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Research Article

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Effect of Organic Farming Practices on Yield of Basmati Rice and Soil Properties in Rice, Wheat Cropping System

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ABSTRACT

This paper analyzes 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 village Jahangirpur in Jewar Tehsil in Gautam Buddha Nagar district of Uttar Pradesh during 2014-2016 in rice-wheat cropping system. In this experiment, different treatments comprising organic amendments such as Blue Green Algae (BGA) 15kg/ha, SGM 10.0 tonne/ha, and Farm Yard Manure (FYM) 10.0 tonne/ha each applied alone or in combination were tested in organic crop production. These treatments were compared with absolute control (N0P0K0). For rice, a scented variety 'Pusa Basmati 1' were taken. 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 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. 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 2 or 3 organic amendments. The study revealed that addition of three organic amendments viz. BGA, SGM, and FYM could give the optimum yield (4.05 t/ha) of organic Basmati rice and improve grain and soil quality.

Keywords: *Organic farming, Bio fertilizer, Organic amendments, Grain quality, Basmati rice, Soil microbial activity*

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.

MATERIALS AND METHODS

The present investigation has been undertaken during the two cropping cycles *viz.* Kharif (rice) 2015 to rabi (wheat) 20015-16. The details of field experiment and methodology adopted have been described under the following heads:

Experimental site:-Farmer field is situated in the village Jahangirpur here farmers are practicing organic farming since last 8 years. Jahangirpur is in Jewar Tehsil in Gautam Buddha Nagar district of Uttar Pradesh State. It comes under Jahangirpur Panchayat and belongs to Gautam Buddha Nagar Division. It is located 32 km towards South from District headquarters Noida. Geographically is situated at 28.18°N 77.72°E latitude; 196 m above mean sea level. It has a semiarid and subtropical climate with hot dry summer and severe cold winter. The tempreture in summer rises up to 48 ^{0}C with desiccating dust, sweeping winds.

3.1.2 Climate:- Jahangirpur climate lies in Sub-tropical semi-arid (steppe) climatic zone. This climate is a transitional climate falling between tropical desert and humid sub-tropical, with temperatures which are less extreme than the desert climate. The annual rainfall is between 30 and 65 cm but is very unreliable and happens mostly during the summer monsoon season. Maximum temperatures during summer can rise to 48 °C. Minimums during winter can drop down to freezing point. Areas under this belt do not experience high humidity throughout the year except during the monsoon season, and are generally dry.

3.1.2 Soil characteristics :- Taxonomically, the soil of the study area falls in sandy clay loam soil (typical Ustochrept, 51.46% sand, 23.02% silt and 25.52% clay) of low in organic C (0.57%), medium in available phosphorus (19.87 kg/ha), high in available potassium (247.12 kg/ha) and low in available nitrogen (163.2 kg/ha) and of pH 8.

Field studies:- The field experiment was conducted on a pre-established long-term field experiment which comprised of 6 treatments each replicated four times was continued for the purpose of present investigation. The treatment detail was as under

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- T1 (CONTROL) is absolute control does not have any fertilizer or organic matter it is denoted as N0P0K0
- T2 FYM @10 T/ha field treated with farm yard manure with 10 t/ ha
- T3 SGM @10 T/ha field treated with segbania Green manure with 10 t/ ha
- T4 SGM+BGA @10 T/ha +15 kg /ha BGA field treated with combination of SGM and blue green algae at the rate of 10 T/ha and 15 kg /ha BGA respectively.
- T5 SGM+FYM @5 T/Ha+5 T/Ha field treated with SGM and FYM at the rate of 5 t/ha each.
- T6 SGM+FYM+BGA 5 T/Ha+5 T/Ha+15 kg /ha BGA field treated with SGM , FYM and BGA at the rate of 5 t/ha ,5 t/ha and 15 kg/ha respectively

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 2 seasons (20014-20016) 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 midcrop stage of Microbial population of Actinomycetes, Bacteria, Fungi and BGA in a composite soil sample before starting of experimentation in 2003 was 74x103, 203 x103, 14 x103 and 3 x103 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).

Table 1:

No Treatments	Rice grain yield (t/ha)	Content in rice grain (ppm)			
T1	2.54	Fe	Zn	Cu	Mn
T2	2.65	35.1	32	12	34
T3	2.85	36.6	32.4	14.2	36
T4	3.41	38.1	34.5	16.6	36.6
T5	3.96	39.3	33	17	41
T6	4.05	40	37	17.4	42

Table 2: Evaluation of soil microbiological parameters from rice field, as influenced by various microbial formulations at midcrop stage

Sample	Dehydrogenase (µg/g/d)	Soil chlorophyll (mg/g soil)	MBC (µg g soil^{-1})
T1	32.89	0.160	731.808
T2	66.22	0.254	809.424
T3	120.62	0.248	1530.144
T4	154.90	0.235	1053.36
T5	50.66	0.180	1552.32
T6	117.95	0.452	1186.416
SEM	0.016	0.016	15.29
CD	0.043	0.043	42.20

Dehydrogenase activity is known as an indicator to increase markedly with increasingly active viable cells (Casida et al., 1964). In an earlier study, higher values of dehydrogenase activity were recorded in inoculated treatments as compared with control as result of a marked increase in microbial activity (Nain et al., 2010). At 45 DAT Dehydrogenase activity mean value was quite low and ranged from 32.89 µg/g soil in controls to 154.90 µg/g/d soil in the microbial treatments.(Table 2). T4(SGM+BGA) which was highest followed by T6(SGM+FYM+BGA) in basmati 1 were the top ranked treatments. The soil dehydrogenase activity was significantly higher due to the application of microbial formulations than the control T1. Rashid et al., (2016) documented importance of microorganisms in nutrient-acquisition and emphasized the potential role of fungal and bacterial inoculants in restoring the fertility of degraded lands. Soil chlorophyll was highest in T6 (SGM+FYM+BGA), (0.452) and significantly higher as compared to all treatments and control. At 45 DAT, all microbial formulations recorded higher values. Microbial biomass carbon (Table 2) was highest in T3 (SGM) (1530.1) and significantly higher as compared to all treatments and control. The microbial biomass carbon is a small but considered as an important reservoir of C and the biomass helps in transforming carbon (Dick, 1992). The higher MBC in the soils under cover crop-related rotations represent either a sink or source for higher plant-available C, depending on cropping changes in the soil environment. At 45 DAT, all microbial formulations recorded higher values (Table 2).Earlier studies observed that cover crop-related rotations increased soil MBC. The changes of MBC were similar to those observed under a range of ecosystems from temperate and tropical regions (Prasad et al., 1994, Tian et al., 2009). Mineralization of soil organic matter and nutrients are mediated by soil microorganism (Balota et al., 2004).

Table 3: Evaluation of soil microbiological parameters from rice field, as influenced by various microbial formulations at midcrop stage

Treatment	Carbon %	Available Nitrogen (kg/ha soil)	Available Phosphorus(kg/ha soil)
T1	0.567	134.67	13.893
T2	0.533	150.37	17.600
T3	0.567	110.27	13.547
T4	0.500	168.87	25.733
T5	0.550	181.77	28.373
T6	0.750	167.17	34.347
SEM	0.016	4.39	0.827
CD	0.043	12.02	2.24

Carbon (%) values ranged from 0.567–0.750, with no significant differences observed among the treatments (Table 14). Vazquez et al., (2000) found that the inoculation of corn (Zea mays L.) with G. deserticola decreased the population of fluorescent pseudomonads in the rhizosphere, which they attributed to a reduction in rhizosphere C levels associated with AMF colonization. Walley & Germida (1997) reported that a strain of Pseudomonas cepacia, previously identified as a PGPR, reduced AMF spore germination, percent AMF colonization, and root length of wheat (*Triticumae stivum* L.) colonized by G. clarum.. Earlier reports showed that some medicinal and aromatic plants improved the growth and fresh biomass yield after inoculating endophyticbioinoculants (Tiwari et al., 2010, Singh et al., 2012a). Previous study reported by several researchers that due to use of organic manures and bioinoculants increased the soil organic carbon content (Singh et al., 2013). Since these bioinoculants provides major soil nutrients and other micronutrients which helps in maintaining soil health and quality crop yield. (Vafadaret al., 2013) Available N of soil analysis T5 (SGM+FYM) showed highest values after 45 DAT (181.77 kg/ha) (Table 3). All treatment showed significant effect over control; upon comparison it as found that more increment was seen in treatments .Soil available P was recorded highest in T6 (34.34 kg/ha) after 45 DAT which was at par with two other treatments and control; Microbial treatments showed positive effects on enhancement of soil available nutrient like nitrogen and phosphorus; Soil available nitrogen was maximum elicited by T6 in both time-based data. On other hand available P was maximum elicited byT6. Verma et al. (2016) studied the influence of synergistic partnership of *Providencia* sp. PW5-*Anabaena laxa* CW1 in two cultivars of pea; Arkel and GP-17 and concluded that in both cultivars, significant increment was recorded in alkaline phosphatase, glomalin, dehydrogenase, acid phosphatase and microbial biomass carbon.

Table 4: Defense enzyme activity in plant root samples from rice field, as influenced by various microbial formulations at midcrop stage

Treatments	Peroxidase activity (IU/g fresh wt.)	
	Root	Shoot
T1 (Control)	0.134	0.187
T2 (FYM)	0.303	0.142
T3 (SGM)	0.114	0.145
T4 (SGM+BGA)	0.135	0.133
T5 (SGM+FYM)	0.356	0.196
T6 (SGM+FYM+BGA)	0.414	0.201
SEM	0.257	0.118
CD	0.709	0.325

It is well known that large amounts of H_2O are produced due to cellular processes, as a response to stress factors or to external sources to plant–pathogen interactions and micro-organisms can elicit enhanced activity of these enzymes. Plant peroxidases are associated with several cellular processes related to plant development and stress responses (Mika, Boenisch, Hopff, & Luthje, 2010) and represent versatile biocatalysts with an ever-increasing number of applications, as they can detoxify or generate reactive oxygen species polymerise cell wall compounds and regulate H2O2 level (Passardi, Cosio, Penel, & Dunand, 2005) Peroxidase activity of root found in 45 DAT was highest in T6 (SGM+FYM+BGA) (0.414) and T5 (0.356) all treatments showed significantly higher values over control except T3(SGM) (Table 4). Similarly in shoot sample an increasing trend was seen after 45 DAT in case of T6 (SGM+FYM+BGA) (0.201) and T5 (SGM+FYM) (0.196), T6 (SGM+FYM+BGA) showed two fold increment over control. In an earlier study, cyanobacterial formulations were found to trigger high levels of plant defense enzyme activity in tomato plants, which was found to be among the underlying bioprotection mechanisms against *Fusarium* wilt (Prasanna, Chaudhary, et al., 2013).

Table 5: Defense enzyme activity in plant root samples from rice field, as influenced by various microbial formulations at midcrop stage

Treatments	Poly Phenol Oxidase activity (IU/g fresh wt.)	
	Root	Shoot
T1 (Control)	0.014	0.022
T2 (FYM)	0.018	0.033
T3 (SGM)	0.014	0.023
T4 (SGM+BGA)	0.014	0.019
T5 (SGM+FYM)	0.015	0.036
T6 (SGM+FYM+BGA)	0.023	0.044
SEM	0.048	0.205
CD	0.132	0.565

At 45 DAT, The highest Polyphenol oxidase activity in root was recorded in microbial inoculant T6 (SGM+FYM+BGA) 0.023 IU g^{-1} fresh tissue followed by T2(FYM) 0.018 and T5 (SGM+FYM) 0.015 IU g^{-1} fresh tissue, all treatments showed significantly higher activity than control.whereas in shoot tissues at 45 DAT highest Polyphenol oxidase activity was recorded in T6 (SGM+FYM+BGA) followed by T5 (SGM+FYM) and lowest value was recorded in T1 (Control) (Table 5). PPO and other defenses were also found to be strongly induced by MeJA and oligogalacturonic acid, major plant defense signaling compounds (Constabel et al., 1995). Since PPO induction in tomato by multiple signals occurs in parallel with a suite of other anti-herbivore proteins including several types of protease inhibitors (PIs) and the anti-nutritive enzymes arginase and threonine deaminase (Bergey et al., 1996; Chen et al., 2005), PPO is thought to play a similar role in defense against insects. In tobacco, PPO and PIs are upregulated by tobacco systemin as well as by MeJA (Constabel & Ryan, 1998; Ren & Lu, 2006). Likewise, strong herbivore-, wound-, and MeJA-induction of PPO was shown in leaves of several poplar species (Constabel et al., 2000, Haruta et al., 2001).

Table 6: Defense enzyme activity in plant root samples from rice field, as influenced by various microbial formulations at midcrop stage

Treatments	Phenylalanine lyase activity (IU/g fresh wt.)	
	Root	Shoot
T1 (Control)	43.65	92.24
T2 (FYM)	106.64	312.02
T3 (SGM)	124.87	284.83
T4 (SGM+BGA)	188.54	250.18
T5 (SGM+FYM)	114.33	317.23
T6 (SGM+FYM+BGA)	199.81	361.97
SEM	0.127	0.110
CD	0.350	0.303

At 45 DAT, Plant defense enzyme activity, such as Polyphenol oxidase, peroxidase, phenylalanine ammonia-lyase enzymes was analyzed in the root and shoot samples of basmati 1 rice plant. In root highest PAL activity recorded in T6 (SGM+FYM+BGA) 119.81 IU g^{-1}fresh tissue followed by T4 (SGM+BGA) 188.54 IU g^{-1} fresh tissue lowest activity showed by T1 (Control) (Table 6). Likewise at 45 DAT, in shoot highest PAL

activity recorded in T6 (SGM+FYM+BGA) 381.97 IU g^{-1} fresh tissue followed by T5 (SGM+FYM) 317.23 IU g^{-1} fresh tissue. which was significantly higher as compared with T1 (Control) 92.24 IU g^{-1} fresh tissue.

Antioxidant enzyme activity in plant root samples from rice field, as influenced by various microbial formulations at midcrop stage

In present study SOD activity in root positively enhanced by microbial inoculation SGM+FYM+BGA (T6) and SGM (T3), Which antioxidant activity against oxidative stress, Microbial inoculant showed higher activities over control in 45 day of sampling. Likewise in catalase Co-inoculant (T6) showed pronounced effect against oxidative stress and on 45 DAT was recorded higher in T6 (0.051 IU/mg protein) and T5(0.046 IU/protein) followed by T2, all treatments significantly higher over control (Table 7).likewise APX activity in root on 45 DAT was recorded higher in T6 (0.046 IU/mg protein) and T5(0.041 IU/protein) followed by T3, all treatments significantly higher over control. The PGPR have also been reported to enhance the yield and quality of egg- plants under stressed environment. As an example, the inoculation effect of PGPR, Pseudomonas sp. DW1 on growth, mineral uptake and physiological activities of the antioxidant enzymes including superoxide dismutase (SOD), peroxidase (POD) and catalase (CAT) of eggplant plants grown under salinity stress was found variable (Fu et al., 2010). Pseudomonas-inoculation increased the germination percentage and also enhanced the growth relative to un-inoculated eggplants. While comparing the impact of Pseudomonas inoculation and salinity on eggplants, it was found that salinity significantly decreased K+ concentration and increased Na concentration, but did not significantly decrease Ca^{2+} content in shoots of eggplants. In contrast, Pseudomonas sp. inoculated plants had higher shoot Ca^{2+} but no increase in shoot Na^{+} concentration compared to non-inoculated plants grown under salinity stress. Instead, Pseudomonas application reduced NaCl in plants grown in soils treated even with 2 and 3 g kg soil -1 NaCl.

CONCLUSION

Use of different organic amendments viz. Blue Green Algae, SGM 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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