Indian Journal of Agricultural Sciences **92** (8): 1026–1028, August 2022/Short Communication
https://doi.org/10.56093/ijas.v92i8.119692

Diversification of rice (*Oryza sativa*)-based cropping system of Varanasi for enhanced productivity and employment generation

PRIYANKA SAHA[1]*, JITENDRA SINGH BOHRA[2], HARSITA NAYAK[2], TEJBAL SINGH[2] and ANAMIKA BARMAN[1]

Banaras Hindu University, Varanasi, Uttar Pradesh 221 005, India

Received: 31 December 2021; Accepted: 18 April 2022

Keywords: Cropping sequence, Diversification, Rice equivalent yield, System productivity

Rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) system is the most prevalent cropping system, practiced on an area of approximately 10.5 Mha of Indo-Gangetic Plain (IGP) zone of India over decades (Kakralia *et al*. 2018) due to its stability in production and less manpower requirement. Being the staple food, this system shares about 38% to the national food basket (Kumar *et al.* 2015) and considered as the backbone of Indian food grain production by playing a vital role in food security. Although, the production potential of rice-wheat cropping system is very high, but its continuous adoption has resulted in yield plateau, productivity stagnation, declined factor productivity as well as degradation of soil health, posing serious threats to long term sustainability of the agro-ecosystem (Ladha *et al.* 2007). Further, it is reported that cereal-cereal based cropping sequences are more exhaustive in nature as it puts tremendous pressure on soil resources than cereal-legume and cereal-oilseed based crop sequences (Banjara *et al.* 2022). Thus, to ensure long term stability and sustainability in production and to improve livelihood of small as well as marginal farmhouse hold, the prevailing rice-wheat system is need to be diversified. Since, the prevailing agro-climatic condition and soil topography of the area favours rice cultivation during rainy (*kharif*) season, the only possible option left is to include suitable crop in post-rainy and summer (*rabi*) season as a part of system diversification. Diversification and intensification by inclusion of winter and/ or summer legumes and vegetables in the cropping sequence enhanced the productivity and profitability, improved land use efficiency and generated more employment as compared to the rice-wheat-fallow sequence (Banjara *et al.* 2021). Keeping the above facts in view, the present study was carried out to find out the feasibility of various alternative rice based cropping sequences to the traditional rice-wheat system under integrated farming system.

A field experiment was conducted at Agricultural Research Field, Banaras Hindu University, Varanasi, Uttar Pradesh (25°15′17″ N, 82°59′27″ E and 74.4 m amsl), during 2019–20, with an objective to diversify the existing rice-wheat and rice-mustard crop sequence for optimizing productivity of Varanasi region. The experiment consisted of 10 crop sequences, viz. rice HUR 3022- wheat HUW 234- fallow (S_1), rice HUR 3022- mustard RH 749 -fallow (S_2), *Sesbania* (G.M.)*rice HUR 3022- lentil local variety- black gram Azad 3 (S_3), *Sesbania* (G.M.)*rice HUR 3022- vegetable pea Kashi nandini- black gram Azad 3 (S_4), *Sesbania* (G.M.)* rice HUR 3022- mustard RH 749- black gram Azad 3 (S_5), *Sesbania* (G.M.)* rice HUR 3022- mustard RH 749- green gram HUM 16 (S_6), Sudan fodder MFSH 4- berseem Premier- cowpea fodder Hariyali (S_7), cowpea fodder Hariyali- berseem Premier- maize fodder African tall (S_8), high value rice Rajendra kasturi- potato Kufri khyati- lady's finger Lucky 267 (S_9), high value rice Rajendra kasturi- capsicum F1 hybrid- vegetable cowpea Kashi kanchan (S_{10}). The soil of the experimental field was sandy clay loam in texture having slightly alkaline *p*H of 7.7 and bulk density 1.45 g/cc. As per initial soil analysis, the soil was low in organic carbon (4.3 g/kg) and available nitrogen (196.5 kg/ha); medium in available phosphorus and potassium (13.7 kg/ha and 211.8 kg/ha, respectively). Recommended dose of fertilizer was applied according to the crops. For better comparison, the yield of different crops was converted into rice equivalent yield which can be calculated as:

$$\text{Rice equivalent yield (REY)} = \Sigma\ Yi \times Pi/\ P(p)$$

where Yi, yield of different crops; Pi, price of respective crops and P(p), price of rice (Baishya *et al*. 2016). Land use efficiency, system productivity, system profitability and economic viability were worked out using the standard procedure.

Among the rainy (*kharif)* season crops, Sudan fodder in sequence S_7 recorded the highest REY (4411.8 kg/ha) and

[1]ICAR-Indian Agricultural Research Institute, New Delhi; [2]Banaras Hindu University, Varanasi, Uttar Pradesh. *Corresponding author email: priyankasaha993352@gmail.com

remained at par with high value rice variety Rajendra kasturi in sequence S_9 and S_{10}, proved significantly superior to rest of the crops in different sequences (Table 1). This could be attributed to the higher productivity of sudan fodder. In spite of comparatively low productivity of high value rice variety Rajendra kasturi in sequences S_9 and S_{10}, it recorded markedly higher REY than rice variety HUR 3022 in sequences S_1 to S_6. Higher market price of Rajendra kasturi over HUR 3022' might be the reason for higher REY. Similar result was recorded by Kumar *et al*. (2015) and Bohra *et al.* (2007). However, REY of winter (*rabi*) season crop was significantly higher in capsicum (S_{10}) which was followed by potato in sequence S_9 mainly due to better market price of capsicum and higher yield potential of potato. As per the summer crops, lady's finger gave the highest rice equivalent yield. Further, with respect to system, rice equivalent yield, high value rice-potato-lady's finger (S_9) registered maximum rice equivalent yield (18040 kg/ha) followed by high value rice-capsicum-vegetable cowpea. In sequences S_2, S_3, S_4 and S_5, where *Sesbania* was incorporated, significantly higher yield was recorded over traditional sequences. It was noticed that the system productivity was distinctly higher in high value rice-potato-lady's finger sequence over all other sequences except S_{10} (Table 1). The higher system productivity of S_9 was attributed to higher yield potential of potato and lady's finger but in S_{10} better marketed value of capsicum resulted into higher system productivity. These findings are in conformation with Prasad *et al.* (2013) who reported that the system productivity was maximum for rice-potato + wheat (1:1)–greengram followed by that of rice–potato–greengram. The system productivity in terms of rice equivalent yield mainly depends on the winter crop as rice is the base crop and contribution of summer crops is only marginal. Since, here, lady's finger was taken as summer crop which has higher production potential and market price, the sequence rice-potato-lady's finger recorded maximum system productivity. Similarly, high value rice-potato-lady's finger as well as high value rice-capsicum-vegetable cowpea registered improved land use efficiency than the other sequences. Banjara *et al*. (2022) reported that diversification of the rice-wheat cropping system with either rice-potato-green gram or rice-berseem-cowpea fodder sequence had better productivity, profitability and energetics of rice in the IGP region. As the land-use-efficiency mainly depends on the total duration of the crops, inclusion of summer crops in these sequences occupied field for longer duration. Bastia *et al.* (2008) had also opined that the land use efficiency (LUE) was maximum for rice-groundnut-cowpea system (91.96%), followed by rice-groundnut-green gram system (90.96%) compared to rice-toria system. The data on labour employment (Table 1) revealed that high value rice-potato-lady's finger sequence (S_9) engaged maximum labour followed by sequence S_{10}. However, the lowest labour requirement was found with rice-mustard-fallow system. This might be due to requirement of more labour for the cultivation of potato, lady's finger and capsicum. According to Bhargavi *et al*. (2019), the employment generation was maximum in cropping system having okra

Table 1 Effect of crop diversification on *rabi*, winter and summer crop's REY, system REY, land use efficiency, system productivity and labour employment

Treatment	REY of *kharif* crop (kg/ha)	REY of *rabi* crop (kg/ha)	REY of summer crop (kg/ha)	System REY (kg/ha)	Land use efficiency (%)	System productivity (kg/ha/day)	Labour employment (mandays)
Rice-wheat-fallow (S_1)	3579	4478	-	8056	64.9	22.07	181
Rice-mustard-fallow (S_2)	3600	4097	-	7698	62.3	21.09	180
Sesbania (G.M.)* Rice-lentil-black gram (S_3)	3846	4824	4225	12894	88.8	35.33	253
Sesbania (G.M.)* Rice-veg. pea-black gram (S_4)	3686	3791	4862	12338	83.8	33.80	255
Sesbania (G.M.)* Rice-mustard-black gram (S_5)	3611	4349	4043	12003	88.8	32.88	253
Sesbania (G.M.)* Rice-mustard-green gram (S_6)	3750	4324	5502	13575	89.9	37.19	264
Sudan fodder-berseem-cowpea fodder (S_7)	4412	5761	2818	12991	88.2	35.59	249
Cowpea fodder-berseem-maize fodder (S_8)	2890	6352	3311	12552	89.9	34.39	250
High value rice-potato-lady's finger (S_9)	4263	7258	6519	18040	92.3	49.42	357
High value rice-capsicum-vegetable cowpea (S_{10})	4342	8371	4814	17527	90.4	48.02	305
SEm±	154	325	186	461	-	1.26	-
CD (P=0.05)	457	966	552	1370	-	3.75	-

in sequence due higher labour requirement in weeding and harvesting operations.

SUMMARY

A field experiment was conducted during 2019–20 with an objective to study the effect of diversification of rice- wheat cropping system with different fodder, legume and high value crops for enhanced productivity and employment generation under irrigated ecosystem. The rice equivalent yield was maximum with sudan fodder (4412 kg/ha), capsicum (8371 kg/ha) and lady's finger (6519 kg/ha) for rainy (*kharif*), winter (*rabi*) and summer season, respectively. However, high value rice-potato-lady's finger recorded significantly higher system productivity and was comparable to high value rice-capsicum-vegetable cowpea sequence. Cropping sequences containing more than one crop gave better land use efficiency and more employment generation opportunities by engaging more farm labours. Hence, both the sequences, S_9 and S_{10} recorded higher land use efficiency and labour engagement over other crop sequences thus leading to better employment generation.

REFERENCES

Baishya A, Gogoi B, Hazarika J, Hazarika J P, Borah M and Sutradhar D P. 2016. Maximizing system productivity and profitability through crop intensification and diversification with rice (*Oryza sativa*)-based cropping systems in acid soils of Assam. *Indian Journal of Agronomy* **61**(3): 274–80.

Banjara T R, Bohra J S, Kumar S, Singh T, Shori A and Prajapat K. 2021. Sustainable alternative crop rotations to the irrigated rice-wheat cropping system of Indo-Gangetic plains of India. *Archives of Agronomy and Soil Science* 1–18.

Banjara T R, Bohra J S, Kumar S, Ram A and Pal V. 2022. Diversification of rice–wheat cropping system improves growth, productivity and energetics of rice in the Indo-Gangetic Plains of India. *Agricultural Research* **11**(1): 48–57.

Bastia D K, Garnayak L M and Barik T. 2008. Diversification of rice (*Oryza sativa*)–based cropping systems for higher productivity, resource-use efficiency and economics. *Indian Journal of Agronomy* **53**(1): 22–26.

Bhargavi B, Behera U K, Rana K S, Singh R, Prasad S, Pandey R N and Singh G. 2019. Crop diversification with high-value crops for higher productivity and profitability under irrigated ecosystem. *Indian Journal of Agronomy* **64**(4): 440–44.

Bohra J S, Singh R K, Singh U N, Singh K and Singh R P. 2007. Effect of crop diversification in rice-wheat cropping system on productivity, economics, land use and energy use efficiency under irrigated ecosystem of Varanasi. *Oryza* **44**(4): 320–24.

Ladha J K, Pathak H and Gupta R K. 2007. Sustainability of the rice-wheat cropping system. *Journal of Crop Improvement* **19**(1-2): 125–36.

Kumar S, Bohra J S, Kumar R, Goswami G and Kumawat N. 2015. Assessment of productivity, profitability and energetics of rice-based cropping sequences in irrigated ecosystem of Eastern Uttar Pradesh, India. *Ecology, Environment and Conservation* **21**: 303–10.

Prasad D, Yadava M S and Singh C S. 2013. Diversification of rice (*Oryza sativa*)-based cropping systems for higher productivity, profitability and resource-use efficiency under irrigated ecosystem of Jharkhand. *Indian Journal of Agronomy* **58**(2): 77–83.

Kakraliya S K, Jat H S, Singh I, Sapkota T B, Singh L K, Sutaliya J M, Sharma P C, Jat R D, Choudhary M, Lopez-Ridaura S and Jat M L. 2018. Performance of portfolios of climate smart agriculture practices in a rice-wheat system of western Indo-Gangetic plains. *Agricultural Water Management* **202**: 122–33.