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Combined effect of different organic manures and organic biofertilizers on physico-chemical properties of soil

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Abstract
The current experiment was conducted in the month of October, 2021-22 in sacks at the open shade area of the roof top of house situated at Sodala, Jaipur, Rajasthan. Five different treatments of organic manure (Farm yard manure, vermicompost and crop residue) in combination with organic biofertilizers like liquid and carrier-based biofertilizers were applied to test the changes in physico-chemical properties of experimental soil. The results obtained with highest pH, electrical conductivity (ds/m), porosity (%), organic carbon (%), Available Phosphorus (kg/ha) and Available Nitrogen (kg/ha) in the treatment T_4 [3.75 t Farm Yard Manure/ha + 1.5 t Crop Residue/ha + Liquid based biofertilizer (*Rhizobium*) (800ml/ha)] than other treatments and control. It was concluded from the study that the use of organic manures (Farm yard manure and vermicompost and crop residue) alone and in combination with organic biofertilizers (Liquid and Carrier-based biofertilizers) improved the soil's physico-chemical properties.

Keywords: Organic manure, farm yard manure, vermicompost, crop residue, organic biofertilizer, soil

Introduction
Organic agriculture has gained significant global interest due to a substantial surge in consumer demand for organically cultivated products in the past decade. This increased demand is primarily attributed to the perceived benefits, it offers to both the environment and human health (Yadav *et al.*, 2022) [22, 29]. The global area of organic agriculture is expanding yearly. Soil health refers to a ‘soil’s ability to operate within the limits of an ecosystem, supporting biological productivity, upholding environmental quality, and fostering the well-being of plants and animals, as defined by Doran and Parkin in 1994 and Sharma *et al.*, 2023 [3, 26]. According to a number of studies, organic farming has a good impact on soil health, including the characteristics of the microbial community (Lori *et al.*, 2017) [13]. The utilization of high-yield crops, fertilizers, and chemical plant protection substances brings about alterations in the soil environment within the agricultural ecosystem, as indicated by Gajda and Przewloka (2012) [4]. The overuse of chemical fertilizers has resulted in the introduction of detrimental substances into the food chain and the depletion of essential natural microorganisms. It is widely believed that the adoption of organic fertilizers can potentially address numerous issues associated with this problem. This approach is thought to not only sustain soil productivity but also enhance natural processes and cycles in alignment with the environment (Yadav *et al.*, 2022) [22, 29]. On the other hand, organic manure such as farm yard manure, vermicompost, and crop residue are recognized for their positive impact on soil quality. Nevertheless, their restricted nutrient content and the challenge of obtaining them in substantial quantities hinder their broader application (Solanki *et al.*, 2020). Vermicompost and farm yard manure improve soil fertility, soil health, and crop productivity and its positive impacts on physical, chemical, and biological characteristics of soil and level of plant nutrition (Verma *et al.*, 2022) [27].

Biofertilizer formulations represent a highly promising and cutting-edge agricultural technique. Despite offering numerous benefits over traditional agrochemicals, this innovative approach has sparked significant debate within the farming community. One of the primary issues at the center of this controversy is the sustainability and viability of the microorganisms involved in the biofertilizers. The primary concern with carrier-based biofertilizers is their limited shelf life, which extends only up to three months and does not endure for the entire duration of the crop cycle (Nama *et al.*, 2021) [15]. Contrary to this, liquid biofertilizer which is comparatively more beneficial than carrier based biofertilizer (good for soil health, environmentally conscious and affordable alternative to chemical fertilizers (Kataria *et al.*, 2022; Sharma *et al.*, 2022) [11, 29]. Keeping this in view the present investigation has been carried out entitled "Combined effect of different organic manures and organic biofertilizers on physico-chemical properties of soil".

Material and Methods

The present investigation was conducted in the month of October 2021-22 in sacks at the open shade area of the roof top of house situated at Sodala, Jaipur, Rajasthan. The experiment comprised of 5 treatment combinations *viz*. T_1- 5 t Farm Yard Manure/ha, T_2- 2.5 t vermicompost/ha, T_3- 3.75 t Farm Yard Manure/ha + 1.5 t Crop Residue/ha + Carrier based biofertilizer (*Rhizobium*) (600gm/ha each), T_4- 3.75 t Farm Yard Manure/ha + 1.5 t Crop Residue/ha + Liquid based biofertilizer (*Rhizobium*) (800ml/ha), and T_5- Absolute control.

It was conducted in a completely randomized design (CRD) with three replications dividing the experimental into 15 sacks. The measurement of sacks used was 55.88 cm x 45.72 cm. To avoid the effect of any fertilizer used in agricultural fields, the soil for the experiment was procured from an uncultivated field and was filled in 15 sacks. Each sack was filled with 30 kg of the procured soil. Liquid biofertilizer, Carrier-based biofertilizer and organic manure (farm yard manure, vermicompost and crop residue of mustard) were procured from Rajasthan Agricultural Research Institute, Durgapura, Jaipur, Rajasthan, a constituent research institute under Sri Karan Narendra Agriculture University, Jobner. To check the changes in soil properties, the procured soil was sampled on day 1 i.e. before the application of organic manure (farm yard manure, vermicompost, and crop residue) and organic biofertilizer (Liquid biofertilizer, Carrier-based biofertilizer) and on day 90 i.e. after the application of organic manure and organic biofertilizer from their respective sacks. Further, the samples for each treatment were analyzed for various physico-chemical parameters.

Results and Discussion

Physico-chemical analysis of the experimental soil

Various physico-chemical parameters of soil like soil pH (pH meter using the procedure of Jackson, 1973) [8], soil electrical conductivity (EC meter using the procedure of Jackson, 1973) [8], organic carbon (Walkley and Black's rapid titration method, 1934) [28], available nitrogen (Alkaline Permanganate method- Subbiah and Asija, 1956) [26], available phosphorus (Olsen's method, 1954) and bulk density and porosity (Method No.31 USDA Hand Book No.60 (Richards, 1954) were analyzed in the experimental year (2021-22). To check the changes in soil properties, the procured soil was sampled on day 1 i.e. before the application of organic manure (farm yard manure, vermicompost, and crop residue) and organic biofertilizer (Liquid biofertilizer, Carrier-based biofertilizer) and on day 90 i.e. after the application of organic manure and organic biofertilizer from their respective sacks.

Day 1

It was loamy sand in texture, low in available nitrogen (193.1 kg/ha), medium in available phosphorus (34.17 kg/ha), pH (7.3), EC (0.69 dS) and low in organic carbon (0.32%).

Day 90

The effect of liquid biofertilizer, carrier based biofertilizer and combined treatment of different organic manure (Farm yard manure, vermicompost and crop residue) on soil pH, EC, Bulk density and porosity, organic carbon, available nitrogen and available phosphorus of post- harvest soil is presented in Table 1 and 2.

Soil pH and Electrical Conductivity (ds/m)

The data showed that pH, EC (pH- 7.2 and EC- 0.80 ds/m) was recorded minimum in T_4 -3.75 t Farm Yard Manure/ha + 1.5 t Crop Residue/ha + Liquid based biofertilizer (*Rhizobium*) and maximum (pH- 8.3 and EC- 2.3 ds/m) was recorded in T_5- absolute control. The formation of organic acids formed due to the decomposition of organic manure and crop residues may be responsible to decrease the pH (Parewa *et al.*, 2014; Sharma *et al.*, 2013; Singh *et al.*, 2023) [17, 21, 24]. According to Nama *et al.* (2021) [15] application of bio-inoculants can lead to a slight decrease in soil pH, possibly due to the release of organic acids by rhizobium, PSB, and azotobacter in liquid biofertilizers. In a study conducted by Singh *et al.*, (2007), the combination of chemical fertilizers and bioinoculants resulted in a marginal change in EC values. Contrary to this, Govindan and Thirumurugan (2003) [5] found no significant difference in EC values when bio-inoculants were used.

Soil Bulk Density (g/ cm³) and Porosity (%)

Data furnished in Table 1 indicated that lower bulk density and higher porosity of soil was increased in treatment T_4 (1.31 g/cm³ and porosity-50.3%) over other treatments and was at par with T_3 (1.41 g/cm³ and porosity-46.9%). Highest bulk density and lowest porosity (1.75 g/cm³ and porosity-34.0%) were recorded with the absolute control (T_5) treatment. According to Rai *et al.* (2014) [18] and Singh *et al.* (2023) [24] the addition of organic manures (FYM and vermicompost) reduced the bulk density and increased the porosity of soil.

Organic Carbon (%)

The findings concerned with the effect of liquid biofertilizer, carrier-based biofertilizer and combined use of various organic manures on organic carbon are presented in Table 2. It is clear from the results that the treatment T_4 recorded higher (0.30%) content of organic carbon over all other treatments and control (T_5) (0.12%). Results of T_4 were at par with T_3 (0.26%) and treatment T_1 (0.22%). The rise in organic carbon may have resulted due to seed treatment with *Rhizobium* (liquid biofertilizer), which increased microbial activity that supported greater root penetration, and produced leaves that shed more leaves of the mungbean plant (Nama *et al.*, 2021) [15]. Iraj *et al.* (2009) [7] also noted a notable rise in organic carbon concentration when *Rhizobium* as a biofertilizer was used in comparison to control. The addition of FYM directly adds organic carbon and encourages the development and activity of microorganisms. It's possible that greater biomass production also increased the soil's organic carbon content. (Jat *et al.*, 2012; Babulkar *et al.*, 2000) [10, 1]. Yaduvanshi (2001) [30] noted comparable results as well.

Available Phosphorus (kg/ha)

The data regarding available P content in soil (0-15 cm) after harvest of the crop are presented in table 2. The combined application of liquid biofertilizer and organic manure treatment T_4 recorded higher available phosphorus content (47.3 kg/ha) over other treatments and was at par with T_3

(45.5 kg/ha) and T_2 (42.5 kg/ha). The lowest phosphorus content was found in absolute control (T_5) treatment (38.7 kg/ha). The application of liquid biofertilizer led to an elevation in the soil's phosphorus content. This was attributed to its ability to convert insoluble phosphorus into a soluble form, thereby providing an immediate source of phosphorus for both plants and microorganisms.

Another reason may be the release of different organic acids from organic manures (farm yard manure and vermicompost). This causes the addition of both phosphorus as well as the dissolved form of native phosphorus in the soil (Gupta *et al.*, 2019) [18]. Similar outcomes were observed by Rai *et al.*, 2014. Kumar *et al.*, 2003 and Jamir *et al*., 2013 have also mentioned an increase in available phosphorus status as a result of the combined usage of organic manure with synthetic fertilizers.

Available Nitrogen (kg/ha)

A critical analysis of the data availability N content in the soil after harvest of the crop is presented in Table 2. Higher available nitrogen (235.2kg/ha) was recorded by the treatment T_4 over other treatments. T_4 was found to be at par with T_3 (228.3 kg/ha) and treatment T_2 (216.3 kg/ha). The lowest available nitrogen (193.1 kg/ha) was recorded in absolute control (T_5). The increase in the available nitrogen in T_4 treatment was due to the application of liquid biofertilizer that led to an increase in the adaptability of microbes, prompting the conversion of organically bound nitrogen into an inorganic form. This, in turn, enhanced the efficiency of applied fertilizers, ultimately leading to greater nitrogen availability. These results are consistent with those of Rajesh (2012) [19] and Chesti *et al.* (2013) [2]. Since no nutrients were applied in the control (T_5), the available nutritional status was found to be lower than in other group treatments. Another reason for improving available nitrogen with organic manure application may be because of the direct addition of nitrogen by vermicompost and farm yard manure to the accessible pool of the soil (Gupta *et al.*, 2019) [6]. Similar outcomes were observed by Singh *et al.* (2023) [24].

Table 1: Soil physico-chemical properties

Treatments	Soil pH	Electical Conductivity (ds/m)	Bulk density (g/cm³)	Porosity (%)	Organic carbon (%)
T_1	7.6±0.054	1.23±0.007	1.50±0.0006	40.9±0.498	0.22±0.115
T_2	7.7±0.083	1.45±0.003	1.53±0.0003	42.2±0.502	0.21±0.075
T_3	7.4±0.084	0.96±0.003	1.41±0.0004	46.9±0.532	0.26±0.055
T_4	7.2±0.114	0.80±0.001	1.31±0.0001	50.3±0.204	0.30±0.045
T_5	8.3±0.194	2.3±0.017	1.75±0.0001	34.0±0.235	0.12±0.122

Table 2: Soil physico-chemical properties

Treatments	Available Phosphorus (kg/ha)	Available Nitrogen (kg/ha)
T_1	43.9±0.685	221.4±1.72
T_2	42.5±0.935	216.3±2.21
T_3	45.5±0.635	228.3±1.41
T_4	47.3±0.634	235.2±2.21
T_5	38.7±0.813	193.1±2.80

Conclusion

On the basis of above findings, it may be concluded that using organic manure (Farm yard manure, vermicompost and crop residue), biofertilizers (liquid biofertilizer and carrier-based biofertilizer) had a positive role in improving all tested soil properties (pH, electrical conductivity, organic carbon, available phosphorus and available nitrogen). From this experiment, it is clear that the integrated use of liquid biofertilizer with organic manure in treatment T_4- 3.75 t FYM/ha + 1.5 t CR/ha + Liquid based biofertilizer (*Rhizobium*) increased almost all tested physico-chemical parameters of the soil at the harvesting time of the crop.

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