Use of fortified compost for improving soil properties and enhancing wheat grain yield in an acid Alfisol

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Abstract

An experiment on wheat (cv. HS-295) was conducted in growth chamber of the Department of Organic Agriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur during *rabi* 2011 with seven treatments and four replications in completely randomized design. Biocomposts were prepared from cow dung, *Eupatorium* weed and with two levels of rock phosphate i.e. (5% and 10%). The best one among three biocomposts i.e. cowdung + *Eupatorium* weed + 5% rock phosphate was selected and applied to wheat in combination with fertilizers. The highest grain yield was recorded in treatment- fortified compost + 5ml bio-inoculants + 5% cow urine + 1% urea (T_3). After harvest of crop, soil samples were analyzed for chemical and microbiological properties. The results revealed that after harvest the highest available nitrogen nitrogen (N) and sulphur (S) i.e. 146.6 mg kg^{-1} and 14.7 mg kg^{-1} respectively were observed in 100 % recommended NPK. The highest available P and K i.e. 11.3 mg kg^{-1} and 92.2 mg kg^{-1} respectively were recorded in treatment involving unfortified compost (no rock phosphate)+50% recommended NPK. The highest total N, P, K and S contents i.e. 599 mg kg^{-1}, 128 mg kg^{-1}, 1430 mg kg^{-1} and 246 mg kg^{-1}, respectively were recorded in treatment involving unfortified compost+50% recommended NPK (T_4). The highest total microbial count was recorded in fortified compost + 5ml bio-inoculants. Microbial biomass carbon and urease activity were recorded highest i.e. 93.67 µg g^{-1} and 6.4 µg g^{-1} min^{-1} in unfortified compost + 50% recommended NPK(T_4). Grain and straw samples were analyzed for total N, P, K and S contents and results revealed that N, P, K and S content in grain and straw increased with addition of fortified compost.

Key words: Wheat, biocompost, *Eupatorium*, rock phosphate and bioinoculants.

Fertilizers have played a prominent role in increasing food grain production of the country in the past and are going to be crucial input in future as well. However, due to intensification of agriculture the soils are being rapidly depleted of their fertility and are now showing signs of fatigue. The inadequate and imbalanced use coupled with neglect of organic manure has caused deficiency of secondary and micronutrients in many parts of the country. The falling organic matter levels in the soils are adversely affecting the physical, chemical and biological soil properties and have resulted in widespread nutritional imbalances throughout the country. The organic carbon content of a soil in India, which has been traditionally low, has declined further during the post green revolution era from 1.2% to 0.6% (Ramasamy 2005). However, the contents of water soluble aggregates carbon increased with fertilization as compared to control on basis of nine year study on carbon sequestration under the alluvial soils of Punjab as reported by Brar *et al.*(2013). Under such situation, supplementing nutrient needs of crops through organics in combination with inorganics is one of the best option for sustaining farm productivity and improving soil quality. Fortification of biocompost with rock phosphate is essential for improving the phosphorus content. Hence study on the use of fortified compost on soil properties and crop yield was conducted.

Materials and Methods

A growth chamber experiment was conducted during 2011 on silty clay loam soil with wheat (cv. HS-295) at CSK Himachal Pradesh Krishi

Vishvavidyalaya, Palampur. The climate of the experimental site is characterized as wet temperate with mild summers (March to June) and cool winters. The mean annual rainfall ranges between 1500 to 3000 mm, out of which about 80% is received during monsoon period from June to September. The mean maximum temperature remains about 31^{0}C during the hottest months of May to June. December to February are the coldest months with minimum temperature of about 4-6 ^{0}C. Biocomposts were prepared by using cow dung, *Eupatorium* weed and were fortified with two levels of rock phosphate i. e. (5% and 10%). Biocomposts were analyzed for moisture content, pH (Jackson 1967), cation exchange capacity CEC (Black 1965), electrical conductivity (EC) (Richards 1954), total carbon (Allison 1960), total nitrogen, phosphorus and potassium (NPK) (Jackson 1967), micronutrients (Lindsay and Norvell 1978), carbon:nitrogen (C:N ratio), microbial biomass carbon (C), N(nitrogen) and sulphur (S) (Vance *et al.* 1987). The best biocompost prepared from cowdung + *Eupatorium* weed + 5%) rock phosphate was selected and applied to the crop in combination with fertilizers depending upon the treatment in the growth chamber experiment by taking wheat (cv. HS-295) as the test crop. The treatment detail is given in Table 1. There were seven treatments and four replications in completely randomized design with individual pot size 15840 cm^{3}dimensions.

The soil had pH 5.4 , 10.6 g kg^{-1} organic carbon, 138.5 mg kg^{-1} available N, 8.3 mg kg^{-1} available P, 74.5 mg kg^{-1} available K and 12.4 mg kg^{-1} available S, 516.4 mg kg^{-1}total N, 88.6 mg kg^{-1}total P, 989.5 mg kg^{-1} total K and 179.3 mg kg^{-1}total S, 54.8 µg g^{-1} microbial biomass carbon, microbial count as 18.9x10^5 cfu g^{-1} bacteria, 12.9x10^3 cfu g^{-1} fungi and 20x10^4 cfu g^{-1} actinomycetes and 1.6 µg g^{-1}min^{-1}urease activity.

Results and Discussion

Crop yields

Highest grain yield per plant i.e. 2.74 g was recorded in treatment fortified compost + 5ml bioinoculants + 5% cow urine + 1% urea-T_3(Table2). Treatment involving fortified compost + 5 ml bio-inoculants (T_1) was at par with the treatment fortified compost + 5 ml bio-inoculants + 5% cow urine + 1% urea (T_3). Maximum straw yield per plant i.e. 3.45 g was recorded in treatment fortified compost + 5 ml bio-inoculants (T_1). Treatments involving fortified compost + 5 ml bio-inoculants + 5% cow urine (T_2) and fortified compost + 5 ml bio-inoculants + 5% cow urine + 1% urea (T_3) and recommended NPK (T_5) were at par with treatment fortified compost + 5 ml bioinoculants (T_1). The highest grain and straw yields per plant were observed in the treatment where combined use of chemicals, organics and inoculants was done. It may be attributed to the fact that the organics, inorganics and microbial inoculants sustain optimum yields, maintain soil physical, chemical and microbiological properties which in turn make soil a better medium for plant growth. An integrated nutrient management system can be a much better approach in sustaining soil health. Similar reports are presented by Yadav and Kumar (2000) and Steffens *et al.* (1992) and Sharma *et al.* (2008).

Table 1.Treatment details

Treatments
T_1.Fortified compost (5% rock phosphate) + 5 ml bioinoculants (i.e. *Azotobacter* and PSB)
T_2.Fortified compost (5% rock phosphate) + 5 ml bioinoculants + 5% cow urine
T_3.Fortified compost (5% rock phosphate) + 5 ml bioinoculants + 5% cow urine + 1% urea
T_4.Unfortified compost + 50% recommended NPK
T_5.Recommended NPK
T_6.Unfortified compost only
T_7.Control (i.e. no compost and no fertilizers)

Available nutrients in soil

Available nitrogen was maximum i.e. 147.14 mg kg^{-1} in treatment fortified compost + 5 ml bio-inoculants + 5% cow urine + 1% urea (T_3). The application of fortified compost increased the available nitrogen content in the soil over the recommended dose of fertilizers. Also compost along with other organic and inorganic fertilizers might have helped in improvement of nitrogen fixation. The nitrogen was slowly released by the composts which increased its content in the soil. Also addition of larger biomass to soil provided opportunity to free living organisms to fix atmospheric nitrogen. Similar results were reported by Dinesh and Dubey (1999).

Available phosphorus was maximum i.e. 11.3 mg kg^{-1} in treatment unfortified compost + 50% recommended NPK (T_4). Integrated nutrient management practices were found to be significantly superior to inorganic treatment. Upon decomposition of organic matter by various microorganisms, the organic phosphorus is converted slowly to inorganic form. Anwar *et al.* (2005) also reported higher values of available P in the pots receiving organic manures in addition to mineral fertilizer compared to those pots treated with chemical fertilizers alone. Available potassium was maximum i.e. 92.2 mg kg^{-1} in treatment unfortified compost + 50% recommended NPK (T_4). Application of fortified compost increased the available potassium content of soil. Similar results were reported by Chettri *et al.* (2004). Likewise significant improvement in fertility status of the soils due to the addition of FYM or crop residues has also been reported by Roy *et al.* (2001). Available sulphur was maximum i.e. 14.7 mg kg^{-1} in treatment recommended NPK (T_5). Addition of N fertilizers resulted in significant increase in available sulphur as compared to control. The increase in available sulphur may be due to the synergistic effect of N and S. Chaube and Dwivedi (1995) reported positive interaction between N and S. Addition of organic and inorganic fertilizers also significantly increased the available sulphur in the soil. Similar results were reported by Sharma *et al.* (2000).

Total nutrients in soil

Total nitrogen was highest i.e. 599 mg kg^{-1} in treatment unfortified compost + 50% recommended NPK (T_4) and it was significantly higher than all the treatments. Integrated use of organic and inorganic fertilizers gave highest amount of total nitrogen in soil because both the sources have contributed to total nitrogen in the soil. Total phosphorus was highest i.e. 128 mg kg^{-1} in treatment unfortified compost + 50% recommended NPK (T_4) and it was significantly higher than all the treatments. Integrated use of organic and inorganic fertilizers gave highest amount of total phosphorus in soil. It might be attributed to the fact that the application of organic and inorganics increase organic form of nutrients in soil and increase the activity of microbes. Similar findings were reported by Bedi and Dubey (2009).

Total potassium was the highest i.e. 1430 mg kg^{-1} in treatment unfortified compost + 50% recommended NPK (T_4) and it was significantly higher than all the treatments. Application of fortified compost increased the total potassium content of soil. Similar findings were reported by Chettri *et al.* (2004). Likewise significant improvements in fertility status of the soils due to the addition of FYM or crop residues have also been reported by Roy *et al.* (2001). Total sulphur was the highest i.e. 246mg kg^{-1} in treatment unfortified compost + 50% recommended NPK (T_4) and it was significantly higher than all the treatments. Integrated use of organic and inorganic fertilizers gave highest amount of total sulphur in soil than control because more availability of sulphur from both the nutrient sources. Similar results were reported by Basumatary and Talukdar (2011).

Microbiological properties of soil

Bacterial population was maximum i.e. 5.4 x 10^5 cfu g^{-1} soil in treatment fortified compost + 5 ml bioinoculants-T_1(Table 3). The fortified compost contains higher count of bacteria which would have increased bacterial population in soil. It might be due to the fact that proper and continuous mineralization of nutrients from organic to inorganic pool resulted in maintaining the continuous supply of food as well as energy for the growth of microorganisms. Similar results were reported by Bedi (2004). Fungal population was maximum i.e. 5.6 x 10^3 cfu g^{-1} soil in treatment fortified compost + 5 ml bioinoculants (T_1) and it was statistically higher than all the treatments. Actinomycetes population was maximum i.e. 63 x 10^4 cfu g^{-1} soil in treatment fortified compost + 5 ml bioinoculants (T_1) and it was statistically higher than all the treatments. Due to microbiological changes during decomposition of organic matter in the soil brought the highest proliferation of fungi and actinomycetes in soil. Similar results were reported by Mukherjee *et al.* (1999).

Microbial biomass carbon after harvest was maximum i.e. 93.6 µg g^{-1} soil in treatment unfortified compost + 50% recommended NPK (T_4). Microbial biomass carbon in integrated nutrient management was higher than the other treatments might be due to more microbial population and organic carbon in the integrated nutrient management which resulted in more biomass carbon due to increase in chemical nitrogen with organic material application. Results are corroborated with the finding of Santhy et *al.* (2004). Urease activity after harvest was maximum i.e. 6.4 µg g^{-1} soil min^{-1} in treatment unfortified compost + 50% recommended NPK (T_4) and it was statistically higher than all the treatments. The maximum urease activity was found in the combined application of organics and inorganics together than organics and inorganics alone, might be due to the application of organic source and inorganic source together which maintain the continuity of conversion of nutrients from organic to inorganic form because it acts on C-N bonds other than peptides in linear amidases and thus belongs to a group of enzymes that include glutaminase and amidase. The results are corroborated with the findings of Jaun *et al.* (2008) and Kadlag *et al.* (2007).

Table 2. Effect of treatments on yield, total and available nutrients

Treatments	Yield plant^{-1} (g)		Total nutrients(mg kg^{-1})				Available nutrients(mg			
	Grain	Straw	N	P	K	S	N	P	K	S
T_1.Fortifiedcompost (5% rock phosphate) + 5 ml bioinoculants (i.e. *Azotobacter* and PSB)	2.74	3.45	561	89	1184	180	140	6.1	76.6	10.9
T_2.Fortified compost + 5 ml bioinoculants + 5% cow urine	2.09	3.18	554	92	1086	188	145	6.3	76.1	11.7
T_3.Fortified compost + 5 ml bioinoculants + 5% cow urine + 1% urea	3.24	3.05	579	96	1268	192	147	6.7	78.3	12.8
T_4.Unfortified compost + 50% recommended NPK	1.86	2.33	599	128	1430	246	139	11.3	92.2	14.3
T_5.Recommended NPK	1.42	2.64	572	122	1412	223	147	11.0	80.3	14.7
T_6.Unfortified compost only	1.89	2.21	529	101	1311	209	139	8.7	88.8	13.2
T_7.Control (i.e. no compost and no fertilizers)	1.32	1.04	491	84	987	173	132	5.6	68.3	11.8
CD(P=0.05)	0.92	0.91	5.7	3.9	110.5	5.0	4.6	2.18	3.66	2.15

Table 3. Effect of treatments on microbiological properties

Treatments	Bacteria (x 10^5 cfu g^{-1} soil))	Fungi (x 10^3cfu g^{-1} soil))	Actinomycetes (x 10^4 cfu g^{-1} soil))	Microbial biomass carbon (μg g^{-1} soil)	Urease activity (μg g^{-1} soil min^{-1})
T_1	5.4	5.6	63	87.3	3.6
T_2	5.2	5.1	52	92.5	4.0
T_3	4.5	4.7	49	89.6	5.7
T_4	4.2	4.6	42	93.6	6.4
T_5	3.5	3.2	35	67.3	5.6
T_6	4.0	4.3	43	83.7	5.4
T_7	2.6	2.5	30	55.8	2.0
CD (P= 0.05)	0.36	0.32	2.9	3.55	0.44

On the basis of grain and straw yield of wheat treatment involving fortified compost + 5 ml bioinoculants+5% cow urine+1% urea (T_3) proved significantly better than rest of the treatments. However for soil sustenance viewpoint treatment involving unfortified compost+50% recommended NPK (T_4) proved the best. On the basis of soil properties except microbial count treatment unfortified compost + 50% recommended NPK (T_4) was found significantly better than rest of the treatments.

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