International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(6): 875-879

Received: 04-09-2017
Accepted: 07-10-2017

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Changes in soil chemical properties due to moisture regimes and sources of organic manures

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Abstract
Study was conducted to know the influence of moisture regimes and sources of organic manures on soil chemical properties in Inceptisols, an incubation study was conducted under laboratory conditions. The research work was carried out at the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dhule. The study comprises five levels of moisture, viz., 0 bar, 1/3 bar (Field capacity), 5 bar, 10 bar and 15 bar (permanent wilting point), and sources of organic manures viz., control, FYM and vermicompost were replicated thrice in factorial complete randomized design. The results revealed that the pH, EC, organic carbon and calcium carbonate does not much vary with moisture levels. The soil pH, EC and calcium carbonate values were found lower with vermicompost as compared to FYM. Available NPK contents increased significantly with the increase in moisture levels up to field capacity. The moisture levels above the field capacity reduced their availability. The availability of NPK and organic carbon content was significantly increased with the application of vermicompost as compared to FYM. The interaction effect of moisture levels and organic manures was found to be significant during 0^{th} and 120^{th} days of incubation period. The interaction of moisture at field capacity and vermicompost showed the maximum content of available nitrogen (145.36 and 157.22 kg ha^{-1}), phosphorus (10.13 and 11.99 kg ha^{-1}) and potassium (504.31 and 524.20 kg ha^{-1}) at 0 day and at 120^{th} day of incubation, respectively.

Keywords: soil chemical properties, soil moisture, vermicompost, farm yard manure

Introduction

The productivity and stability of soil as a medium for plant growth depends greatly on the balance between living and non living microorganisms. A major agriculture research priority is to sustain soil productivity and to develop better methods to monitor changes in soil physical, chemical and biological properties as influenced by the management practices. Nutrient cycling in soil involves biochemical and physiochemical reaction, which are greatly affected by moisture and organic matter present in soil. The native or added organic matter transformation in the soil involves many reactions which are catalyzed by enzymes existing outside the microorganism and plant root system in presence of moisture (Sarpatka, 2003) [14]. Organic matter has both a direct and indirect effect on the availability of nutrients for plant growth while, the proper soil moisture is require for the dissolution and mobilization of ions. It is well known fact that, changes in soil moisture and carbon input have a large effect on the soil microbial biomass and its activity, which, in turn, affect nutrient availability due to soil organic matter turnover. However, limited data exist on the magnitude of changes in soil chemical properties under different water regimes. Hence, the present investigation was undertaken to record the changes in some chemical parameters due to different soil moisture regimes and organic manure in inceptisols.

Material and Methods

An incubation study was conducted under laboratory condition. The plastic pots were filled with 1 kg soil. The soil moisture at different bars 0 bar (M_1), 1/3 bar (M_2), 5 bar (M_3), 10 bar (M_4) and 15 bar (M_5) and sources of organic manure vermicompost (O_3), FYM (O_2) and control (O_1) were added in soil as per treatment. The sources of organic manure were added in soil @ 1% of organic carbon content. Soil moisture levels maintained as per the treatment during incubation period. The soil properties and chemical composition of organic manures were presented in Table 1 and 2. The fifteen treatment combinations were replicated thrice in a complete randomized design (factorial). The soil samples were drawn at 0 and 120 days of incubation and analyzed for pH, electrical conductivity (EC), organic carbon, calcium carbonate and available NPK.

Soil moisture at different bar was determined by Pressure plate membrane apparatus (Klute and Dirksen, 1986) [5]. Soil pH (potentiometry), electrical conductivity (conductometry), organic carbon (wet oxidation) and available potassium (Flame photometry) were determined as per the methods suggested by Jackson (1973) [4]. Available nitrogen was estimated by alkaline permanganate method (Subbiah and Asija, 1956) [15], available phosphorus determined by colorimetric method (Watanabe *et al.*, 1965) [18] and calcium carbonate was estimated by acid neutralization method (Piper, 1966) [12]. The total calcium and magnesium in organic manures were estimated by versenate titration method (Chapman and Pratt, 1961) [2], total nitrogen by microkjeldahl method (Parkinson and Allen, 1975) [10], total phosphorus by vanadomolybdate colorimetric (Piper, 1966) [12], total potassium by flame photometry (Chapman and Pratt, 1961) [2] and organic carbon by ignition method (Gorsuch, 1970) [3]. The data generated was statistically analyzed in Factorial Complete Randomised Design (FCRD) as suggested by Panse and Sukhatme (1965).

Results and Discussion

Soil pH and EC

The pH activity in soil does not vary with moisture level (Table 3). However, the moisture at 0 bar (M_1) treatment showed highest pH activity as compared with other moisture levels. The application of vermicompost (O_3) treatment showed the decreased pH activity as compared with FYM (O_2) and control (O_1). The highest pH activity in (O_1) treatment was showed at 0 and 120th day of incubation. The vermicompost reduce the soil pH as compared with FYM and control was also reported by Parthsarthi *et al.* (2008) [11]. The interaction effect of moisture level and organic manure was found significant for pH activity in soil at 0 and 120th day of incubation. The highest pH (8.2) was recorded on 0 day of incubation for interaction M_1O_1 and interaction M_5O_3 showed minimum pH value (8.1) at 120th day of incubation.

The moisture at 0 bar (M_1) treatment as compared with other moisture levels shows the highest EC (0.34 dSm^{-1}) at 0 days of incubation. The increase in EC of soil with increase in moisture levels was also reported by Zhang and Wienhold (2002) [19]. The application of vermicompost (O_3) treatment showed the decreased EC of soil as compared with FYM (O_2) and control (O_1). The highest EC of soil in (O_1) treatment was showed at 0 and 120th day of incubation. The vermicompost reduced the soil EC as compared with FYM and control was also reported by Parthsarthi *et al.* (2008) [11]. The observation on EC of soil in relation to organic manure is close conformity with Thamaraiselvi *et al.* (2012) [16]. They reported that the addition of FYM showed the higher EC of soil as compared with vermicompost. The interaction effect of moisture level and organic manure was found significant for EC at 0 and 120th day of incubation. The highest value of significant interaction was (0.29) recorded on 0 day of incubation for M_1O_1 and interaction M_5O_3 showed minimum EC value (0.23) at 120th day of incubation.

Soil organic C and calcium carbonate

The effects of different moisture levels and organic manures on organic carbon content and $CaCO_3$ in soil are given in Table 4. The application of moisture at different levels had significantly increase organic carbon content in soil. The organic carbon content of soil is more or less unaffected by moisture levels at 0 and 120th day of incubation. The application of vermicompost (O_3) treatment showed the increased organic carbon content as compared with FYM (O_2) and control (O_1). The vermicompost (O_3) treatment shows the highest value of 0.34 and 0.35% of organic carbon content in soil at 0 and 120th day of incubation, respectively. The vermicompost increased the organic carbon content in soil as compared with FYM was also reported Okur *et al.* (2009) [8]. The interaction effect of moisture levels and organic manures was found significant for organic carbon content in soil. The interaction M_2O_3 showed the highest value (0.39 %) of organic carbon content at 0 day, and interaction M_2O_3 showed the highest value (0.41 %) of organic carbon content at 120th day of incubation. The levels of moisture with vermicompost show the higher organic carbon content as compared with other moisture levels and FYM.

The application of moisture at different levels had no sharp increase and decrease in calcium carbonate content in soil. The calcium carbonate content of soil is more or less unaffected by moisture levels at 0 and 120th day of incubation. Although, the application of vermicompost (O_3) treatment showed the decreased calcium carbonate content as compared with FYM (O_2). The FYM (O_2) treatment show the highest values of 5.09 % and 4.66 % of calcium carbonate content in soil at 0 and 120th day of incubation, respectively. The interaction effect of moisture levels and organic manures was found significant for calcium carbonate content in soil. The interaction M_1O_1 showed the highest value (5.09 %) of calcium carbonate content at 0 day, and interaction M_5O_3 showed the highest value (4.66 %) of calcium carbonate content at 120th day of incubation. The different levels of moisture with FYM and vermicompost showed the quite similar effects on the calcium carbonate content of soil.

Soil available NPK

The soil moisture significantly enhanced the NPK contents in soil over control throughout the incubation period. The moisture at field capacity (M_2) was significantly superior over other treatments of moisture. The treatment (M_2) shows the highest available nitrogen content as compared with other treatments. Antil (2002) [1] reported that the effect of soil moisture on nitrogen mineralization increased with increased in moisture content up to field capacity and decreased drastically at flooding. Higher mineralization of nitrogen at field capacity moisture content might be due to the greater activity of nitrifying micro-organism. Misra and Tyler (1999) [7] reported that the phosphorus and potassium concentration was increased with increased soil moisture levels and Laximinarayana and Rajagopal (2004) [6] reported that the sub-mergence of the soils increased the available phosphorus status in soil.

The application of vermicompost significantly enhanced the available NPK contents in soil over control throughout the incubation period. The vermicompost (O_3) treatment shows the highest NPK contents as compared to FYM (O_2) treatment. Increases in nitrogen and phosphorus contents with the application of vermicompost was recorded by Reddy and Reddy (1998) [13]. The increased content of nitrogen in soil might be due to addition of organic matter to soil which increased the microbial population and soil enzyme activity. The increase in available potassium status upon vermicompost application could be due to increase in exchangeable potassium status upon release of potassium from non-exchangeable sites Waghmare (1997) [17].

The interaction effect of levels of moisture and different organic manures was found to be significant throughout the incubation period. The interaction M_2O_3 (moisture at field capacity and vermicompost) showed the maximum content of available nitrogen (145.36 and 157.22 kg ha^{-1}), phosphorus (10.13 and 11.99 kg ha^{-1}) and potassium (504.31 and 524.20 kg ha^{-1}) at 0 day and at 120^{th} day of incubation, respectively. The level of moisture with vermicompost shows the higher available nitrogen content as compared with FYM.

The application of moisture at different levels had significantly decreased the pH activity and increased the EC of soil. The organic carbon, available nitrogen, phosphorus and potassium content in soil were increased in soil with the application of moisture at field capacity of soil and application of vermicompost. The calcium carbonate content in soil was unaffected by application of moisture and organic manures. Hence, it was concluded that the organic manure along with proper moisture maintained the soil chemical fertility.

Table 1: Physical and chemical properties of experimental soil

S. No.	Particulars	Value
A)	Physical properties	
I	Soil moisture at,	
i.	0 bar	100 %
ii.	1/3 bar	52.25 %
iii.	5 bar	41.82 %
iv.	10 bar	22.38 %
v.	15 bar	8.0 %
B)	Chemical properties	
1	pH (1:2.5)	8.8
2	EC (dSm^{-1})	0.95
3	Calcium carbonate (%)	2.62
4	Organic carbon (%)	0.33
5	Available Nitrogen (kg ha^{-1})	135.60
6	Available Phosphorus (kg ha^{-1})	9.33
7	Available Potassium (kg ha^{-1})	435.10

Table 2: Chemical composition of FYM and vermicompost

Sr. No.	Particulars	FYM	Vermicompost
1	pH	7.9	8.0
2	EC (dSm^{-1})	2.66	4.69
3	Ca (%)	20.0	18.0
4	Mg (%)	3.6	8.0
5	Total nitrogen (%)	0.61	1.2
6	Total phosphorous (%)	0.39	0.42
7	Total potassium (%)	0.79	0.99
8	Organic Carbon (%)	12.0	15.0
9	C/N Ratio	19.67	12.50

Table 3: Effect of moisture regimes and organic manures on soil pH and EC (dSm^{-1}) of soil

M/O	O_1	O_2	O_3	Mean	O_1	O_2	O_3	Mean
pH at 0 days of incubation					**EC at 0 days of incubation**			
M_1	8.22	8.18	8.15	8.18	0.34	0.29	0.24	0.29
M_2	8.20	8.19	8.15	8.18	0.32	0.27	0.24	0.27
M_3	8.19	8.18	8.17	8.18	0.32	0.27	0.25	0.28
M_4	8.20	8.17	8.15	8.17	0.30	0.27	0.25	0.27
M_5	8.22	8.17	8.15	8.18	0.29	0.27	0.24	0.26
Mean	8.21	8.17	8.15		0.31	0.27	0.24	
Interaction	S.E ±		C.D. at 5%		S.E ±		C.D. at 5%	
M	0.025		0.069		0.018		0.049	
O	0.020		0.055		0.014		0.038	
M x O	0.044		0.121		0.031		0.085	
pH at 120^{th} days of incubation					EC at 120^{th} days of incubation			
M_1	8.20	8.15	8.12	8.15	0.32	0.27	0.23	0.27
M_2	8.20	8.17	8.12	8.16	0.32	0.25	0.22	0.26
M_3	8.19	8.14	8.13	8.15	0.30	0.26	0.24	0.27
M_4	8.20	8.16	8.13	8.16	0.29	0.26	0.24	0.26
M_5	8.21	8.15	8.10	8.15	0.27	0.25	0.23	0.25
Mean	8.20	8.15	8.12		0.30	0.26	0.23	
Interaction	S.E ±		C.D. at 5%		S.E ±		C.D. at 5%	
M	0.021		0.058		0.014		0.038	
O	0.016		0.044		0.011		0.030	
M x O	0.036		0.099		0.025		0.069	

Table 4: Effect of moisture regimes and organic manures on organic C (%) and $CaCO_3$ (%)

M/O	O_1	O_2	O_3	Mean	O_1	O_2	O_3	Mean
Organic C at 0 days of incubation					**$CaCO_3$ at 0 days of incubation**			
M_1	0.30	0.32	0.34	0.32	5.09	4.64	4.57	4.77
M_2	0.34	0.37	0.39	0.36	4.77	4.57	4.50	4.61
M_3	0.33	0.35	0.38	0.35	4.60	4.69	4.82	4.70
M_4	0.31	0.34	0.36	0.33	4.88	4.78	4.76	4.80
M_5	0.31	0.32	0.33	0.32	4.61	4.67	4.77	4.68
Mean	0.31	0.34	0.32		4.79	4.67	4.68	
Interaction	**S.E ±**		**C.D. at 5%**		**S.E ±**		**C.D. at 5%**	
M	0.010		0.027		0.056		0.170	
O	0.004		0.011		0.044		0.132	

M x O	0.018		0.049		0.096		0.290	
Organic C at 120th days of incubation					**$CaCO_3$ at 120th days of incubation**			
M_1	0.31	0.33	0.35	0.33	4.40	4.33	4.46	4.40
M_2	0.37	0.40	0.41	0.39	4.26	4.36	4.36	4.33
M_3	0.34	0.38	0.40	0.37	4.50	4.46	4.30	4.42
M_4	0.32	0.36	0.38	0.35	4.26	4.06	4.43	4.25
M_5	0.31	0.33	0.34	0.32	4.46	4.56	4.66	4.56
Mean	0.33	0.36	0.37		4.38	4.36	4.44	
Interaction	S.E ±		C. D at 5%		S.E ±		C. D at 5%	
M	0.021		0.058		0.082		0.246	
O	0.016		0.044		0.060		0.181	
M x O	0.036		0.099		0.138		0.415	

Table 5: Effect of moisture regimes and organic manures on availability of soil NPK (kg ha^{-1})

M/O	O_1	O_2	O_3	Mean	O_1	O_2	O_3	Mean	O_1	O_2	O_3	Mean
Available N at 0 days of incubation					**Available P_2O_5 at 0 days of incubation**				**Available K_2O at 0 days of incubation**			
M_1	135.60	137.23	139.79	137.54	8.96	9.01	9.09	9.02	419.45	435.20	438.58	431.08
M_2	140.35	143.21	145.36	142.97	9.82	9.96	10.13	9.97	448.14	484.12	504.31	478.85
M_3	139.22	140.60	142.36	140.72	9.66	9.77	9.99	9.80	435.10	450.51	468.18	451.26
M_4	137.82	138.12	140.78	138.90	9.32	9.08	9.27	9.22	421.63	439.57	444.24	435.14
M_5	134.42	137.10	138.62	136.71	8.88	8.99	9.21	9.03	416.60	426.84	435.24	426.22
Mean	137.48	139.25	141.38		9.33	9.36	9.53		428.18	447.24	458.11	
Interaction	S.E ±		C.D. at 5%		S.E ±		C.D. at 5%		S.E ±		C.D. at 5%	
M	0.460		1.333		0.055		0.133		1.840		5.323	
O	0.356		1.035		0.043		0.109		1.425		4.120	
M x O	0.798		2.311		0.096		0.243		3.187		9.236	
Available N at 120th days of incubation					Available P_2O_5 at 120th days of incubation				Available K_2O at 120th days of incubation			
M_1	137.19	138.93	142.14	139.42	9.21	9.72	9.88	9.60	435.19	445.60	461.22	447.33
M_2	145.62	151.35	157.22	151.39	11.10	11.66	11.99	11.49	471.36	505.61	524.20	500.39
M_3	143.58	148.92	152.67	148.39	11.21	11.32	11.72	11.51	460.71	491.14	517.14	489.33
M_4	141.26	145.61	148.18	145.01	9.88	9.73	9.81	9.82	448.68	472.41	495.13	472.07
M_5	136.92	138.12	140.25	138.43	9.62	9.92	10.04	9.86	430.61	442.55	458.14	443.76
Mean	140.91	144.58	148.09		10.20	10.48	10.68		449.31	471.46	491.16	
Interaction	S.E ±		C. D at 5%		S.E ±		C. D at 5%		S.E ±		C. D at 5%	
M	0.654		1.897		0.080		0.220		0.734		2.121	
O	0.507		1.470		0.062		0.175		0.568		1.649	
M x O	1.134		3.280		0.139		0.381		1.271		3.686	

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