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APPLICATION OF BIO-ORGANICS AND CHEMICAL FERTILIZERS INFLUENCES PHYSICO-CHEMICAL PROPERTIES OF LOAMY-SAND SOIL UNDER BARLEY

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ABSTRACT

Field studies were conducted during winter/ *rabi* seasons of 2011-12 and 2012-13 at the Agronomy farm of S.K.N. College of Agriculture Jobner, Rajasthan, to study the effect of different bio-organics and fertilizer levels on soil physico-chemical properties under barley crop. Results revealed that addition of FYM @ 10 t/ha along with *Azotobacter* and PSB registered lowest bulk density (1.35 Mg/m^3) and highest saturated hydraulic conductivity (8.93 cm/h) of the soil. The application of vermicompost @ 5 t/ha + *Azotobacter* and PSB showed significantly highest moisture retention (13.50% and 3.33%), CEC [6.70 cmol (P$^+$)/kg] as well highest values of soil organic carbon (2.44 g/kg), total N (183.0 mg/kg), total P (262 mg/kg), organic P (81.7 mg/kg) and inorganic P (172.2 mg/kg) of the soil at harvest of the crop. The treatment FYM @ 10 t/ha along with biofertilizers also observed equally effective in improving above soil parameters in most of the cases. The increasing levels of fertilizers significantly influenced the soil chemical properties viz., organic carbon content, total nitrogen, total phosphorus and inorganic phosphorus content. Therefore, based on availability either vermin compost or FYM along with biofertilizers and 75% RDF of fertilizers could be used under fertilization for better soil condition.

KEY WORDS
Bio-organics
Bio fertilizers
Fertilizers, FYM, Physico-chemical properties, Vermicompost

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INTRODUCTION

Barley (*Hordeum vulgare* L.) is worlds forth most important cereal crop after rice, wheat and maize. It is grown in nearly 100 countries worldwide occupying about 48.60 m ha area. Barley is an important cereal crop grown during *rabi* season in northern plains of India. Rajasthan, Haryana, Punjab and western UP are the major states growing barley. Its production was 1.7 m t from 0.69 m ha area with productivity of 2521 kg/ha during 2012-13 in the country. In water scarce, saline or sodic and marginal lands, barley is preferred crop over wheat as it thrives well under these conditions due its hardy nature.

Barley mainly grown on light texture soil having low water holding capacity, poor nitrogen, phosphorus and organic matter content in semi-arid region with limited irrigations without proper nutrient management where wheat does not do well. Being a cereal crop it requires considerable amounts of major nutrients particularly N and P for harnessing potential yield. It becomes essential to determine the optimum rate of both the nutrients for the crop under particular growing condition. The main soil related production constraints in light textured soil is attributed to its poor physical properties including high bulk density, low soil aggregation and narrow range of moisture for field operation. The low content of soil organic carbon in these soils is one of the major reasons for the deterioration of soil health resulting in low and unsustainable productivity. The light texture soils which are low in organic matter content and application of fertilizers without integrating any organic source could not meet the requirement of all essential nutrients as well as organic matter is also essential for maintaining favourable physico-chemical and biological properties of soil. Binding of soil particles into stable aggregates is essential for optimum soil condition (Selvi *et al*., 2005). Soil physical and chemical parameters are sensitive indicators of treatment effects on soil process that indicate nutrient flow in agro ecosystems and soil quality is very closely linked to its biological properties (Zhao *et al*., 2008). Organic matter affects crop growth and yield directly by supplying nutrients and indirectly by modifying soil physical properties such as stability of aggregates, porosity, water storage capacity and favourable environment for the root growth (Bandyopadhyay *et al*., 2010; Nayak *et al*., 2015). The application of FYM in conjunction with 100% NPK reduced the bulk density, increased the porosity and hydraulic conductivity of the soil (Selvi *et al*., 2005). Secondly, biofertilizers such as *Azotobacter* naturally fixes atmospheric nitrogen in the rhizosphere, while the use of phosphate solubilizing bacteria (PSB) helpful in increasing the availability of fixed phosphorus in soil (Gaur, 2006). Therefore, adoption of integrated plant nutrient supply (IPNS) and management strategies for enhancing soil quality, input use efficiency and crop productivity is extremely important for food and nutritional security in agriculture (Carter, 2002). The present study was undertaken to ascertain the effects of fertilizers and organics on changes in soil physico-chemical properties of loamy-sand soil under barley cultivation.

MATERIALS AND METHODS

Field experiments were conducted during *rabi* seasons of 2011-12 and 2012-13 at the Agronomy farm of S.K.N. College of Agriculture, Jobner (Rajasthan), India situated at 26.05° N, 75.28° E and at 427 m above mean sea level. The soil of the experimental site was loamy sand in texture with pH 8.2, cation exchange capacity 5.7 c mol/kg and EC 1.2 dS/m in the top 15 cm. The soil was low in available nitrogen (128.6 kg/ha), available phosphorus (8.5 kg/ha) and organic carbon (0.42%) and medium in available potassium (170.6 kg/ha). The initial physico-chemical properties of soil are presented in Table 1. The treatments comprised of six treatments of bio-organics (B_0-Control; B_1-FYM @ 10 t/ha; B_2-vermicompost @ 5 t/ha; B_3-*Azotobacter* + PSB; B_4-FYM @ 10 t/ha + *Azotobacter* + PSB and B_5-vermicompost @ 5 t/ha + *Azotobacter* + PSB) and four level of fertilizers (F_0-Control; F_1-50% RDF; F_2-75% RDF and F_3-100% RDF). The recommended dose of fertilizers (RDF) was 60:30:0 of $N:P_2O_5:K_2O$ kg/ha, respectively. The experiment was laid out in split-plot design and replicated thrice. The barley 'RD 2052' was taken for experiment and sown at 22.5 cm x 5 cm spacing. Required quantity of FYM was applied as per treatments one month before sowing of crop. Vermi compost was applied before sowing in respective plots. Nitrogen and phosphorus were applied as per treatments through urea and dia-ammonium phosphate (DAP), respectively. Half of the dose of nitrogen was given at sowing of crop and remaining half was top dressed at first irrigation and phosphorus was applied at 8-10 cm depth before sowing as per treatments. Seeds were treated with *Azotobacter* and PSB for respective treatments. The crop was grown with recommended package of practices.

Soil samples (0-15 cm) were collected at the start of the experiment and after harvesting of the barley crop from net plots for the study of physico-chemical properties. These samples were air dried and passed through 2.0 mm sieve for subsequent analysis. Bulk density (B.D.) of soil was determined by core sampler method from three randomly chosen areas in each plot (Bodman, 1942). Saturated hydraulic conductivity (SHC) of the soil was determined using undisturbed soil taken for B.D. by constant head method (Klute and Dirksen, 1986). Soil moisture retention at 33 kPa (1/3rd bar) and 1500 kPa (15 bar) tensions was determined on pressure plate membrane apparatus as per method described by Gardner (1986). Organic carbon was estimated by using wet digestion method (Walkley and Black, 1934). Total N in the soil was determined by using microkjeldahl method given by Bremner and Mulvaney (1982). Total soil P was determined by digesting soil samples with $HClO_4$ (Jackson, 1973). After digestion, the aliquot was used to determine total soil P by the Olsen's method. The method outlined by Walker and Adams (1958) and Watanabe and Olsen (1965) was employed for the determination of organic and inorganic P in the soil. The EC and pH of soil were estimated after preparing 1:2 soil water suspension by conducto metrically and electro meterically using glass electrode methods (Piper, 1950), respectively. Statistical analysis of the data was carried out using standard analysis of variance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Soil physical properties

Application of different bio-organics significantly influenced the physical properties viz., bulk density, saturated hydraulic conductivity and moisture retention of soil (Table 2). A significant reduction in B.D. of soil was observed with different bio-organics over control and it was recorded significantly lowest (1.35 Mg/m^3) under the application of FYM @ 10 t/ha along with *Azoto bacter* and PSB (B_4) followed by application of FYM @ 10 t/ha alone. This treatment also showed significantly highest value of saturated hydraulic conductivity (8.93 cm/h) of the soil. The lowering of soil bulk density due to the application of FYM coupled with *Azotobacter* + PSB might be attributed to higher soil biomass, organic carbon, more pore space and good soil aggregation (Thakur *et al.*, 2011). The decomposition of organic matter also plays a vital role in improving soil permeability and in increasing water stable soil aggregates (Verma *et al.*, 2010) as a result of complex series of polysaccharides synthesized by the soil microbes and their secretary products. The improvement in aggregation and soil structure and reduction in bulk density with the application of organic manures also attributed to the fixing of the low density material with dense mineral fraction of the soil (Pareek and Yadav, 2011). Significant increase in the hydraulic conductivity with incorporation of organic manures coupled with bio-fertilizers might be due to reduction in bulk density, increase in soil aggregation and increase in organic carbon content of the experimental soils (Verma *et al.,* 2010).The application of vermi compost @ 5 t/ha + *Azotobacter* and PSB (B_5) recorded significantly highest moisture retention at 33 kPa (13.50%) and 1500 kPa (3.33%) and cation exchange capacity [6.70 cmol (P^+)/kg] of soil (Table 2). The treatments B_1, B_2, B_4 and B_5

Table 1: Initial physico-chemical properties of the soil at the start of experiment

S.No.	Soil characteristics	Value
A.	Mechanical composition	
	Coarse sand (%)	20.36
	Fine Sand (%)	59.08
	Silt (%)	11.45
	Clay (%)	8.94
	Textural class	Loamy sand
B.	Physical	
	Bulk density (Mg/m^3)	1.52
	Particle density (Mg/m^3)	2.55
	Field capacity (%)	12.50
	Moisture retention at 1/3 bar	10.98
	Moisture retention at 15 bar	2.88
	Saturated hydraulic conductivity (cm/hr)	5.89
C.	Chemical	
	Organic carbon (%)	0.16
	Available N (kg/ha)	128.6
	Available P_2O_5 (kg/ha)	19.58
	Available K_2O (kg/ha)	170.6
	EC [1:2 soil water suspension] at 25^{0}C (dS/m)	1.26
	pH [1:2 soil water suspension]	8.2
	CEC [cmol (p^+)/kg]	5.7
	Total N (mg/kg)	150
	Total P (mg/kg)	210
	Organic P (mg/kg)	70.4
	Inorganic P (mg/kg)	151.7

Table 2: Effect of bio-organics and fertilizer levels on physico-chemical properties of soil (pooled data of two years)

Treatment	Bulk density (Mg/m^3)	SHC (cm/h)	Moisture retentionat 33 kPa (%)	Moisture retentionat 1500 kPa (%)	CEC[cmol (P^+)/kg]	EC(dS/m)	pH	Organic carbon (g/kg)	Total N (mg/kg)	TotalP (mg/kg)
Bio- organics										
B_0- Control	1.49	6.06	10.46	2.80	5.52	1.24	8.31	1.76	158	235
B_1- FYM @10 t/ha	1.36	8.49	13.29	3.23	5.86	1.28	8.25	2.13	171	249
B_2- VC @ 5 t/ha	1.41	7.18	13.38	3.34	6.67	1.28	8.20	2.42	180	257
B_3- *Azotobacter* + PSB	1.47	6.84	11.40	2.81	5.79	1.23	8.25	1.77	163	240
B_4- FYM @10 t/ha + *Azotobacter* + PSB	1.35	8.93	13.26	3.23	5.88	1.27	8.22	2.24	175	256
B_5- VC @ 5 t/ha + *Azotobacter* + PSB	1.39	7.38	13.50	3.33	6.70	1.26	8.20	2.44	183	262
SEm±	0.01	0.07	0.16	0.04	0.08	0.01	0.06	0.02	2	3
CD (p=0.05)	0.03	0.22	0.48	0.12	0.22	NS	NS	0.05	5	9
Fertilizer levels (% RDF)										
F_0- 0	1.44	7.32	12.22	3.05	6.03	1.25	8.25	2.03	166	240
F_1- 50	1.41	7.46	12.59	3.11	6.09	1.25	8.24	2.11	172	249
F_2- 75	1.40	7.54	12.68	3.16	6.12	1.26	8.23	2.19	174	254
F_3- 100	1.39	7.61	12.70	3.17	6.14	1.28	8.22	2.22	175	256
SEm±	0.01	0.07	0.14	0.03	0.09	0.01	0.05	0.02	2	3
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	0.05	5	9

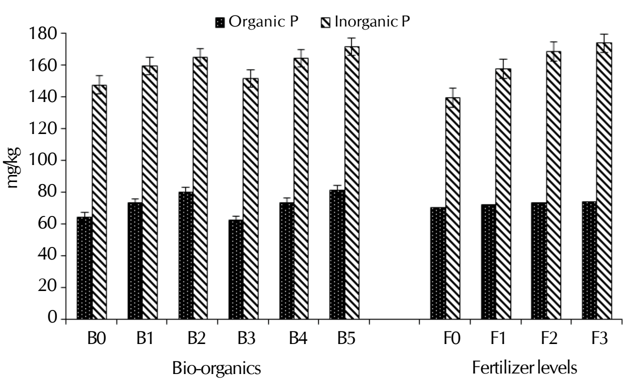

Figure 1: Effect of bio-organics and fertilizer levels on organic and inorganic P content in soil (pooled data of two years). Error bars indicates values of LSD (P=0.05). Bars without error bars indicates non-significant difference

performed equally as of B_5 in moisture retention at 33 and 1500 kPa. Whereas, the treatment B_2 and B_5 remained at par with regard to CEC of the soil. The increase in water retention as a result of organic manure (vermicompost) is expected from the aggregation resulting in favourable pore-geometry of the soils (Nandapure *et al.,* 2011). The existence of positive correlation between organic carbon and available water content and higher soil organic carbon content in vermicompost treated plots could be responsible for increased moisture retention of the soil (Rasool *et al.,* 2008). This could also be ascribed to the improvement in structural condition of the soil resulted with the application of vermicompost + *Azotobacter* + PSB.The application of all the bio-organics did not bring significant changes in EC and pH of the soil. The increasing levels of fertilizers from 0 to 100% RDF could not influence the all above physical properties of the soil to significant level.

Soil organic carbon and total nitrogen

The different bio-organics had significant effect on organic carbon and status of total N in soil (Table 2). All the treatments of bio-organics showed significant increase in organic carbon and total N of soil over control except inoculation of *Azotobacter* + PSB alone. The significantly highest organic carbon (2.44 g/kg) and total N (183.0 mg/kg) were recorded with the application of vermicompost @ 5 t/ha + *Azotobacter* and PSB (B_5) which remained statistically at par with vermicompost @ 5 t/ha (B_2). The increase in organic carbon content of soil at harvest of the crop with the application of vermi compost coupled with *Azotobacter* + PSB might be due to additive effect of vermicompost and biofertilizer in maintaining higher organic carbon level and dead cells of soil biomass (Tabassum *et al.*, 2010) and recycling of organic materials in the form of crop residues like plant roots which added a good amount of biomass to the soil (Singh *et al.*, 2011). The increase in total nitrogen with the application of organic manure coupled with biofertilizers might have attributed to faster development of soil microbes, could convert organically bound N to inorganic form under the favorable soil condition and the organic manures might have facilitated the mineralization of soil nitrogen leading to build up of higher total nitrogen (Vipin Kumar and Singh, 2010). The results of the present study resembles the findings of Kokani *et al.* (2015) and Ali and Pandey (2015).

Similarly, the status of the organic carbon content of the soil also showed significant increase under the treatment of increasing levels of fertilizers and significantly highest organic carbon content (2.19 g/kg) was recorded in the plot where levels of fertilizer supplemented @ 75% RDF (F_2). This could be attributed to the fact that added fertilizers enhanced the availability of nutrients to plants and resulted in better plant growth, profuse shoot and root growth, which in turn added more root biomass to the soil and might increased the organic carbon in soil. The total nitrogen in soil at harvest of the crop also increased with the increasing levels of fertilizers but the difference was significant at 100% RDF over control. It is well established fact that the fertilizer application increases production of plant biomass, especially of below-ground material, which is an important source of soil organic carbon, total and available nutrients in the soil (Katterer *et al.*, 2011).

Total phosphorus

The treatment of bio-organic B_5 where vermicompost @ 5 t/ha + *Azotobacter* + PSB was applied, registered significantly highest total P (262 mg/kg) of the experimental soil at harvest of the crop over control (Table 2). The treatments B_2 and B_4 also recorded statistically similar values of total P that of recorded under B_5. The appreciable build up in total P in soil with organic manure might attributed to the influence of organic manure in increasing the labile P through complexing of cations like (ca^{+2} and mg^{+2}) which are responsible for fixation of phosphorus (Singh *et al.*, 2005). The increased total P with organics could be ascribed to their solubilising effect on native soil P and then consequent contribution of labile pool mineralization of organic P due to microbial action and enhanced mobility of P.

The increasing levels of RDF also increased the total P in soil at harvest of the crop (Table 2). However, only F_3 treatment (100% RDF) differ significantly from control with regard to total P. Build-up in the soil phosphorus content could be attributed to low uptake of applied recommended dose of P by the crop and leaving a substantial residual P in the soil (Teterwal *et al.*, 2012).

Organic and inorganic phosphorus

Significant influence of organic manures and biofertilizers applied either alone or in combinations, have been observed on organic and inorganic P of the soil (Fig. 1). The significantly maximum organic (81.7 mg/kg) and inorganic P (172.2 mg/kg) content were recorded in the plots where vermicompost @ 5 t/ha along with *Azotobacter* and PSB (B_5) was applied. The treatment B_2 and B_5 remained at par with regard to organic P content in the soil. Whereas, conjoint supplementation of vermicompost and biofertilizers (*Azotobacter* + PSB) registered significant superiority in increasing inorganic P content of the soil over sole application of vermicompost, FYM and FYM + *Azotobacter* and PSB.

Though, there was marginal increase in organic P content in the soil with increasing levels of fertilizers but none of difference was significant (Fig. 1). While the inorganic P content of soil increased significantly with increasing levels of fertilizers and each level of fertilizers differed significantly with each other with highest at 100% RDF (174.3 mg/kg). The low use efficiency (20-25%) of applied phosphate fertilizer might also be a source of increased inorganic P of the soil. The addition of phosphate fertilizer might have built up the soil organic biomass and added P fraction to the soil organic pool, which intern into higher built up of soil P (Singh *et al.*, 2004). The increase in inorganic P could also be attributed to mineralization of organic P which was higher for the treatments receiving higher doses of fertilizer P. Similar observations were also made by Bhardwaj *et al.* (2000).

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