EFFECT OF SOME NATURAL SOIL AMENDMENTS ON SOME SOIL PHYSICAL PROPERTIES, PEANUT AND CARROT YIELDS IN A SANDY SOIL

SADDIK, WAFAA M. A. AND LAILA K. M. ALI.

Soils, Water and Environment Research Inst., Agric. Res. Center, Giza, Egypt.

(Manuscript received 17 January 2004)

Abstract

Two successive field experiments were conducted in Ismaillia Agricultural Research Station to study the effect of natural soil amendments application on soil physical properties and yield of peanut (cv. Giza 5) and carrot (cv. Local). The first experiment was carried out to evaluate the effect of organic manure (rice straw compost and chicken manure) mixed with clay minerals (bentonite and vermiculite) on peanut yield and soil physical properties. Each clay mineral was added to the soil at a rate of 7 ton/fed., while organic manures were added at a rate of 5 ton/fed. The second experiment was carried out to evaluate the residual effect of soil amendments on soil physical properties and yield of carrot. The results of the first season showed that added different organic manures to the soil improved its physical properties. Addition of rice straw compost or chicken manure to the soil decreased bulk density and increased total porosity compared to the soil without organic manures. Hydraulic conductivity decreased by addition of natural amendments to the soil while soil field capacity increased. In the second season organic residues decreased bulk density and hydraulic conductivity and increased total porosity. The most important results indicate that soil amendments improved soil moisture retention in the following order: chicken manure mixed with vermiculite> chicken manure mixed with bentonite > rice straw compost mixed with bentonite> rice straw compost mixed with vermiculite. Also results showed that the yield of peanut and carrot increased significantly by natural amendments application compared to no amendment application. However, the highest yields of peanut and carrot were obtained with the application of chicken manure mixed with vermiculite followed by chicken manure mixed with bentonite and rice straw compost mixed with bentonite. The lowest value of yield of the two crops was obtained from adding rice straw compost mixed with vermiculite.

Keywords: Soil amendments, rice straw Compost, Chicken manure, Bentonite, Vermiculite, Peanut, Carrot.

INTRODUCTION

In the recent years, the safe agriculture is one of the main attitudes in the world (El – Kouny, 2002). Also, he added that there has been an increasing awareness of the undesirable impact of mineral fertilizers on the environment, as well as the potentially dangerous effects of chemical residues in plant tissues on the health of human and animal consumers.

Bentonite is a natural deposit widespread in different locations in Egypt. Its physical and chemical properties differ from one location to another one and subsequently it can be used in different purposes. The dominant clay mineral and the exchangeable cations in bentonite are responsible for selecting of its use. EL–Sherif (1987) used bentonitic deposit of Quser EL-sagha (EL-Fayom Governorate) as a soil conditioner for sandy soils and found that application of bentonite at the rate of 9% improved the physical and chemical properties of sandy soils.

Regarding the response of physical properties to bentonite application, many properties such as particle size distribution, bulk density, total porosity, and moisture retention characteristics were reported to be improved. EL-Halawany *et al.* (1991) reported that bentonite application resulted in a highly significant increase in soil porosity and available water content, contrary to bulk density and hydraulic conductivity where values were significantly decreased. Mba (1996) reported that increasing C.E.C of the used sandy soil through the addition of bentonite and vermiculite clay minerals led to the improvement of nutrients retention and decreased their losses from the root zone.

Recycling (composting) of organic wastes such as organic crop residues and animals' wastes in agriculture may have a role in decreasing the enormous consumption of chemical fertilizers in Egypt. Awad (1994) pointed out that the importance of organic matter to Egyptian agriculture comes directly next to water importance. At the same time, organic amendments are usually added to soils to improve their physical, chemical and biological properties and/or provide plants with nutrients. Aly (1988) reported that the water holding capacity increased in newly reclaimed sandy and calcareous soils of Egypt after addition of organic manures. Aziz *et al.* (1999) showed that, soil bulk density decreased due to adding soil conditioners, i.e. tafla, farmyard manure and their mixtures. they also mentioned that soil conditioning slightly and the values of FC increased, while the values of soil moisture content at WP were not apparently influenced. On the other hand, soil hydraulic

conductivity decreased due to soil conditioning, especially in the mixture treatments.

Montasser (1987) showed that soil available nitrogen increased with the application of different organic manures. Sandy soils occasionally responded to organic amendments and produced better yields. Regarding crop production, EL-Halawany *et al.* (1991) indicated that bentonite application increased Lentil crop. Wassif *et al.* (1995) confirmed the significant increase in wheat yield as a result of farmyard manure application.

The aim of the present study was to investigate the effect of some natural soil amendments on some physical properties of a sandy soil and yield of peanut and carrot.

MATERIALS AND METHODS

Two field trails were successively conducted in summer season (peanut cv. Giza 5) and winter season (carrot cv. local) of 2002/2003 on a sandy soil in Ismaillia Agricultural Research Station under drip irrigation conditions. Some physical and chemical properties of the soil were determined (Cotteine 1980) and the data are presented in Tables 1 and 2.

Table 1. Some physical properties of the experimental soil

Particle size distribution %				Texture class	BD g/cm^3	Hydraulic conductivity (HC) cm/min	Field capacity (FC) %	Wilting point (WP) %	Available water (AW) %
Coarse sand	Fine sand	Silt	Clay						
70.7	17.0	2.7	11	sandy	1.97	5.60	18.20	7.8	10.5

Table 2. Some chemical properties of the experimental soil

pH	SP	EC	$CaCO_3$	Anions meq /L				Cations meq /L			
1:2.5	%	dS/m		$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^{++}	K^+
8.0	17	2.61	0.46	0	3.21	14.8	8.43	7.04	3.96	13.8	1.84

Available nutrients (ppm)						
N	P	K	Fe	Mn	Zn	Cu
19.0	13.5	126.5	9.7	9.2	13.4	2.3

The natural soil amendments tested include two organic manures, i.e. rice straw compost and chicken manure, and two natural clay minerals, i.e. bentonite and vermiculite. The experiment was designed in a split-split design with three replicates. The main plots were for the organic manures (rice straw compost and chicken manure). The sub plots were for the natural clay minerals (vermiculite and bentonite).

The treatments were:

1- Control (without any application of soil amendments)
2- Rice straw compost (Comp.).
3- Rice straw compost + vermiculite (Comp. + Ver.)
4- Rice straw compost + bentonite (Comp.+ Ben.)
5- Chicken manure (Chick. m.).
6- Chicken manure + vermiculite (Chick. m. + Ver.).
7- Chicken manure + bentonite (Chick. m. + Ben.)
8- Vermiculite (Ver.).
9- Bentonite (Ben.)

Soil amendments were added by thoroughly mixing with the surface soil layer only before peanut cultivation at the rate of 5 ton/fed. for rice straw compost or chicken manure and 7 ton/fed for bentonite or vermiculite with a control plot standing up to represent no amendment added. To evaluate the residual effects of the soil amendments carrot was cultivated directly after peanut harvest.

Some chemical properties of the used amendments were shown in Tables (3 and 4) determined according to Cotteine (1980). Every crop was fertilized with N, P and K in the recommended doses. In each season, the plants were harvested to determine the yields. At the end of each cultivated season two soil samples were taken to evaluate the change of soil physical properties to the application of the used amendments. The values of yield in both seasons were statistically analyzed (Power *et al.*, 1982).

Table 3. Some chemical properties of the vermiculite and bentonite used

	Available nutrients (ppm)			EC dS/m	pH
	N	P	K		
Vermiculite	116	8.73	76.1	1.00	7.49
Bentonite	216.6	2.1	950.6	3.80	7.80

Table 4. Some characteristics of rice straw compost and chicken manure

	Rice straw compost	Chicken manure		Rice straw compost	Chicken Manure
EC (1:10) dS/m	6.61	-	C/N ratio	14.1	18.15
pH (1:10)	7.57	6.63	Micronutrients (ppm)		
Organic matter %	56.64	8.24		Available	Total
Total N %	2.33	2.5	Fe	400.8	3531
Available P (ppm)	5033	-	Zn	100.0	952
Available K (ppm)	6319	-	Cu	22.7	177.0
			Mn	116.0	955

RESULTS AND DISCUSSION

The studied physical properties are: soil Bulk density, total porosity, soil moisture characteristics, pore size distribution and soil hydraulic conductivity. The results obtained show the followings:

A- Physical properties

1- Soil bulk density and total porosity

Soil bulk density is considered as a good indicator for the improvement of the main physical properties. It is well known also that total soil porosity, hydraulic conductivity, soil moisture constants, pore size distribution and the other physical properties are related either directly or indirectly to soil bulk density.

Data presented in Table 5 show that the values of soil bulk density significantly decreased due to soil conditioning with natural amendment, especially when applying organic manures in combination with natural clay minerals (mixed treatments). The application of Chick. m. + Ver. was better than other treatments as compared to either Chick. m. or Ver. only. This finding can be attributed the role of the decomposed products in enhancing aggregation processes and the production of suitable structure parameters which increase the apparent soil volume and, consequently decrease bulk density (Gouda 1984).

Table 5. Effect of some soil amendments on soil bulk density and total soil porosity of the experimental soil

Treatments	Bulk density gm/cm^3		Total porosity %	
	First season	Second season	First season	Second season
Control	1.68	1.56	38.91	43.27
Rice straw compost (Comp.)	1.56	1.53	43.27	44.36
Chicken manure (Chick. m.)	1.59	1.53	42.55	44.36
Vermiculite (Ver.)	1.54	1.51	41.40	42.32
Bentonite (Ben.)	1.56	1.50	42.02	43.26
Chick. m. + Ver.	1.40	1.36	49.09	50.55
Chick. m. + Ben.	1.48	1.43	46.18	48.00
Comp. +Ben.	1.49	1.45	45.82	47.27
Comp. +Ver.	1.52	1.42	44.73	48.36
L.S.D 0.50%	0.07		0.09	

Concerning the effect of soil amendments after the second season, the obtained results show that the addition of any amendments causes a slightly decrease in the values of soil bulk density as compared to those obtained after the first season. This is due to increasing the decomposition rate of organic matter by time and to the indirect effect of organic matter on soil biochemical and physical properties. These results are in good agreement with those obtained by Aziz *et al.* (1999).

2- Soil moisture characteristics

The addition of natural amendments increased the available water (AW) (Table 6). In all treatments of the values of FC, WP and AW were improved after the second season as compared to the values after the first season. The efficiency of the used materials on increasing soil field capacity could be arranged in the following order, Chick. m. + Ver. > Chick. m. + Ben. > Comp.+ Ben. > Comp. + Ver. as compared to control treatment. Aziz *et al.* (1999) stated that the increase in soil moisture content according to soil conditioning is more pronounced under the low applied pressures (<0.5 atm), while the effect of soil conditioning treatments is weak and not clearly noticeable under the high applied pressures (> 2.0 atm),

El-Toukhy (1982), stated that the addition of mineral and organic conditioners together is better than adding those individual additions.

Adding soil conditioners increases the retained water at different pressures comparing with control (sand) according to the following order: incorporated › organic manure › bentonite › vermiculite. This finding can be attributed to the increment in water holding forces of soil by adding the hydrophobic substances, i.e. clay minerals and organic manure (El-Toukhy, 1982).

Table 6. Effect of soil amendments on soil moisture constants in the experimental soil.

Treatments	Field capacity %		Wilting point %		Available water %	
	First season	Second season	First season	Second season	First season	Second season
Control	7.25	7.81	1.86	1.91	5.39	5.9
Rice straw compost (Comp.)	9.98	12.12	2.70	3.01	7.28	9.11
Chicken manure (Chick.m.)	8.93	11.42	1.97	2.49	6.96	8.93
Vermiculite (Ver.)	8.72	11.06	2.00	2.52	6.72	8.54
Bentonite (Ben.)	9.11	12.00	2.30	2.91	6.81	9.09
Chick. m. + Ver.	13.16	15.16	2.31	3.34	10.85	11.82
Chick. m. + Ben.	12.44	15.12	2.88	3.41	9.56	11.71
Comp. +Ben.	11.12	13.78	2.27	2.59	8.85	11.19
Comp. +Ver.	10.22	12.21	2.18	3.01	8.04	9.2
L.S.D 0.50%	0.28		0.21		0.39	

3- Pore size distribution

Data in Table 7 show the pore size distribution in the experimental soil as affected by application of the natural amendments (organic manures and natural clay minerals). It is clear that sand has a slightly effect on some pore groups, i.e., water holding pores (8.26 – 0.19μm), fine capillary pores (< 0.19μm) and coarse capillary pores (28.8 – 0.19μm). In general, adding the natural amendments to sandy soils leads to a decrease in the volume of macro pores and in contrary soil micro pores are increased. The results indicated that the fine and coarse capillary pores significantly increased by the application of the organic manures incorporated with natural minerals as follow: Comp. + Ver. > Comp.+ Ben. > Chick. m. + Ver. > Chick. m. + Ben. as compared to the application of the organic manures or natural clay minerals separately.

Table 7. Water holding pores, fine capillary pores and coarse capillary pores as affected by soil amendments after each of the two crops harvest.

Treatments	After peanut harvesting			After carrot harvesting		
	* WHP	** FCP	*** CCP	* WHP	** FCP	*** CCP
Control	3.02	1.86	5.39	2.70	1.91	5.90
Rice straw compost (Comp.)	3.43	2.70	7.28	3.60	3.01	9.11
Chicken manure (Chick. m.)	3.41	1.97	6.69	2.65	2.49	8.93
Vermiculite (Ver.)	3.01	2.00	6.72	2.32	2.52	8.54
Bentonite (Ben.)	3.86	2.30	6.81	2.15	2.91	9.09
Chick. m. + Ver.	3.41	2.31	6.69	5.78	3.34	11.82
Chick. m. + Ben.	3.71	2.88	9.56	5.31	3.41	11.71
Comp. +Ben.	3.76	2.27	8.85	4.12	2.59	11.19
Comp. +Ver.	3.10	2.18	4.08	2.71	3.01	9.20
L.S.D 0.50%	0.46	0.02	0.51	0.31	0.01	0.46

* WHP = Water holding pores (8.26- 0.19 μ)
** FCP = Fine capillary pores (< 0.19 μ)
*** CCP = Coarse capillary pores (28.8-0.19 μ)

4- Soil hydraulic conductivity

Soil hydraulic conductivity (HC) is one of the most important soil characteristics. It plays a vital role in irrigation and drainage practices and the behavior of soil water.

Table 8. Effect of soil amendments on hydraulic conductivity.

Treatments	Hydraulic conductivity cm/hr	
	First season	Second season
Control	12.31	11.79
Rice straw compost (Comp.)	9.72	8.37
Chicken manure (Chick. m.)	10.47	9.04
Vermiculite (Ver.)	9.92	8.01
Bentonite (Ben.)	9.87	8.60
Chick. m. + Ver.	8.39	7.06
Chick. m. + Ben.	9.07	7.37
Comp. +Ben.	8.86	7.84
Comp. + Ver.	9.85	8.03
L.S.D 0.50%	0.17	

Data in Table 8 show that HC values in the surface soil layer (0-15 cm) were significantly decreased as a result of adding soil amendments. These findings could be due to that improving soil bulk density and pore size distribution which lead, in general, to raise water holding capacity of soil and increases soil metric potential as a result of increasing soil surface area (Hillel, 1982).

B- Response of peanut and carrot yields to amendments application

Data in Table 9 indicate that application of organic or mineral amendments to soil increased pods and straw of peanut significantly as compared to control treatment (no amendment addition). The residual effect of these amendment additions on carrot yield showed the same trend of the direct effect on peanut yield. Adding Chick. m. or Comp. to soil increased significantly yields of peanut and carrot as compared to control (sandy soil only) according to following order : Chick. m. > Comp. > control. These results are in agreement with those of Tester (1990) and Saker *et al.* (1992).

Table 9. Effect of soil amendments on peanut and carrot yields.

Treatments	Peanut (ton/fed)		Carrot (ton/fed)	
	Pods	straw	Root	Whole plant
Control	1.332	1.212	5.360	6.302
Rice straw compost (Comp.)	1.843	1.631	7.050	8.003
Chicken manure (Chick.m.)	1.730	1.442	6.421	7.501
Vermiculite (Ver.)	2.041	2.003	7.604	8.922
Bentonite (Ben.)	1.823	1.900	6.833	8.141
Chick. m. + Ver.	3.610	2.760	10.600	12.351
Chick. m. + Ben.	3.004	2.211	9.322	11.100
Comp. + Ben.	2.851	2.430	8.201	9.950
Comp. + Ver.	2.202	1.981	7.961	9.073
L.S.D 0.50%	0.319	0.315	0.002	0.492

Adding vermiculite or bentonite with chicken manure or rice straw compost to soil increased significantly peanut and carrot yields as compared to organic amendment or clay mineral only. The effect was more pronounced in the case of Chick. m. + Ver. Vermiculite has a high cation exchange capacity and hence this is affecting the soil nutritional capacity and the supply of nutrients to plants than other treatments. Also, vermiculite has a high water absorbing capacity than other minerals thus will affect positively the yield (Wafaa, 2001).

From the above mentioned results the studied soil amendments can be arranged in the following order regarding their effect on carrot and peanut yields: Chick. m. + Ver. > Chick. m. + Ben. > Comp. + Ben. > Comp. + Ver.

It could be concluded that application of amendments to sandy soils improve soil physical properties such as bulk density, total porosity, and moisture retention characteristics. Also, they improve nutrients retention and decreased their losses from root zone resulting in greater yield components.

Acknowledgment: The authors wish to express their sincere gratitude and appreciation to Prof. Dr. Ahmed S. Ahmed for his assistance and cooperation as well as giving all facilities needed for accomplishing this study.

REFERENCES

1. Aly, M. R. 1988. Effect of certain amendments on improving soil fertility and performance in newly reclaimed sandy soil. M.Sc. Thesis, Fac. Agric., Minia Univ., Egypt

2. Awad, A. M. A. 1994. Crop residue effects on soil organic matter, wheat yield and nutrients dynamics. Ph. D. thesis, Fac. Agric., Alex. Univ., Egypt.

3. Aziz, M. A., F. A. Sallam, A. M. El-Gendy and M. Abd El-Moniem. 1999. Some physical and hydrological properties of sandy soils of Inshas as affected by conditioning and irrigation conditions. Egypt J. Soil Sci. 39: 531-559.

4. Chang, A. C., A. L. Page, and J. E. Varneke. 1983. Soil conditioning effects of municipal sludge compost. J. Environ. Eng. (ASCE) 109,574.

5. Cotteine, A. 1980. Soil and plant testing as a basic of fertilizer recommendation. FAO Soil Bull.

6. EL-Halawany, K. S., M. A. Abdel-Reheem and A. E. Ibrahim. 1991. Effect of bentonite application on sandy soil properties and yield of lentil crop. Zagazig J. Agric. Res. Egypt. 18: 891-896.

7. El-Kouny, H. M. 2002. Effect of organic fertilizer in different application rates under salinity stress condition on soil and plant. International Symposium on Optimum Resources Utilization in Salt-Affected Ecosystems in Arid and Semi-arid Region. 8-11 April 2002, Cairo, Egypt, Abst. Book, PP33.

8. EL-Sherif, A. F. 1987. Sandy soil reclamation. Final report. Academy of Scientific Research and Technology. pp. 53-75.

9. El-Toukhy, A. A. 1982. Studies on reclamation of sandy soils. Ph.D. Thesis, Fac. Agric., Moshtohor, Zagazig Univ., Benha Branch, Egypt.

10. Gouda., M. A. 1984. Soil and water management of sandy soils. Ph.D. Thesis, Fac. of Agric., Zagazig Univ., Egypt.

11. Hillel, D. 1982. Introduction to soil physics. 2nd ed. Academic press, Inc., New York

12. Mba, C. C. 1996. Treated-cassava peel vermicomposts enchanced earthworm activities and cowpea growth in field plots. Conservation & Recycling. 17:219 (C. F. Soil & Fertilizers. 60: 6975).

13. Montasser, S. Y. B. 1987. Organic manuring and behavior of certain elements in Egyptian soils with a special reference to response of grown plants. Ph.D. Thesis, Fac. Agric., Ain Shams Univ., Egypt

14. Power, P., R. Freed, S. Goetz, , D. Reicoskg, V. W. Smail and P. W. Wolberg. 1982. MSTAT microcomputer statistical program for design, management and analysis of agronomic research experiments. Version 4.0 Michigan State University.

15. Saker, A. A., S. A. Rizk and A. S. El-Sebaay. 1992. Effect of organic manures on plant growth and NPK uptake by wheat and maize plants. Egypt .J. Soil Sci. 32: 249-263.

16. Tester, C. F. 1990. Organic amendment effects on physical and chemical properties of a sandy soil. Soil Sci. Soc. Am. J. 54,827.

17. Wassif, M. M., M. K. Shabana, S. M. Saad, S. E. El-Maghraby and I. A. Ashour. 1995. Influence of some soil amendments on calcareous soil properties and its production of wheat under saline irrigation water. Egypt. J. Soil Sci. 35: 439-451.

18. Wafaa, M. A. S. 2001. Biological weathering of K-bearing minerals. Ph.D. Thesis, Fac. Agric., Ain Shams Univ., Egypt.

تأثير إضافة بعض محسنات التربة الطبيعية على بعض الخواص الطبيعية ومحصول الفول السوداني والجزر فى الأراضي الرملية

وفاء محمد أحمد صديق ، ليلى قرني محمد علي

معهد بحوث الأراضي والمياه والبيئة – مركز البحوث الزراعية – الجيزة – مصر .

أجريت تجربتان حقليتان متتابعتان بمحطة البحوث الزراعية بالإسماعيلية (أرض رملية) لدراسة تأثير إضافة بعض المحسنات الطبيعية العضويه (كمبوست قش الأرز و مخلفات الدواجن) أو المعدنيه (معدن طين الفيرمكوليت ومعدن طين البنتونيت) سواء منفرده أو مخلوطه وذلك علي بعض الخواص الطبيعية مثل الكثافة الظاهرية والتوصيل الهيدروليكي والسعة الحقلية لهذه الأراضي، وكذلك علي إنتاجية محصول الفول السوداني (صنف جيزة ٥) في الموسم الأول بالأضافه الى تقييم الأثر المتبقى للأستخدام هذه المحسنات على خواص الأرض و محصول الجزر (صنف بلدى) فى الموسم التالى.

تم إضافة المحسن العضوي بمعدل ٥ طن/فدان بينما أضيف المحسن المعدنى بمعدل ٧ طن/فدان.

أوضحت النتائج وجود تأثير معنوي لإضافة المحسنات موضع الدراسة على كل من الخواص الطبيعية للأراضي الرملية وإنتاجية محصولي الفول السوداني والجزر.

أدت إضافة مخلفات الدواجن + معدن الفيرمكوليت لزيادة محصولي الفول السوداني والجزر في كلا الموسمين يليها معاملة مخلفات الدواجن + معدن البنتونيت ثم معاملة الكمبوست + معدن البنتونيت ثم معاملة الكمبوست + معدن الفيرمكوليت.

نتج عن إضافة مخلفات الدواجن + معدن الفيرمكوليت للأراضي الرملية إلى زيادة كلا من السعة الحقلية والماء الميسر والمسامية وكانت النتائج أوضح في الموسم الثاني مقارنة بالموسم الأول.

أدت إضافة معاملة مخلفات الدواجن + معدن الفيرمكوليت للأراضي الرملية إلى انخفاض كل من الكثافة الظاهرية والتوصيل الهيدروليكي يليها معاملة مخلفات الدواجن + معدن البنتونيت ثم معاملة الكمبوست + معدن الفيرمكوليت ثم معاملة الكمبوست + معدن البنتونيت.

نستنتج مما سبق أن إضافة المحسنات العضوية مخلوطة بالمعادن الطبيعية مثل الفرمكوليت أو البنتونيت تحسن من الخواص الطبيعية للأراضي الرملية وتزيد من إنتاجية محصول الفول السوداني كما أن لها أثر متبقى موجب على خواص الأرض ومحصول الجزر التالى.