Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 14 Issue 6 Version 1.0 Year 2014
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Evaluation of Rice (*Oryza Sativa* L) Based Cropping Systems in Major Soil Series of Upper Brahmaputra Valley Asom

By Dharam Singh, B.P. Bhaskar, U. Baruah & Dipak Sarkar

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Keywords: rice, winter crops, soil series, brahmaputra valley.

GJSFR-D Classification : FOR Code: 820402, 070199

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Dharam Singh [α], B.P. Bhaskar [σ], U. Baruah [ρ] & Dipak Sarkar [ω]

Abstract- On farm field experiments were conducted during 2005 to 2008 to evaluate production and land use efficiency of rice (*Oryza sativa* L.) based cropping systems in four major soil series of upper Brahmaputra valley of Asom. The rice cultivar *Basundhara and Satyaranjan* were followed by three winter crops viz., potato (*Solanum tuberosum*), peas *(Pisum sativum)* and mustard (*Brassica nigra*) on four major soil series viz., Lahangaon *(Aeric Fluvaquents), Bhogdai (Fluvaquventic Endoaquepts), Matikhola (Typic Endoaquepts) and Teok (Typic Fluvaquents)* of Jorhat district in split-split plot design under farmers practice (FP) and recommended package of practices (RPP). The pooled data on rice equivalent yield (REY) of rice–potato *Lahangaon* series (156.6 q ha-1) under RPP was found economically significant followed by *Bhogdai* (138.4 q ha-1) and *Matikhola* (111.07 q ha-1) but rice –pea (100.9 q ha-1) in *Teok* series. The high production efficiency is recorded for rice –pea system with mean of 54.95 kg ha-1day-1 and highest of 66.7 kg ha-1day-1 in *Lahangaon* series and an increase of land use efficiency from 35 to 70 percent. The agronomic performance of rice based systems under RPP was well over FP at all the soil series, but best results were recorded at *Lahangaon* series.

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I. Introduction

A cropping system signifies the sequence of crops grown over a specific piece of cultivated land and to increase the benefits from the available physical resources. Therefore, the basic approach in an efficient cropping system is to increase production and economic returns (Yadav *et al*. 1998). *A* flexible cropping system helps in capturing economic opportunities and environmental realities (Gangwar *et al*. 2004) and in ensuring balanced farm growth at regional level (Reddy and Suresh 2009). Hence, selection of component crops needs to be suitably planned for efficient utilization of resource base and to increase overall productivity (Anderson 2005). Inclusion of crops like oilseeds, pulses, vegetables and fodder crops will improve the economic condition of small and marginal farmers owing to higher price and/or higher volume of their main and by-products (Sharma *et al* . 2007). Economics of the rice-based cropping systems showed that the highest profit (Rs 85,012/-) was found in case of rice – lentil followed by rice – wheat - mungbean which gave Rs 82,671/- per hectare. The lowest profit (Rs 38,065/-) was obtained in case of rice-wheat-sesbania cropping pattern (Ali *et al*. 2012). Among other cereals, wheat and maize was gaining some popularity among the farmers in Assam. Oilseed was next to rice in coverage, and then the fibers and pulses. Pulses, oilseeds and jute jointly accounted for 16% of area (Bhowmick *et al*. 2005). The agro-economic studies in the region lack the link of soil informatics and their relevance in exploring the suitability for expansion of area under pulses and oil seeds. The reconnaissance soil information was used to work out possible crop combinations suitable for this region (Vadivelu et al. 2005 and Bhaskar *et. al*.2010). Rice (Kharif) potato (Rabi) sequence recorded highest gross return of Rs.17 ,644 ha^{-1} and it was found to be superior to all other sequences whereas lowest gross return of Rs.6261 ha-l was reported for jute (S) - niger (R) - cowpea (R) sequence (Maibangsa *et al*. 2000). Based on field observations and interactions with local farmers, economically viable rice based systems with potato, peas and mustard were carried out and worked out the productivity potential, resource use efficiency and land use efficiency under four major soil series of upper Brahmaputra valley.

II. Materials and Methods

On farm field experiments were undertaken on four major soil series in Jorhat district of Assam viz. i. *Lahangaon* Series (26° 37'21" N and 94° 20'43" E, Coarse loamy, Aeric Fluvaquents), ii. *Bhogdai* Series (26°40'45" N and 94° 12'34"E, Fine loamy, Fluvaquentic Endoaquepts), iii. *Matikhola* Series (26° 49'06" N and 94° 22'56" E, Fine loamy, Typic Endoaquepts) and iv. *Teok* series (26° 49'00" N and 94° 14'00" E, Coarse silty Typic Fluvaquents).The climate is humid to sub-humid and average rainfall 2076 mm. Experimental area is the part of Brahmaputra river basin with elevation of 80 to

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120 m above mean sea level. Brief description of soil series is given below:-

Moderately well drained *Lahangaon* series on very gently sloping alluvial plains have stratic textural contrast with water table below 3.5 m and have yellowish brown mottles below 0.75 m to 1m.This soil has coarse loamy particle size and moderately acid with 98% base saturation and deficiency of phosphorus and moderate amounts of nitrogen and potassium (Table 1). Moderately well drained *Bhogdai* series have fine loamy texture (clay content >33.84%) and base saturation less than 55%.This soil is poorly drained during rainy season but improves during winter as ground water recedes below 3 m. Poorly drained, fine loamy *Matikhola* series is frequently flooded during rainy season with strong acid but coarse silty Teok series have shallow water table (< 1 m) and deficient in potassium and phosphorus.

The field experiments in Spilt-Split Plot Design with 5 replications (Cochran and Cox 1957) were conducted during November 2005 to December 2007. Tow rice cultivar, Basundhara and Satyaranjan under two management levels i.e., farmers practices (FP) and Recommended Package of Practices (RPP). The cropping sequences consisting of (i) Rice-fallow under FP, while (ii) Rice-Potato (iii) Rice-Pea and (iv) Rice Mustard under RPP. Plot size is 50 m^2 each. These crops were raised under rainfed conditions. Potato, pea and mustard were sown in 2^{nd} week of December. Rice seedling was prepared in nursery with 60 kg seeds for transplanting of one hectare area as per standard recommendation of DOA and AAU. Seed rate was 25 q ha^{-1} for potato and 40 kg ha^{-1} for pea and 15 kg ha^{-1} for mustard respectively.

Recommended doses of NPK (kg ha^{-1}) were 60:100:100 for potato, 20:40:0 for pea and 60:40:6 for mustard. Fertilizers were supplied through urea, single super phosphate (SSP) and muriate of potash (MOP) respectively. Half the quantity of recommended N and entire amount of P_2O_5 and K_2O was applied as basal dose. Remaining half dose of N has been applied in two split doses i.e., at 45 days and 60 days after sowing as top dressing. Similar practices were also followed for rice with the application of 40:20:20 N, P_2O_5 and K_2O kg ha^{-1}. Soil physical and chemical properties of the experimental fields were determined for samples taken during planting in the Soil and Plant Analysis Laboratory of Regional Centre, Jorhat.

The land use efficiency was worked out by dividing total duration of crops in individual crop sequence by 365 days (Chuang 1973). Production efficiency values were obtained by dividing total production in sequence by total duration of a cropping sequence (Tomar and Tiwari 1990).The rice equivalent yield, was calculated as :- REY $=\Sigma(\text{yi.ei})$

Where REY = Rice equivalent yield (Q/ha/yr), ei = the rice equivalent factor and calculated as PC/PR, where PC is the price of a unit weight of rabi crop and PR is the price of a unit weight of rice and y i= economic yield of 1 to n number of crops (Angeneyulu *et al*.1982).

Minimum support price or prevailing market rate of product (rice @ Rs.650 q^{-1}, potato @ Rs.300 q^{-1}, mustard @ Rs 2400 q-^{1}, green pea pods @ Rs.900 $^{q-1}$, rice straw, potato haulm, mustard Stover and pea fodder @ Rs.20 q^{-1}) were taken.

III. Result and Discussion

a) Kharif rice yield

The rice gave maximum yield of 60.6 q ha^{-1} in *Lahangaon* series under RPP as compared to *Bhogdai* series (54.2 q ha^{-1}), *Matikhola* (53.37) and *Teok* (54.6 q ha^{-1}).The yields are almost double under RPP over FP with similar yield trends with respect to soil types. These findings are in agreement with results of Gogoi *et at*. 2010. The slight variations in rice yields over soil types under farmers practice vary from 28.45 q ha^{-1} in *Lahangaon* series to 26.25 q ha^{-1} in *Teok* series (Table 2).

b) Rabi crop yield

The mean tuber yield of *rabi* potato *rabi)* is 141.9 q ha^{-1} where as 55.47 q ha^{-1} for *kharif* rice 46.4 q ha^{-1} for *rabi* pea and 5.77 q ha^{-1} for *rabi* mustard. The yield of potato, pea and mustard under farmers practice is 53.41, 21.20, and 2.75 q ha^{-1}, respectively but highest relative yield of 165.68 percent over control is recorded in case of potato but of 118.86 per cent for pea and 109.8 percent for mustard. It was reported that the agronomic performance of rice-potato system is good with incorporation green manure @10t ha^{-1} or legume crop in Nepal (Khatri *et al*. 2004). The mustard yields are high in coarse loamy *Lahangaon* series which is in agreement with the findings of Shekhawat *et al*. (2012) who reported that mustard is moderately tolerant to soil acidity, preferring a pH from 5.5 to 6.8, thrives in areas with hot days and cool night and requires well-drained sandy loam soil with water requirement of 240–400 mm. The variations in yield of *rab*i crops may be due to genetic make as well as environmental factors in which crop species grown (Sahu 1972). The upland moderately well drained *Lahangaon* and *Bhogdai* series are adjudged as suitable for potato and peas crops during *rabi* as drainage improves along with porosity and structure. The mustard is grown extensively in the region as irrigation potential is meager and requires low water.

c) Rice based cropping sequences

i. *REY of rabi crops*

The pooled data indicate that under farmers practice , peas recorded REY of 35.3 in *Lahangaon* soil and 19.9 in *teok* soil but under RPP, REY in same soil types for peas varied from 80.3 to 46.3 (Table 2). Potato gave highest REY in *Lahangaon* soil under RPP (96) but decreased to 84.2 in *Bhogdai*, 57.7 in *Matikola* and 24.1 in *Teok* series with a mean of 65.50 which is slightly higher than peas (64.3) q ha-1. This is probably due to higher production potential of potato and peas coupled with the high price in the sequence that increased the rice-equivalent yield values (Banik and Bagchi 1996 and Banik *et al*. 1999).

ii. *REY of cropping systems*

REY of pooled data shows distinct variations with respect to soil types with overall productivity mean of 86.32 and an increase in yield over Farmers practice of 290.96 per cent. The order of increasing in REY for cropping systems under RPP is as follows. *Lohangaon, Bhogdai, Matikhola and Teok* (Table 2) and highest for rice – potato (mean of 121.19) q ha-1. The per cent increase over farmers practice is highest for rice -potato (346.87%) which is more than 342 per cent for peas and 184.92 for mustard systems. The REY data shows that *Lohangaon* series is suitable for rabi potato, peas and mustard as compared to Matikhola and Teok series. These findings are in agreement with observations of Vadivelu et al. (2005) with coarse silts over sand, slightly to moderately alkaline, low amount of exchangeable potassium, available phosphorus and zinc.

d) System productivity

Highest productivity 156.6 was recorded under rice -potato cropping system at Lahangoan series with RPP followed by rice-pea 140.9 and rice- mustard 95.6 q ha^{-1} as compared to FP. Similar trends were also observed in Bhogdai and Matikhola series but at Teok rice- pea (100.9) performed better then rice-potato (78.7) and rice - mustard 57.92 q ha^{-1}. Overall productivity mean under RPP was 106.06 q ha^{-1} and an increase in system productivity yield 291.41 percent over to FP.

e) Production efficiency

The low production efficiency under farmers practice is varied from 22.23 in *Lohangaon* series to 20.66 kg ha^{-1} day^{-1} in *Teok* series for rice fallows with an overall mean of 20.23 kg ha-1 day-1. The high production efficiency is recorded for rice – pea system with mean of 54.95 and highest of 66.7 kg ha-1 day-1 in *Lahangaon* series (Table 2). The production efficiency of rice - potato under RPP is high in *Bhogdai* series (64 kg ha^{-1} day^{-1}). The production efficiency of rice - mustard system is even though low as compared to rice-pea and rice –potato system but shows an order of decrease from *Lohangaon* (45.1) to 25.9 kg ha^{-1} day^{-1} in Teok series. Higher production efficiency was obtained with integrated use of chemical fertilizers because of prolonged supply of nitrogen as a result of minerailization (Reddy *et al*. 2004)

f) Land Use Efficiency

The land use efficiency for rice fallow is 35 per cent but varied from 32 in *Lahangaon /Bhogdai* series to 37 per cent in *Matikhola/Teok* series. The 70 per cent land use efficiency is recorded for rice-potato, 68 per cent for rice -peas and 65 per cent for rice – mustard under RPP. The improved land use efficiency with the inclusion of potato, peas and mustard in rice fallows is from 35 to 68 per cent. It was reported that land use efficiency increased to 80 per cent under rice –potato-green gram sequence in Varanasi due to intensification and employment generation (Bohra et al. 2007 and Tripathi and Alok Kumar, 2010).

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Table 1 : Soil-site characteristics

Soil-site characteristics	Coarse loamy Aeric Fluvaquents *Lahangaon* series	Fine loamy Fluvaquentic Endoaquepts *Bhogdoi* series	Fine loamy Typic Endoaquepts *Matikhola* series	Coarse silty Typic Fluvaquents *Teok* series
Slope (%)	Very gently (1-3)	Nearly level (0-1)	Nearly level (0-1)	Nearly level (0-1)
Elevation (m)	120	100	90	80
Physiography	Lower piedmont	Gently sloping upland	Very gently sloping plain	Lower flood plain
Sand (%)	54.0	21.03	48.22	42.70
Silt (%)	29.5	45.13	31.28	34.90
Clay (%)	16.5	33.84	20.50	22.40
pH (H_2O 1: 2.5)	5.5	5.2	5.1	5.0
OC (%)	1.06	0.80	1.26	1.26
CEC	6.0	10.7	12.82	5.28
Base saturation (%)	98.0	55.0	98.00	18.00
Drainage	Poor in rainy season and well drain winter	Poor in rainy season and well drain winter	Poor in rainy season and moderately well in winter	Poor in rainy season and moderately well in winter
Water Table (m)	3.5	3.0	(flooding) 1.5	(flooding) 1.00
Soil fertility status kg ha^{-1}				
N	264.50	352.80	352.80	423.36
P_2O_5	3.23	3.27	3.67	3.09
K_2O	145.86	165.43	91.37	90.60

Table 2 : Crops yield, rice-equivalent yield, production efficiency, land-use efficiency of different rice base cropping sequences in major soils of Asom (pooled)

cropping system	Coarse- Loamy (Aeric Fluvaquents) *Lahangaon* Series	Fine-Loamy (Fluvaquentic Endoaquepts) *Bhogdai* Series	Fine-Loamy (Typic Endoaquepts) *Matikhola* Series	Coarse-Silty (Typic Fluvaquents) *Teok* series	Mean	Increase in yield over control (%)
Crop Yield (q ha^{-1})						
Rice –fallow	28.45	27.20	26.40	26.25	27.12	-
Rice (RPP) *Kharif*	60.60	54.20	53.37	54.60	55.47	104.54
Increase in yield (%)	113.01	99.27	102.16	108.0	104.54	-
Rabi						
Potato (control)	58.07	62.10	48.00	45.45	53.41	-
Potato (RPP)	208.00	182.50	125.00	52.10	141.90	165.68
Mustard (control)	25.50	24.30	20.70	14.30	21.20	-
Pea (RPP)	58.00	55.30	38.70	33.40	46.40	118.86
Pea (control)	4.10	4.10	2.50	0.30	2.75	-
Mustard (RPP)	9.48	8.10	4.60	0.90	5.77	109.80
Rice equivalent yield of *rabi* crops (q ha^{-1})						
Potato (control)	26.80	28.70	22.20	21.00	24.65	-
Potato (RPP)	96.00	84.20	57.70	24.10	65.50	165.72
Pea (control)	35.30	33.70	28.70	19.90	29.35	-
Pea (RPP)	80.30	76.60	53.60	46.30	64.20	118.71
Mustard (control)	15.20	15.00	9.20	1.11	10.16	-
Mustard (RPP)	35.00	29.90	17.00	3.32	21.31	109.74
Rice equivalent yield of cropping systems (q ha^{-1})						
Rice-Fallow (FP)	28.45	27.20	26.40	26.25	27.12	-
Rice –Potato (RPP)	156.60	138.40	111.07	78.70	121.19	346.86
Rice- Pea (RPP)	140.90	130.80	107.00	100.90	120.00	342.47
Rice–Mustard (RPP)	95.60	84.10	70.37	57.92	77.00	184.91
CD (p=0.05)	22.17	9.97	13.58	6.61	*106.00	*291.41
Production efficiency kg ha^{-1} day^{-1}						
Rice –fallow	22.23	20.25	21.49	20.66	20.23	-
Rice –Potato (RPP)	65.10	64.00	44.40	33.10	51.65	255.31
Rice- Pea (RPP)	66.70	59.10	48.00	46.00	54.95	271.63
Rice–Mustard (RPP)	45.10	39.00	33.40	25.90	35.85	177.21
Land use efficiency (%)						
Rice –fallow	32.30	32.30	37.80	37.80	35.05	-
Rice –Potato (RPP)	70.00	70.00	70.70	70.70	70.35	200.71
Rice- Pea (RPP)	68.50	68.50	69.30	69.30	68.90	196.58
Rice–Mustard (RPP)	64.40	64.40	65.20	65.20	64.80	184.88

**Mean of RPP*

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