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Effect of rice and wheat varieties on rice equivalent yield, system productivity and nutrient uptake under organic farming in Jharkhand

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ABSTRACT

Globally organic farming is well known and appreciated. Due to continuous use of synthetic fertilizers, the harmful elements enter into the food web and ultimately cause health hazard not only to human beings but also have a detrimental effect on environment. In this regard the demand for organic produce is gaining momentum for safe and healthy food. The present study explains the "Effect of rice and wheat varieties on rice equivalent yield, system productivity and nutrient uptake under organic farming in Jharkhand". A field experiment was conducted at research farm of Birsa Agricultural University, Jharkhand with an objective to evaluate yield and nutrient uptake of rice and wheat varieties which are influenced by organic farming. The soil of experimental plot was sandy clay loam in texture having average carbon (6.16 Kg/ha), nitrogen (254.78 kg/ha), phosphorous (39.59 Kg/ha) and potassium (208.26 Kg/ha) with soil pH 6.04. Field experiments were carried out using randomized block design replicated thrice involving twelve treatments with twelve varieties. Rice varieties are: T_1: Birsa vikas Dhan 203, T_2 : Birsa Dhan 201, T_3 : Birsa vikas Sugandha 1, T_4 : B.V.D 110, T_5 : Sahbhagi, T_6 : Birsamati, T_7 : Anjali, T_8: Lalat, T_9: M.T.U. 1010, T_{10}: Akshay, T_{11}: Pusa Sugandha and T_{12}: Naveen. Whereas,wheat varieties are : Raj 4250, GW 366, NW 2036, K 0307, K 9107, HI 1563, Raj 4229, DBW 14, WR 544, BG 3, HD 2733 and DBW 39. Results showed: both the grain yield (40.22 kg/ha) and straw yield (62.96 kg/ha) of rice were maximum in MTU 1010. Likewise, the grain yield (31.56 kg/ha) and straw yield (45.78 kg/ha) of wheat were maximum in K 0307 and Raj 4229 respectively. The best rice equivalent yield of wheat was found maximum (33.19 q/ha) in B.V.D. 110-K 0307 cropping system, both the system productivity (66.52 Rs./ha) and system production efficiency (28.18 kg/ha/day) were highest in MTU 10101-WR 544 rice-wheat cropping system. Highest nutrient uptake in grain (N-53.33 kg/ha, P-11.31 kg/ha and K-10.20 kg/ha) and in straw (N-37.77 kg/ha, P-7.42 kg/ha and K-71.53 kg/ha) were observed in MTU 1010 rice variety. K0307 recorded highest nutrient uptake in wheat grain (N-47.93 kg/ha, P-8.74 kg/ha and K-10.06 kg/ha), however nutrient uptake in wheat straw (N-24.41 kg/ha, P-6.84 kg/ha and K- 38.40 kg/ha) was obtained maximum in Raj 4229.

Key words : *Organic farming, Rice equivalent yield, System productivity, System production efficiency, Nutrient uptake*

Introduction

For millions of people in the world, rice is the lifeline particularly in developing countries. Out of the rice growing countries, India has the largest area (43.4 m ha) and ranks second in production (104.32 mt) next to china with productivity of 2404 kg/ha. In Jharkhand, rice is grown in about 1.59 m ha with production of 2.88 mt and productivity of 1814 kg/ha (Directorate of Economics and Statistics, Ministry

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of Agriculture and Farmer Welfare Government of India, 2016-17). Wheat is India's most staple crop, placed second to rice. In 2015-16, total wheat production in India amounted to 93.50 mt, in area of about 30.23 m ha with average production of 3093 kg/ha. In Jharkhand total wheat production accounts to 0.27 mt, in area of about 0.16 mha with average production of 1701 kg/ha (Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare Government of India, 2016-17).

Rice–wheat cropping sequence is the world×s largest agricultural production system spread over mainly Asia's five countries namely, India, Pakistan, Nepal, Bangladesh and China which occupies about 28.8 million hectares (Timsinia and Connor, 2001; Prasad, 2005). In India rice-wheat cropping system covers about 12 million hectares spreading over states of Punjab, Haryana, UP, Bihar, West Bengal, Himachal Pradesh, Uttarakhand, Madhya Pradesh and Rajasthan. Rice-wheat cropping system accounts for about one-fourth of total food grain production of South-East Asia (Abrol *et al.,* 1997). This indicates the contribution of rice-wheat cropping system in meeting food requirements of the country. The rice-wheat cropping system, which is regarded as the backbone of food self sufficiency, is however dealing with a sustainability problem due to practices of modern production system with careless use of chemical fertilizers and pesticides (Duxbury and Gupta, 2000; Ladha *et al.,* 2000; Yadav *et al.,* 2000; Prasad, 2005). The concerns like declining factor productivity (Biswas and Sharma, 2008; Patil, 2008; Yadav, 2008), depletion of soil organic carbon and mineral nutrients content (Prakash *et al.,* 2008), water logging and salinization, increasing nitrate concentration in well water (Singh *et al.,* 1995) etc are the consequents of modern rice-wheat production system with unbalanced and injudicious use of chemical fertilizers and pesticides. The adverse effects of these chemicals are clearly visible on soil structure, microflora, and quality of water, food and fodder. The quality of produce is also deteriorated due to entry of chemical residues in the plant body and then to food chain.

The emerging scenario necessitates the need of adoption of the practices which maintains the soil health, keeps the production system sustainable and provides qualitative food for meeting the nutritional requirements of human beings. There is a great demand for high quality products and organically grown foods in the international market and can capitalize on its potential to go for organic farming on a large scale. India, with its varied agro-climatic conditions and agricultural biodiversity, is most suited for organic farming. It is essential to educate the farmers about the scientific methods of organic farming so that their income will increase gradually. So in the context of improved quality of food and maintenance of ecological balance the two major source of food that is rice and wheat and their cropping system under organic farming is emphasized. Adoption of organic farming will be able to make rice-wheat cropping system more sustainable without adverse effects on the natural resources and the environment (Stockdale *et al.,* 2001).

Materials and Method

The experiment to study the effect of rice and wheat varieties on rice equivalent yield, system productivity and nutrient uptake under organic farming in Jharkhand was conducted at research farm of Birsa Agricultural University, Kanke, Ranchi during *kharif* and *rabi* season of 2017-18. The experimental plots had assured irrigation facility coupled with uniform topography, good drainage and soil characteristics typical to suit rice and wheat cultivation. The experiment was laid out in Randomized Block Design with twelve treatments replicated thrice. Rice varieties are as follow; T_1 : Birsa vikas Dhan 203, T_2 : Birsa Dhan 201, T_3 : Birsa vikas Sugandha 1, T_4 : B.V.D 110, T_5 : Sahbhagi, T_6 : Birsamati, T_7 : Anjali, T_8: Lalat, T_9: M.T.U 1010, T_{10}: Akshay, T_{11}: Pusa Sugandha and T_{12}: Naveen. Whereas, wheat varieties areas follow; Raj 4250, GW 366, NW 2036, K 0307, K 9107, HI 1563, Raj 4229, DBW 14, WR 544, BG 3, HD 2733 and DBW 39. The soil of experimental plot was sandy clay loam in texture having average carbon (6.16 Kg/ha), nitrogen (254.78 kg/ha), phosphorous (39.59 Kg/ha) and potassium (208.26 Kg/ha) with soil pH 6.04. The crops received a total rainfall of 33.3 mm from November 2017 to April 2018, during the cropping period of wheat the maximum temperature varied between 33.9°C and 20.0°C while minimum temperature ranged between 21.1°C and 2.0 °C., total experimental area was 62.5m × 11m, gross plot size was 5m × 3m. The experimental plots where the trial is going on for the last 5 years was ploughed down in summer to reduce the infestation of insect-pest, diseases and weeds. The field was again ploughed twice 15 days

before planting while one ploughing was done just a week before transplanting.

A well drained fertile land having good irrigation facility was selected for raising seedlings. The nursery plot was ploughed twice in the dry condition and then puddled giving two ploughings in standing water to convert the upper layer of the soil into fine soft mud. The field was lavelled properly and twelve beds of 6.0 × 1.0 m^2 area were prepared. Seed beds were kept saturated with water. Although after 5 days after sowing of seeds, a thin film of water was maintained and then the water level was gradually increased up to 5 cm as the seedlings grow. Excess water was drained out in periods of heavy rain. The twenty five days old seedlings were transplanted in the field at the rate of 3 seedlings/hill on 27/07/2017. The row to row and plant to plant spacing were kept 20 cm and 10 cm, respectively. Harvesting of rice was done on three different dates *i.e.* variety B.V.D 110, Anjali, Shahbhagi Dhan and Akshay on 4th November, 2017 while, Naveen, Birsa Dhan 201, Birsa Vikash Dhan 203 and Pusa Sugandha were harvested on 8th November, 2017 and rest four varieties, *i.e.* Lalat, Birsamati, Birsa vikashsugandha 1 and MTU 1010 were harvested on 9th Nov., 2017.

The wheat crops were sown on 3 dates i.e., timely sown on 13/11/2017, late sown on 28/11/2017 and very late sown on 13/12/2017 as per the harvesting of rice variety of different maturity period. Continuous sowing of wheat seeds is done manually in the line spaced at 20 cm. Seeds were then covered with soil manually. The field was prepared on 5th Nov. 2017, 14th Nov. 2017 and 20th Nov. 2017 for timely sown, late sown and very late sown wheat varieties respectively and levelled properly. Drainage channel 50 cm wide was constructed in between the two treatments. Harvesting of timely sown varieties, late sown varieties and very late sown varieties were done on 31st March 2018, 2nd April 2018 and 13th April 2018, respectively. All necessary precautions were taken to maintain uniform plant population in each treatment per replication. Observations were recorded on yield attributes of ten randomly selected plants in each replication. Grain and straw yield were recorded at harvesting. In calculation of economics, the purchase rates of input and the selling rates of outputs were assumed as per the prevailing local market rates.

To meet out the nutrient requirement of rice and wheat crops, i.e. 80:40:20 and 100:50:25 kg NPK/ha, respectively farm yard manure, vermicompost and karanj cake were applied based on nitrogen requirement. Each of the sources were applied in amount to meet out the 1/3rd of the nitrogen requirement of the recommended level of nitrogen for each crop. The farm yard manure and karanj cake were applied at the time of field preparation while vermicompost was applied in two equal splits at tillering and panicle initiation stage in rice and crown root initiation stage and tillering stage in wheat crop.

Statistical analysis

The data were analyzed statistically by applying "Analysis of Variance" (ANOVA) technique of RBD. The significance of different sources of variations was measured by Error mean square of Fisher Snedecor's 'F' test at probability level 0.05. Least significant difference (LSD) at 5% level of significance was worked out for each character of the experiment.

Results and Discussion

Effect of rice and wheat varieties on system performance under organic farming

Rice grain and straw yield: The maximum rice equivalent yield of wheat was recorded from rice - wheat system B.V.D 110 – K 0307 closely followed by Anjali – Raj 4229, Naveen – DBW 39 and Birsa Dhan 201 – GW 366 (Table 1). The higher yield of wheat variety K 0307 is responsible for higher rice equivalent yield of wheat. This experimental finding has similar conformity with Shrivastava *et al.* (2003). The system productivity of rice-wheat cropping system was recorded maximum with inclusion of MTU 1010 - WR 544 of rice and wheat varieties, respectively in the cropping sequence followed by Naveen – DBW 39, Lalat – DBW 14, Birsa Dhan 201 – GW 366, Birsamati – HI 1563 and B.V.D 110 – K 0307. The rice crop mostly governed the rice equivalent grain yield of the systems, because the contribution of wheat crop was only marginal. The higher production potential of rice was instrumental for attaining higher rice equivalent grain yield. In transplanted rice, the pH value of soil turns towards neutral facilitating better availability of nutrients resulting in higher yield of rice crop while, in wheat the organic manure applied, i.e. farm yard manure, vermicompost and karanj cake were not able to mineralize due to low soil temperature and poor soil

Table 1. Effect of rice and wheat varieties on rice equivalent yield of wheat and system productivity under organic farming

Treatments	Rice		Treatments	Wheat		Rice equivalent yield of wheat (q/ha)	System Productivity (Rs./ha)	System Production Efficiency (kg/ha/ day)
	Grain yield (kg/ha)	Straw yield (kg/ha)		Grain yield (q/ha)	Straw yield (q/ha)			
T_1 : Birsa vikas Dhan 203 (127)	34.33	56.56	T_1 : Raj-4250 (111)	22.44	39.13	23.61	57.94	24.34
T_2 : Birsa Dhan 201 (116)	33.33	52.00	T_2 : GW-366 (122)	28.78	45.16	30.27	63.60	26.82
T_3 : Birsa vikas Sugandha 1(128)	32.44	54.00	T_3 : NW-2036 (113)	25.56	41.56	26.88	59.32	24.61
T_4 : B.V.D 110 (101)	26.67	47.78	T_4 : K-0307 (127)	31.56	42.22	33.19	59.85	25.15
T_5 : Sahbhagi (116)	30.22	48.89	T_5 : K-9107 (117)	26.67	43.24	28.05	58.27	25.01
T_6 : Birsamati (126)	36.44	58.42	T_6 : H.I 1563 (111)	24.22	40.00	25.48	61.92	26.57
T_7 : Anjali (104)	27.33	46.44	T_7 : Raj-4229 (129)	30.22	45.78	31.79	59.12	25.37
T_8 : Lalat (121)	38.44	60.20	T_8 : DBW-14 (115)	25.33	40.89	26.64	65.09	27.58
T_9 : M.T.U 1010 (126)	40.22	62.96	T_9 : W.R-544 (110)	25.00	40.00	26.29	66.52	28.18
T_{10} : Akshay (117)	29.56	51.22	T_{10} : B.G-3 (117)	27.00	44.18	28.40	57.95	24.77
T_{11} : Pusa Sugandha (131)	34.89	54.98	T_{11} : H.D-2733 (110)	21.56	39.33	22.67	57.56	23.88
T_{12} : Naveen (122)	35.56	57.11	T_{12} : DBW-39 (119)	28.89	44.22	30.38	65.94	27.36
SEm ±	1.58	2.68	SEm±	1.25	1.99	1.32	2.42	0.99
C.D. (P=0.05)	4.63	7.85	C.D(P=0.05)	3.68	5.83	3.87	7.09	2.90
C.V.(%)	8.21	8.56	C.V(%)	8.21	8.17	8.21	6.85	6.63

moisture condition led to poor yield of wheat crop.

The cropping sequence with M.T.U 1010 – WR-544 gave maximum system production efficiency which was statistically superior over B.V.D 110 – K 0307, Sahbhagi – K9107, Akshay – BG 3, Birsavikas Sugandha1 – NW 2036, Birsavikas Dhan 203 – Raj 4250 and Pusa Sugandha – HD 2733 but remained at par with rest of the varieties in rice-wheat system. The varietal combination in different cropping sequence is such that the system duration of all the cropping sequence is more or less similar, i.e. non significant so, the production efficiency depends upon the rice equivalent yield of system and follows almost similar trend.

Effect of rice and wheat varieties on nutrient uptake under organic farming

Among rice varieties, MTU 1010 recorded the highest NPK uptake by grain and straw as well as total NPK uptake than other rice varieties which could be ascribed to better vegetative and reproductive growth thereby producing higher grain and straw yield of MTU 1010 since uptake of a nutrient is a function of concentration of nutrient and yield per hectare. The nutrient uptake by the rice crop mainly depends on the biomass (grain and straw yields) of crop and concentration of a particular nutrient in the produce (Table 2). Similar findings were also recorded by Quyen and Sharma (2003) and Singh *et al.* (2004). Similarly in wheat varieties, K 0307 showed significantly higher nitrogen, phosphorous and potassium uptake by grain while Raj 4229 had highest nitrogen, phosphorous and potassium uptake by straw as well as total NPK uptake. The variation in nutrient content and yield of wheat cultivars were responsible for the variability in the nutrient uptake (Kumar and Singh, 2012). Singh and Agarwal (2004) and Kademani *et al.* (2003) were also recorded the similar results.

Conclusion

Based on one year experimentation both the grain yield (40.22 kg/ha) and straw yield (62.96 kg/ha) of rice were maximum in MTU 1010. Likewise, the grain yield (31.56 kg/ha) and straw yield (45.78 kg/ha) of wheat were maxi-

Table 2. Effect of rice and wheat varieties on nutrient uptake under organic farming

Treatments	Nutrient Uptake (kg/ha) of rice					
	Grain			Straw		
	N	P	K	N	P	K
T_1 : Birsa vikasDhan 203 (127)	44.83	9.48	8.56	33.24	6.62	63.55
T_2 : Birsa Dhan 201 (116)	43.32	9.16	8.24	30.42	5.96	57.61
T_3 : Birsa vikas Sugandha 1 (128)	43.21	9.19	8.27	32.48	6.38	61.18
T_4 : B.V.D 110 (101)	31.88	6.76	6.11	25.84	5.07	49.27
T_5 : Sahbhagi (116)	38.78	8.21	7.13	28.15	5.54	53.31
T_6 : Birsamati (126)	48.47	10.26	9.21	34.94	6.85	66.24
T_7 : Anjali (104)	33.00	6.97	6.28	25.22	4.98	47.78
T_8 : Lalat (121)	50.54	10.69	9.65	35.77	7.03	67.97
T_9 : M.T.U 1010 (126)	53.33	11.31	10.20	37.77	7.42	71.53
T_{10}: Akshay (117)	38.52	8.18	7.30	29.92	5.89	57.10
T_{11}: Pusa Sugandha (131)	47.20	9.97	8.96	33.34	6.50	63.12
T_{12}: Naveen (122)	46.44	9.82	8.85	33.57	6.60	63.76
SEm ±	1.87	0.52	0.44	1.75	0.42	3.36
C.D(P=0.05)	5.49	1.54	1.28	5.14	1.24	9.86
C.V(%)	7.48	9.92	9.20	9.56	11.79	9.67

Treatments	Nutrient Uptake (kg/ha) of wheat					
	Grain			Straw		
	N	P	K	N	P	K
T_1 : Raj-4250 (111)	37.82	6.36	7.61	19.18	5.67	31.49
T_2 : GW-366 (122)	43.48	7.93	9.23	24.15	6.75	37.58
T_3 : NW-2036 (113)	39.82	7.13	8.52	21.22	5.98	34.10
T_4 : K-0307 (127)	47.93	8.74	10.06	21.59	6.07	34.58
T_5 : K-9107 (117)	41.51	7.29	8.67	22.18	6.21	35.36
T_6 : H.I 1563 (111)	38.93	6.54	7.96	20.49	5.74	32.19
T_7 : Raj-4229 (129)	45.90	8.42	9.87	24.41	6.84	38.40
T_8 : DBW-14 (115)	39.51	7.03	8.23	20.97	5.93	33.58
T_9 : W.R-544 (110)	39.01	6.66	8.14	20.50	5.80	32.41
T_{10}: B.G-3 (117)	41.60	7.43	8.83	22.69	6.38	36.71
T_{11} : H.D-2733 (110)	35.73	6.08	7.34	20.08	5.70	31.88
T_{12} : DBW-39 (119)	44.61	8.03	9.32	23.68	6.46	37.00
SEm±	2.29	0.39	0.42	0.93	0.31	1.48
C.D(P=0.05)	6.70	1.13	1.23	2.74	0.91	4.33
C.V(%)	9.58	9.15	8.40	7.43	8.80	7.39

mum in K 0307 and Raj 4229 respectively. The best rice equivalent yield of wheat was found maximum (33.19 q/ha) in B.V.D. 110-K 0307 cropping system, both the system productivity (66.52 Rs./ha) and system production efficiency (28.18 kg/ha/day) were highest in MTU 10101-WR 544 rice-wheat cropping system. Highest nutrient uptake in grain (N-53.33 kg/ha, P-11.31 kg/ha and K-10.20 kg/ha) and in straw (N-37.77 kg/ha, P-7.42 kg/ha and K-71.53 kg/ha) were observed in MTU 1010 rice variety. K0307 recorded highest nutrient uptake in wheat grain (N-47.93 kg/ha, P-8.74 kg/ha and K-10.06 kg/ha), however nutrient uptake in wheat straw (N-24.41 kg/ha, P-6.84 kg/ha and K- 38.40 kg/ha) was obtained maximum in Raj 4229.

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