

Residual effects of different soil organic amendments applied to aerobically grown rice (*Oryza sativa*) on succeeding wheat (*Triticum aestivum*) under basmati rice–wheat cropping system

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ABSTRACT

A field experiment was conducted during 2012–14 at Jammu, Jammu and Kashmir, to determine the residual effects of different soil organic amendments, viz. control (recommended fertilizer dose); *in-situ* green manuring of prickly sesban or *dhaincha* (*Sesbania cannabina* Willd.) on N-basis; *in-situ* green manuring of *dhaincha* followed by application of vermicompost on N-basis (1:1); *in-situ* green manuring of *dhaincha* followed by application of vermicompost and mulching with *dhaincha* on N-basis (1:1:1); *in-situ* green manuring of *dhaincha* followed by application of farmyard manure (FYM) on N-basis (1:1); and *in-situ* green manuring of *dhaincha* followed by application of FYM and mulching with *dhaincha* on N-basis (1:1:1) on productivity, nutrient uptake and economics of basmati rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L.) cropping rotation. Significant residual effects of different soil organic amendments, viz. *in-situ* green manuring of *dhaincha* followed by application of vermicompost and mulching with *dhaincha* on N-basis (1:1:1) and *in-situ* green manuring of *dhaincha* followed by application of FYM and mulching with *dhaincha* on N-basis (1:1:1) were observed on succeeding wheat in comparison to the control and rest of the treatments. With residual effect of *in-situ* green manuring of *dhaincha* followed by application of vermicompost and mulching with *dhaincha* on N-basis (1:1:1); and *in-situ* green manuring of *dhaincha* followed by application of farmyard manure (FYM) on N-basis (1:1); grain yield of succeeding wheat was 15.36% and 14.90%, respectively, higher than the control. The highest N : P : K uptake in wheat grain and straw were recorded with residual effect of *in-situ* green manuring of *dhaincha* followed by application of vermicompost and mulching with *dhaincha* on N-basis (1:1:1) and *in-situ* green manuring of *dhaincha* followed by application of FYM and mulching with *dhaincha* on N-basis (1:1:1); which in turn were significantly superior to the other treatments. The highest net returns of ₹44,092/ha and net returns/rupee invested 2.22 were obtained with residual effect of *in-situ* green manuring of *dhaincha* followed by application of vermicompost and mulching with *dhaincha* on N-basis (1:1:1)

Key words : Bread wheat, Economics, Farmyard manure, Green manure crop, Nutrient uptake, Productivity, Residual effects, Vermicompost

In India rice–wheat cropping system covers about 13 million ha, spreading over states of Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, Himachal Pradesh, Uttarakhand, Madhya Pradesh and Rajasthan. Rice–wheat cropping system accounts for about one-fourth of total

foodgrain production of South-East Asia (Abrol *et al.*, 1997) and about 31% of the total foodgrain production of India (Prasad, 2005). This signifies its contribution in meeting food requirements of the country. Though rice–wheat cropping system is considered as the backbone of food self-sufficiency, it is facing a sustainability problem due to practices of modern production system with indiscriminate use of chemical fertilizers and pesticides (Nambiar, 1994; Duxbury and Gupta, 2000; Prasad, 2005). There are 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). However, there is a scope to incorporate the summer green manure crop (*dhaincha*),

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vermicompost and FYM before rice, which acts as a source of nutrients for improved productivity and maintenance of soil fertility. Also, the green manuring before rice improves the nutrient-use efficiency of the applied fertilizer (Singh *et al.*, 1991). Typically; a summer green manure crop is grown for a specific period, and then ploughed under and incorporated into the soil. Green-manure crops being leguminous in nature usually perform multiple functions along with vermicompost and farmyard manure (FYM) that include improvement in nutrient content, organic matter addition in soil and soil protection as well as enhance microbial biomass and enzymatic activity in soil.

Farmyard manure is a product of microbial activity and contains large number of microbial population. Application of farmyard manure can increase the microbial activity in the soil, both by activating the microbial action and by aiding the multiplication of microbial population. Owing to these properties, application of farmyard manure is in perfect tune with biological requirement of soil and helps to build the soil on sustainable basis. Increase organic carbon by application of FYM increases enhances population of bacteria, actinomycetes and fungi (Gaur *et al.*, 1990). Vermicompost is the excreta of earthworm, which are capable of improving soil health and nutrient status. Vermiculture is a process by which all types of biodegradable wastes such as farmwastes, kitchen wastes, market wastes, bio-wastes of agro-based industries, livestock wastes etc. are converted while passing through the worm-gut to nutrient-rich vermicompost. Vermi-worms are used here act as biological agents to consume those wastes and to deposit excreta in the process called vermicompost. It is expected that regular incorporation of green-manure crops, FYM and vermicompost before rice may improve not only physico-chemical properties of soil but also enhance availability of macro and micronutrients in soil and its uptake by succeeding wheat under basmati rice-wheat cropping system. Keeping these in view, the present investigation was taken up to quantify the residual effects of summer greenmanure crop (*dhaincha*), FYM and vermicompost sources on productivity, economics and N: P: K uptake by succeeding wheat crop grown after basmati rice in a basmati rice-wheat cropping system.

MATERIALS AND METHODS

The field experiment was conducted at the research farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir, India, during the rainy (*kharif*) season (mid-June-mid-November) and winter (*rabi*) season (mid-November-mid-April) of 2012–13 and 2013–14 on a sandy-loam soil. The trials in both the years were conducted with a fixed lay out

plan in the same field. The soils had 260.10 kg/ha alkaline permanganate-oxidizable nitrogen (N), 12.24 kg/ha available phosphorus (P), 132.52 kg/ha 1 N ammonium acetate-exchangeable potassium (K) and 0.43% organic carbon. The pH of soil was 7.27 (1 : 2.5 soil : water ratio) (Prasad *et al.*, 2006) and diethylene triamine penta acetic acid (DTPA)-extractable Zn in soil was 0.67 mg/kg soil. The experiment was conducted in a split-plot design, keeping 4 Basmati cultivars, viz. 'Basmati 370', 'Basmati 564', 'Saanwal Basmati' and 'Ranbir Basmati', as main-plot treatments and 6 sources of different organic amendments, viz. T₁, control (recommended fertilizer dose); T₂, *in-situ* green manuring of *dhaincha* on N-basis; T₃, *in-situ* green manuring of *dhaincha* followed by application of vermicompost on N-basis (1:1); T₄, *in-situ* green manuring of *dhaincha* followed by application of vermicompost and mulching with *dhaincha* on N-basis (1:1:1); T₅, *in-situ* green manuring of *dhaincha* followed by application of FYM on N-basis (1:1); and T₆, *in-situ* green manuring of *dhaincha* followed by application of FYM and mulching with *dhaincha* on N-basis (1:1:1) in subplots and was replicated thrice. After 45 days, the summer green-manuring crop (*dhaincha*) was incorporated into the soil before direct-seeded rice. A seed rate of 60 kg/ha was used for sowing of *dhaincha*. For *in-situ dhaincha*, seed rate was worked out keeping in view the size of the plots of experimental treatments and the seed was sown by broadcasting. Besides, this an additional *ex-situ* crop of *dhaincha* was also grown by using similar quantity of seed 10 days before to the normal sown *in-situ*. This *ex-situ dhaincha*, crop was used to assess nitrogen content to be taken as reference for working out the quantity of *dhaincha* to meet out the different nitrogen requirement as per of the experimental treatments. Organic amendments, viz. FYM with 45% moisture, vermicompost with 50% moisture and fresh biomass of *dhaincha* with 80% moisture, used as sources of nitrogen were analysed for determine their N content (oven-dry weight basis) to decide the total quantity of these organic amendments to be used to supplement 30 kg N/ha. The quantity of FYM, vermicompost and fresh biomass of *dhaincha* to fulfil the recommended dose of nitrogen on their respective N contents was 10.88, 5.00 and 8.30 t/ha were applied 2 weeks before direct-seeded rice each year. Farmyard manure, vermicompost and *dhaincha* had an average composition of 36.6% C, 0.60% N, 1.3% P and 1.5% K and 1.56% N, 1.6% P, 1.8% K and 1.85% N, 1.7% P, 1.4 K respectively. The *ex-situ* raised *dhaincha* crop was cut near the ground surface and 10 kg (8.33 tonnes/ha) of its fresh biomass was spread in the inter-row spaces of each plot of mulching treatments 20 days after sowing. Recommended doses of N: P: K (30:20:10 kg/ha) were applied. Total P, K and half doses of

N were broadcast before sowing and rest was top-dressed at tillering and flowering stages in equal doses. Direct-seeded basmati rice was sown in lines giving row-to-row spacing of 20 cm using a seed rate of 40 kg/ha and bread wheat 'RSP 561' was sown, 22.5 cm apart, in rows using 100 kg seed/ha in the middle of November and harvested in the last week of April in both the years. The fixed layout plan of preceding basmati rice was used for bread wheat also for both the years of experimentation. Since the objective of this study was to quantify the residual effects of different soil organic amendments applied to preceding basmati rice on succeeding bread wheat, therefore, a blanket crop of wheat 'RSP 561' was taken with its recommended package of cultivation during winter (*rabi*) in all the treatments using 100:50:25:N:P:K kg/ha to assess the impact of rainy season (*khariif*) treatments on the performance of succeeding wheat in rice-wheat system. Ten spikes were randomly selected from each plot for recording the data on yield attributes. One thousand grains were counted randomly from each subplot, and their weight was recorded at 12% moisture and expressed. Harvesting of the bread wheat was undertaken as soon as it attained the harvest maturity. Economics of durum wheat cultivation was calculated based on the prevailing market prices during the respective crop seasons. The gross and net returns were calculated. Benefit: cost ratio (B:C) was calculated. All the replicated data obtained from the experiments were statistically analysed for pooled analysis using the F-test as

per Gomez and Gomez (1984). Critical difference (CD) values at $P = 0.05$ were used to determine the significance of differences between treatment means. Correlation and regression analyses were done by using SPSS 11.5 package of statistical analysis.

RESULTS AND DISCUSSION

Residual effect

Incorporation of soil organic amendments into soil, fixed more atmospheric N biologically in the soil and also added higher amount of organic matter which is good indicator of soil fertility and improved status of available nutrients in the soil (Dwivedi *et al.*, 2005). The total amount of N added was the higher in the soil through soil-applied organic amendments (Table 1).

Yield attributes

Yield attributes of succeeding wheat were numerically higher, when it was preceded by 'Ranbir Basmati' and it was followed by wheat preceded by 'Basmati 370', 'Saanwal Basmati' and 'Basmati 564'. Among different soil organic amendments, the wheat crop in the treatment T_4 , where the preceding crop of basmati rice was grown by supplementing nutrients through *in-situ* green manuring of *dhaincha* + vermicompost + mulching with *dhaincha* on N-basis (1:1:1) recorded highest yield attributes followed by treatments; T_6 , T_3 , T_5 , T_2 , and T_1 , RFD during both the cropping seasons of winter 2012–13 and 2013–14 (Table 1).

Table 1. Effect of basmati rice cultivars and soil organic amendments on yield attributes of succeeding crop of wheat and soil pH, organic carbon and available nitrogen (pooled data of 2 years)

Treatment	Soil pH	Organic carbon (%)	Available N (Kg/ha)	Plants/m ²	Effective ears/ m ²	Grains/ear	1,000-grain weight(g)
<i>Basmati cultivars</i>							
V ₁	7.19	0.52	256	300.3	287.3	41.4	39.2
V ₂	7.18	0.53	257	290.5	279.6	39.5	38.6
V ₃	7.18	0.52	256	299.3	285.6	40.8	39.1
V ₄	7.18	0.52	256	302.5	289.9	41.9	39.3
SEm±	0.18	0.02	6.70	4.89	5.99	3.81	5.27
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS
<i>Soil organic amendments</i>							
T ₁	7.27	0.42	250	287.1	274.5	40	38.7
T ₂	7.18	0.50	268	291.6	280	40.5	38.8
T ₃	7.23	0.46	261	297.4	287.5	41.1	39.2
T ₄	7.21	0.47	263	304.6	296.4	41.4	39.5
T ₅	7.20	0.49	266	294.3	283.7	40.5	38.8
T ₆	7.22	0.48	264	303.1	292.4	41.2	39.3
SEm±	0.03	0.01	2.9	5.77	6.79	6.05	7.13
CD (P=0.05)	0.09	0.03	8.9	NS	NS	NS	NS

Initial values of soil pH, 7.27; OC, 0.43%, and available; N, 260 kg/ha/details of T₁, T₂, T₃, T₄, T₅, and T₆ are given under materials and methods; V₁, Basmati 370; V₂, Basmati 564; V₃, Saanwal Basmati; V₄, Ranbir Basmati

Yield and harvest index

The grain yield of succeeding wheat after rice recorded significant effect by the application of treatment T₄, *in-situ* green manuring of *dhaincha* + vermicompost + mulching with *dhaincha* on N-basis (1:1:1) during the second year of crop-growing season of winter 2013–14 and straw yield during both the cropping seasons (Table 2). It was fol-

lowed by treatment T₆, *in-situ* green manuring of *dhaincha* + FYM + mulching with *dhaincha* on N-basis (1:1:1). These treatments in turn were significantly superior to the other treatments. Wheat grain yield was 15.8% higher in *Sesbania*-incorporated plot than summer fallow. Similarly, wheat straw yield was 10% higher in *Sesbania*-incorporated plots than summer fallow. Similar trend was

Table 2. Effect of basmati cultivars and soil organic amendments on productivity and economics of succeeding wheat (pooled data of 2 years)

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Cost of cultivation(a) ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio
<i>Basmati cultivars</i>						
V ₁	4.2	4.7	48.4	19.8	38.9	1.96
V ₂	3.9	4.4	47.6	19.8	33.7	1.70
V ₃	4.0	4.4	47.3	19.8	38.0	1.91
V ₄	4.2	4.7	49.6	19.8	41.8	2.10
SEm±	1.00	2.16	3.3	-	-	-
CD (P=0.05)	NS	NS	NS	-	-	-
<i>Soil organic amendments</i>						
T ₁	3.8	4.0	48.7	19.8	38.1	1.9
T ₂	4.0	4.4	49.5	19.8	39.1	1.9
T ₃	4.0	4.4	49.6	19.8	39.1	1.9
T ₄	4.4	4.9	49.3	19.8	44.0	2.2
T ₅	4.0	4.4	48.2	19.8	38.8	1.9
T ₆	4.3	4.8	49.1	19.8	42.0	2.1
SEm±	1.1	1.2	1.3	-	-	-
CD (P=0.05)	NS	NS	NS	-	-	-

V₁, 'Basmati 370'; V₂, 'Basmati 564'; V₃, 'Saanwal Basmati' and V₄, 'Ranbir Basmati' were sown in preceding year in rice–wheat system details of T₁, T₂, T₃, T₄, T₅, and T₆ are given under materials and methods

Table 3. Effect of cultivars and soil organic amendments on uptake of N, P and K in wheat (kg/ha) (pooled data for 2 years)

Treatment	Grain			Straw		
	N	P	K	N	P	K
<i>Basmati cultivars</i>						
V ₁	40.3	9.1	21.0	33.4	8.5	59.4
V ₂	40.1	9.0	20.0	32.0	7.3	59.2
V ₃	40.2	9.0	20.0	33.0	8.4	59.3
V ₄	41.0	9.5	21.0	34.0	8.7	60.0
SEm±	0.58	0.61	0.34	0.45	0.96	0.99
CD (P=0.05)	NS	NS	NS	NS	NS	NS
<i>Soil organic amendments</i>						
T ₁	50.0	10.0	20.0	32.1	8.3	58.0
T ₂	49.4	11.1	22.5	33.0	8.9	58.6
T ₃	49.5	11.5	23.0	33.0	9.2	58.9
T ₄	57.1	13.4	26.3	34.4	11.3	64.3
T ₅	49.5	11.5	23.0	33.1	9.0	58.8
T ₆	56.0	13.3	26.1	34.1	11.1	64.0
SEm±	1.62	0.20	0.50	0.30	0.67	1.07
CD (P=0.05)	4.87	1.20	1.5	0.90	2.15	3.22

V₁, 'Basmati 370'; V₂, 'Basmati 564'; V₃, 'Saanwal Basmati' and V₄, 'Ranbir Basmati' were sown in preceding year in rice–wheat system details of T₁, T₂, T₃, T₄, T₅, and T₆ are given under materials and methods

also recorded for harvest index. This could be attributed to the higher supply of N and other micronutrient cations through the incorporation of legumes into soil (Bisht *et al.*, 2006; Pooniya and Shivay, 2011). The increased availability of Fe and other micronutrients in soil with regular summer green manuring every year before transplanting of rice in rice-wheat system was responsible for higher yields in the green manuring plot compared with the non-green-manuring plot (Nayyar and Chhibba, 2000).

Nutrient uptake

Residuals of organic applied treatments had a significant effect on N, P and K uptake in grain and straw by succeeding wheat. The increase in N,P,K uptake by succeeding wheat with the residuals of T₄ and T₆ treatments was significantly higher than rest of the treatments which led to 25.25, 17.57, 17.43 and 17.33% increase over the treatments T₁, T₂, T₅ and T₃ respectively (Table 3).

Economics

The highest net returns (41.8×10^3 ₹/ha) and benefit: cost ratio (2.10) were recorded by wheat crop which was preceded by 'Ranbir Basmati', whereas the lowest were noticed while preceded by 'Basmati 564'. Amongst the soil organic amendments, the highest net returns (44×10^3 ₹/ha) and benefit: cost ratio (2.2) were realized as preceded by treatment *in-situ* green manuring of *dhaincha* followed by application of vermicompost and mulching with *dhaincha* on N-basis (1:1:1).

Based on 2 years study, it can be concluded that the wheat crop preceded by 'Ranbir Basmati' recorded the highest yields and profits, whereas the yield of wheat preceded by basmati was higher with *in-situ* green manuring of *dhaincha* + vermicompost + mulching with *dhaincha* on N-basis (1:1:1).

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