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Impact of Organic Farming on Yield and Quality of BASMATI Rice and Soil Properties

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Abstract:
The management of soil organic matter is critical to maintain a productive organic farming system. No one source of nutrient usually suffices to maintain productivity and quality control in organic system. In addition, the inputs to supplement nutrient availability are often not uniform presenting additional challenges in meeting the nutrient requirement of crops in organic systems. With this concept, a field experiment was conducted at the research farm of Indian Agricultural Research Institute, New Delhi, India during 2003-06 in rice-wheat-green gram cropping system. In this experiment, different treatments comprising organic amendments such as Blue Green Algae (BGA) 15kg/ha, Azolla *1.0 tonne/ha, Vermicompost and Farm Yard Manure (FYM) 5.0 tonne/ha each applied alone or in combination were tested in organic crop production. These treatments were compared with absolute control ($N_0P_0K_0$) and recommended dose of chemical fertilizer ($N_{80}P_{40}K_{40}$). In wheat crop* Azotobacter *replaced* Azolla, *but other treatments remained same. For rice, a scented variety 'Pusa Basmati 1' and for wheat and green gram HYVs were taken. Biomass of green gram was incorporated in soil after picking of pods and wheat was sown using zero tillage practice. The observations on grain yield, contents of Fe, Zn, Mn and Cu in rice grains, insect pest incidence, soil nutrients and microbial activity were taken.*
Results revealed a significant enhancement in grain yield of rice over absolute control due to the application of different organic amendments applied alone or in combinations. Rice grain yield increased by 114 to 116.8% over absolute control when all the 4 organic amendments were applied altogether. The rice grain yield (4.0 t ha^{-1}) obtained under combined application of four organic amendments was at par with the yield recorded under recommended dose of chemical fertilizer application. An interesting observation recorded was that there was no serious attack of any insect pest or disease in organically grown crop. Soil microbial population (Actinomycetes, Bacteria, Fungi and BGA) enhanced due to the application of organic amendments in comparison to absolute control as well as recommended fertilizer application that in turn resulted in a notable enhancement in soil dehydrogenase and phosphatase enzyme activity. Soil organic carbon and available phosphorus contents were also found to be significantly increased due to organic farming practice over control as well as chemical fertilizer application.
Rice grain analysis for nutrients viz. Fe, Zn, Mn and Cu showed a significant increase in Fe and Mn content in the treatments having 2 or more organic amendments over control. Zn and Cu content also increased but the increment was significant with combined application of 3 or 4 organic amendments.
The study revealed that addition of four organic amendments viz. BGA, Azolla, *FYM and Vermicompost could give the optimum yield (4.05 t/ha) of organic Basmati rice and improve grain and soil quality.*

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Introduction:

Organic farming production system aims at promoting and enhancing agro-ecosystem health, biodiversity, biological cycles and soil biological activities. In organic farming we constantly work to build the healthy soil that translates into healthy plants. Crop plants remove varying amounts of different nutrients from soil and to compensate the loss from the soil, organic amendments rich in nutrients must be added (SINGH & MANDAL 2000). In organic farming we feed the soil micro and macro-organisms, which deliver a smorgasbord of minerals, vitamins and other nutrients to the crop at a metered pace.

The rice - wheat production system of South Asia, occupying 11 million ha area in India, is among the most productive cropping systems in the world. However, this system has shown signs of fatigue and evidences suggest that natural resources may be reducing productivity in this system. Problem of such resource degradation may be solved to some extent if organic farming is taken up in selected areas having this system. Basmati (scented) rice is best suited for this due to its lower nutritional requirement. To adopt organic farming of Basmati rice and wheat, areas need to be demarcated and reasonable price guarantee may be necessary (PRASAD 2005). India's export of Basmati rice may be further boosted if it is grown organically. Through organic farming, incidences of occurrence of disease and insects may be reduced; soil and grain quality improved (STOCKDALE 2001) and fragrance (aroma) in Basmati rice may be upgraded. With such background an experiment was conducted to find out the feasibility of organic farming in rice –wheat-green gram cropping system and examine the impact of this on the yield and quality of grain and soil properties.

Methods:

A field experiment was conducted at the research farm of Indian Agricultural Research Institute, New Delhi, India during 2003-06 in rice-wheat-green gram cropping system. In this experiment different treatments comprising organic amendments such as Blue Green Algae (BGA) 15kg/ha, *Azolla* 1.0 tonne/ha, Vermicompost and Farm Yard Manure (FYM) 5.0 tonne/ha each applied alone or in combination were tested in organic crop production. These treatments were compared with absolute control ($N_0P_0K_0$) and recommended dose of fertilizer ($N_{80}P_{40}K_{40}$). The treatments (16) were laid out in Randomized Block Design and replicated thrice with a plot size of 24 m^2 each. In wheat crop *Azotobacter* replaced *Azolla*, but other treatments remained same. For rice, scented variety 'Pusa Basmati 1' and for wheat and green gram HYVs were taken. Biomass of green gram was incorporated in soil after picking of pods and wheat was sown using zero tillage practice. The observations on plant growth, grain yield, concentrations of Fe, Zn, Mn and Cu content in rice grains, insect pest incidence, soil nutrients and soil microbial activity including soil enzymes were taken as per standard procedures.

Results and Discussion:

Grain and straw yield of rice and wheat increased significantly over absolute control due to the application of different organic amendments applied alone or in combination (Tab. 1). Mean data on rice grain yield of 3 seasons (2003-2006) revealed that organic amendments applied alone showed an increase of 14.3 to 44% over control. Positive effects of use of green manuring (MANDAL et al. 1992), BGA and *Azolla* (SINGH & BISOYI 1989, SINGH & MANDAL 2000) and incorporation of crop residues (SINGH & MANDAL 2000) have been reported. Combined application of two and three organic amendments increased the grain yield in rice in the range of 65 to 102% and 100 to 112% respectively, compared to absolute control. Application of all the four organic amendments together had the maximum cumulative effect and increased the rice

grain yield by 114 to 116.8% over absolute control. The rice grain yield (4.05 t/ha) obtained under combined application of four organic amendments was at par with the yield recorded under recommended dose of chemical fertilizer application (4.38 t/ha). Similar trend was recorded in grain yield of wheat but yield of wheat was lower as compared to its optimum yield level. Interestingly, there was no serious incidence of any insect pest or disease in organically grown rice and wheat crop. Soil microbial population *viz.* Actinomycetes, Bacteria, Fungi and BGA increased due to the application of organic amendments which further influenced the soil dehydrogenase and phosphatase enzyme activities.

Tab. 1: Effect of different organic treatments on rice grain yield, content of Iron (Fe), Zinc (Zn), Copper (Cu) and Manganese (Mn) in rice grain and microbial activity in soil at mid crop stage of rice (mean of 3 years). 1*=Actinomycetes; 2*= Bacteria; 3*=Fungi; 4*= BGA; 5*=Dehydrogenase enzyme activity ($\mu gTPE.g^{-1}$ soil.$24h^{-1}$).
Rate of application/ha: *Azolla* 1.0 t; BGA 15 kg; FYM 5.0 t; Vermicompost 5.0 t.

No	**Treatments**	**Rice grain yield (t/ha)**	**Content in rice grain (ppm)**				**Soil microbial population ($x10^3$CFU/gm of soil) and enzymatic activity***				
			Fe	Zn	Cu	Mn	1*	2*	3*	4*	5*
1	*Azolla* (A)	2.54	35.1	32	12	34	332	369	31	59	131
2	BGA (B)	2.46	34.8	31	12	33	341	356	63	74	124
3	FYM (F)	2.24	35.2	32	12	34	261	322	51	61	110
4	Vermi-com-post (V)	2.66	35.3	32	13	35	276	365	43	48	108
5	A+B	3.25	37.2	34	12	35	287	380	32	23	121
6	A+F	3.42	36.2	33	13	36	279	364	33	42	134
7	A+V	3.85	36.9	33	14	34	195	321	32	35	113
8	B+F	3.26	36.1	33	13	35	267	386	34	55	113
9	B+V	3.50	37.1	34	14	36	243	364	37	68	127
10	F+V	3.58	37.4	34	13	35	267	368	34	57	112
11	A+B+F	3.66	38.9	35	15	37	256	376	41	78	120
12	A+F+V	3.70	37.6	35	16	39	380	402	65	98	124
13	B+F+V	3.82	38.3	35	16	38	376	378	75	86	132
14	A+B+F +V	4.05	39.8	36	17	40	301	334	61	87	125
15	$N_{80}P_{40}$ K_{40}	4.38	33.1	32	13	36	164	332	69	23	101
16	N_0 P_0K_0	1.84	32.4	31	12	32	160	312	29	12	101
	CD (at 5%)	0.48	3.4	3	4	4					

Microbial population of Actinomycetes, Bacteria, Fungi and BGA in a composite soil sample before starting of experimentation in 2003 was $74x10^3$, $203 x10^3$, $14 x10^3$ and $3 x10^3$ CFU/gm of soil respectively. Rice grain analysis for Iron and Manganese content showed a significant increase in the treatments having 2 or more organic amendments over control (Tab. 1).

Conclusion:

Use of different organic amendments *viz.* Blue Green Algae, *Azolla*, Vermicompost and Farm Yard Manure in a cumulative manner can meet the nutrient requirement of organic scented rice in rice- wheat-green gram cropping system. Organic farming enhanced soil organic carbon, available phosphorus content and microbial population / enzymatic activity of soil thus making it sustainable for organic crop production. Increase in Fe and Mn content in rice grain further indicated that their use not only maintain the soil productivity but also improve the grain quality.

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