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# Diversification of rice based cropping systems for higher production and productivity in rainfed lowlands of Andaman Islands

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## Abstract

Crop diversification is as an important tool for accelerating agricultural growth in smallholder farms for enhanced production, income and employment generation besides judicious use of natural resources and ecological management. However, in Andaman Islands the productivity of lowland system is very low due to the cultivation of photosensitive, long duration rice with lack of crop diversification. Hence, a field experiment was conducted with four rice based cropping systems viz., rice-maize, rice-green gram, rice-ground nut and rice-vegetable (okra) in completely randomized design with three replications to evaluate its performance under island condition. Use of photo insensitive rice varieties and advancement of transplanting date helped to accommodate dry season crop into the crop rotation. The results showed that rice - ground nut recorded highest production efficiency of 65.6 kg $ha^{-1}day^{-1}$ followed by rice-maize and rice-okra sequences. Among all the treatments rice- maize and rice-ground nut recorded highest net returns and B:C ratio while rice-groundnut recorded highest production efficiency.

**Key words**: Rice monocrop, Lowland, Cropping System, Production, Cost: benefit

## Introduction

Balancing productivity, profitability, with ecological health is a key challenge for agricultural sustainability besides feeding the ever increasing population. As in many of the developing countries and in Southeast Asia, small holder farms constitute the bulk of agricultural production in India. As the smallholder farmers rely on seasonal yields for food and economic returns, achieving yield stability is paramount importance. The crop diversification is considered as an important tool for acceleration of agricultural growth in smallholder farms for enhanced production, income and employment generation besides judicious use of natural resources and ecological management.

Crop diversification involves growing more than one crop of the same or different species in a given area either in the form of crop rotations and or intercropping. The combination of various crops in smallholder farms allows more efficient utilization of agro ecological processes and improves household income, food and nutritional security (Mango *et al.*2018), provides resilience (Lin 2011) to small holder farms. The crop diversification also enhances farm level biodiversity (Swarnam *et al.*2016). It also increases cropping intensity and yield per unit area (Lal *et al.*2017) which is very much essential for maintaining stability in rainfed areas. The Islands have wet tropical climate with a total rainfall of 3100mm spread over 7 months from May to November. The mean annual temperature is 30.1° C, with a minimum of 18.6° C and a maximum of 33.0°C. The relative humidity varies from 63 to 90%. Agriculture in the Islands depends on rains which mostly occur during monsoon months (June-September). Due to heavy concentrated rainfall in a short span, flat topography, low infiltration rate and lack of proper drainage, most of the cultivated fields are deeply waterlogged limiting the cultivation of high yielding varieties (HYV) of rice, instead mono cropping of tall *indica* rice varieties are cultivated in wet season. During dry season, acute shortage of irrigation water along with increase in soil and water salinity in coastal lowlands/ plains due to presence of brackish water table at a shallow depth compelled the farmers to keep their land fallow resulting in lower productivity. Hence, this study was proposed to study different rice based cropping systems in increasing production and productivity of the rainfed lowlands of the island.

## Materials and methods

### Site description

Experiments were conducted during the wet and dry seasons of 2013 to 2014 at Field Crops Research Farm of Central Island Agricultural Research Institute, Port Blair. The two major cropping seasons of the Island includes a wet season from June to November and dry season from December to April. The soil at the experimental site was an Entisol with sandy clay loam texture with bulk density (1.42 Mg $m^3$). The soils are slightly acidic (pH 6.0), non saline (0.028 dS $m^{-1}$), and contained 8.2 g $kg^{-1}$ of organic carbon, 310 kg $ha^{-1}$ of available N, 13.3 kg $ha^{-1}$ P and 176 kg $ha^{-1}$ ammonium acetate K.

### Experimental set up

Four rice based cropping systems viz., rice-maize, rice-green gram, rice-ground nut and rice-vegetable (okra) were carried out in completely randomized design with three replications in plots of 250 $m^2$ area. All the dry season crops of rice-based cropping sequences were chosen on the basis of their importance in ensuring food and nutritional security of samllholder farms in far isolated areas and economic returns as vegetable cultivation is gaining importance in these areas after harvest of rice. The urea, ammonium phosphate and muriate of potash were applied to all the crops in different crop sequences based on the recommended doses of fertilizer for specific crops and all other management practices were followed to raise the crops in different cropping sequences (Gangwar and Bandyopadyay 1996).

### Economic analysis

Economic yields of component crops were converted into rice-equivalent yield (REY), taking into account the prevailing market prices of different crops in the cropping sequences. The above values were computed as per the following formula given by Verma nad Modgal (1983).

Rice-equivalent yield (REY) of a component crop (a) = (Yield of component crop x Market price of a component crop/ Price of rice)

Total REY = Yield f rice in the particular system + a

Production-efficiency values in terms of kg $ha^{-1}$ $day^{-1}$ were worked out for the total production by means of rice equivalent yield in a cropping system divided by total duration of that particular system. The values of production efficiency in terms of INR $ha^{-1}$ $day^{-1}$ were calculated by net monetary returns of the system divided by total duration of the crops in that system (Tomar and Tiwari, 1990).

### Statistical analysis

Various treatments were compared under a randomized block design based on pooled average of yield for both the years. The critical difference (CD) was computed to determine statistically significant treatment differences.

## Results and discussion

### System productivity

The rice transplanting was advanced to June/ July months instead of August so as to clear the land for cultivation of dry season crops. Normally, the traditional long duration varieties are grown during August and harvested after second week of January. Because of lack of moisture and irrigation facilities, land could not be utilized for raising dry season crops. In our experiment new rice varieties like CSR 36 and CARI 5 are transplanted in second half of June or early July and harvest by end of October/ November months so that the land will be free for taking up second crop and sowing of these crops were completed by end of December or first week of January so that the crops won't affected by terminal drought in March.

**Table 1 Yield and production efficiency of rice-based cropping systems**

| Cropping System | Crop Yield (q ha$^{-1}$) Wet season | | Crop Yield (q ha$^{-1}$) Dry season* | | System Yield (q ha$^{-1}$) | | | Mean system duration (days) | Production Efficiency (kg/ha/day) |
|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 | Mean | | |
| R-M | 44 | 46 | 118 | 34 | 161 | 81 | 121$^{a}$ | 205 | 58.1$^{b}$ |
| R- GG | 43 | 43 | 16 | 12 | 59 | 55 | 57$^{b}$ | 173 | 32.8$^{c}$ |
| R-GN | 39 | 45 | 62 | 90 | 121 | 135 | 128$^{a}$ | 195 | 65.6$^{a}$ |
| R-Ok | 47 | 38 | 80 | 72 | 127 | 110 | 118$^{a}$ | 218 | 54.3$^{b}$ |
| CD (p=0.05) | NS | NS | - | - | - | - | 32 | - | 3.82 |

* in terms of REY, R-M rice-maize(cobs), R-GG rice-green gram, R-GN rice-ground nut(table purpose) and R-Ok rice-okra

The perusal of production data indicated that the rice grain yield during wet season in both the years (2013 and 2014) hadn't shown any significant difference with values ranged from 38 to 47 q ha$^{-1}$. However, significant differences were found in yield of dry season crops with highest REY in maize (118 q ha$^{-1}$) followed by okra (80 q ha$^{-1}$) during 2013. However, in 2014 the ground nut outperformed the relative yield of maize and okra in 2014. The maize yield in 2014 was drastically reduced due to heavy rainfall at the time of maturity leading to wilting of plants because of water stagnation. The lowest yield was observed in pulses (12 -16 q ha$^{-1}$) in both the years because of their inherent low productivity.

The analysis of mean system yield indicates that the rice-ground nut, rice-maize and rice-okra performed on par (118 to 128 q ha$^{-1}$) with rice- green gram recording the lowest mean system yield. This was reflected in production efficiency of the respective sequences as well where, the rice - ground nut recording highest production efficiency of 65.6 kg ha$^{-1}$day$^{-1}$followed by rice-maize (58.1 kg ha$^{-1}$day$^{-1}$) and rice-okra sequences (54.3 kg ha$^{-1}$day$^{-1}$). So it can be concluded that the inclusion of maize for green cobs, table purpose ground nut and okra after harvesting of rice in lowland areas will increase the productivity and total production.

## Economic analysis

The cost analysis for different rice based sequences was summarized in Table 2. Among all the treatments rice- maize and rice-ground nut recorded highest net returns INR 93939/- and INR93201/- respectively and it was followed by rice-okra (INR 82683/-). The lowest net return was observed in rice-green gram sequence. This was reflected in production efficiency and B: C ratio as well. The production efficiency in terms of net return was highest in rice-ground nut (table purpose) with INR 478 ha$^{-1}$ day$^{-1}$ which was closely followed by rice-maize sequence. Similar to system production, productivity and net returns, the production efficiency and B: C ratio of the rice-green gram sequence was found to be lowest among all the sequences.

**Table2. Economic analysis of rice based cropping systems (Mean of 2 years)**

| Cropping systems | Cost/return (Rs ha$^{-1}$) Gross Return | Cost/return (Rs ha$^{-1}$) Total cost | Cost/return (Rs ha$^{-1}$) Net return | Production efficiency (INR ha$^{-1}$ day$^{-1}$) | B:C ratio |
|---|---|---|---|---|---|
| Rice - Maize | 166352 | 72413 | 93939 | 458.2 | 2.30 |
| Rice - Green gram | 78160 | 65876 | 12284 | 71.0 | 1.19 |
| Rice - Ground nut | 176774 | 83573 | 93201 | 478.0 | 2.12 |
| Rice - Okra | 163278 | 80595 | 82683 | 379.3 | 2.03 |

## Conclusion

The production and productivity of small holder farms in rainfed lowlands of Andaman Islands can be increased by suitably adjusting the transplanting of wet season rice and growing photo insensitive high yielding rice varieties such as CSR36, CARI5 instead of long duration traditional photosensitive varieties like C-14-8. By advancing the transplanting date and completing the harvesting of rice in November will facilitate the sowing of second or dry season crops like maize, ground nut, vegetables and pulse utilizing residual moisture and with supplementary irrigation. Among various rice based cropping sequences, rice-maize, rice-ground nut performed better followed by rice-okra. While rice-green gram performed poorly but it can be used when there is a moisture stress condition.

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