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Research Article

Performance of Rice (*Oryza sativa* L.) Crop under Various Rice-Based Copping Systems in Central India

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ABSTRACT

Present experiment was conducted during 2011-12 and 2012-13 at the research farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jablapur, Madhya Pradesh to study the performance of rice under various rice-based cropping systems. Total 12 rice-based cropping systems viz., rice followed by wheat, chickpea, onion-green gram, berseem, potato-sesame, gobhi sarson-black gram, vegetable pea-sesame, potato- ground nut, gobhi sarson- sorghum, gobhi sarson- okra, French bean and marigold-sesame were studied during the study period. The performance of rice was assessed by monitoring growth attributes (plant height, effective tillers, panicle length, weight of panicle, sterility percentage etc.), yield attributes (grains per panicle, test weight etc.) and grain yield. The results revealed that, among the various cropping system studied the performance of rice crop was found statistically superior under rice-wheat and rice-chickpea cropping sequence. The poor performance of rice crop was observed under rice-berseem followed by rice-marigold-sesame cropping system.

Keywords: *Rice based cropping system, Growth attributes, Yield attributes, Yield.*

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important cereal crop and staple food in most of the south-east Asian countries including India (Schneider & Asch, 2020). It is grown in an area of more than 43.79 million ha with a production of about 112.91 million tonnes and productivity 21578 kg/ha respectively (Agriculture Statistics at a Glance, 2018). About four-fifths of the worlds rice is produced by small-scale farmers. In India rice-wheat is the dominant cropping system in Indo-Gangetic plains. Rice and wheat are the world's two most important cereal crops contributing 45% of the digestible energy and 30% of total protein in the human diet. Approximately 12.5 m ha area under this system contributed to 25% total food grain production of India (Singh et al., 2011). About 33% of India's rice and 42% of wheat is grown in this rotation.

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Madhya Pradesh is one of the major rice growing states of India which contributes nearly 6.5% to nation rice production. Rice based cropping system has assumed paramount importance to met the dietary habit of 42% population of India (Mahajan et al., 2017). Rice-wheat cropping system is practiced under rainfed ecosystem in pockets, where rainfall is good and soils conserve adequate residual soil moisture to grow wheat succession to rice in a sequence (Bhatt et al., 2019). Madhya Pradesh occupies about1.12 million ha area under both irrigated and rainfed production system mainly in Kymore plateau and Satpura hills agro-climatic zone. As a whole, cultivation of both rice and wheat crop is costly, time consuming, energy exhaustive and tedious. Hence, there is an urgent need for diversification and intensification of cropping system in rice-based cropping system by improving the productivity and profitability per unit area per unit time without jeopardizing the soil health.

In some pockets of these areas where rainfall or irrigation water is not adequate, rice-chickpea cropping system also prevalent. Both rice and wheat crops are fertility exhaustive and require more irrigation water, labourers, much time, energy and investment for their cultivation then other field crops on most of the desired agricultural operation with low productivity (Prasad et al., 2017; & Ramadas et al., 2020). Though the market value of chickpea is considerable good with the less cost of production, its productivity is quite lesser than other crops. Hence, there is need to diversity the rice based cropping system aimed to more profit, increase exports and competitiveness in both domestic and international markets, improving soil health protecting environment and facilitating better cropping system with higher productivity per unit area. Keeping above facts in view, the present investigation was carried out to study the performance of rice crop under various rice-based cropping systems in a vertisol of central India.

MATERIALS AND METHODS

Study area

The field experiment was conducted during *kharif* to summer season 2011-12 and 2012-13 at Krishi Nagar Research Farm, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur (M.P.). The present investigation is a regular experiment under All India Coordinated Research Project on Integrated Farming Systems (AICRP-IFS). This experiment has been started since *kharif* season 2011-12. The Jabalpur district lies between $22^0 49^'$ to $24^0 80^'$ N latitude and $78^0 21^'$ to $80^0 58^'$ E longitude with an average altitude of around 411.78 meters above the mean sea level. Jabalpur district belongs to "Kymore plateau and Satpura" hills agro-climatic zone as per classification by National Agricultural Research Project. Jabalpur enjoys a typical sub-tropical climate associate with hot dry summers and cool dry winters. Temperature ranges in between minimum of 2^0C in the months of December-January to maximum 45^0C in the month of May-June. The average annual rainfall of the locality is ranges between 1000-1500 mm in vicinity of Jabalpur, which are mostly received between mid June to first week of October with an occasional shower in limited quantum during the winter months also.

The experiment

The field experiment consisted with 12 treatments as crop-sequences and they were tested in randomized block design with four replications. The details of the treatments are given in Table 1. Rice crop was grown under different crop sequences with 120:60:40 kg ha^{-1} recommended dose of N: P_2O_5: K_2O, respectively. Rice was grown by transplanting of young seeding. Hence, seedlings were raised in nursery, which accomplished with an adequate irrigation and drainage facilities as and when required. The nursery field was prepared by tilling of land followed by repeated harrowing and leveling. The calculated quantities of fertilizers were applied to the respective plots as per treatments. The N, P and K nutrients were applied through urea, single super phosphate and muriate of potash, respectively. One-third of N along with full P and K fertilizers were applied at the time of transplanting and rest N was top dressed in 2 equal splits at 25 and 45 days after transplanting. After planting of seedling, light irrigation was given immediately according to the need of crops for proper establishment of seedlings. Harvesting was done at the maturity stage.

Observations recorded

Plant height: Observations on plant height were recorded at the time of harvesting. For this purpose, the height of clump was measured from each marked hills with the help of meter scale from the base to neck of last leaf of crop.

Effective tillers: The total number of effective tillers was recorded for the five tagged plants, at the time of harvesting and average was worked out. After this the mean values were converted into number of effective tillers/m^2.

Panicle length: Five earheads were selected randomly from each plot at the time of harvesting. The length of each earhead was measured in centimeters with the help of measuring scale from its base to the tip. Finally, mean was determined for each treatment.

Grains per panicle and sterility: The total grains from each of the five selected earheads were removed plot wise separately and then number of grains was counted. After this, chaffy grains were separated from the total grain in each sample and their counting was made after this, sterility percentage of grains was determined for each plot.

Test weight: Grains samples were collected from the rice and 1000-seeds were counted from each sample. These samples were kept in an oven at 40^0C till to reach the constant weight. After this, treatment wise weight of oven dried grain was recorded on electronic balance.

Grain yield: The weight of clean grain obtained after threshing and winnowing and was recorded and converted into grain yield quintals per hectare by multiplying with appropriate factor.

Statistical analysis

Data recorded on various observations were tabulated and subjected to their statistical analysis by using techniques of the analysis of variance (Panse & Shukhatme, 1967). The difference between the treatments was further tested with the critical difference (C.D.) at 5% level of significance.

RESULTS AND DISCUSSION

Plant height (cm)

The plant height of rice crop grown under various cropping systems is presented in Table 2. The plant height of rice recorded during 2011-12 and 2012-13 was ranged 69.5-73.5 cm and 69.0-73.5, respectively. The pooled data revealed that the plant height of rice was varied between 69.2 cm and 73.5 cm. The highest and lowest plant height of rice was recorded under the cropping system rice-wheat (T1) and rice-onion-green gram (T3), respectively (Table 2). The plant height of rice was significantly influenced by the different rice-based cropping systems. Aher et al. (2019a) observed significant variations in plant height of soybean. Similarly, the plant height of various maize cultivars were reflected significantly different plant height (Mandale et al., 2018a). Dotaniya et al. (2020a) also observed the significantly varied plant height of maize under different nutrient inputs in a vertisols of central India.

Effective tillers

The data pertaining to the effective tillers in rice crop grown under various cropping systems is presented in Table 2. The effective tillers in rice recorded during 2011-12 and 2012-13 was ranged 178.2-238.3/m^2 and 178.6-235.2/m^2, respectively. The pooled data revealed that the effective tillers in rice were varied between 178.4/m^2 and 236.7/m^2. The highest and lowest effective tillers in rice were recorded under the cropping system rice-chickpea (T2) and rice-berseem (T4), respectively (Table 2). The effective tillers in rice were significantly influenced by the different rice-based cropping systems. Zamir et al. (2005) observed significant variations in tillering in rice grown under various rice-based cropping systems (legumes and non-legumes). The effective tillers in wheat found varied between 67.8-89.5 per m row length under various treatments (Aher et al., 2018a).

Panicle length (cm) and weight (g)

The panicle length of rice crop grown under various cropping systems is presented in Table 3. The panicle length of rice recorded during 2011-12 and 2012-13 was ranged 23.1-28.6 cm and 23.4-28.1 cm, respectively. The pooled data revealed that the panicle length of rice was varied between 23.2 cm and 28.3 cm. The highest and lowest panicle length of rice was recorded under the cropping system rice-chickpea (T2) and rice-onion-green gram (T3), respectively (Table 3). The panicle length of rice was significantly influenced by the different rice-based cropping systems.

The weight of panicle of rice crop grown under various cropping systems is presented in Table 3. The weight of panicle of rice recorded during 2011-12 and 2012-13 was ranged 3.42-4.20 g and 3.54-4.25 g, respectively. The pooled data revealed that the weight of panicle of rice was varied between 3.48 g and 4.17 g. The highest and lowest weight of panicle of rice was recorded under the cropping system rice-chickpea (T2) and rice-barseem (T4), respectively (Table 3). The weight of panicle of rice was significantly influenced by the different rice-based cropping systems. Similar observations were recorded by Mandale et al. (2018b) and Yashona et al. (2020).

Grains per panicle

The grains per panicle of rice crop grown under various cropping systems are presented in Table 4. The grains per panicle of rice recorded during 2011-12 and 2012-13 was ranged 98.2-153.8 and 102.7-157.6, respectively. The pooled data revealed that the grains per panicle of rice were varied between 100.4 and 155.7. The highest and lowest grains per panicle of rice were recorded under the cropping system rice-wheat (T1) and rice-barseem (T4), respectively (Table 4). The grains per panicle of rice were significantly influenced by the different rice-based cropping systems.

Sterility percentage and test weight (g)

The sterility percentage in rice crop grown under various cropping systems is presented in Table 4. The sterility percentage in rice recorded during 2011-12 and 2012-13 was ranged 7.9-11.1 and 7.5-10.8, respectively. The pooled data revealed that the sterility percentage in rice was varied between 7.7 and 10.9. The highest and lowest sterility percentage in rice was recorded under the cropping system rice-barseem (T4) and rice-wheat (T1), respectively (Table 4). The sterility percentage in rice was significantly influenced by the different rice-based cropping systems.

The test weight of rice crop grown under various cropping systems is presented in Table 5. The test weight of rice recorded during 2011-12 and 2012-13 was ranged 21.3-28.3 g and 21.2-28.8 g, respectively. The pooled data revealed that the test weight of rice was varied between 21.2 g and 28.5 g. The highest and lowest test weight of rice was recorded under the cropping system rice-chickpea (T2) and rice-barseem (T4), respectively (Table 5). The test weight of rice was significantly influenced by the different rice-based cropping systems. Dotaniya et al. (2020a) also found significant changes in test weight.

Grain yield (q ha^{-1})

The grain yield of rice crop grown under various cropping systems is presented in Table 5. The grain yield of rice recorded during 2011-12 and 2012-13 was ranged 42.43-53.10 q ha^{-1} and 36.48-53.58 q ha^{-1}, respectively. The pooled data revealed that the grain yield of rice was varied between 39.45 q ha^{-1} and 52.36 q ha^{-1}. The highest and lowest grain yield of rice was recorded under the cropping system rice-wheat (T1) and rice-barseem (T4), respectively (Table 5). The grain yield of rice was significantly influenced by the different rice-based cropping systems. The crop yield is generally influenced by the nutrient management (Aher et al., 2012; Aher et al., 2015; & Dotaniya et al., 2020b), soil nutrient availability (Khandagle et al., 2019), moisture availability (Reager et al., 2020), soil health (Rajput et al., 2016), soil microbial activity (Aher et al., 2018b), soil physical conditions (Aher et al., 2019b) etc. However, in present investigation the rice crop was grown with similar dose of fertilizers. But the combination of other crops and their nutrient might have influenced the soil nutrient availability and soil microclimate which reflected in variation in yield. Batista and Mohanty (2002) reported that rice equivalent yield of rice-chickpea was highest (74.9 q/ha) among various rice-based cropping systems i.e. rice-lathyrus (73.4 q/ha) and rice-safflower (70.9 q/ha).

Table 1: Treatment details

Treatments	Crop sequences
T_1	Rice-Wheat
T_2	Rice-Chickpea
T_3	Rice-Onion-Green gram
T_4	Rice-Berseem
T_5	Rice-Potato-Sesame
T_6	Rice-Gobhi sarson-Black gram
T_7	Rice-Vegatable pea-Sesame
T_8	Rice-Potato-Groundnut
T_9	Rice-Gobhi sarson-Sorghum
T_{10}	Rice-Gobhi sarson-Okra
T_{11}	Rice-French bean-(Sorghum+Cowpea)
T_{12}	Rice-Marigold-Sesame

Table 2: Plant height and effective tillers in rice under various rice based cropping systems

Crop -sequences		Plant height (cm)			Effective tillers/m^2		
		2011-12	2012-13	pooled	2011-12	2012-13	pooled
T_1	Rice-Wheat	73.5	73.5	73.5	235.4	232.7	234.7
T_2	Rice-Chickpea	73.4	73.1	73.2	238.3	235.2	236.7
T_3	Rice-Onion-Green gram	69.5	69.0	69.2	190.6	191.1	191.0
T_4	Rice-Berseem	70.9	70.8	70.8	178.2	178.6	178.4
T_5	Rice-Potato-Sesame	72.2	72.4	72.3	193.4	191.5	192.4
T_6	Rice-Gobhi sarson-Black gram	72.5	72.6	72.5	194.2	194.7	194.4
T_7	Rice-Vegatable pea-Sesame	72.9	73.5	73.2	195.6	192.8	194.2
T_8	Rice-Potato-Groundnut	72.6	72.5	72.5	198.3	198.9	198.6
T_9	Rice-Gobhi sarson-Sorghum	72.4	73.0	72.7	194.2	195.5	194.8
T_{10}	Rice-Gobhi sarson-Okra	71.9	72.4	72.1	204.6	205.2	204.9
T_{11}	Rice-French bean-(Sorghum+Cowpea)	72.5	72.4	72.4	197.3	198.5	197.9
T_{12}	Rice-Marigold-Sesame	69.8	69.2	72.4	189.4	190.7	190.0
	SEm±	0.92	1.16	0.70	1.40	1.42	1.02
	CD (P=0.05)	2.73	3.43	2.09	4.16	4.22	3.04

Table 3: Length and weight of rice panicle under various rice based cropping systems

Treatment (Cropping system)		Panicle length (cm)			Weight of panicle (g)		
		2011-12	2012-13	pooled	2011-12	2012-13	pooled
T_1	Rice-Wheat	28.4	28.1	28.2	4.20	4.12	4.16
T_2	Rice-Chickpea	28.6	28.0	28.3	4.10	4.25	4.17
T_3	Rice-Onion-Green gram	23.1	23.4	23.2	3.61	3.72	3.57
T_4	Rice-Berseem	23.3	23.6	23.4	3.42	3.54	3.48
T_5	Rice-Potato-Sesame	24.6	24.9	24.7	3.80	3.72	3.76
T_6	Rice-*Gobhi sarson*-Black gram	24.2	24.6	24.4	3.96	4.00	3.98
T_7	Rice-Vegatable pea-Sesame	24.8	25.0	24.9	3.90	3.86	3.88
T_8	Rice-Potato-Groundnut	24.9	25.3	25.1	3.92	4.02	3.97
T_9	Rice-*Gobhi sarson*-Sorghum	24.7	24.3	24.5	3.94	3.92	3.93
T_{10}	Rice-*Gobhi sarson*-Okra	25.0	25.2	25.1	4.09	3.95	4.02
T_{11}	Rice-French bean-(Sorghum+Cowpea)	24.4	24.3	24.3	3.95	3.87	3.91
T_{12}	Rice-Marigold-Sesame	23.4	23.8	23.6	3.68	3.45	3.56
	SEm±	0.58	0.79	0.57	0.15	0.22	0.10
	CD (P=0.05)	1.72	2.33	1.69	0.46	0.65	0.31

Table 4: Grains per panicle and sterility percentage in rice under various rice based cropping systems

Crop -sequences		Grains/ panicle			Sterility percentage		
		2011-12	2012-13	pooled	2011-12	2012-13	pooled
T_1	Rice-Wheat	153.8	157.6	155.7	7.9	7.5	7.7
T_2	Rice-Chickpea	151.4	152.6	152.0	8.1	7.9	8.0
T_3	Rice-Onion-Green gram	112.6	114.2	113.4	10.7	10.4	10.5
T_4	Rice-Berseem	98.2	102.7	100.4	11.1	10.8	10.9
T_5	Rice-Potato-Sesame	127.0	129.3	128.1	9.7	9.6	9.6
T_6	Rice-*Gobhi sarson*-Black gram	128.0	130.2	129.1	9.5	9.3	9.4
T_7	Rice-Vegatable pea-Sesame	128.0	125.6	126.8	9.6	9.5	9.5
T_8	Rice-Potato-Groundnut	126.4	128.3	127.3	9.9	9.5	9.7
T_9	Rice-*Gobhi sarson*-Sorghum	128.2	127.9	128.0	9.3	9.3	9.3
T_{10}	Rice-*Gobhi sarson*-Okra	135.0	132.4	133.7	9.2	9.1	9.1
T_{11}	Rice-French bean-(Sorghum+Cowpea)	132.0	130.3	131.1	9.4	9.2	9.3
T_{12}	Rice-Marigold-Sesame	114.0	115.7	114.8	10.2	10.8	10.5
	SEm±	0.84	0.45	0.41	0.32	0.40	0.26
	CD (P=0.05)	2.54	1.33	1.22	0.96	1.18	0.78

Table 5: Test weight and grain yield in rice under various rice based cropping systems

Crop -sequences		Test weight (g)			Grain yield (q/ha)		
		2011-12	2012-13	pooled	2011-12	2012-13	pooled
T_1	Rice-Wheat	27.4	27.6	27.5	51.14	53.58	52.36
T_2	Rice-Chickpea	28.3	28.8	28.5	53.10	51.43	52.26
T_3	Rice-Onion-Green gram	25.7	25.1	25.4	45.81	44.95	45.38
T_4	Rice-Berseem	21.3	21.2	21.2	42.43	36.48	39.45
T_5	Rice-Potato-Sesame	26.2	26.6	26.4	44.00	45.49	44.74
T_6	Rice-*Gobhi sarson*-Black gram	26.1	26.8	26.4	45.43	46.01	45.72
T_7	Rice-Vegatable pea-Sesame	26.7	26.3	26.5	46.00	44.87	45.43
T_8	Rice-Potato-Groundnut	26.2	26.5	26.3	47.57	46.75	47.16
T_9	Rice-*Gobhi sarson*-Sorghum	26.9	26.3	26.6	45.72	45.46	45.59
T_{10}	Rice-*Gobhi sarson*-Okra	26.9	27.0	26.9	48.57	47.37	47.97
T_{11}	Rice-French bean-(Sorghum+Cowpea)	26.7	26.9	26.8	47.76	46.92	47.34
T_{12}	Rice-Marigold-Sesame	25.9	25.6	25.7	44.22	43.92	44.07
	SEm±	0.53	0.67	0.37	0.44	0.42	0.32
	CD (P=0.05)	1.58	2.00	1.10	1.31	1.25	0.96

CONCLUSION

Among the various cropping system studied the performance of rice crop was found statistically superior under rice-wheat and rice-chickpea cropping sequence. Thus, for obtaining optimum yield of rice crop, rice-wheat and/or rice-chickpea system is recommended for "Kymore plateau and Satpura" hills agro-climatic zone of central India.

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