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Productivity, Nutrient use and Profitability through Intensification and Diversification of Traditional Rice – Wheat Cropping System in Purnea District of Bihar

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ABSTRACT: *A field experiment, with five rice based cropping systems, was conducted at the farmer's field during 2011-12 and 2012-13 to study the effect of crop diversification on productive potential, apparent nutrient use, production efficiency and economics of rice based cropping systems. Rice, as a base crop in kharif, was sequenced with other feasible winter crops viz wheat, maize, potato and mustard during rabi and moong in summer season. Rice-potato-moong (148.0 q/ha rice equivalent yield), response (73.1%) over rice-wheat system recorded significantly higher yield than rice-winter maize system (120.2 q/ha rice equivalent yield) and traditional rice-wheat system (85.5 q/ha rice equivalent yield) as well as other systems tested. Highest apparent nutrient use productivityvalue was found in rice-winter maize (32.93 kg gain /kg NPK) at par with rice-mustard (29.41 kg gain /kg NPK) and rice-potato-moong (27.40 kg gain /kg NPK) and minimum in case of rice-wheat (23.75 kg gain/kg NPK) system. The rice-potato-moong sequence gave significantly higher production efficiency (41.07kg ha^{-1}day^{-1}), net return of Rs.79374 ha^{-1} year^{-1}, monetary advantage (274 Rs ha^{-1}day^{-1}) and nutrient uptake (231.8, 70.04 and 231.9 of N,P and K respectively) over rice-mustard and traditional rice-wheat system. The maximum B:C ratio was obtained with rice-winter maize followed by rice-wheat-moong and minimum in traditional rice-wheat. Among three crop sequence, rice-potato-moong had significantly more system productivitythan rice-wheat-moong system. Among two crop sequence, rice- winter maize had significantly more system productivity than other system*

Key words*: Rice based cropping, crop diversification, productive potential, production efficiency apparent nutrient use, economics and uptake*

INTRODUCTION

Rice-wheat cropping system covers an estimated area of 10.5 million ha in India contributing about 23% to the national food grain production (Yadav *etal.*, 1998; Chhokar *et al.*, 2002). Continuous adoption of rice –wheat system in most parts of northern India has resulted in a decline in factor productivity. Besides adoption of proper input management technology, diversification of the system through crops of diverse nature may be a good proposition to break the yield barrier under rice-wheat system. The farmers for concerning higher per hectare yield and income per unit area in a time frame can be overcome by adopting a cropping system which is profitable and economically viable. An attempt was made in the present study to find out the effect of crop diversification on productivity, profitability and soil fertility in rice based cropping system.

MATERIALS AND METHODS

Field experiments on a medium land was carried during rainy, winter and summer season of 2011-12 and 2012-13 at 24 locations of farmer's field of (in six blocks and each block having four villages) Purnea district with rice based cropping system. The land was situated at 25° 51 N, 87° 332 E at an altitude of 25.8 m above mean sea level in inceptisole. The soil of the experimental area was sandy loam with pH 6.7 and organic carbon 4.0 g kg^{-1}. The amount of $KMnO_4$-N, Bray-P_1 and NH_4OAC-K in soil was 245, 35 and 265 kg ha^{-1}, respectively. The experiment was laid out with

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five cropping systems consisting of cereals, pulses, oil seeds, and tuber crops with twenty four replications in Randamised Block Design. The base crop Rice (cv- Rajendrasweta) was transplanted in July and harvested in October, wheat (cv- PBW-343), Winter maize (cv-Shaktiman-4) Potato (cv- Kufarikanchan) and Mustard (cv- Rajendrasuflam) were sown in month of November and harvested as per maturity of crops. Summer moong (cv- Pusa Vishal) was sown in last week of Feburary and harvested in the last week of April. The recommended spacing was adopted for different crop, like rice (15x15 cm), Wheat (20x- cm), Winter maize-(60x20cm), potato (60x20 cm), Mustard (30x10 cm), Moong (30x10 cm). Recommended fertilizers were applied in Rice (80: 40: 20), Wheat (120:60:40 Kg/ha), Winter maize (120:75:50 Kg/ha), Potato (150:90:100 Kg/ha), Mustard (80: 40: 20 Kg/ha) and Moong (15:40:00 Kg/ ha). The crop duration was different for different crop, like rice (140 days), Wheat (130 days), Winter maize-(155 days), Potato (85-90 days), Mustard (120 days) and Moong (65 days) from sowing to harvesting. Need based plant protection measures were adopted. Irrigation was provided at critical physiological stages of the crops. The productivity of different crop sequence was computed by converting the yield of all crops into rice equivalent yield based on prevailing market price. Apparent nutrient use productivity was calculated by productivity of different crop sequence divided by fertilizer nutrient used in system. The productivity efficiency of different crop sequence was computed by converting the rice equivalent yield of system and divided by days of crop grown in field. Relative economic efficiency was calculated by using the following formula

Relative economic efficiency (%)

$$= A-B/\ B \times 100$$

Where

A: net return of diversified system

B: net return of existing rice-wheat system

Monetary efficiency was calculated by net return of system divided by days of crop grown in field. The grain and straw were collected and dried in oven at 65±5 °c ground , digested and N by Kjeldhal method with titration of absorbed ammonia by sulphuric acid, P content by yellow colure developed by Vandomolybedate and reading by spectrophotometer and K concentration were estimated by flame photometer respectively. The percentage of nutrient content multipliedwith biomassof crop yield for calculating of nutrient uptake.

RESULTS AND DISCUSSION

System Productivity

There was no significant difference in yield of rice under different systems. Rice yield ranged from 39.48 to 40.52 q/ha (Table 1). The wheat yield varied from 39.54 to 39.69q/ha under normal sown condition, while winter maize, potato and mustard yield varied from 81.90, 200.30 and 9.41 q/ ha respectively in rabi and moong 8.03 and 9.50 q/ha in summer in different treatments. Rice-wheat sequence gave significantly lower rice equivalent yield (85.5 q/ha) compared to other crop sequences. Rice-potato- moong (148.0q/ ha rice equivalent yield) recorded significantly higher than other rice based systems, which was 73.1% higher than that of rice wheat system, this is in conformation with the finding of (Mubarak, T and Singh, K.N. 2009 and Chatrath R. and Singh, S. K. 2010). Total production was significantly higher where potato (200.3 q/ha) was grown between rice and moong. This was in accordance with the findings of Kharub*et al* (2003). Chaudhary *et al.* (2001) also reported higher productivity by replacement of wheat under rice-wheat system with vegetables like radish and potato. There was no significant difference between rice-wheat - moong and rice – winter maize cropping system in terms of rice equivalent yield of system. Among three crop sequence, rice-potato-moong had significantly more system productivitythan rice-wheat-moong system. Among two crop sequence, rice- winter maize had significantly more system productivity than other system .

Apparent Nutrient use Productivity and Economic Efficiency

Highest apparent nutrient use productivityvalue was found in rice –winter maize (32.93 kg gain /kg NPK applied) at par with rice-mustard (29.41 kg gain /kg NPK applied) and rice –potato-moong (27.40 kg gain /kg NPK applied) and minimum in case of rice-wheat (23.75 kg gain /kg NPK applied) system. The rice-mustard sequence (cereal – oil sequence) gave significantly higher apparent nutrient use productivity (29.41 kg gain /kg NPK applied**)** over traditional rice-wheat (cereal- cereal) system. The rice-potato-moong sequence gave significantly higher production efficiency (41.07kg $ha^{-1}day^{-1}$**),** net return of Rs-79374 ha^{-1} $year^{-1}$ and monetary advantage (274 Rs $ha^{-1}day^{-1}$) over rice-mustard and traditional rice-wheat system. The rice-mustard sequence (cereal – oil sequence) gave significantly lower net return of Rs-31894 ha^{-1} $year^{-1}$ and monetary advantage (123 Rs

Table 1
Crop Productivity (q/ha), System Productivity and Response of Cropping System (Pool of two years)

Treatment	*Yield (q/ha)*					*System Productivity/ Relative Equivalent Yield (q/ha)*	*Response over rice-wheat system*
	Kharif	*Rabi*	*Summer*				
		Physical	*REY*	*Physical*	*REY*		
Rice-Wheat (Traditional)	39.54	35.49	46.0	-	-	85.5	-
Rice-Wheat-Moong	39.69	35.57	46.1	8.03	30.38	116.2	35.9
Rice-winter maize	40.52	81.90	79.7	-	-	120.2	40.6
Rice – Mustard	39.48	9.41	30.5	-	-	105.9	23.9
Rice-Potato-Moong	39.71	200.30	108.3	9.50	35.95	148.0	73.1
C.D.(P=0.05)	NS	15.13	-	-	-	19.1	-

Table 2
Apparent Nutrient use Productivity (q/ha).Production Efficiency, Economics and Nutrient Uptake by Crop System (Pool of Two Years)

Treatment	*Apparent nutrient use productivity (kg gain /kg NPK applied)*	*Production efficiency (kg ha^{-1} day^{-1})*	*Net return (Rs/ha)*	*Benefit: cost Ratio*	*Monetary efficiency (Rs ha^{-1}day^{-})*	*Uptake (kg/ha) by the cropping system*		
						N	*P*	*K*
Rice-Wheat (Traditional)	23.75	30.71	43481	1.87	161	128.7	31.7	140.4
Rice-Wheat-Moong	26.40	34.88	62524	2.01	189	170.0	37.0	158.9
Rice-winter maize	32.93	40.23	71301	2.27	243	192.3	49.2	219.1
Rice – Mustard	29.41	35.92	31894	1.75	123	129.0	27.5	129.6
Rice-Potato-Moong	27.40	41.07	79374	1.99	274	231.8	70.04	231.9
C.D.(P=0.05)	5.23	6.10	3425	-	33.0	33.2	5.7	27.6

Selling price (Rs/q): Rice-Rs 900, Wheat-Rs.1100, Winter maize Rs 850 Potato-Rs 400, Mustard-Rs. 3000, Moong- Rs. 3500

ha^{-1} day^{-1}) traditional rice-wheat system. The maximum economic efficiency was recorded in case of rice- winter maize and rice – mustard - system.The maximum B: C ratio was obtained with rice-winter maize followed by rice-wheat-moong and minimum in traditional rice-wheat. Among three crop sequence, rice-potato-moong had significantly more system productivity, response over rice-wheat system, production efficiency and monetary efficiency than rice-wheat-moong system. Among two crop sequence, rice- winter maize was significantly more system productivity, response over rice-wheat system production efficiency and monetary efficiency than othersystem .

Nutrient Uptake

The rice-potato-moong sequence gave significantly higher nutrient uptake 231.8, 70.04 and 231.9 of N,P and K respectively over rice-mustard and traditional rice-wheat system. The highest N uptake by rice-potato-moong (231.8 kg/ha) followed by rice-winter maize (192.3 kg/ha) and minimum in rice-mustard system. The highest K uptake by rice-potato-moong (231.9 kg/ha) at par with rice-winter maize (219.1kg/ha) and minimumin rice mustard system. The rice-winter maize sequence gave significantly higher nutrient uptake 192.3, 49.2 and 219.1 of N, P and K respectively over rice-wheat-moong and traditional rice-wheat system. Among three crop sequence, rice-potato-moong was significantly more nutrient uptakethan rice-wheat-moong system. Among two crop sequence, rice- winter maize had significantlymore nutrientuptake than othersystem.

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