ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Productivity and profitability of rice-wheat system under organic and inorganic farming in mid hills of Himachal Pradesh

Mankotia BS*

ICAR-Indian Institute of Rice Research, Hyderabad, Telangana-500030
**Corresponding author: aartisingh810@gmail.com*

Received: 18th Sept. 2018 Accepted: 18th Dec. 2018

Abstract

A field experiment was conducted AICRP-Rice during 2017-18 at CSK HPKV Rice and Wheat Research Centre, Malan to study the productivity and profitability domain of rice-wheat system under organic and inorganic farming in mid hills of Himachal Pradesh. Five treatments viz. $T_{1:}$ 100% RDF (recommended dose of fertilizers) through inorganic fertilizer , T_2: 100% RDF through organic fertilizers (equivalent of N), T_3: 75% through inorganic and 25% through FYM, T_4: Control (No fertilizer), T_5: Farmers' practice were tested in randomized block design with four replications. 'Kasturi' (basmati rice) was grown in *kharif* season followed by 'HS 542' wheat cultivar in *rabi* season. 210 Kg N (90 rice + 120 wheat), 100 kg phosphorus (40+60) and 70 kg potash (40+30)/ha were applied as recommended dose (T_1) in rice-wheat system. 42 t FYM on dry weight basis (18 t to rice + 24 t to wheat) was applied on N equivalent basis in T_2. Results revealed that Kasturi recorded productivity level of 4.08 t/ha under organic system (T_2) which was at par with 100% recommended dose of fertilizers (3.74 t/ha) applied through inorganic fertilizers (T_1). T_3 (integrated nutrient management) recorded more rice productivity of 4.10 t/ha, however, compared to 100%RDF. Wheat productivity in organic system was 4.34 t/ha which was at par with integrated nutrient supply system (3.78 t/ha, T_3) and the latter being at par with inorganic fertilizer nutrient (T_1; 3.60t/ha). Gross returns of rice –wheat system revealed that organic system (T_2) recorded higher value of Rs.2,28,412/ha followed by integrated nutrient management (T_3, Rs.2,14,212/ha) and 100% RDF (Rs.2,00,293). However, net return (Rs. 1,09,753/ha) and benefit cost ratio (1.21) was higher with inorganic nutrient supply system (T_1). Cost of FYM in organic system inflated the cost of cultivation; therefore, economic analysis was done by excluding the cost of FYM with the assumption that it is freely available with the hill farmers in integrated farming (but in reality FYM is not available for free). Hence, economic analyses done by excluding the cost of FYM revealed that maximum net returns of Rs. 1,49,474/ha & benefit cost ratio of 1.89 was recorded in organic production system (T_2) which is a sustained production system. The values of growth and yield attributes were low inabsolute control (T_4) and farmers' practice (T_5) and hence low productivity and profitability. Thus, farmers of mid hills should apply full dose of fertilizers to Kasturi basmati (90,40,40 kg NPK)- wheat (120,60,30 kg NPK) for higher productivity and profitability under inorganic production system. Under organic production system, an application of FYM (equivalent to fertilizer N) to both 'Kasturi' rice-wheat (18 t/ha to rice + 24 t/ha to wheat on dry weight basis) recorded more productivity (4.08 + 4.34 t/ha) and gross returns. The latter also records more net returns (Rs.1,49,474/ha) and benefit : cost (1.89) if farmers have FYM free of cost available with them as in integrated hill farming of Himachal Pradesh.

Key words: Rice –wheat system, organic, inorganic, integrated nutrient management, productivity, economics

Introduction

Rice (*Oryza sativa* L. –wheat (*Triticum aestivum* L. emend. Fiori&Paol) is the major cropping system in India, covering 10-12 million hectare areas. This system is equally important in Himachal Pradesh. There are indications of stagnation or even decline in productivity of this cropping system due to decline in soil organic matter, over-mining of nutrient reserves, loss of nutrients and non availability of cost effective fertilizers. Further, the application of inorganic fertilizers even in balanced fertilizers may not sustain soil productivity under continuous cropping. However, integrated use of organics and inorganics including crop residues may improve the soil productivity (Mankotia, 2007). In hills the fertilizer and pesticide inputs, by default, are being used less as compared to the plains-neighboring states. The whole of Himachal Pradesh has been has been

included in GI (Geographical Indication) for basmati and there exists ample scope to contribute in the export pool of the country *vis a vis* to improve the economic condition of the hill farmers. Therefore, the present investigation was undertaken.

Materials and methods

A field experiment was conducted All India Coordinated Rice Improvement Project during 2017-18 at CSK HPKV Rice and Wheat Research Centre, Malan (76° 2′ E, 32° 1′ N and 950 m above mean sea level) to study the productivity and profitability domain of rice-wheat under organic and inorganic farming in mid hills of Himachal Pradesh. Five treatments *viz.* $T_{1:}$ 100% RDF (recommended dose of fertilizers) through inorganic fertilizers, T_2: 100% RDF through organic fertilizers (equivalent of N), T_3: 75% through inorganic and 25% through FYM, T_4: Control (No fertilizer), T_5: Farmers' practice were tested in randomized block design with four replications. These treatments were given to both the crops. The recommended dose of fertilizers to rice is 90-40-40 kg & to irrigated wheat is 120-60-30 kg $NP_2O_5K_2O$/ha. Thus, 210 Kg N (90 rice + 120 wheat), 100 kg phosphorus (40+60) and 70 kg potash (40+30)/ha were applied as recommended dose (T_1) in rice-wheat system. 42 t FYM on dry weight basis (18 to rice + 24 t to wheat) was applied at the time of field preparation, on N equivalent basis in T_2. 'Kasturi' (basmati rice) was grown in *kharif* season followed by 'HS 542' wheat cultivar in *rabi* season. The soil was medium in available nitrogen (428 kg), phosphorus (42 kg) & medium in potash (232 kg/ha) and acidic in reaction (pH 5.7). During rice cropping season 2108 mm rainfall was received in 67 days, however, the irrigations were provided to both the crops to avoid any moisture stress. The economics was computed by taking into account the prevailing market cost of inputs and price of inputs. The economic analyses included the cost of FYM. Cost of FYM in organic system inflated the cost of cultivation; therefore, economic analysis was also done by excluding the cost of FYM with the assumption that it is available with the hill farmers free of cost in integrated farming.

Results and Discussion

Effect on rice

Growth in terms of plant height & number of tillers per unit area and development (days taken to 50 % flowering) of rice crop were significantly varied by the treatments (Table 1). Application of nutrients either as organic ($T_{2:}$ 100% RDF through organic fertilizers (equivalent of N)) or inorganic ($T_{1:}$ 100% RDF (recommended dose of fertilizers) through inorganic fertilizers) or in integrated nutrient management (INM, $T_{3:}$ 75% through inorganic and 25% through FYM) resulted in statistically plants of the same height but significantly taller than in absolute control (T_4) and farmers' practice (T_5). In organic (T_2), plants were taller by 1, 6.6& 10.5 cm over inorganic (T_1), farmers practice (T_5) and absolute control (T_4), respectively. The variation in plant height is because of the varied availability of the nutrients under different treatments. Inorganic T_1&INM T_3 recorded more number of tillers per unit area being at par with organic T_2 compared to absolute control and farmers' practice. T_1 produced 53 more tillers compared to absolute control. The development of the crop i.e. days taken to 50 per cent flowering were varied significantly, recording significantly more days in organic (T_2) as well as in absolute control and farmers practice. Plants in organics took 3.8 more days to flowering compared to inorganic T_1. Absolute control took more days among the treatments.

INM (T_3) produced significantly more panicles compared to that of other treatments (Table 1). Application of 100 % RDF through inorganics (T_1) and organics (T_2) were statistically on par in producing the panicles per unit area. Number of filled spikelets per panicle were more in T_1being at par with organic and INM, However, unfilled spikelets per panicle were also more in INM being statistically at par with organic. Test weight was not varied significantly however lowest value was observed in absolute control. Panicle weight was statistically comparable in inorganic and INM but significantly more than absolute control and farmers' practice.

As the crop nutrition improved growth and yield attributes of rice crop, thereby the grain and straw yield was significantly affected by the treatments. Results revealed that Kasturi recorded productivity level of 4.08 t/ha under organic system (T_2) which was at par with 100% recommended dose of fertilizers (3.74 t/ha) applied through inorganic fertilizers (T_1). However, T_3 (integrated nutrient management) recorded more rice productivity of 4.10 t/ha compared to 100% RDF. Organic produced 9.2 per cent (0.34 t/ha) more grain yield over 100 % RDF and 32.5 per cent (1.0 t/ha) more over farmers' practice. Straw yield in INM was at par with 100% RDF & organic. Similar results have been reported by Anonymous (2017) & Mankotia and Shekhar, 2007.

Table 1: Effect of organic and inorganic nutrition on growth, development, yield attributes and yield of rice-wheat

Treatment / Parameter	T_1-100% RDF through inorganic fertilizers	T2-100% RDF through organic fertilizers (equivalent of N)	T3-INM (75% through inorganic and 25% through organic sources)	T4-Control (No fertilizer)	T5-Farmers' practice	CD (P=0.05)
Effect on rice						
Plant height (cm)	107.8	107.7	108.8	98.3	102.2	5.4
Number of tillers/m^2	173.5	164.5	173.5	120.7	151.0	28.5
Days taken to 50% flowering (d)	97.7	101.5	98.5	103.8	103.0	1.4
Number of panicles/m^2	151	155.5	171.2	111.2	124.2	13.8
Filled spikelets/panicle	127.8	126.5	124.2	100.5	108	13.41
Unfilled spikelets /panicle	21	23.7	29	17.5	17	6.37
Fertility %age	85.9	84.3	81.1	85.3	86.4	NS
Panicle weight(g)	2.78	2.73	2.7	2.15	2.25	0.25
Test weight(g)	22.97	22.21	22.89	22.2	21.8	NS
Straw yield (t/ha)	6.606	6.872	7.092	4.251	5.258	0.627
Grain yield(t/ha)	3.736	4.08	4.104	2.418	3.079	0.34
Effect on wheat						
Plant height (cm)	84.1	88.3	86.3	77.7	79.6	6.3
No. of ears/m^2	303.3	310.0	322.3	285.0	289.3	15.4
No. of grains/ear	30.2	33.8	32.4	27.1	27.9	3.45
Spike length (cm)	10.1	10.3	10.1	9.1	9.4	0.4
Test weight (g)	35.53	41.19	36.99	34.29	33.67	2.64
Straw yield (t/ha)	6.670	8.081	6.834	4.300	4.727	10.22
Grain yield (t/ha)	3.597	4.339	3.777	2.192	2.428	0.528

Effect on wheat crop

Growth and yield attributes of wheat crop were significantly varied by the treatments (Table 1). Wheat plants were taller in organic (T_2) being at par with 100 RDF (T_1) & INM (T_3) compared to absolute control and farmers practice. In organic, the plant attained 2.1, 8.7 & 10.6 cm more height over 100% RDF, farmers practice' and absolute control, respectively, due to the varied nutrient supply. Number of ears per unit area was more in INM, followed by organics and 100% RDF. Organics recorded 20.7 more ears/m^2 over farmers' practice. Length of spike was significantly less in absolute control and farmers' practice. The number of grains was more in organic (33.8/ear) being at par with INM and the latter was at par with 100 % RDF. However, test weight (41.2 g) was significantly more in organic (T_2) followed by INM (37.0 g) and 100% RDF (35.5 g) latter both being at par with each other.

As the growth and yield parameters of the wheat were improved with nutrition thereby the straw yield of the crop was significantly affected. Straw yield was significantly more in organic treatment. Wheat productivity in organic system (T_2) was 4.34 t/ha which was at par with integrated nutrient supply system (3.78 t/ha, T_3) and the latter being at par with inorganic fertilizer nutrient (T_1; 3.60 t/ha). Farmers' practice was significantly superior compared to absolute control. Results are in conformity with Bindia *et al,* 2005 and Mankotia *et al,* 2006 & 2008.

Economic returns of rice-wheat cropping sequence

Gross returns of rice –wheat system revealed that organic system (T_2) recorded higher value of Rs.2,28,412/ ha followed by integrated nutrient management (T_3, Rs.2,14,212/ha) and 100% RDF (Rs.2,00,293) (Table 2). T_2 recorded Rs.21,412, 28,119 & 75938/ha more returns over INM, 100% RDF & farmers practice, respectively largely due to the variation in grain and straw yields of the crops. However, net return (Rs. 1,09,753/ha) and benefit cost ratio (1.21) was higher with inorganic nutrient supply system (T_1) as the cost of FYM inflated the cost of cultivation in organic and INM. Cost of FYM in organic system inflated the cost of cultivation; therefore, economic analysis was also done by excluding the cost of FYM with the assumption that it is freely available with the hill farmers in integrated farming. Hence, economic analyses done by excluding the cost of FYM revealed that maximum

net returns of Rs. 1,49,474/ha & benefit cost ratio of 1.89 was recorded in organic production system (T_2) which is a sustained production system. As the values of productivity were low in absolute control (T_4) and farmers' practice (T_5) and hence these treatments recorded low profitability too.

Table 2: Profitability of organic and inorganic rice–wheat system

Treatment	Gross returns (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	Benefit:cost (Rs./Rs. invested)	Cost of cultivation (Rs./ha)	Net returns (Rs/ha)	Benefit:cost (Rs/Rs invested)
		Including cost of FYM			Excluding cost of FYM		
T_1-100% RDF through inorganic fertilizers	2,00,293	90,540	1,09,753	1.21	90,540	1,09,753	1.21
T_2-100% RDF through organic fertilizers (equivalent of N)	2,28,412	1,57,938	70,474	0.45	78,938	1,49,474	1.89
T_3-INM (75% through inorganic and 25% through organic sources)	2,14,212	1,08,638	1,05,574	0.97	87,638	1,26,574	1.44
T_4-Control (No fertilizer)	1,27,565	78,938	48,627	0.62	73,938	53,627	0.72
T_5-Farmers' practice	1,52,474	81,438	71,036	0.87	81,438	71,036	0.87

Price ((Rs./t)): rice grain=25000, rice straw=2500, wheat grain= 14000, wheat straw=6000, FYM=500

Conclusions

Thus, farmers of mid hills should apply full dose of fertilizers to Kasturi basmati (90,40,40 kg NPK) - wheat (120,60,30 kg NPK/ha) for higher productivity and profitability under inorganic production system. Substitution of 25% N with FYM in integrated nutrient management is also encouraging. Under organic production system, an application of FYM (equivalent to fertilizer N) to both 'Kasturi' rice-wheat (18 t/ha to rice+ 24 t/ha to wheat on dry weight basis) records more productivity (4.08 + 4.34 t/ha) and gross returns. The latter also records more net returns (Rs.1,49,474/ha) and benefit : cost (1.89) if farmers have FYM free of cost available with them as in integrated hill farming of Himachal Pradesh.

Acknowledgements

The authors are also thankful to the Director, ICAR-IIRR for providing financial assistance under AICRIP, Rice for carrying out the study. I am also thankful to the Director of Research, CSK Himachal Pradesh KrishiVishvavidyalaya for proving the facilities.

References

Anonymous.2017. Progress Report, All India Co-ordinated Rice Improvement Project 3:4.209-4.212.

Bindia, Kalia BD and Mankotia BS. 2005. Effect of integrated nutrient management on growth and productivity of wheat crop. *Agricultural Science Digest* 25 (4):235-239.

Mankotia BS. 2007. Effect of fertilizer application with farmyard manure and *in-situ* green manuring in standing rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agricultural Sciences* 77 (8):512-515.

Mankotia BS and Shekhar J. 2007. Integrated nutrient supply and seed rate for direct seeded rainfed upland rice (*Oryza sativa*) in mid hills of Himachal Pradesh. *Indian Journal of Agricultural Sciences* 77 (9):604-606.

Mankotia BS and Shekhar J, Thakur RC and Negi SC. 2008.Effect Effect of organic and inorganic sources of nutrients rice ((*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* 53 (1):32-36.

Mankotia BS, Thakur RC, Kumar J and Kumar S 2006. Use of *Lantana* and *Eupatorium* in rainfed maize – wheat system in North West Himalayas.*Indian Journal of Weed Science* 38 (3&4): 263-66.