ha)**		**Gross return (≠/ha)**		**Net return (≠/ha)**		**B:C Ratio**	
	2016	**2017**	**2016**	**2017**		**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
T_1: Rice-Rice-Njavara rice (*Ad hoc* POP)	6.05	5.22	16.59	14.29	0.00**	2,26,685	2,29,830	4,94,085	4,70,289	2,67,400	2,40,459	2.18	2.05
T_2: Rice-Rice-Njavara rice (*Ad hoc* POP + *foliar spray of LOMs)	6.99	6.14	19.15	16.83	0.02	2,38,540	2,42,070	5,89,942	5,52,350	3,51,402	3,10,280	2.47	2.28
T_3: Rice-Rice-Salad cucumber (*Ad hoc* POP)	26.35	22.98	72.20	62.95	0.20	3,80,498	3,85,515	10,02,793	9,12,052	6,22,295	5,26,537	2.64	2.37
T_4: Rice-Rice-Salad cucumber (*Ad hoc* POP + foliar spray of LOMs)	31.57	27.58	86.50	75.55	0.26	3,92,353	3,97,755	11,55,769	10,84,591	7,63,416	6,86,836	2.95	2.73
T_5: Rice-Rice-Vegetable cowpea (*Ad hoc* POP)	12.99	11.38	35.58	31.19	0.07	2,47,190	2,51,470	6,68,171	7,07,804	4,20,981	4,56,334	2.70	2.81
T_6: Rice-Rice-Vegetable cowpea (*Ad hoc* POP + foliar spray of LOMs)	14.90	12.96	40.83	35.52	0.10	2,59,045	2,63,710	7,46,355	8,14,935	4,87,310	5,51,225	2.88	3.09
T_7: Rice-Rice-Amaranthus (*Ad hoc* POP)	5.85	5.09	16.04	3.96	0.00	2,12,405	2,15,635	4,93,050	4,71,842	2,80,645	2,56,207	2.32	2.19
T_8: Rice-Rice-Amaranthus (*Ad hoc* POP + foliar spray of LOMs)	6.75	5.83	18.49	15.97	0.03	2,24,260	2,27,875	5,80,850	5,67,016	3,56,590	3,39,141	2.59	2.49
T_9: Rice-Rice-Fallow (*Ad hoc* POP)	0.42	0.44	1.15	1.21	0.00	1,53,985	1,55,015	3,17,428	3,36,650	1,63,443	1,81,635	2.06	2.17
SEd±	0.22	0.60	0.61	1.64	-								
CD at 5%	0.66	1.79	1.82	4.91	-								

DAP- Days after planting, **Jeevamrutham* (15 DAP), *Panchagavya* (30 DAP), Green leaf extract (45 DAP) and Fish amino acid (60 DAP), **Negative indices are considered as zero, Market price of njavara paddy- ≠80/kg, Market price of paddy straw- ≠5/kg, Market price of salad cucumber- ≠30/kg, Market price of vegetable cowpea- ≠50/kg in 2016 and ≠60/kg in 2017, Market price of amaranthus- ≠15/kg

Results and Discussion

Crop diversification increased the intensity of operations, availability of nutrients on the same piece of land and crop productivity. In another hand, foliar application of LOMs improved the growth and yield attributes of all the crops and thus increased the yield to a certain extent. Among the various diversified cropping systems, rice-rice-salad cucumber with/ without LOMs produced significantly higher rice equivalent yield than rest of the sequences (31.57 and 27.58 t ha^{-1} in 2016 and 2017 respectively) followed by the same system without LOMs (26.35 and 22.98 t ha^{-1} in 2016 and 2017 respectively). High yielding ability, better market price of salad cucumber (particularly during summer) and higher grain yield of preceding rice crops were responsible for attaining maximum rice equivalent yield. The higher yield of rice due to the application of LOMs in previous seasons further enhanced the REY of the system. Prasad (2011) [5] and Vipitha (2016) [9] also observed the similar findings in diversified conditions of rice based cropping systems. Rice-rice-salad cucumber with/ without LOMs also registered highest system productivity and sustainability yield index during both the years followed by rice-rice-vegetable cowpea with/ without LOMs (Table 2). Here, the higher production efficiency of salad cucumber in terms of rice equivalent yield increased the system productivity followed by vegetable cowpea. It was found to be less in the second year where the rice equivalent yield was affected by water scarcity. The higher sustainability yield index (0.26 and 0.20 in rice-rice-salad cucumber with/ without LOMs respectively) was due to increase in productivity of component crops which was close to estimated yield. Similarly, diversification resulted highest index (Singh *et al*. 2013) [8]. The index was found to be the lowest (0) in traditional system where keeping land fallow in summer reduced the estimated yield. Similar findings were also observed by Samant (2015) [6] in rice-fallow system.

In general, sequences at 300% cropping intensity produced significantly higher net return and among them, rice-rice-salad cucumber with LOMs was found to be higher (≠7,63,416 in 2015-16 and ≠6,86,836 in 2016-17) compared to rice-rice-fallow (≠1,63,443 in 2015-16 and ≠1,81,635 in 2016-17) at 200% cropping intensity. This was only due to increased production potential of the sequences besides increased cropping intensity. Among the sequences, rice-rice-salad cucumber with LOMs gave more B:C ratio in the first year (2.95) while it was found to be the highest in rice-rice-vegetable cowpea with LOMs in the succeeding year (3.09). This was mainly due to higher net return from salad cucumber in 2015-16 and premium price for vegetable cowpea in 2016-17. The findings were in line with Ali *et al*. (2012) and Singh and Kumar (2014) [7]. Hence, it was concluded that crop diversification, especially under organic management, ensures sustained production beside improves the economic conditions of the farmers.

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