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Effect of Soil Amendments on Physical Properties of Heavy Clay Soil in Northern Nile Delta

E.M. El-Hadidi, A.M. El-Ghamry and Amira M.I. El-Emshaty

Department of Soil Science, Faculty of Agriculture, Mansoura University, Egypt.

A FIELD trial was conducted at Gamalia district, Dakahlia Governorate (Egypt) during year 2001 to investigate the effect of soil amendments (gypsum "G", farmyard manure "FYM", and sand "S"), on physical properties of heavy textured soil. The treatments were; control, S_{10}, S_{20}, $G_{2.5}$, G_5, FYM_{10}, FYM_{20}, S_{10}+$G_{2.5}$, S_{10}+FYM_{10} and FYM_{10} + $G_{2.5}$ ton/fed. Two crops used in the experiment were cowpea (*Vigna sinensis* savi) and potato (*Solanum tuberasum* L.).

The results indicated that the addition of sand increased coarse sand and fine sand but silt and clay percentage did not clearly changed. Addition of FYM slightly affected coarse and fine sand while clay contents were slightly increased. Gypsum addition did not affect soil texture.

Sand, FYM and gypsum decreased bulk density in all treatments, but real density was increased in all treatments by using sand. Porosity was also increased by all soil amendments.

The results indicated that FYM alone or coupled with gypsum increased hydraulic conductivity (H.C). The highest increase under potato was achieved for FYM mixed with gypsum, but the highest increase under cowpea with sand at 20 ton/fed. Soil amendments using affected soil penetration resistance in all studied treatments. The best result was found with gypsum added at 2.5 t/fed under cowpea and potato crop.

It was recommended to use soil amendments especially FYM 20 t/fed, gypsum at 5 t/fed and FYM 10 t/fed mixed with gypsum at 2.5 t/fed for improving the physical properties of the heavy clay soil.

Most of Northern Nile Delta soil are heavy clay or clayey soils which contain 40% to 65% clay. These soils have poor physical properties which reflected on their productivity.

Soil conditioners may be either natural such as organic materials in different stages of decomposition, gypsum and lime or synthetic material.

A regular addition of farmyard manure and gypsum is required to improve physical properties of heavy clay soils (Badole *et al.*, 1999). Sand fraction as one

of the texture components plays an important role in improving the physical properties and fertility level of the heavy textured soil. While gypsum is commonly used for reclaiming saline and alkaline soils to bring about changes in their physical characteristics which affect tillage operations, infiltration rate, surface crusting, seedlings emergence, plant growth, and yield (Scotter and Loveday, 1996).

Borges *et al.* (1997) also found that application of gypsum and dried plant residues decreased soil density, increased total porosity, and improved the water to air ratio in the compacted layer.

Zein (1996) found that FYM alone or coupled with gypsum treatment significantly decreased bulk density and hence increased total porosity particularly in the surface layer.

Gaffer *et al.* (1992) studied the effect of FYM and sand on the performance of sorghum and sodicity of soils. Results indicated that adding sand improved soil texture, and physical conditions of the top soil and permeability.

The objectives of present study were to investigate the effect of several soil amendments (gypsum, FYM and sand) on physical properties of the heavy textured soil.

Material and Methods

To study the effect of soil amendments (gypsum, sand, and FYM) on physical properties of heavy clay soils, a field trail was conducted at Gammalia district, Dakahlia Governorate, Egypt. Randomized completely block design (RCB) was used with 10 treatments in 3 replicates. The treatments were: control, sand $_{10}$, sand $_{20}$, FYM $_{10}$, FYM $_{20}$, gypsum $_{2.5}$, gypsum $_{5}$, sand$_{10}$+FYM$_{10}$, sand$_{10}$+gypsum $_{2.5}$, and gypsum $_{2.5}$ + FYM $_{10}$ t/fed. Two crops (Cowpea and potato) were cultivated. The whole experimental area was 540 m^2.

Some chemical and physical properties of the studied soil before planting are presented in Table 1.

The amendment was added before planting for both crops, cowpea and potato, to the surface of soil and then ploughed to be mixed in the surface and subsurface layers.

After harvesting each crop, soil bulk density was determined by using paraffin wax method (Dewis and Frcilas, 1970).

Particle real density was determined by using pycnometer method (Black *et al.*, 1965). Porosity was calculated according to Hillel (1972).

TABLE 1. Some physico-chemical properties of the soil used.

Soil physical properties	Soil sample		Soil chemical properties		Soil sample	
	0-20 cm	20-40 cm			0-20 cm	20-40 cm
H.W. %	10.53	10.05	pH value*		7.5	7.6
S.P. %	116.6	124.5	EC dS/m**		1.68	1.34
F.C %	47.5	45.0	O.M %		1.43	1.53
P.W.P %	25.2	24.8	GR t/fed		6.13	5.68
H.C. cm/h	0.041	0.065	Soluble cations meq / 100 g soil	Ca^{++}	1.16	1.18
BD g/cm^3	1.25	1.28		Mg^{++}	1.12	1.04
RD g/cm^3	2.67	2.72		Na^{+}	0.21	0.32
Total Porosity%	53.18	52.94		K^{+}	1.0	1.1
Fine sand %	2.61	2.22	Soluble anions meq / 100 g soil	CO_3^{--}	0.0	0.0
Coarse sand %	11.60	11.42		HCO_3^{-}	0.25	0.30
Silt %	20.4	20.84		Cl^{-}	1.94	1.88
Clay %	65.39	65.52		SO_4^{--}	1.10	1.40
Soil texture	Clayey soil		ESP		7.8	7.6

* In soil paste **In 1:5 extract (The soil used in this research was heavy clay soil).

Collected data were subjected to the statistical analysis, the technique of analysis variance (ANOVA) for Randomized Complete Block Design (R.C.B) was used. The treatments means were compared using least significant difference (LSD).

Particle size distribution was determined using the international pipette methods as described by Piper (1950).

Hydraulic conductivity (K) of the soil samples columns was determined using the constant head permeater in disturbed soil (Singh, 1980). K = QL / HAT where:K=Hydraulic conductivity coefficient cm/sec, Q=the volume of water being passed through the soil column at time (T), cm^3, A=Cross section area, cm^2, L=length of soil column, cm, H=Hydraulic head (cm).

Results and Discussion

Effect of soil amendments on mechanical analysis

Data in Table 2 showed the effect of soil amendments on soil mechanical analysis under cowpea and potato crops.

TABLE 2. Effect of soil amendments on top soil mechanical analysis under cowpea and potato crops.

Treatments	Cowpea					Potato				
	Coarse sand%	Fine Sand %	Silt %	Clay %	Texture class	Coarse sand%	Fine Sand %	Silt %	Clay %	Texture class
Control	2.61	11.60	20.40	65.39	Clayey	2.68	11.82	18.69	66.81	Clayey
S_{10}	4.15	16.66	13.87	65.32	Clayey	4.81	16.20	13.49	65.50	Clayey
S_{20}	4.37	18.69	12.62	64.32	Clayey	4.21	16.34	13.30	65.15	Clayey
FYM_{10}	2.10	11.33	20.02	66.55	Clayey	2.66	11.42	18.96	66.96	Clayey
FYM_{20}	2.31	11.73	19.55	66.41	Clayey	2.22	11.23	19.55	67.00	Clayey
$G_{2.5}$	2.63	11.28	19.17	66.92	Clayey	2.22	11.42	20.84	65.52	Clayey
G_5	2.71	11.68	19.37	66.24	Clayey	2.17	11.10	20.43	66.30	Clayey
S_{10}+FYM_{10}	3.13	14.50	17.17	64.20	Clayey	3.40	15.26	17.00	64.34	Clayey
S_{10}+$G_{2.5}$	3.77	14.09	17.73	64.41	Clayey	4.37	14.26	15.72	65.65	Clayey
FYM_{10}+$G_{2.5}$	2.27	12.01	19.43	66.29	Clayey	2.45	12.40	19.04	66.11	Clayey

Under cowpea and potato crops with addition of sand at two rates of 10 and 20 t/fed coarse sand increased from 2.611 to 4.15 % and 4.37%, respectively. Also, fine sand was increased from 11.6% (control) to 16.66 and 18.69%, but silt and clay percentage did not clearly change. The soil texture was clayey. FYM addition at two rates of 10 and 20 t/fed under cowpea plant had a slight effect on coarse and fine sand while increased slightly clay content.

Gypsum addition under cowpea crop at two rates of 2.5 and 5 t/fed did not affect soil texture. Sand at 10 t/fed mixed with FYM at 10 t/fed increased coarse sand from 2.61 to 3.13 while this addition increased fine sand from 1.6 to 3.13%.

Mixing FYM at 10 t/fed with gypsum at 2.5 t/fed did not show a marked change in soil texture.

Effect of soil amendments on bulk density, real density and porosity

Data in Fig. 1,2 and 3 illustrated the effect of soil amendments on bulk density, real density and porosity.

Bulk density

The bulk density decreased in all treatments except for sand addition. Sand application under cowpea at two rates of 10 and 20 t/fed increased bulk density from 1.26 to 1.29 and 1.32 g/cm^3, respectively, but adding sand at 10 t/fed mixed with FYM at 10 t/fed decreased bulk density. Applying sand with gypsum at 2.5 t/fed decreased BD to be 1.22 g/cm^3.

FYM addition under cowpea at 10 and 20 t/fed decreased bulk density. The effect of FYM was the same for gypsum on forming macro aggregates havin less weight and more volume.

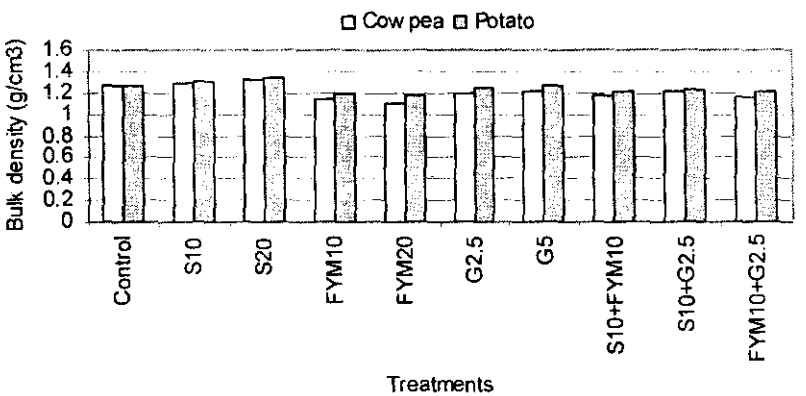

Fig. 1. Effect of using soil amendments on bulk density under cowpea and potato crops.

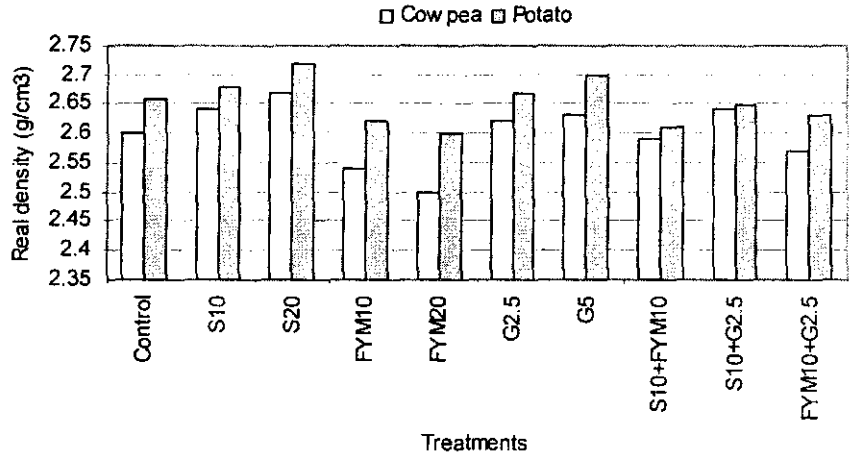

Fig. 2. Effect of using soil amendments on real density under cowpea and potato crops.

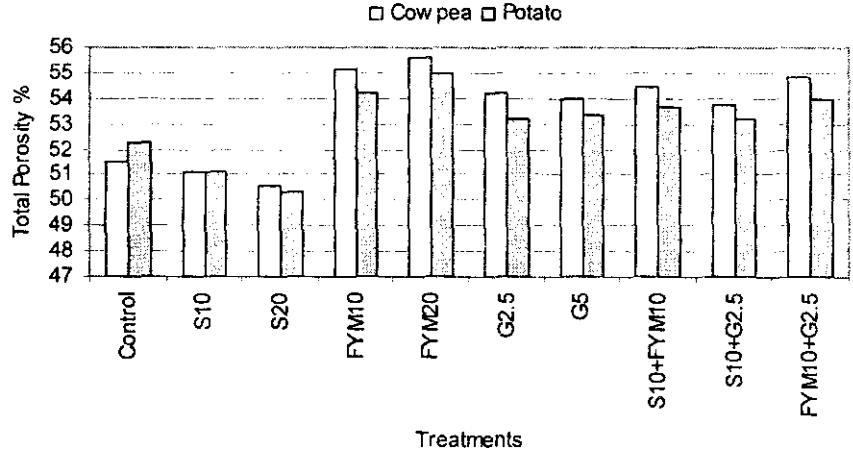

Fig. 3. Effect of using soil amendments on porosity under cowpea and potato crops.

The same trend was obtained when FYM at 10 t/fed was mixed with gypsum at 2.5 t/fed and added to the soil resulting in bulk density of 1.16 gm/cm^3 with reduction of 7.94% from the control value. The soil amendments had a beneficial effect on bulk density under potato and cowpea crop.

Lowering bulk density by FYM addition is due to high organic carbon, more pore space and good soil aggregation (Mishra and Sharma, 1997).

Real density

Sand addition under cowpea crop at two levels (10 and 20 t/fed) slightly increased real density with an increase of 1.53 and 2.69%, respectively, while sand added at 10 t/fed mixed with FYM at 10 t/fed slightly decreased real density by 0.38% reduction, but sand at 10 t/fed mixed with gypsum at 2.5 t/fed increased (real density) RD to 2.64 g/cm^3. This effect is due to high real density of sand fraction, while organic matter has a little real density (about 0.2 g/cm^3).

FYM under cowpea at two rates of 10 and 20 t/fed decreased real density to 2.54 and 2.5 g/cm^3, while gypsum addition only under cowpea crop at two rates increased real density. Sand application under potato crop at two rates also increased real density. Mixing sand at 10 t/fed with gypsum at 2.5 t/fed decreased real density by 0.38%. This was due to high specific gravity of sand (quartz). FYM application under potato crop decreased real density, while gypsum at two rates had increased real density.

Porosity

The total porosity was increased in all treatments except for the individual addition of sand at two rates which decreased the total porosity. Sand addition under cowpea and potato crop decreased total porosity. Mixing sand at 10 t/fed with gypsum at 2.5 t/fed increased total porosity. It was due to the effect of sand in creating new macro aggregates which contain higher porosity.

FYM addition at two rates of 10 and 20 t/fed under cowpea and potato crop increased porosity. Gypsum at two rates (2.5 and 5 t/fed) under cowpea and potato crop increased total porosity.

Effect of soil amendments on hydraulic conductivity (H.C.)

Data in Table 3 showed the beneficial effect of soil amendments using on hydraulic conductivity in all treatments under cowpea and potato crop.

The addition of sand under cowpea and potato at two rates of 10 and 20 tons/fed has increased (H.C.) and, sand at 10 t/fed mixed with FYM at 10 t/fed has also increased the hydraulic conductivity.

This effect of sand was due to its role on making macro pore spaces which affect downward movement of water within soil.

The addition of FYM at two rates 10 and 20 t/fed under cowpea or potato crops increased (H.C.) and FYM added at 10 t/fed mixed with gypsum at 2.5 t/fed increased H.C. to 1.31 cm/h by 35.05% increase over control.

Gypsum application at 2.5 and 5 t/fed under cowpea and potato crop increased H.C.

TABLE 3. Effect of using soil amendments on hydraulic conductivity, and soil penetration resistance under cowpea and potato crops.

Treatments	Cowpea		Potato	
	H.C cm/h	P.R Kg/cm^2	H.C cm/h	P.R Kg/cm^2
Control	0.97	1.10	1.40	1.20
S_{10}	1.48	1.24	2.23	1.50
S_{20}	1.54	1.20	2.10	1.25
FYM_{10}	1.12	1.34	1.99	1.60
FYM_{20}	1.31	1.32	2.02	1.50
$G_{2.5}$	1.10	1.93	1.62	2.00
G_5	1.14	1.90	1.88	1.85
S_{10}+FYM_{10}	1.46	1.60	2.36	1.75
S_{10}+$G_{2.5}$	1.41	1.80	2.03	1.92
FYM_{10}+$G_{2.5}$	1.31	1.90	2.07	1.85

Sand mixed with FYM or mixed with gypsum also increased H. C. This acceleration in H.C. resulted from FYM addition was due to its effect on establishment of new aggregates which make wide pore spaces affecting downword movement of water in soil.

Effect of soil amendments on penetration resistance (PR)

Data in Table 3 showed the response of penetration resistance to the addition of soil amendments used under cowpea and potato crops.

The sand addition under cowpea crop at two rates (10 and 20 t/fed) increased PR from 1.1 kg/cm^2 (control) to 1.24 kg/cm^2 and 1.2 kg/cm^2 causing an increase of 12.73 and 9.09%, respectively. A similar trend was also found after mixing S_{10}+FYM_{10} which increased PR to 1.6 kg/cm^2.

This effect can be interpreted by minimizing effect of sand on consistence force of soil particles and also by FYM effect to make soil looser. FYM addition under cowpea crop at two rates (10 and 20 t/fed) has increased PR and also by mixing FYM with gypsum. The same trend of adding soil amendments under cowpea was also seen under potato crop. Gypsum increases PR due to the calcium cation which makes as a bridge between particles helping in forming new aggregates to obtain more penetration.

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تأثير محسنات التربة علىالخواص الطبيعية للأرض الطينية الثقيلة بشمال دلتا النيل

السيد محمود الحديدي ، أيمن محمد الغمرى و أميرة محمود الأمشاطي

قسم الأراضي – كلية الزراعة – جامعة المنصورة – مصر.

أجريت تجربتين حقليتين خلال موسم ٢٠٠١ في أرض طينية ثقيلة في مركز الجمالية محافظة الدقهلية. حيث أضيفت محسنات التربة هذه بمعدلي إضافة في حالة فردية أو بالخلط مع بعضها البعض وتم إضافة الرمل بمعدلين هما (١٠، ٢٠ طن/فدان) والسماد البلدي بمعدلين هما (١٠، ٢٠ طن/فدان) والجبس بمعدلين هما (٢,٥، ٥ طن/فدان) وكان تصميم التجربة المستخدم هو نظام القطاعات الكاملة العشوائية في ١٠ معاملات وهي كالآتي: (الكنترول – الرمل بمعدل ١٠ طن/الفدان – الرمل بمعدل ٢٠ طن/الفدان – السماد البلدي بمعدل ١٠ طن/الفدان – السماد البلدي بمعدل ٢٠ طن/الفدان – الجبس بمعدل ٢,٥ طن/الفدان – الجبس بمعدل ٥ طن/الفدان – الرمل بمعدل ١٠ طن/الفدان + السماد البلدي بمعدل ١٠ طن/الفدان – الرمل بمعدل ١٠ طن/الفدان + الجبس بمعدل ٢,٥ طن/الفدن – السماد البلدي بمعدل ١٠ طن/الفدان + الجبس بمعدل ٢,٥ طن/الفدان وكانت النتائج كالآتي:

تشير النتائج إلى أن إضافة الرمل زاد من الرمل الخشن والناعم لكن نسبة السلت والطين لم تتغير. بينما كانت إضافة المادة العضوية لها تأثير طفيف على الرمل ولكنها زادت محتوى الطين بنسبة بسيطة. بينما لم تؤثر إضافة الجبس في قوام التربة.

أدت جميع المعاملات المضافة سواء في صورة فردية أو مخلوطة إلى خفض الكثافة الظاهرية في جميع المعاملات بينما إرتفعت الكثافة الحقيقية ونسبة المسامية في جميع المعاملات.

أدت إضافة محسنات التربة إلى زيادة التوصيل الهيدروليكي للتربة الطينية الثقيلة القوام. وكان أعلى إرتفاع في التوصيل الهيدروليكي تحت محصول اللوبيا مع إضافة الرمل بمعدل ٢٠ طن/الفدان. بينما كان أعلى إرتفاع له تحت محصول البطاطس في حالة السماد البلدي مخلوطا مع الجبس.

أثرت محسنات التربة المستخدمة على مقاومة الإختراق للتربة. فقد زادت مقاومة الإختراق للتربة في جميع المعاملات. وكان أفضل معاملة هي إضافة الجبس بمعدل ٢,٥ طن/فدان في كل من محصولي اللوبيا والبطاطس.