Int.J.Curr.Microbiol.App.Sci (2020) *9*(10): 1741-1745

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 9 Number 10 (2020)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2020.910.211

Diversification of Existing Rice-Wheat Cropping System for Increasing Productivity and Profitability under Irrigated Upland Conditions of Bihar

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Keywords

High, value, Vegetable, Crops, System, Productivity, Efficiency, Profitability REY

Article Info

Accepted:
15 September 2020
Available Online:
10 October 2020

A B S T R A C T

An experiment was conducted at College of Horticulture, Noorsarai during 2012-2015 to diversify and intensify the rice-wheat cropping system by including vegetables as cash crops for developing need based intensive and profitable cropping system for small farmers of irrigated upland conditions of Bihar. Among the tested diversified crop sequences, Onion-Onion-Bottle gourd recorded significantly higher rice equivalent yield (369 q/ha) and highest production efficiency (101.1kg/ha/day) over all the crop sequences, which was 229% higher over existing rice-wheat cropping (112.2q/ha) system followed by Okra-Cabbage-Bottle gourd and Okra-Potato-Okra with rice equivalent yield (305.3 and 304.7) q/ha respectively. Result indicated that diversification of existing rice-wheat cropping offers better system productivity and profitability. Hence, Onion-Onion-Bottle gourd can be adopted as most profitable cropping system because it can potentially increase farm incomes, especially in a country like India where demand of high-value vegetable crops increasing more rapidly than that of staple food crops. As it is bitter truth that, Indian agriculture is overwhelmingly dominated by smallholders and therefore, they need to diversify their systems towards high value crops.

Introduction

Rice-wheat cropping system (RWCS) is a long-established crop rotation in south Asian countries that occupies about 13.5 million hectares in the Indo-Gangetic Plains (IGP), of which 10 million hectares are in India, 2.2 million hectares in Pakistan, 0.8 million hectares in Bangladesh and 0.5 million hectares in Nepal. Although, the relative importance of rice and wheat varies between countries (Hobbs, and Morris 1996). This cropping system is dominant in most Indian states, such as Punjab, Haryana, Bihar, Uttar Pradesh and Madhya Pradesh, and contributes to 75% of the national food grain production (Mahajan and Gupta, 2009). India's gross domestic product (GDP) shrank by 23.9 per cent in the June quarter of 2020-2021, due to COVID-19 pandemic and the lockdown. With this (-23.9) per cent reduction in GDP, India has officially entered in the recessionary phase this year. The COVID-19 pandemic-induced economic turbulences that, dented

India's economy badly with its worst performance since quarterly measurement began in 1996 and probably the first contraction since 1980.This drastic reduction have been noticed in all the sectors; manufacturing (-39.3%), trade, hotel, transport, communication and & services related to broadcasting (-47%), mining (23.3%) and public administration, defence & other services (-10.3%). But, agriculture is the only sector that not merely remained stagnant (3.0% in April to June, 2019-2020), but grew up to 3.4% in April to June, 2020-2021 (https://epeper.jansatta, 2020). Therefore, to boost up agriculture sector, emphasis should be given by policy maker; by giving subsidy on inputs, offer appropriate price of the product, crop insurance and compensatory caused by natural calamities and researchers; on efficient utilization of available and natural resources and shifting of traditional crops to high value crops by considering weather and its vagaries. The rice-wheat system now a day's, operates at low yield because of inadequate nutrients and inappropriate water management (Timsina and Connor, 2001). The environmental requirements for the growth and development of both rice and wheat crops are contrastingly different. Rice grows best under stagnant water conditions, while wheat requires a well-pulverized soil with a proper balance of soil moisture, air and thermal requirements. Due to erratic and uneven distribution of rain, rice crop suffered every year severely. Intergovernmental Panel on Climate Change (IPCC) estimates for 2050 showed that changing rainfall patterns and increasing temperature, along with flooding, droughts and salinity, will possibly decline rice and wheat production by 8 and 23% against 1990 baseline production values (Cancelliere *et al.*, 2007). In addition to these natural hazards, labour demand is another problem, causing reduction in the per hectare income of the farmers. The challenge to research is to understand the system responses to the required combination of crops so that cropping systems can be devised for more productivity and profitability per unit area. Therefore, inclusion of new crop in the system may be an alternative of increasing crop productivity and profitability. Considering this an experiment was planned to diversify rice-wheat cropping system of irrigated up land conditions with high value vegetable crops for small and marginal farmers to increase the productivity and profitability.

Materials and Methods

This experiment was conducted at Nalanda College of Horticulture, Noorsarai, Nalanda during three consecutive years; 2012-13, 2013-14 and 2014-2015 to diversify and intensify the rice-wheat cropping system by including vegetables as cash crops for developing need based intensive and profitable cropping system for small & marginal farmers of irrigated upland conditions of Bihar. There were eight crop sequences *viz.*, (1)-Rice-Wheat (Existing cropping system), (2)-Maize-Potato-Onion, (3)-Okra-Potato-Okra, (4)-Okra-Cabbage-Bottlegourd, (5)-Okra-Cauliflower-Spongegourd, (6)-Onion-Onion-Bottle gourd, (7)-Okra-Tomato-Cowpea and (8)-Okra-Brinjal-Cowpea have been taken for study. The soil of the experimental plot was clay loam with 7.45 pH and 0.61% organic carbon, 258 kg, 14.45 kg and 138 kg ha^{-1} available N, P and K respectively. The experiment was laid down in Randomized Block Design with three replications. Recommended package of practices for all the crops in system were followed. Crop-wise yield had been recorded in quintal per hectare and converted into rice equivalent yield (REY) quintal per hectare. On the basis of minimum support price (MSP) of rice of every marketing season the crop-wise economics were calculated.

Results and Discussion

The crop-wise yield (mean of three years) of different crops of different seasons (Table 1) recorded. Result showed that among the crops and cropping systems, onion in the *kharif* season in CS_6 and okra and onion in CS_4 and CS_6 in *rabi* season and bottle gourd in CS_4 and CS_6 in z*aid* recorded highest yield as compared to existing rice-wheat and other crops and cropping systems. Yield of these crops and cropping system have been converted in rice equivalent yield (REY) given in (Table 2). Result indicate that among the *kharif* crops, onion from CS_6 recorded significantly highest rice equivalent yield (148.3 q/ha) followed by okras. Similarly, in *rabi* season, onion again from CS_6 recorded significantly highest rice equivalent yield (119.7 q/ha) followed by potato. Likewise, in *zaid* bottle gourd recorded significantly highest rice equivalent yield in CS_4 followed by sponge gourd in CS_5 and bottle gourd again in CS_6.

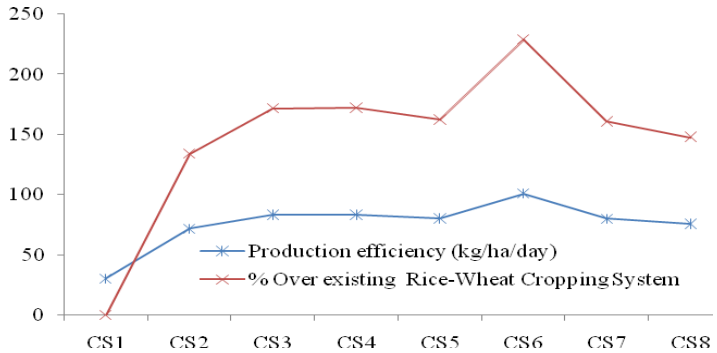
Table. 1 Average yield of different crops (Three year mean data)

Cropping system	Yield (q/ha)		
	Kharif	*Rabi*	*Zaid*
CS_1 Rice-wheat	62.3	51.6	-
CS_2 Maize-Potato-Onion	58.7	222.1	211.0
CS_3 Okra-Potato-Okra	118.5	222.4	121.1
CS_4 Okra-Cabbage-Bottle gourd	115.6	267.0	307.6
CS_5 Okra-Cauliflower-Sponge gourd	115.8	168.7	186.3
CS_6 Onion-Onion-Bottle gourd	165.5	261.5	246.7
CS_7 Okra-Tomato-Cowpea	119.8	252.5	110.4
CS_8 Okra-Brinjal-Cowpea	116.9	224.5	90.1

Table. 2 Rice Equivalent Yield (q/ha) of different cropping system (pooled mean of three years)

Cropping system	Yield (q/ha)			REY of the system	Lac/ha			
	Kharif	*Rabi*	*Zaid*		Gross Return	Total cost	Net return	B:C Ratio
CS_1 Rice-wheat	61.2	50.9	0.0	112.2	1.54	0.686	0.85	1.25
CS_2 Maize-Potato-Onion	57.9	110.7	94.3	262.9	3.69	1.439	2.25	1.56
CS_3 Okra-Potato-Okra	101.4	110.6	92.7	304.7	4.20	1.365	2.83	2.07
CS_4 Okra-Cabbage-Bottle gourd	99.2	83.8	122.2	305.3	3.97	1.056	2.92	2.76
CS_5 Okra-Cauliflower-Sponge gourd	99.3	91.5	103.6	294.4	3.66	1.043	2.62	2.51
CS_6 Onion-Onion-Bottle gourd	148.3	119.7	101.0	369.0	5.05	1.239	3.81	3.07
CS_7 Okra-Tomato-Cowpea	102.4	97.4	93.2	292.9	3.89	0.921	2.97	3.22
CS_8 Okra-Brinjal-Cowpea	99.9	99.9	78.2	278.0	3.55	0.947	2.60	2.74
SE (d)	4.2	3.0	4.0	6.8			0.078	0.08
LSD 5%	8.0	5.6	7.5	12.8			0.147	0.15

Fig.1 Production efficiency (kg/ha/day) and % increase over existing cropping system



The overall rice equivalent of the system was calculated and it was found significantly highest (369.0 q/ha) in Onion-Onion-Bottle gourd (CS_6) followed by Okra-Cabbage-Bottle gourd (CS_4) cropping system. Likewise, rice-potato-onion (Sharma *et al.*, 2015) cropping sequence also found relatively superior in terms of rice equivalent yield (16342 kg/ha/annum) over (5387 kg/ha/annum) in rice-wheat cropping system. Onion-onion-bottle gourd (CS_6) recorded highest production efficiency 101.0 kg/ha/day followed by 83.6 kg/ha/day in Okra-Cabbage-Bottle gourd (CS_4) cropping system (Fig. 1). The diversification in the rice-wheat system helps to sustain the productivity, improve soil fertility, conserve water recourses and increased the profitability of the system (Hobbs, and Morris 1996). Choudhary *et al.*, (2001) reported also the greater productivity by replacing wheat crop in existing rice-wheat cropping system with vegetables like radish and potato. Similarly, onion-onion-bottle gourd (CS_6) recorded highest increase in REY (229%) over existing rice-wheat cropping system followed by 172.2% in Okra-Cabbage-Bottle gourd (CS_4) cropping system. It might be due to the remunerative price of *kharif* onion, which is harvested during the period of onion scarcity in the market that too at high proce. Sethi, *et al.*, (2016) reported 219% increase in system productivity in rice (DSR)-potato-cowpea cropping system over rice-wheat. Tripathi and Singh, (2008) reported in the result of his 6 year experiment that rice vegetable pea- wheat-greengram cropping system produced 27.91 % higher wheat equivalent yield as compared to existing rice-wheat. The economics was calculated based on the MSP of rice of every marketing season indicated that the onion-onion-bottle gourd (CS_6) cropping system recorded highest gross return (Rs. 5.05 lac/ha) and net return (Rs. 3.81 lac/ha). Although, the B: C ratio was recorded highest (3.22) in okra-tomato-cowpea (CS_7) followed by onion-onion-bottle gourd (CS_6) cropping system. High B: C ratio in CS_7 is due to low cost of cultivation particularly of summer crop (cowpea). Cropping intensity which is often close to 200% in traditional rice-wheat systems may increased to 300% or more by diversifying them. Similarly, findings suggested that inclusion of oilseeds, vegetables, ornamental or fodder crops to diversify the existing rice-wheat system helped in achieving higher rice equivalent yield (Kumar *et al.*, 2008; Sharma *et al.*, 2008).

On the basis of findings of this experiment it is concluded that onion-onion-bottle gourd being highest in rice equivalent yield (369 q/ha), highest production efficiency (101.1kg/ha/day) and net return (Rs. 3.81 lac/ha) with 229% higher REY over existing

rice-wheat cropping found most productive and profitable cropping system in irrigated upland condition of Bihar.

Acknowledgement

The authors wish to acknowledge the Directorate of Research, Bihar Agriculture University Sabour, Bhagalpur, Bihar for their financial support to carry out this research work.

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How to cite this article:

Santosh Kumar Chaudhary, Sushil Kumar Yadav, Dilip Kumar Mahto, Sanjay Kumar Singh, Mahesh Kumar and Neha Sinha. 2020. Diversification of Existing Rice-Wheat Cropping System for Increasing Productivity and Profitability under Irrigated Upland Conditions of Bihar. *Int.J.Curr.Microbiol.App.Sci.* 9(10): 1741-1745.
doi: https://doi.org/10.20546/ijcmas.2020.910.211