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Effect of fertility levels, organic sources and bio-inoculants on soil physic-chemical properties of wheat (*Triticum aestivum* L.)

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Abstract
A field experiment was conducted at Agronomy Farm, Rajasthan College of Agriculture, Udaipur during *rabi* season in 2015-16 and 2016-17. The experiment consisted of 24 treatment combinations comprising of three levels of fertility (50, 75 and 100 per cent RDF), four organic sources (FYM @ 5 and 10 t ha^{-1}, vermicompost @ 2.5 and 5 t ha^{-1}), and two bio-inoculations (Without inoculation and *Azotobacter* + PSB). Experiment was conducted under factorial randomized block design replicated thrice taking wheat var. Raj- 4037 as test crop. Enrichment of soil with 75 per cent RDF, application of vermicompost @ 5 t/ha and dual inoculations of *Azotobacter* + PSB significantly improve water holding capacity and organic carbon of soil. However, bulk density particle density, porosity, pH and EC were found non - significant. The maximum monetary return of ₹ 63688 with benefit cost ratio of 2.28 was obtained with 75% RDF, ₹ 64661 was found with vermicompost @ 5 t/ha and ₹ 63711 with benefit cost ratio of 2.28 was obtained with dual inoculation of *Azotobacter* + PSB.

Keywords: *Azotobacter*, PSB, bulk density, particle density, porosity, pH, EC, water holding capacity

Introduction

Wheat (*Triticum aestivum* L.) belongs to family Poaceae is one of the most important cereal crops of the world. Among the world's most important food grain, it ranks next to rice. In Rajasthan production of wheat is about 13.8 m t from an area around 3.5 m ha (Anonymous, 2018-2019) [1]. Although, India is well placed in meeting its needs for food grains and the major objective of food and nutritional security for its entire population has not been achieved. The demand for food grains is expected to rise not only as a function of population growth but also as more and more people cross the poverty line with economic and social development. The integrated use of organic materials and chemical nitrogenous fertilizers has received considerable attention in the past with a hope of meeting the farmer's economic need as well as maintaining favorable ecological conditions on long-term basis (Kumar *et al.*, 2007) [14]. The use of organics in an integrated way renders the benefits through, the maintenance of soil fertility and plant nutrient supply at optimum level for sustaining the desired productivity. This is achieved, through the optimum benefits of all possible sources of plant nutrients in integrated manner so as to attain the maximum yield without any effect on physical, chemical and biological soil properties. The major components of organic integrated nutrient management system involves the organic manures with variable nutrient release patterns mainly FYM, vermicompost, crop and bio-fertilizers along with natural soil reserves. Farmyard manure improves the physical. condition of soil by increasing water holding capacity for maximum utilization of water. The organic sources with fertilizers and bio-inoculants help to restore and sustain fertility and crop productivity. It also helps to check the emerging deficiency of nutrients other than N, P and K. Further, it brings economy and efficiency in fertilizers. The integration of fertilizers and organic sources with biofertilizers favorably affects the physical, chemical and biological environment of soils. Integrated use of mineral fertilizers together with organic manure and biofertilizer in suitable combination compliments and each other to optimize input use and maximize production and sustain the same without impairing the crop quality or soil health. It enables gainful utilization of organic wastes. (Dhaka *et al*, 2012) [9, 10]. The information about different sources and combination of organic manures and inorganic fertilizer on growth and yield of wheat is scantly in Rajasthan. The response of organic sources of nutrients are also vary depending upon soil fertility and is highly location specific.

The present study was undertaken with objective to assess the effect of fertility levels, organic sources and bio-inoculants on wheat

Materials and Methods

A field study was conducted for two years during *rabi* season of 2015-16 and 2016-17 at Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur (24º.35' N latitude, 74º.42' E longitude and an altitude of 579.5 m above mean sea level). The experiment consisted of 24 treatment combinations comprising of three levels of fertility (50, 75 and 100 per cent RDF), four organic sources (FYM @ 5 and 10 t ha^{-1}, vermicompost @ 2.5 and 5 t ha^{-1}), and two bio-inoculations (Without inoculation and *Azotobacter* + PSB) were evaluated in randomized block design with three replications. The soil of experimental site was clay loam having 0.61% organic carbon, 7.52 pH, 315, 21 and 305 kg/ha available N, P and K, respectively. Wheat 'Raj-4037' was sown on 20 November 2015, and 21 November 2016 at 22.5 cm row-to row spacing and was harvested on 10 April 2016 and 15 April 2017, respectively. Fertilizers were placed beneath the seed, after placing the seed in furrows it was covered with soil for uniform germination and to protect from bird damage. Total rainfall received during the crop season was 0.0 mm during 2015-16 and 12.4 mm in 2016-17, respectively. Besides pre-sowing irrigation, 5 irrigations were applied as per requirement of crop using sprinkler irrigation method.

Results and Discussion

Effect on soil physico-chemical properties

Soil nutrients *viz*. organic carbon, available N, P, and K are good indicators of soil qualities because of their favorable effect on physical and chemical properties of the soil. The significant improvement in physical and chemical properties of soil was observed by the addition of recommended fertilizer dose however bulk density, particle density, porosity, pH and EC remained unaffected due to different level of fertilizers. Results revealed that application of increase in levels of fertilizer significantly enhance the water holding capacity of soil. The increased water holding capacity with increase in levels of fertilizer in soil might be due to the enhanced rhizosphere in soil which ultimately enhanced the water holding capacity in soil (Bhatt *et al.*, 2017) [3].

Organic carbon varied significantly under the various treatments applied in soil after harvest of wheat. Significantly the higher values of organic carbon was observed up to 75% RDF compared to 50% RDF clearly indicated the significant effect of fertilizers on build up of organic carbon. Use of fertilizers helps in increasing the soil organic carbon due to the higher biomass in terms of dry matter and differential rate of oxidation of the organic matter by microbes (Dhonde and Bhakare, 2008, Shukla *et al*., 2013 and Parewa *et al.,* 2014) [11, 20, 16].

The use of organic manures plays an important role in maintaining the soil health due to build up of soil organic matter in soil. Organic manures like FYM and vermicompost affect the physical and chemical properties of soil significantly. However, bulk density, particle density, porosity, pH and EC were not significantly influenced due to different sources of organic manures. Application of 5 t vermicompost ha^{-1} significantly improved the water holding capacity of the soil as compared to other treatments of organic manures. This might be due to the fact that vermicompost has stable and low C: N ratio when added to soil, it maintains low bulk density and high moisture holding capacity for longer period compared to other organic sources under the study, which having relatively higher and less stable C: N ratio (Madhavi *et al.*, 2009 and Choudhary and Channappagouda, 2015) [15, 7].

Organic manures application improved the soil physical properties, aggregate stability, water holding capacity at both field capacity and wilting point, increase the soil aggregation and decrease the volume of micro pores while increase the macro pores, saturated hydraulic conductivity and water infiltration rate (Brar *et al.*, 2015) [5]. Despite of this, organic manures supply macro, micro and secondary nutrients to plants, improved the soil permeability to air and water and also increase the proportion of water stable aggregates in soil (Bhattacharyya *et al.*, 2007) [4].

Besides improving the physical properties organic manures also affect chemical properties of soil. The soil organic carbon content increased significantly with different organic manures. Incorporation of FYM @ 10 t ha^{-1} significantly improved the soil organic carbon as compared to other treatments of manures. The higher values of soil organic carbon with organic manures might be due to the direct addition, biological immobilization and continuous mineralization of FYM on surface layer of soil. Result of the investigation is close harmony with findings of (Ramesh *et al*., 2008, Bhardwaj *et al*., 2010 and Datt, *et al*., 2013) [18, 2, 8].

Application of biofertilizers to arable soil influenced the physical and chemical properties as well as water holding capacity of soil. Inoculation of *Azotobactor* + PSB resulted in higher water holding capacity of soil after harvest of the crop. Bulk density, particle density, porosity as well as pH, EC and organic carbon content in soil were not influenced due to biofertilizers. Wu *et al.*, 2005 resulted that biofertilizers are products containing arbuscular mycorhizal fungi, N-fixers (*Azotobactor chroococcum*), P-solubilizers (*Bacillus megaterium*) and K solubilizers (*Bacillus mucilaginous*) which improve the chemical properties of soil. Biofertilizer also improve the soil texture, structure, nutrient supply and useful micro-organism which enhances the root biomass and ultimately organic carbon content in soil (Sharma, 2011 and Parewa *et al*., 2014) [19, 16].

Economics

The significantly highest net return (₹ 63688 ha^{-1}) and benefit cost ratio (2.28) were recorded with 75% RDF which was statistically at par with 100% RDF (Table 2). This trend of the net returns for crop depends upon the cost of input and treatment effect on the grain and straw yield. Similar results were reported by (Jat *et al.*, 2014 and Chauhan, 2014) [12, 6].

Application of vermicompost 5 t ha^{-1} obtained significantly higher net returns of ₹ 64661 ha^{-1} and benefit cost ratio (2.14) than other organic manures treatment. This trend in economic return is mainly due to the higher cost and treatment effect on the grain and straw yield of wheat. Similar findings were given by (Choudhary *et al*., 2013 and Baishya *et al.*, 2015) [7].

The highest net return (₹ 63711 ha^{-1}) and benefit cost ratio (2.28) was obtained with dual inoculation of *Azotobacter* + PSB as compared to without inoculation (Table 2). Use of efficient strains of bio-fertilizers are environment friendly, low cost agricultural inputs that have an important role in improving nutrient supply to crops but also reducing the cost of production (Kumar, 2013) [13]. These results corroborate the findings of (Ram and Mir, 2006) [17].

Table 1: Effect of fertility levels, organic sources and bio-inoculants on bulk density, particle density, water holding capacity and porosity of soil (pooled data of 2 years)

Treatments	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	Porosity (%)	Water holding capacity (%)
	Pooled	Pooled	Pooled	Pooled
Fertility levels				
50% RDF	1.44	2.52	42.92	43.53
75% RDF	1.42	2.50	43.11	45.55
100% RDF	1.42	2.49	43.13	47.12
S.Em ±	0.004	0.009	0.138	0.26
CD (P = 0.05)	NS	NS	NS	0.74
Organic sources				
FYM (5 t ha^{-1})	1.41	2.48	42.95	43.40
FYM (10 t ha^{-1})	1.45	2.56	43.30	44.56
VC (2.5 t ha^{-1})	1.41	2.46	42.83	45.89
VC (5 t ha^{-1})	1.43	2.52	43.14	47.76
S.Em ±	0.005	0.010	0.159	0.30
CD (P = 0.05)	NS	NS	NS	0.85
Bio-inoculants				
Without inoculation	1.42	2.50	43.11	44.81
Azotobactor + PSB	1.43	2.51	43.00	46.00
S.Em ±	0.003	0.007	0.113	0.21
CD (P = 0.05)	NS	NS	NS	0.60

Table 2: Effect of fertility levels, organic sources and bio-inoculants on pH, EC and organic carbon content in soil (pooled data of 2 years)

Treatments	pH	EC (dSm^{-1})	Organic carbon (%)
	Pooled	Pooled	Pooled
Fertility levels	8.05	0.46	0.63
50% RDF	8.03	0.47	0.68
75% RDF	8.00	0.46	0.69
100% RDF	0.06	0.004	0.005
S.Em ±	NS	NS	0.015
CD (P = 0.05)			
Organic sources	7.88	0.45	0.68
FYM (5 t ha^{-1})	7.99	0.46	0.70
FYM (10 t ha^{-1})	8.08	0.47	0.63
VC (2.5 t ha^{-1})	8.16	0.47	0.65
VC (5 t ha^{-1})	0.07	0.005	0.006
S.Em ±	NS	NS	0.017
CD (P = 0.05)			
Bio-inoculants	8.02	0.46	0.66
Without inoculation	8.04	0.47	0.67
Azotobactor + PSB	0.05	0.003	0.004
S.Em ±	NS	NS	NS
CD (P = 0.05)			

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