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ASSESSMENT OF PHYSICAL, CHEMICAL AND BIOLOGICAL PROPERTIES OF SOIL IN ONION BASED CROPPING SYSTEMS THROUGH ORGANIC NUTRIENT MANAGEMENT[#]

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Abstract

Considering the importance of organic farming and soil health environment, field studies were conducted for 2 years (2015-16 to 2016-17) on a clay loam soil at the IFSRP, Rahuri, to assess the influence of organic nutrient management systems on soil physical, chemical and biological properties in the onion based cropping systems. In respect of all above assessment the application of 50% N through FYM + 50% N through Vermicompost to *kharif* crops followed by 100% N through organic (In equal split of N through 50 : 50% FYM : Vermicompost) recorded higher values of physical, chemical and biological properties of soil.

Keywords: Onion, cropping system, soil properties, organic nutrient

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Introduction

Today, the burgeoning population pressure has forced many countries to use chemicals and fertilizers to increase the farm productivity for meeting their ever-increasing food requirements. The applications of such high input intensive technologies have undoubtedly increased the production and labour efficiency, but, there is a growing concern over their adverse effects on soil productivity and environmental quality. Promoting organic agriculture offers one of the most promising options available for achieving food security and other basic needs of humanity apart from conserving natural resources viz., soil as well as biodiversity. People are gradually realizing the danger of modern day production system and asking for chemical fertilizer and pesticide residue free food items and that encouraging the rapid development of organic agriculture in the country. Application of scientific approaches to organic farming practices holds the possibility of maintaining and in some cases increasing the yield over long run, while sustaining bio-diversity, soil fertility, soil biological cycles and natural ecosystem processes and services that underpin the agriculture. Apart from this, it allows the farmers to overcome the risk of crop failures and increased cost of production. The philosophy behind the concept of organic farming is to feed the soil, rather than the crop and it is a means of giving back to nature what has been taken from it. Hence, the organic farming is a sustainable production and management system which focuses on health of soil, ecosystem and human beings.

The physical properties of soil denote structure, texture, bulk density, porosity, water-holding capacity etc and positive effects of organic farming on soil physical properties *viz.* soil structure, water holding capacity, soil aeration and soil temperature. Organic management can improve soil structure, organic matter content, and porosity in soil. Crop rotation is an important component under organic farming which directly and indirectly influences the physical structure of soil. Accumulation of organic matter in soil during the lean phase has a direct influence in the modification of soil structure. The architectural form of different root systems of several crops included in the crop rotation also helps to modify the soil structure. Mulching of soil surface with organic materials renders the soil soft, pulverized, and humid that ultimately creates a congenial environment for beneficial microbes to maintain bulk density and porosity in the soil. Organic farming adds more organic matter to the soil, which is the basic requirement for improving soil health. Presence of this organic matter in soil increases its moisture retention capacity. A combination of organic sources of nutrient (crop residue mulching) and no-tillage increases soil fertility, crop production, and control soil erosion. Further, residue decomposition adds organic matter to the soil, which contributes to reduce the soil hydrological response, increase soil water repellency that reduces infiltration rates. Application of organic manures not only provides nutrient to the standing crop but also to the succeeding crop. The improvement of soil physical properties due to organic farming has spatio-temporal dimension also that organic farming is better in areas having extreme rainfall because of the higher absorption and less run-off of water in the field (Biswas *et al.*, 2014).

Unlike conventional agriculture, organic agriculture follows the natural cycle to add essential nutrients for quality improvement. Organic farming has potential to maintain soil fertility and increase organic carbon in soil. Application of different organic inputs like FYM, vermicompost, green manuring, neem seed cake etc. ensures both the sustainability of soil organic carbon and supply of nutrients to the plants. Application of good quality FYM improves the total nitrogen and organic matter in the soil, which is "an important substrate of cationic exchange and the warehouse of most of the available nitrogen, phosphorus, and sulphur; the main energy source for microorganisms; and is a key determinant of soil structure". Significant differences and higher values of soil organic carbon, carbon stocks, and carbon sequestration rate were observed in organically managed plots compared to non-organic plots. It is undoubtedly an important controlling factor for C:N ratio, total and available N, N mineralization, soil moisture, microbial activity, and soil texture. Strikingly, several studies have reported that organically amended soil holds more available N than the soil receiving inorganic fertilization mainly due to relatively slower and constant mineralization rates, ultimately decreasing nitrogen leaching. Organic acids and humus fraction of decomposing matter are more efficient in releasing phosphorus and reducing its fixation in soil. Nutrient supply through organic sources also ensures micronutrient availability to the plant (Biswas *et al.*, 2014).

Although many researchers confine the concept of soil quality to physical and chemical properties, others value biological parameter as an important aspect, which should be incorporated in soil quality assessment process. These biological properties are very important while assessing soil quality since soil quality is strongly influenced by the flora and fauna present in the soil. Soil micro-organisms are the living part of soil organic matter present in the soil. The microbial biomass and microbial activities in soil are crucial to sustain the productivity of soil. For ensuring consistent release of nutrients to the plants, there is a need to have balanced ratio of microbial biomass and activity in soil. Organic farming is reported to have enhanced both microbial biomass and microbial activity by 20-30% and 30-100%, respectively. The soil having high organic matter content ensures greater microbial activity and greater soil N supplying power than the soil having less organic matter (which is managed inorganically). In addition to this, soil organic matter has a capacity to sink the atmospheric CO2 and thereby increasing the carbon content in the soil, which further enhances the microbial biomass and respiration. It has also been well documented that the organically managed soil enriched with several beneficial microorganisms like arbuscular mycorrizal fungi for ensuring improved crop nutrition and decreasing soil borne diseases. Arbuscular mycorrizal fungi is a special fungal group, which makes symbiotic association with the plant's root system enhancing plant nutrient uptake and water absorption. This mutualistic relationship primarily helps plant to take more P from the soil and also protects plants from several diseases. As organic farming increases the microbial activity, leads to increased competition, parasitism and predation in the rhizosphere, it collectively reduces the chances of plant disease infestation. Application of quality organic inputs enhances the microbial population in the soil. Organic fertilizer application improved nodule dry weight, photosynthetic rates, N2 fixation, and N accumulation as well as N concentration in several crops. However, it was also found that organic agroecosystem management strongly influences the soil nutrients and enzyme activity while it has lesser influence on soil microbial communities. Several composts like vermin-compost, farmyard manure etc. are generally used for nutrient management in organic farming, which ultimately promote the beneficial macro and micro flora in the soil. Application of organic inputs like human urine, sewage sludge, municipal waste, deep litter, cattle slurry, cattle manure etc. ensures higher soil microbial biomass. Hence, household waste and sewage sludge help to maintain the highest number of colony forming heterotrophic bacteria in the soil (Biswas *et al.*, 2014).

Materials and Methods

An experiment was conducted during 2015-16 and 2016-17 at the IFSRP, MPKV, Rahuri. The soil of the experimental field was clay loam in texture, low in available nitrogen, medium in available phosphorus and very high in available potassium, respectively with pH 8.14. The experiment was laid out in split spit plot design with three replications. Nine combinations of three crop sequences (onion-sorghum, onion-wheat and onion - chickpea) and three combinations of organic nutrient sources *viz.,* 50% N through FYM + 50 % N through Vermicompost, 50% N through FYM + 50% N through Neem cake and 50% N through Vermicompost + 50 % N through Neem cake were the main plot treatments in *kharif* season replicated three times in randomized block design. During *rabi* season each main plot treatments of residual effect of organic nutrient sources was split into three sub plot treatments of organic nutrient levels *viz.,* 100, 75 and 50% N through organic (In equal split of N through 50: 50% FYM: vermicompost) to *rabi* season crops (Sorghum, Wheat and Chickpea) resulting in twenty seven treatment combinations replicated three times in split plot design. One additional control treatment of GRDF included for comparison.

Result and Discussion

Physical Properties

Among the organic nutrient sources residual effect of 50% N through FYM + 50% N through VC and direct effect of 100% N through organic (50% N through FYM + 50% N through VC) to rabi crops was found in first rank with respect of infiltration rate, bulk density, porosity, field capacity and permanent wilting point over rest of the treatments of organic sources during 2015-16 and 2016-17, respectively (Table 1). Improvement in physical properties due to increased organic carbon by addition of organic manures. Similar findings were reported by Meena *et al*. (2014). All values of physical properties observed lower in control plot of 100% GRDF in comparison with organic treatments during 2015-16 and 2016-17, respectively.

Chemical Properties

The marginally higher values of pH, EC and organic carbon observed under the treatment of residual and direct effect of 100% N through organic (50% N through FYM + 50% N through VC) after second cycle. The residual effect of 50% N through FYM + 50% N through VC recorded significantly higher values of available N (156 and 161 kg ha^{-1}), P (22 and 24 kg ha^{-1}) and K (258 and 268 kg ha^{-1}) over rest of treatments. However, values of P and K it was at par with 50% N through VC+ 50% N through NSC during both the years. Under direct application of nutrients to *rabi* crops, the treatment of 100% N through

Table: 1. Effect Of Different Treatments on Infiltration Rate, Bulk Density Porosity, Field Capacity and Permanent Wilting Point of Soil After End of First and Second Cycle

Treatment		Infiltration rate (mm hr^{-1})		Bulk density (g cm^{-3})		Porosity (%)		Field capacity (%)		Permanent wilting point (%)	
		2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
A.	**Effect of organic sources**										
K_1:	50 % N FYM + 50 % N VC	8.98	9.96	1.32	1.30	50.02	50.78	35.64	35.65	16.61	17.50
K_2:	50 % N FYM + 50 % N NSC	8.58	9.24	1.32	1.31	50.31	50.44	34.25	35.10	15.56	15.88
K_3:	50 % N VC + 50 % N NSC	8.93	9.58	1.33	1.31	49.90	50.52	34.60	35.27	16.50	16.68
	SE m±	0.38	0.27	0.01	0.01	0.48	0.38	0.39	0.28	0.64	0.53
	CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
B.	**Effect of organic nutrient levels**										
R_1:	100 % N-Organic	9.23	10.39	1.31	1.30	50.69	50.99	35.90	36.14	17.35	17.91
R_2:	75 % N-Organic	7.68	9.38	1.33	1.31	49.90	50.65	34.35	35.13	16.01	16.11
R_3:	50 % N-Organic	7.58	9.01	1.33	1.32	49.64	50.10	34.25	34.75	15.31	16.05
	SEm±	0.50	0.49	0.01	0.01	0.31	0.26	0.50	0.49	0.43	0.49
	CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	1.33	1.51
	Interaction										
	A x B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Mean	8.17	9.59	1.32	1.31	50.08	50.58	34.83	35.34	16.22	16.69
	Control-GRDF	7.53	8.38	1.33	1.32	49.69	50.23	33.20	33.27	17.29	17.36
	Initial	**8.30**		**1.32**		**50.29**		**34.30**		**16.32**	

organic recorded significantly higher values of N (157 and 163 kg ha^{-1}), P (23 and 24 kg ha^{-1}) and K (257 and 268 kg ha^{-1}) over rest of treatments. However, it was at par with 75% N through organic with respect of K during 2015-16 and 2016-17 after harvest of crop sequence (Table 2). Organic sources response was more with the use of FYM and vermicompost which might have been due to its rich constituents and sustained availability. Similar findings reported by Maheswarappa *et al. (1997),* Koushal *et al.* (2011), Srinivasan (2012), Meena *et al*. (2014) and Patra *et al.* (2016). Under control the soil available N and K improved by application of 100% GRDF (FYM+ RDF) as compared to all organic treatments during both the years. Gudadhe (2008) reported similar findings.

Biological Properties

The soil biological properties viz., bacteria (75.93 and 79.49 cfu x 10^{-6} g^{-1} soil), fungi (28.03 and 30.72 cfu x 10^{-5} g^{-1} soil) and actinomycetes (43.82 and 46.67 cfu x 10^{-3} g^{-1} soil) improved significantly under the treatment of residual effect of 50% N through FYM + 50% N through VC than rest of treatments after completion of crop cycle during 2015-16 and 2016-17. However, it was at par with 50% N through VC + 50% N through NSC in respect of fungi and actinomycetes during both the years. Under direct effect, 100% N through organic (50% N through FYM + 50% N through VC) recorded significantly maximum count of bacteria (77.21 and 80.99 cfu x 10^{-6} g^{-1} soil), fungi (30.38 and 32.19 cfu x 10^{-6} g^{-1} soil) and actinomycetes (45.94 and 48.13 cfu x 10^{-3} g^{-1} soil) than rest of treatments (Table 3).

Table: 2. Effect of different treatments on soil pH, electrical conductivity, organic carbon and soil available NPK after end of first and second cycle

Treatment		pH		EC (dSm^{-1})		Organic carbon (%)		Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})	
		2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
A.	**Effect of organic sources**												
K_1:	50 % N FYM + 50 % N VC	8.23	8.21	0.27	0.40	0.57	0.58	156	161	22	24	258	268
K_2:	50 % N FYM + 50 % N NSC	8.25	8.24	0.23	0.36	0.54	0.55	150	157	17	19	248	258
K_3:	50 % N VC + 50 % N NSC	8.24	8.22	0.25	0.39	0.56	0.57	153	158	20	22	252	263
	SE m±	0.03	0.02	0.003	0.02	0.01	0.004	0.72	0.71	0.58	0.67	1.78	1.73
	CD at 5 %	NS	NS	NS	NS	NS	NS	2.85	2.78	2.27	2.65	7.01	6.81
B.	**Effect of organic nutrient levels**												
R_1:	100 % N-Organic	8.23	8.22	0.24	0.40	0.57	0.58	157	163	23	24	257	268
R_2:	75 % N-Organic	8.23	8.22	0.26	0.40	0.55	0.56	152	157	19	21	253	264
R_3:	50 % N-Organic	8.25	8.23	0.26	0.35	0.54	0.55	151	156	18	19	247	258
	SEm±	0.03	0.02	0.01	0.02	0.004	0.003	0.96	0.97	0.91	0.87	2.43	2.42
	CD at 5 %	NS	NS	NS	NS	NS	NS	2.98	2.99	2.82	2.68	7.50	7.46
	Interaction												
	A x B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Mean	8.23	8.22	0.25	0.38	0.55	0.56	153	159	20	21	253	263
	Control-GRDF	8.25	8.25	0.25	0.38	0.54	0.58	157	162	21	23	282	293
	Initial	**8.25**		**0.29**		**0.53**		**181**		**15**		**403**	

The favorable effect of organics on soil biological properties is a proven fact which help in providing ideal conditions and presumably increased microbial activity because of the available high organic matter. Similar findings reported by Meena *et al.* (2014), Maheswari and Sivasakthivelan (2015) and Patra *et al.* (2016). The direct effect of 100, 75 and 50% N through organic were recorded maximum population of bacteria, fungi and actinomycetes than treatment of 100% GRDF after completion of crop sequence during first and second year, respectively. Similar findings reported by Gudadhe (2008).

Table: 3. Effect of Different Treatments on Soil Biological Properties after End of First and Second Cycle

Treatment	Bacteria (CFU x $10^{-6}g^{-1}$ soil)		Fungi (CFU x $10^{-5}g^{-1}$ soil)		Actinomycetes (CFU x $10^{-3}g^{-1}$ soil)	
	2015-16	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**
A. Effect of organic sources						
K_1 : 50 % N FYM + 50 % N VC	75.93	79.49	28.03	30.71	43.82	46.67
K_2 : 50 % N FYM + 50 % N NSC	70.06	74.06	27.17	29.95	42.73	44.91
K_3 : 50 % N VC + 50 % N NSC	72.77	77.11	27.88	30.24	42.98	45.83
SE m$\pm$	0.43	0.19	0.47	0.33	0.55	0.54
CD at 5 %	1.70	0.76	1.28	1.16	1.87	1.89
B. Effect of organic nutrient levels						
R_1 : 100 % N-Organic	77.21	80.99	30.38	32.19	45.94	48.13
R_2 : 75 % N-Organic	73.37	77.15	27.84	31.23	43.05	45.90
R_3 : 50 % N-Organic	68.17	72.50	24.84	27.49	40.54	43.39
SEm$\pm$	0.38	0.46	0.49	0.55	0.63	0.71
CD at 5 %	1.16	1.42	1.52	1.76	1.94	2.19
Interaction						
A x B	NS	NS	NS	NS	NS	NS
Mean	72.92	76.88	27.69	30.30	43.18	45.81
Control-GRDF	41.06	44.84	12.31	16.39	32.61	33.41
Initial	**56.00**		**22.37**		**35.66**	

Conclusion

It was concluded that application of 50% N through FYM + 50% N through Vermicompost to *kharif* crops followed by 100% N through organically recorded higher values of physical, chemical and biological properties of soil.

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