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Soil viscosity as a new physico-chemical approach for measuring the improvement in calcreous soil treated with compost

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ABSTRACT

Soil viscosity provide as a new parameter for measuring the improvement of calcareous soils those treated with several samples of plant residues compost. The aim of this paper is to study the soil viscosity and its relations with some soil properties as affected by twenty four compost samples of rice and corn wastes. The samples prepared by two different composting methods with some additional treatments through composting process, so that used in ameliorating Maryut calcareous soil. The data indicate good response of treated soils, referring to viscosity values, due to either kind or amount of compost samples. Furthermore, the degree of effectiveness correlated significantly with many of compost characters either as internal structure like molecular weight (M.wt) and thermal index (RI) or as physico-chemical properties like heat capacity (Cp), water holding capacity (WHC), moisture content, organic matter content (OM%) and cation exchange capacity (CEC). Soil viscosity in relation with treated calcareous soil has significant negative correlations with CP and WHC, while have significant positive correlations with bulk density and EC. Finally, we provide this new aspect to be considered with the classic soil measurements as it may need more investigations to apply with different soil types.

KEYWORDS

Soil viscosity;
Calcareous soil;
Plant residues compost;
Physico-chemical properties.

INTRODUCTION

The physical and chemical properties of soils and the associated processes are intimately related to the interaction between the soil particles (clay particle) and water molecules as a result of hydrogen bonding between the water molecules and the oxygen atoms in the surface of crystal and the hydration of adsorbed cations.

Masayuki et al.[16] and Karmakar and Kushwaha[11,12] pointed out that viscosity as a structure-sensitive property of colloidal clay suspensions which gives valuable information about the influence of clay particles upon the structure of adsorbed water. Colloids are generally divided into two groups, i.e; hydrophilic and hydrophobic. Hydrophilic colloids are characterized by a relatively high viscosity, while hydrophobic ones do not posses high viscosity. The viscosity of a colloidal system is a function of "active volume" of the dispersed phase, colloidal aggregate, containing water immersed among the particles constituting the aggregate, will have a large volume than the total volume of the individual particles. Therefore, a suspension containing aggregates will posses a low viscosity than one contains the same number of particles in a monodispersed state. So, the viscosity of clay suspensions show high measures by the effect of; (1) The surface density of the exchangeable cations. (2) The bonding energies between the exchangeable cations and the surface and (3) The hydration shells of both the cations and the surface as well.

From biochemical point of view[11,12,19] reported that the highly viscous organic materials are those having complex structures which also having higher molecular weights. The effect of these viscous organic materials on soil characters extends beyond penetrability to soil water movement impedance and may be also to root penetration into soil. The effect of viscous materials may be needed for coarse textured soils like sandy to coagulate single particles into clods, so enhancing aggregation of soil. In calcareous soil there are two main problems, i.e., single fine grains and $CaCO_3$ content which lead such soils to have high viscosity, penetrability and workability. So that, the role of organic components is some what complicated in which to achieve considerable reduction in soil viscosity. The role of organic components may be divided into two items; i.e., physical effect by their gross and fibrous mass and chemical by their effect on pH, salinity and other chemical reactions with soil components especially $CaCO_3$. Gideon (2004) reported the values of viscosity of a clay loam soil as it found in the range of 53×10^3 to 283×10^3 poise. Finally, Van Baars[22] reported that, viscosity is in fact a relaxation of the shear stresses over time, which results for constant stress states in a corresponding elastic strain relaxation. In other words viscosity is a sort of slow plasticity.

EXPERIMENTAL

Split-split design (with complete randomized distribution in each split) in green house experiment with three replications for each treatment was carried out, where each pot contained 3Kg of a virgin calcareous soil collected from the surface layer Maryut research station of Desert Research Center (DRC), the analytical data of examined soil presents in TABLE 1. The soil in each pot was mixed thoroughly with twenty four compost samples prepared and some characters in TABLE 2 as described by Amal[2,3] with three doses namely; 1, 2 and 3 % (w/w) , beans was the test plant. Five seeds were planted in each pot and followed up to the maximum growth stage which lasted 60 days. Soil moisture in all pots was kept between field capacity and 50% of available water level by means of weighing pots every day according to that described by Hicks[9]. The soil viscosity measured by using Ostwald's Viscometer as described by K.Kumada and Y.Kawamura[14]. In addition, soil heat capacity Cp, bulk density, water holding capacity WHC, total and active $CaCO_3$ has been measured as described by Klute[13].

RESULTS AND DISCUSSION

Soil viscosity

Soil viscosity values of treated Maryut calcareous soil by different compost samples are present in TABLE 3 in which it can be conclude to the following;

(1) Generally, rice compost samples give higher decreases, which mean more improvement, in viscosity reading than with corn samples for any corresponded treatments, so the general decrease in viscosity values compared with original soil value reached to 38.1 and 22.6% for rice and corn compost samples, respectively.

(2) The minimum and maximum reductions in viscosity values resulted were with C12 (1%) and C10 (3%)

TABLE 1 : Physical and chemical properties of calcareous soil (Maryut)

Depth (cm)	Coarse sand	Fine sand	Silt	Clay	Soil texture	Bulk density (g/cm^3)	Water holding capacity (%)
0-15	2.50	49.80	20.50	27.20	*Sandy clay loam*	1.69	37.67
Viscosity (poise)	**Heat capacity (cal/g)**	**pH**	**EC(ms/cm)**	**OM%**	**Total $CaCO_3$ %**	**Active $CaCO_3$ %**	
18800	0.2697	7.50	2.15	1.83	37.70	19.07	

TABLE 2: Some characters of rice and corn compost samples

Compost sample	Treatment			Some characters of Humic acid extract		Bulk density	Moisture content %	Water holding capacity	Heat capacity	C/N ratio	OM%	CEC	EC 1:5 ms/cm	pH
	method	Chem.	sludge	M.wt	RI									
Characters of rice compost														
C1	A	O	0	578	1.7	0.61	46.6	287	0.7813	16.4	66.7	46.6	3.6	7.11
C2	A	O	1	549	1.5	0.59	49.3	269	0.5399	15.2	65.2	44.4	3.9	7.27
C3	A	O	2	523	1.2	0.51	42.9	253	0.5219	17.4	60.3	42.8	3.8	7.39
C4	A	W	0	551	1.6	0.62	46.1	280	0.6317	15.4	67.2	44.9	6.1	7.45
C5	A	W	1	368	0.8	0.60	40.9	287	0.4129	18.9	63.3	41.2	5.6	7.37
C6	A	W	2	369	0.9	0.51	40.1	280	0.4605	14.2	59.1	41.5	5.1	6.66
C7	NAA	O	0	578	2.0	0.56	46.9	305	0.7501	12.1	68.0	47.1	3.5	7.44
C8	NAA	O	1	578	2.4	0.53	47.0	300	0.8064	11.5	69.8	47.3	3.4	7.37
C9	NAA	O	2	386	0.7	0.49	41.9	240	0.4753	8.2	60.9	42.3	3.6	7.25
C10	NAA	W	0	649	2.5	0.56	47.6	311	0.9856	9.2	71.6	47.6	5.5	7.31
C11	NAA	W	1	523	0.9	0.50	42.5	261	0.5157	10.9	62.6	42.6	5.8	7.26
C12	NAA	W	2	265	0.9	0.49	39.8	245	0.4008	11.1	55.8	41.0	5.8	6.55
Characters of corn compost														
C13	A	O	0	283	0.6	0.52	39.9	220	0.4134	16.9	51.8	45.6	5.7	7.33
C14	A	O	1	313	1.4	0.51	41.7	225	0.4875	16.4	53.3	46.1	5.9	7.37
C15	A	O	2	356	0.7	0.50	42.9	255	0.6186	18.9	55.4	47.2	7.4	7.35
C16	A	W	0	383	1.3	0.52	45.9	280	0.6569	19.5	58.1	48.2	6.5	7.33
C17	A	W	1	371	1.1	0.52	44.1	274	0.6425	19.1	56.7	47.7	7.4	7.38
C18	A	W	2	330	0.7	0.49	42.3	270	0.5468	18.7	55.0	46.9	7.7	7.33
C19	NAA	O	0	538	2.1	0.51	49.1	305	0.8052	14.8	59.1	50.9	5.6	7.34
C20	NAA	O	1	424	1.5	0.51	47.9	300	0.7384	12.3	58.3	50.2	5.6	7.42
C21	NAA	O	2	313	0.6	0.48	41.6	276	0.4860	11.9	52.9	45.3	6.1	7.62
C22	NAA	W	0	578	2.3	0.51	49.8	292	0.9752	17.9	59.7	51.3	6.9	7.14
C23	NAA	W	1	260	1.9	0.51	48.7	298	0.7918	14.8	59.0	50.5	8.5	7.22
C24	NAA	W	2	430	0.5	0.48	38.9	210	0.4457	12.5	48.7	45.1	8.1	7.31

A is Aerobic conditions, NAA is Non-aerobic – Aerobic conditions, O is without addition and W is with addition.

for rice, while C24 (1%) and C22 (3%) for corn compost samples. However, these pairs of treatments are correspondent in their preparation conditions, as the sludge addition (C12, C24) may cause more compactness to soil.

(3) Almost all values show reduction coordinate with percent addition of compost, but reduction percentage was varied among different compost samples.

(4) The NAA compost samples cause general more reduction in viscosity reading than the A ones.

Effect of some compost characters on viscosity values of treated soil samples

TABLE 4 indicates the simple correlation coefficients between soil viscosity readings and the characters of compost samples, which the data can conclude to the following:

i. All significant relations were found with the three addition doses of compost to soil.

ii. For rice straw compost samples at 1, 2 and 3% additions, the soil viscosity values are in significant negative relations with M.wt, RI, Cp, WHC, moisture content, OM% and CEC, while almost at 2 and 3% low significance has been found with pH. However, no effective relation with bulk density, CN and EC of rice compost.

iii. For corn compost samples at 1, 2, 3% addition, soil viscosity values are in negative significant relations with RI, Cp, WHC, moisture content and OM% but at 2, 3% low significance was found with CEC. Also, no effective relation with bulk density, CN, EC, pH and M.wt at 1 and 3%.

Effect of some internal compost characters

Molecular weight (M.wt)

High molecular weight of HA extracted from rice compost reduced soil viscosity at different percent addition of rice compost due to HA higher content of aromatic groups[2,3] which may have flexible chains or a stretched structure. These structures behave as hydrated sphere colloids in a good solvent, these results are in agreement with Masayuki et al.[16]. Where as, HA of corn compost has higher content of aliphatic groups[2,3] and lower M.wt than HA of rice compost. Thereby, the M.wt of HA of corn compost has almost no significant effect on soil viscosity values.

Thermal index (RI)

Prado et al.[20] and De Melobenites et al.[7] revealed that thermal analysis is a simple and powerful tool to investigate the thermal resistance and identify heat effects. Generally, HA is one of the end products of biological decay of organic matter and it has great resistance to further decomposition. Thermal analysis used to determine the stability index which is defined as the ratio between the weight losses associated with the second and first exothermic reactions. The differences in decomposition rates were related to the different degree of aromaticity of HA. The data in TABLE 2 indicate higher resistance for HA yield from rice than corn by about 17%, which could indicate the occurrence of polycyclic aromatic molecules. From TABLE 4 it is found negative correlation between soil viscosity and thermal index of both rice and corn compost. This means that the more resistance of compost the more the reduction of soil viscosity as well.

Heat capacity (Cp)

Heat capacity is a fundamental physical property that influences the storage and transfer of heat in substance mass and it is useful for surface energy balance measurements. Awadalla et al.[3] reported that heat capacity values can be used as a new indicator for compost internal structure and quality level, where as it gives also same trends with some other compost properties. Whereas, viscosity criteria indicate the internal resistivity of the material to laminar movement, so it is expect that as much as viscosity value the heat required to move of lamina is also high. So, the highly viscous media will also characterized by high Cp values. The data in TABLES 2 and 3 indicate that soil viscosity reduces by increasing in heat capacity values of both rice and corn composts. So, TABLE 4 clearly indicate highly significant negative correlation between compost Cp and soil viscosity on the three levels of compost additions to soil, i.e., 1, 2 and 3% either as a total value for the whole samples or as partial value for each compost material (rice and corn) as well. Regardless the highly significant relations, the regression coefficient of rice compost samples are mostly higher than those for corn samples by 60-70%. This means that rice composts are more able to affect the soil viscosity than corn ones by this ratio as well.

TABLE 3 : Viscosity (poise) of calcareous soil affected by different addition and percent of both rice and corn compost samples.

Rice Compost				Corn Compost			
Compost samples	1%	2%	3%	Compost samples	1%	2%	3%
C1	11100	7300	5100	C13	16400	14600	12100
C2	14100	7500	5700	C14	16600	15000	12800
C3	14500	9200	6600	C15	15800	14100	11900
C4	13100	7500	5400	C16	14200	13700	9200
C5	17400	13900	12500	C17	14700	14000	10100
C6	16500	13900	11800	C18	15800	14100	11900
C7	9300	7200	4600	C19	10500	10100	8200
C8	8900	9700	4500	C20	12400	11200	9000
C9	15600	12900	10900	C21	16000	14200	12000
C10	8300	6900	5500	C22	9900	8100	8000
C11	14300	7600	6100	C23	11100	10700	9900
C12	17900	16600	14100	C24	18700	16500	16000

The viscosity of calcareous soil (control) is 18800 poise.

Water holding capacity (WHC)

Abdel-Azeem[1] and Michael and Tiry[18] reported that the WHC of compost is necessary for soil management effect on water regime as WHC of good quality compost ranges between 70-300% (dry weight basis), as the increase in WHC could be considered as an indicator to good compost maturity. Amal[2,3] concluded that in order to get high WHC values, composting process for both rice and corn compost should be carried under NAA condition, lower sludge percent and with addition of active chemical solution. Generally, from

TABLE 4 : Simple correlation between soil viscosity and some characters of prepared rice and corn compost samples addition by different percent to calcareous soil.

X	Y	1% r	1% a	1% b	2% r	2% a	2% b	3% r	3% a	3% b
	Rice compost samples addition									
Soil viscosity	M.wt	-0.890***	910.6	-0.031	-0.956***	822.2	-0.03	-0.965***	740.47	-0.03
	RI	-0.943***	3.79	-1.77E-04	-0.659*	2.63	-1.22E-04	-0.758**	2.46	-1.34E-04
	Cp	-0.963***	1.32	-5.33E-05	-0.696*	0.98	-3.79E-05	-0.748**	0.91	-3.92E-05
	Bulk density	-0.307 ns	--	--	-0.479 ns	--	--	-0.405 ns	--	--
	WHC	-0.589*	431.2	-0.01	-0.656*	399.6	-0.014	-0.634*	360.3	-0.01
	Moisture %	-0.809**	55.02	-7.99E-04	-0.836***	52.4	-8.11E-04	-0.864***	50.55	-0.81E-04
	OM	-0.899***	81.26	-0.001	-0.762**	74.8	-0.001	-0.794**	72.4	-0.001
	C/N	0.275 ns	--	--	-0.023 ns	--	--	0.011 ns	--	--
	EC	0.398 ns	--	--	0.242 ns	--	--	0.378 ns	--	--
	CEC	-0.979***	54.11	-7.45E-04	-0.766**	49.84	-5.72E-04	-0.848***	48.8	-6.08
	pH	-0.488 ns	--	--	-0.671*	7.78	-5.85E-05	-0.666*	7.63	-5.61
	Corn compost samples addition									
	M.wt	-0.51 ns	--	--	-0.581*	648.6	-0.02	-0.460 ns	--	--
	RI	-0.910***	4.13	-2.02E-04	-0.899***	4.15	-2.24	-0.789**	3.51	-2.08E-04
	Cp	-0.945***	1.46	-5.80E-05	-0.943***	1.49	-6.58E-05	-0.859***	1.32	-6.27E-05
	Bulk density	-0.457 ns	--	--	-0.361 ns	--	--	-0.549 ns	--	--
	WHC	-0.822***	418.2	-0.01	-0.791**	412.1	-0.01	-0.869***	407.2	-0.01
	Moisture %	-0.977***	63.5	-0.001	-0.938***	63.3	0.001	-0.923***	60.82	-0.001
	OM	-0.922***	72.1	-0.001	-0.858***	71.5	-0.001	-0.963***	71.3	-0.001
	C/N	-0.036 ns	--	--	0.005 ns	--	--	-0.235 ns	--	--
	EC	0.130 ns	--	--	0.138 ns	--	--	0.292 ns	--	--
	CEC	-0.969***	--	--	-0.942***	59.4	-8.84E-04	-0.881***	57.4	-8.65
	pH	0.437 ns	--	--	0.465 ns	--	--	0.248 ns	--	--

Note: X is independent factor, Y is dependent factor, r is correlation coefficient, a is intercept, b is slope (regression coefficient), * is significant on 0.05 level, ** is significant on 0.01 level, * is significant on 0.005 and ns is non significant.**

TABLES 2 and 3 it is clear that soil viscosity values decreasing by increasing WHC of both rice and corn compost samples, also from TABLE 4 it is clear a negative significant correlation between soil viscosity and WHC. So, soil viscosity status could be expected by WHC value for both rice and corn compost samples.

Moisture content

Moisture content is the percentage of water in the compost expressed as percentage of total weight. Moisture content is important in storing, handling and transporting of compost and its effect on bulk density. However, the optimum moisture content ranges between 40 to 50 percent. Dryer compost is recommended for areas expose to high rainfall because it can absorb more water and thus reducing the chance of leaching ground by water erosion so could hold water in soil, while compost that is too dry may be difficult to apply. On the other hand, compost which is too wet, is more expensive, difficult to transport, and may be sticky so difficult to be mixed with soil. In general, compost which have high organic matter materials have also higher water holding capacity and moisture content according to Mark[15] and Maurice[17]. Generally, the moisture content in TABLE 2 had been folded several times than initial materials and its values range between 39.8 to 47.6% and 38.9 to 49.8% for rice and corn compost, respectively. The data in TABLES 3 and 4 indicate negative significant correlation for soil viscosity with moisture content, so soil viscosity values reduced by increasing of moisture content.

Organic matter (OM)

Organic matter content of compost is the percent-

TABLE 5 : The measured soil characters of calcareous soil of Maryut as affected by the additions of different compost samples.

Rice compost addition																		
Samples	1%						2%						3%					
	Heat capacity (cal/g)	Bulk density (Mg m^{-3})	WHC (%)	EC (dsm^{-1})	Total CaCO3	Active CaCO3	Heat capacity (cal/g)	Bulk density (Mg m^{-3})	WHC (%)	EC (dsm^{-1})	Total $CaCO_3$	Active $CaCO_3$	Heat capacity (cal/g)	Bulk density (Mg m^{-3})	WHC (%)	EC (dsm^{-1})	Total $CaCO_3$	Active $CaCO_3$
C1	0.2899	1.49	47.72	3.07	31.9	16.9	0.2957	1.54	46.68	3.75	31.9	17.0	0.3052	1.56	46.68	3.94	31.7	16.7
C2	0.2776	1.50	46.31	3.92	32.2	17.3	0.2914	1.56	45.29	3.39	32.1	17.1	0.2979	1.58	45.29	3.86	31.9	16.9
C3	0.2705	1.53	47.28	2.82	31.6	16.7	0.2764	1.59	45.85	2.93	31.6	16.7	0.2775	1.59	45.85	3.03	31.5	16.6
C4	0.2837	1.50	46.98	3.19	31.7	17.00	0.2957	1.56	45.21	3.31	31.6	16.9	0.3031	1.58	45.21	3.98	30.9	16.6
C5	0.2742	1.60	44.52	2.19	30.9	16.5	0.2742	1.60	42.13	2.39	30.8	16.4	0.2785	1.66	42.13	2.48	30.8	16.2
C6	0.2713	1.60	43.08	2.18	32.7	17.7	0.2741	1.61	41.73	2.83	32.7	17.7	0.2783	1.66	41.73	2.99	32.6	17.6
C7	0.2839	1.49	47.92	3.19	32.7	17.1	0.3017	1.53	46.97	3.22	32.7	16.9	0.3040	1.55	46.97	3.94	32.7	16.8
C8	0.2853	1.47	48.63	3.51	30.7	16.4	0.2813	1.53	47.59	3.56	30.5	16.4	0.2838	1.55	47.59	3.86	30.4	16.2
C9	0.2718	1.57	42.63	2.56	31.9	17.0	0.2775	1.59	42.06	2.61	31.6	17.1	0.2798	1.66	42.06	3.02	31.5	17.0
C10	0.2948	1.45	48.53	3.31	30.7	16.7	0.2957	1.49	47.09	3.77	30.6	16.7	0.3083	1.52	47.09	3.93	30.3	16.4
C11	0.2724	1.55	45.09	2.89	31.2	16.6	0.2745	1.57	43.62	2.95	31.2	16.5	0.2776	1.60	43.62	3.04	31.0	16.4
C12	0.2709	1.60	44.77	2.22	32.4	17.4	0.2725	1.61	44.53	2.82	32.1	17.3	0.2761	1.67	44.53	2.98	31.8	17.1

Corn compost addition																		
Samples	1%						2%						3%					
	Heat capacity (cal/g)	Bulk density (Mg m^{-3})	WHC (%)	EC (dsm-1)	Total $CaCO_3$	Active $CaCO_3$	Heat capacity (cal/g)	Bulk density (Mg m^{-3})	WHC (%)	EC (dsm^{-1})	Total $CaCO_3$	Active $CaCO_3$	Heat capacity (cal/g)	Bulk density (Mg m^{-3})	WHC (%)	EC (dsm^{-1})	Total $CaCO_3$	Active $CaCO_3$
C13	0.2707	1.56	44.03	3.23	35.6	17.4	0.2761	1.58	43.74	3.46	35.2	17.3	0.2795	1.62	43.13	3.55	35.0	17.0
C14	0.2710	1.54	42.86	3.59	35.8	17.6	0.2752	1.57	42.08	3.62	35.6	17.6	0.2782	1.59	41.56	3.92	35.6	17.3
C15	0.2716	1.51	46.65	2.84	33.7	16.9	0.2736	1.57	46.0	2.84	33.5	16.7	0.2742	1.59	45.35	2.99	33.4	16.6
C16	0.2737	1.49	47.33	3.57	36.0	17.9	0.2787	1.55	46.85	3.89	35.9	17.8	0.2797	1.57	45.65	3.98	35.7	17.4
C17	0.2721	1.50	45.76	3.77	36.7	18.4	0.2741	1.55	45.47	3.82	36.4	18.2	0.2774	1.58	45.44	3.98	36.3	17.9
C18	0.2715	1.52	46.05	2.80	35.9	17.6	0.2732	1.57	45.75	2.84	35.7	17.6	0.2730	1.59	44.58	3.01	35.5	17.5
C19	0.2786	1.49	49.03	3.67	36.7	18.7	0.2816	1.54	47.6	3.88	36.7	18.3	0.2870	1.55	47.13	3.97	36.6	18.0
C20	0.2773	1.51	46.81	3.85	34.9	16.9	0.2785	1.55	46.3	3.90	34.8	16.9	0.2853	1.56	45.99	3.99	34.8	16.8
C21	0.2708	1.54	44.86	3.28	34.7	17.5	0.2721	1.55	44.3	3.37	34.7	17.4	0.2742	1.61	43.56	3.76	34.6	17.2
C22	0.2783	1.49	50.59	3.92	35.1	17.6	0.2865	1.53	49.16	3.93	34.9	17.5	0.2893	1.55	47.61	3.98	34.9	17.4
C23	0.2782	1.50	48.67	3.79	35.5	18.1	0.2836	1.54	47.21	3.88	35.5	17.86	0.2845	1.55	46.47	3.97	35.3	17.7
C24	0.2701	1.58	46.36	3.18	33.4	16.6	0.2734	1.59	43.15	3.85	33.4	16.5	0.2767	1.64	41.68	3.89	33.3	16.5

Initial soil characters: Heat capacity (0.2697 cal/g), Bulk density (1.69 g/cm^3), Water holding capacity (37.67%), Soluble salt (2.15 ms/cm), Total CaCO (37.7%)$_3$ and Active $CaCO_3$(19.07%).

age of carbon based on materials in compost and it play an important role in soil structure and water holding capacity. Organic matter content for good compost varies widely, yet it must be ranged between 40-70% on dry basis[21,23]. TABLE 2 found that OM of rice compost increase by preparing under NAA conditions without addition of sludge and active solution while for corn compost it can be prepared under NAA conditions but with addition of active chemical solution and without sludge addition. Also, TABLES 3 and 4 concluded to that soil viscosity values reduced by increasing of OM content of compost, so negative significant relation was found between soil viscosity and OM for rice and corn compost at different percent additions. Quantitatively, these results indicate that increasing OM by one unit the soil viscosity decrease by 81.3 to 72.4 and 72.1 to 71.3 poise with rice and corn compost samples, respectively. However, the effect of OM in soil aggregation and making many slickensides for these aggregates seems to be responsible for this behavior.

TABLE 6 : The correlation and regression analyses between soil viscosity as Y with measured soil characters of Maryut calcareous soil with different compost samples

Y	X	1%			2%			3%		
		r	a	b	r	a	b	r	a	b
Rice compost addition										
Soil viscosity	Heat capacity	-0.872***	109954	-346188	-0.759**	77637	-237948	-0.670*	59422	-178753
	Bulk	0.937***	-75373	58064	0.779**	-100760	70784	0.933***	-93176	63134
	Water holding capacity	-0.847***	76361	-1364	-0.660*	57968	-1068	-0.631*	54354	-1048
	Soluble salt(EC)	0.728**	26182	-4370	-0.736**	27590	-5619	-0.814**	25788	-5277
	Total $CaCO_3$	0.315 ns	--	--	0.135 ns	--	--	0.214 ns	--	--
	Active $CaCO_3$	0.389 ns	--	--	0.384 ns	--	--	0.458 ns	--	--
Corn compost addition										
Soil viscosity	Heat capacity	-0.968***	229384	-785807	-0.897***	143960	-472323	-0.716**	96187	-304600
	Bulk density	0.816**	-101248	76087	0.864***	-167322	115793	0.914***	-102472	71619
	Water holding capacity	-0.805**	62380	-1031	-0.868***	60657	-1043	-0.904***	57729	-1043
	Soluble salt (EC)	-0.696*	31670	-5012	-0.413 ns	--	--	-0.340 ns	--	--
	Total $CaCO_3$	-0.409 ns	--	--	-0.316 ns	--	--	-0.604*	59569	-1386
	Active $CaCO_3$	-0.541 ns	--	--	-0.379 ns	--	--	-0.603*	60677	-2880

Note: X is independent factor, Y is dependent factor, r is correlation coefficient, a is intercept, b is slope (regression coefficient), * is significant on 0.05 level, ** is significant on 0.01 level and * is significant on 0.005 and ns is non significant.**

Cation exchange capacity (CEC)

Chung et al.[6] and Jean VanderGheyust[10] revealed that CEC is a measure of the possibility of any material to exchange cations in its structure and it reflects the changes in the components during reconstitution processes as a useful parameter for estimating the degree of maturity of compost. Ceppi et al.[5] suggested that the CEC in compost increases as a function of humification due to formation of carboxylic and phenolic groups. Carboxylic groups are formed by the oxidation of lateral chains of aromatic rings or the hydrolysis of esters or lactones which are fairly stable compounds which also have high molecular weights. Butler et al.[4] declare that CEC increases with the humification degree of compost and CEC of stable or good compost may be<50 cmol(+) / Kg dry compost. Generally, from TABLES 2 and 3 soil viscosity values decrease by increasing in CEC of compost. Meanwhile, CEC is usual positive coordination with OM content. Therefore, the data in TABLE 4 show that soil viscosity values are in negative correlation with CEC for both rice and corn composts which mean that soil viscosity affected by the quality of rice and corn compost samples.

Interrelations between soil viscosity and some characters of the treated calcareous soil with different composts

TABLE 5 show the measured soil characters for the whole 72 soil samples including; heat capacity, bulk density, water holding capacity, total CaCO3 and active CaCO3. According to detect the interrelations between soil viscosity and the measured soil characters both correlation and regression analysis were carried out and presented in TABLE 6 which can be pointed out to the following:

1. Significant negative correlation between soil viscosity with heat capacity especially with lower addition rates (1 and 2%). So, as heat capacity values ranged between 0.2697 (intial soil) and 0.3083 cal/g and soil viscosity values ranged between 18800 (intial soil) and 4500 poise, so the highly correlation make these properties in link to can estimate any value from the other. Heat capacity and soil viscosity are both physico-chemical properties which affected greatly with the internal properties of compost like OM% and M.wt, so it is expected that whether O.M and M.wt values increased in good composts quality, so heat capacity increased as well. The high O.M and best compost encourage coagulation and aggregation, so decreasing soil viscosity by formation of many slickensides so reducing the internal energy among particles.
2. Positive highly significant correlation between bulk density and soil viscosity values which is expected

as the higher density means compaction, so high internal forces among particles, so high viscosity values as well.

3. Negative significant correlation between water holding capacity and soil viscosity values which is also expected as holding energy of water is also indicative to fine materials and O.M%, so the best qualifications of compost will decrease viscosity due to increasing of hydration shells of soil particles and minimize the laminar friction of friction of hydration shells.
4. Negative correlation between EC and soil viscosity as could be expected from the same point of view of increasing the hydration shell by increasing salinity which make particles apart through saline hydration shells. In addition to the effect of calciorganic materials which enhance coagulation of single particle into aggregates.
5. No significant correlation between both total and active CaCO3 and soil viscosity except for corn composts of 3% addition. In fact, may this trend is unexpected with calcareous soil like Maryut but may the effect of compost characters overcome the CaCO3 effect, so the solely effect of CaCO3 and active CaCO3 hided by these strong characters.

CONCLUSION

We provide this new aspect to be considered with the classic soil measurements as it may need more investigations to apply with different soil types.

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