Effect of Crop Diversification and Fish Integration in Productivity Enhancement of Rice

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Abstract

The field experiment was conducted during Virippu season 2016-'17 in the low land rice fields. Seven rice based farming systems viz., T₁: rice succeeding fallow; T₂: rice succeeding amaranthus; T₃: rice succeeding culinary melon; T₄: rice succeeding fodder cowpea; T₅: (rice + fish) succeeding (amaranthus + fish); T₆: (rice + fish) succeeding (culinary melon + fish); T₇: (rice + fish) succeeding (fodder cowpea + fish) were evaluated for assessing the effect of crop diversification and fish integration on the productivity of rice. Diversification of summer rice fallows with different crops resulted in a yield improvement to the tune of 10.22 per cent over the rice succeeding fallow. Whereas, in fish integrated systems, the yield improvement was 15.56 per cent more than the sole crop of rice. The grain yield (6.62 t ha⁻¹) and straw yield (6.84 t ha⁻¹) were significantly higher in rice + fish succeeding fodder cowpea + fish. The productivity of rice grain and straw was less in the rice – rice – fallow system. In general, crop diversification and fish integration resulted in productivity improvement in rice based farming systems.

Introduction

Rice is the single largest food source for the poor and the source of one quarter of global per capita. In India, rice is cultivated in an area of 43 million hectares (GOI, 2016). As far as Kerala is concerned, the major crop rice is an integral part of the wetland ecosystem with specific ecological functions. However, the recent years have witnessed the rapid decline in paddy area. Over the last three decades, area under rice in Kerala declined from 8.5 lakh ha to 1.99 lakh ha (FIB, 2017). According to the long term studies conducted
in Asian countries by Pingali et al., (1990) the intensive modern monoculture of rice has resulted in declined yield trends and the rice production systems have become practically unsustainable. Further, it has reduced the environmental quality also.

Degradation of resources including soil and water, severity in pest and disease incidence are also consequences of monoculture. In this scenario sustainable rice based farming system approach, which ensures increased productivity besides conserving the environmental quality and sustainability is gaining much importance.

Rice-rice-fallow was identified as the major rice based cropping system in the southern districts of Kerala (John et al., 2014). The summer rice fallows are major avenues for the cultivation of other remunerative crops like pulses, vegetables, tuber crops and short duration fodder crops.

Instead of keeping the field fallow during summer, going for a cropping system approach can increase cropping intensity, economic returns as well as create diversity in the field.

Judicious integration of rice enhances the income base of farmer as well as sustains rice production (Padmakumar, 2013). Inclusion of animal components in the cropping systems can further improve the system productivity.

Rice-fish integration is one such production system which provides additional food and income by diversifying farm activities and increasing the yield of both.

In this context, a study was undertaken to assess the impact of crop diversification and fish integration in yield enhancement of Virippu rice in lowland rice fields of southern Kerala.

**Materials and Methods**

A field study was carried out in the lowland rice fields of Integrated Farming System Research Station, Karamana, Thiruvananthapuram during Virippu 2016-17. The soil of the experimental site was clayey in texture, acidic in pH (5.33), high in organic carbon (1.58 per cent), low in available nitrogen (249.20 kg ha\(^{-1}\)), medium in available phosphorus (24.70 kg ha\(^{-1}\)) and potassium status (154.85 kg ha\(^{-1}\)).

The experiment was laid out in randomised block design with seven treatments, replicated thrice. The treatments comprised seven rice based farming systems viz., T\(_1\): rice succeeding fallow; T\(_2\): rice succeeding amaranthus; T\(_3\): rice succeeding culinary melon; T\(_4\): rice succeeding fodder cowpea; T\(_5\): (rice + fish) succeeding (amaranthus + fish); T\(_6\): (rice + fish) succeeding (culinary melon + fish); T\(_7\): (rice + fish) succeeding (fodder cowpea + fish). The variety of rice was Uma (MO 16). The plot size was 6 m x 6 m. In the treatments where fish was integrated with crops (T\(_5\)-T\(_7\)), half of the plot was converted into trenches of size 6m x 3m x 1m. The fish species viz., catla (Catla catla) and rohu (Labio rohita) were reared in the trenches. The crops were raised as per the Kerala Agricultural University Package of Practices Recommendations (KAU, 2016). The fishes were introduced into the trenches after transplanting Virippu crop and were harvested after the summer crop. After summer season, the trenches were desilted and the silt was added and incorporated into the respective plots, before raising Virippu rice. The trench silt was characterized for quantity, physico-chemical and biological properties. The observations on yield attributes and yield were recorded at the time of harvest of the Virippu rice. Observations on the yield attributes (productive tillers m\(^{-2}\), grain weight panicle\(^{-1}\), total number of grains panicle\(^{-1}\), filled grains
panicle\(^{-1}\), sterility percentage) were recorded from ten randomly selected hills from the net plot area. Grain yield and straw yield (on dry weight basis) were recorded after harvesting the net plot area and drying the produce to constant weights.

The data generated were statistically analysed using analysis of variance (ANOVA) for Randomized Block Design (Cochran and Cox, 1965). Wherever significant differences among treatments were observed, CD values at 5 per cent level of significance were calculated for comparison of means.

**Results and Discussion**

The data on the yield attributes and yield of *Virippu* rice are presented in Table 2. The number of productive tillers per m\(^2\) did not vary significantly among the treatments. Though non-significant, the productive tiller count was relatively higher in treatments with fish integration. Significantly higher grain weight panicle\(^{-1}\) (4.08) was obtained in the system rice + fish succeeding fodder cowpea + fish (T\(_7\)) and was on a par with rice + fish succeeding amaranthus + fish (T\(_5\)) and culinary melon + fish (T\(_6\)) combinations. Sole crop of rice succeeding fallow recorded significantly lower number of filled grains panicle\(^{-1}\) and it remained at par with rice succeeding amaranthus (T\(_2\)), rice succeeding culinary melon (T\(_3\)), and rice succeeding fodder cowpea (T\(_4\)). Rice succeeding fallow recorded the lower number of grains and filled grains per panicle.

Significantly lower sterility percentage (5.69 per cent) was recorded in T\(_5\) (rice + fish succeeding amaranthus + fish) and it was observed to be on a par with T\(_6\). The highest percentage of chaffy grains (13.18 per cent) was observed in T\(_2\) (rice succeeding amaranthus) which was at par with T\(_4\), T\(_1\) and T\(_3\).

### Table 1 Physico-chemical properties of trench silt

| Sl. No. | Parameters                          | Value   |
|--------|-------------------------------------|---------|
| 1      | Texture                             | Clayey  |
| 2      | Bulk density (Mg m\(^{-3}\))        | 0.78    |
| 3      | Water holding capacity (%)          | 47.38   |
| 4      | pH                                  | 5.41    |
| 5      | Electrical conductivity(dS m\(^{-1}\)) | 0.51   |
| 6      | Organic carbon (%)                  | 2.12    |
| 7      | Available nitrogen (mg kg\(^{-1}\)) | 709.33 |
| 8      | Available phosphorus (mg kg\(^{-1}\)) | 7.53   |
| 9      | Available potassium (mg kg\(^{-1}\)) | 204.28 |
Table 2: Yield attributes and yield of rice

| Treatments                                      | Productive tillers m⁻² | Grain weight panicle⁻¹ (g) | Total number of grains panicle⁻¹ | Filled grains panicle⁻¹ | Sterility percentage | Grain yield (t ha⁻¹) | Straw yield (t ha⁻¹) | Grain: straw ratio |
|------------------------------------------------|------------------------|-----------------------------|----------------------------------|-------------------------|----------------------|----------------------|----------------------|---------------------|
| T₁: Rice succeeding fallow                      | 426.62                 | 3.61                        | 126.35                           | 112.02                  | 12.77                | 4.89                 | 5.19                 | 0.94                |
| T₂: Rice succeeding amaranthus                  | 442.17                 | 3.33                        | 135.00                           | 117.73                  | 13.18                | 5.37                 | 5.86                 | 0.92                |
| T₃: Rice succeeding culinary melon              | 452.17                 | 3.22                        | 129.56                           | 114.07                  | 11.93                | 5.31                 | 5.76                 | 0.93                |
| T₄: Rice succeeding fodder cowpea               | 468.84                 | 3.40                        | 136.48                           | 123.37                  | 13.03                | 5.50                 | 5.95                 | 0.92                |
| T₅: Rice + fish succeeding amaranthus + fish    | 482.17                 | 4.02                        | 153.30                           | 137.84                  | 5.69                 | 5.87                 | 6.14                 | 0.96                |
| T₆: Rice + fish succeeding culinary melon + fish| 486.61                 | 3.91                        | 148.35                           | 137.67                  | 7.21                 | 5.77                 | 5.99                 | 0.96                |
| T₇: Rice + fish succeeding fodder cowpea + fish | 557.72                 | 4.08                        | 159.80                           | 144.35                  | 7.86                 | 6.62                 | 6.84                 | 0.97                |
| CD (0.05)                                       | -                      | 0.532                       | 18.985                           | 17.338                  | 1.628                | 0.960                | 0.770                | -                   |
Sterility percentage was found to decrease in treatments integrated with fish. The treatments with fish integration had higher biomass production which might have contributed to better grain filling as suggested by Peng et al., (1999). Fish integration meant incorporation of trench silt also. The trench silt was rich in N and K (Table 1). The higher nitrogen content of trench silt might have improved photosynthesis and consequently increased the amount of photosynthates available for grain filling in the crop (Moridani and Amiri, 2014). While N is important in the production of assimilates, K is the key nutrient that determines the source-sink relationship that favors better grain filling (Hayashi et al., 2013).

The grain yield was significantly higher (6.62 t ha\(^{-1}\)) in the rice + fish succeeding fodder cow pea + fish. Straw yield was significantly higher and remained at par with the systems of rice + fish succeeding fodder cow pea + fish (6.84 t ha\(^{-1}\)) and rice + fish succeeding amaranthus + fish (6.14 t ha\(^{-1}\)). Similar increase in yield with fish integration has been recorded by Mohanty et al., (2010). The grain : straw ratio was found non-significant among treatments.

Yield is a function of yield attributes. Significantly higher grain weight per panicle, total number of grains and filled grains per panicle might have contributed to increased grain yield of Virippu rice in the system rice + fish succeeding fodder cow pea + fish. The increased yield attributes and yield realised with fish integration could also be due to the addition and incorporation of the nutrient rich trench silt (Table 2). Further, being an experiment in vogue for the past four years, trench silt addition might have also improved the soil physical conditions. Mohanty (2003) observed a similar increase in yield attributes and yield of rice with fish integration and attributed this to the improvement in soil fertility and consumption of planktons, weeds, insects and bacteria by fish. The positive effect of fish sediments in improving soil structure and soil fertility by enhancing soil aeration, water and nutrient holding capacities, root penetration by crops and thereby increasing crop growth and yield have also been reported by Ihejirika et al., (2012).

The specific yield increase recorded by rice + fish succeeding fodder cow pea + fish may be due to the legume effect. Legumes can be considered as small nitrogen factories in the field. Legumes also help to solubilize insoluble soil P, improve the soil physical conditions and increase the soil microbial activity (Ghosh et al., 2007). The residual effect of fodder cow pea raised during summer might have contributed to improving the yield attributes of the succeeding Virippu rice. Prabhakaran and Janardhana (1997) reported that the grain yield of Kharif rice increased from 4.7 t ha\(^{-1}\) to 5.4 t ha\(^{-1}\) in rice – groundnut – cowpea system while a decline in grain yield was observed from (4.5 t ha\(^{-1}\) to 4.1 t ha\(^{-1}\)) in rice – rice sequential cropping system.

The present study revealed that, crop diversification increased the productivity of Virippu rice. In general, diversification of summer rice fallows with component crops resulted in an yield increase of 10.22 per cent over the rice succeeding fallow. Rice succeeding amaranthus, culinary melon and fodder cow pea recorded 9.82 per cent, 8.59 per cent and 12.47 per cent increase in productivity respectively as compared to rice succeeding fallow. Integrating fish in rice based farming systems enhanced the yield of Virippu rice by 15.56 per cent.

**Acknowledgement**

The authors are grateful to the Kerala Agricultural University, Integrated Farming System Research Station of KAU and the Indian Institute of Farm Systems Research (ICAR) for the research grant and facilities provided for undertaking the study.

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How to cite this article:

Reshma, M.R., P. Shalini Pillai, Jacob John and Manorama Thampatti, K.C. 2019. Effect of Crop Diversification and Fish Integration in Productivity Enhancement of Rice. *Int.J.Curr.Microbiol.App.Sci.* 8(11): 382-387. doi: [https://doi.org/10.20546/ijcmas.2019.811.048](https://doi.org/10.20546/ijcmas.2019.811.048)