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Towards Proper Management of Clayey Soils: 11. Combined Effects of Plowing and Compost on Soil Physical Properties and Corn Production

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Abstract: A field experiment was conducted at the experimental farm of National Research Center (N. R. C), El-Kalubia governorate, Egypt. The aim of this study is to maximize the efficiency of plowing through incorporating some types of composts to a clayey soil during plowing operation and creating the physical soil and water conditions suitable for corn production. Two plowing depths namely, shallow(20 cm.) and deep(40 cm.) plowing accompanied by composts of cotton stalks wastes, sugar cane refuse and water hyacinth at rate of 20 tons/ fed were applied. The obtained results revealed that soil bulk density (SBD) significantly decreased and total porosity (TP) increased with the treatments of plowing + composts compared with plowing only treatment (control). The reduction and / or increase were higher in shallow plowing than deep one. The percentage of water stable aggregates (WSA%) >0. 25mm. significantly increased more than those <0. 25mm. which acted positively upon the structure coefficient (SC). On the other hand, drainable pores(DP) significantly increased and water holding pores (WHP) as well, but the increase in DP was much higher than those of WHP. The changes in WSA% and pore system significantly influenced on soil water content and saturated hydraulic conductivity (SHC). The grain yield of corn significantly increased and it was higher with the deep plowing than with shallow one. According to the obtained results, one can say generally that applied composts had the ability to change positively clayey soil hydrophysical properties and raising its productivity.

Key wards: Plowing, compost, soil bulk density, water stable aggregates, structure coefficient, saturated hydraulic conductivity

ITRODUCTION

In the first part of this work(No-tillage and plowing effects on soil physical properties and corn production) Wanas found that soil aggregate distribution of clayey soil under plowing directed towards that have less diameters compared to the no-tillage system and this means that plowing broke down the larger aggregates to the smaller ones. Therefore, in this part of the work compost as a source of organic matter was used accompanied by plowing for facing some negative results of plowing when applied alone. In Egypt, corn represents one of the main crops cultivated in a wide area of the agricultural soils especially which has known as clayey soil. It is used in human and animal nutrition as well as in oil production. Clayey soil suffers from some of the impeded hydro-physical characteristics which inversely influence on crop production. Avoiding the environmental seriousness and producing crops that have a good quality requires utilizing the natural byproducts which became a necessity. Compost one of the most effective materials generated from agricultural residues via what known as composting process. It plays a vital role in improving soil properties and sustaining nutrients status. Many investigators mentioned that composts led to beneficial effects on hydrophysical properties of studied soils such as bulk density, pore size distribution, aggregate stability, soil water retention, soil hydraulic conductivity and infiltration rate. Wanas[1-6]. On the other hand, plowing which considered one of the primary tillage operations go shares to a great extent in preparing a good tilth to the seedbed and improving the hydrophysical properties of clayey soil. Ibrahim[2,7-9] reported that plowing and/ or composts caused marked changes on soil porosity, infiltration rate, soil penetrability, consumptive use, water use efficiency and yield of crops.
This study aims at:

1) maximizing the efficiency of plowing through incorporating some types of composts to a clayey soil during plowing operation;
2) Creating the soil physical and water conditions suitable for corn growth.

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MATERIALS AND METHODS

A field trial was conducted in the experimental farm of NRC, El-Kalubia governorate, to study the combination effects of both plowing and composts in improving the hydro-physical properties of clayey soil which in turn affect on corn production. Composts were prepared by mixing chicken manure(at ratio of 1:3) with organic wastes of sugar cane refuse stemming from juiciness residues, agricultural wastes of cotton stalks and water hyacinth plants (aquatic plants) which collected from the River Nile stream at El-Kanater El-Khiria, Egypt. All wastes converted to compost through what is known as composting process. (Dalzell *et al*[10] and [11]. The experimental design was randomized blocks with four replications. The size of each plot was 2 by 3 m. Corn (Zea mays) was used as a test plant. All plots received 50% of the recommended chemical fertilizers except the control treatment (plowing only) which received 100% of the recommended NPK fertilizers, (120 Kg N) of ammonium sulphate (20. 6% N) + 50Kg P2O5 of superphosphate (15. 5%P2 O5) + 25Kg K2O/ fed of potassium sulphate (48. 7% K2 O). The composts at rate of 20 tons/ fed were incorporated with the soil in course of plowing at two depths namely, shallow plowing (20 cm) and deep plowing (40 cm).

The treatments were as follows:

1) Plowing only treatment (control) at two depths, 20 and 40cm.
2) Plowing + cotton stalks compost
3) Plowing + sugar cane refuse compost
4) Plowing + water hyacinth plant compost

After 12 weeks from sowing the corn plants were harvested and dry weight of grains was recorded. Disturbed and undisturbed soil samples from the experimental site were collected before and after planting and analyzed for particle size distribution (Pipette method), soil bulk density (core method) at 20 and 40 cm depths was determined and total porosity was calculated using the values of soil bulk density and real density (2. 65 Mg/m3) after Majumdar[12]. Wet sieve technique was used to determine the water stable aggregates >0. 25 mm and that < 0. 25 mm after Black[13]. Structure coefficient (SC) as suggested by El-Shafei[14] was calculated. It is the ratio of the percentage content of the total amount of fractions greater than 0. 25 mm in diameter to the percentage content of fractions less than 0. 25 mm. Soil moisture content on dry weight basis was determined at 0. 0, 33. 0, and 1500 kPa using the method described by Klute [15], then converted to volumetric water content to calculate soil pores, (drainable and water holding pores) according to De Leenher[16]. Saturated hydraulic conductivity (SHC) was determined after Black[13]. Soil chemical analyses (PH, EC, OM, and N. P. K) were determined according to Jackson[17]. Data were statistically analyzed using Costat software[18]. Soil and compost characteristics under study are shown in Table (1).

Table 1: Some Properties of soil and composts under study.

Soil properties		Compost analyses	Sugar cane	Cotton	Water hyacinth
Clay %	49.22	PH	6.64	7.17	6.95
Silt %	29.18	EC	3.20	2.80	1.70
Sand %	21.60	C / N	20.40	20.20	18.90
Texture	Clay	N %	1.20	1.62	1.00
PH	7.80	P %	0.65	0.89	0.88
EC (ads/m)	1.14	K %	1.75	1.85	1.60
OM %	2.10	-	-	-	-

RESULTS AND DISCUSSIONS

Soil bulk density and total porosity: Fig (1) depicted the effect of plowing and used composts on soil bulk density. It was noticed generally that plowing only treatment for the two levels of plowing exhibited the highest values of SBD against significant reduction with the treatments of plowing accompanied by applied composts. The values of SBD amounted to1. 20 and1. 22 Mg/m3 for shallow and deep plowing, respectively. On the other hand, the reduction in SBD reached 10. 83, 13. 33 and 15 % for cotton, sugar cane and water hyacinth for shallow plowing. The same trend was found for deep plowing level where the reduction in the values of SBD reached 7. 38, 9. 02 and 12. 3for previously mentioned treatments under shallow plowing. On the contrary to SBD, Fig (2) showed that plowing + composts induced significant changes in total porosity (TP) towards an increase in its values relative to the plowing only regardless the depth of plowing. The values increased by 8. 95, 11. 02 and 12. 41% for shallow plowing against 6. 30, 7. 69 and 10. 49% for deep plowing one for cotton, sugar cane and water hyacinth. It is obvious that the decrease or / and increase in the values of both SBD and TP attendant to the composts with plowing was greater under shallow plowing treatments than that of deep plowing ones.

The preceding results may be arising from the continuous exposure of soil surface layer to tillage operations in addition to its initial organic matter content relative to the subsurface layer which ordinarily lacks of convenient organic matter content and it is normally more dense and compacted as well. Bledsoe *et al*[19] found that SBD values resistance decreased at four plowing depths 20, 40, 60 and 80 cm.

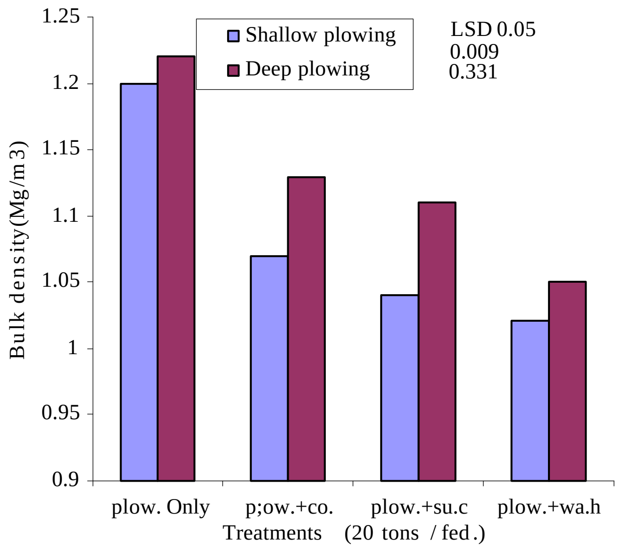

Fig. 1: Bulk density of clayey soil as affected by plowing and compost.

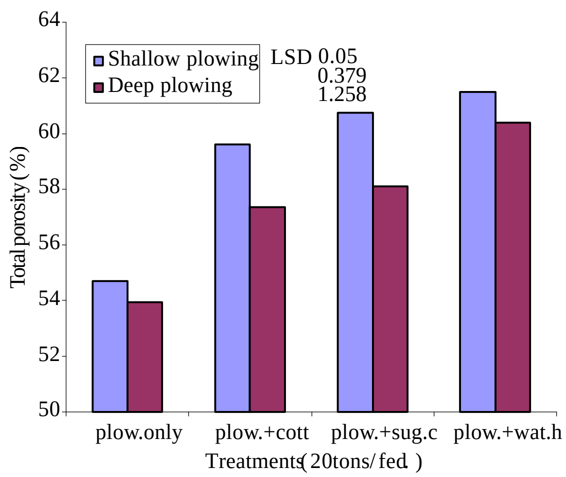

Fig. 2: Total Porosity of Clayey soil as affected by plowing and compost.

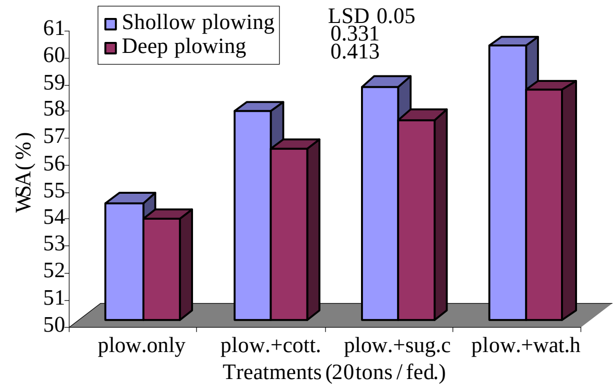

Fig. 3a: Water stable aggregatyes (>0.25mm) of clayey soil treated with plowing and compost.

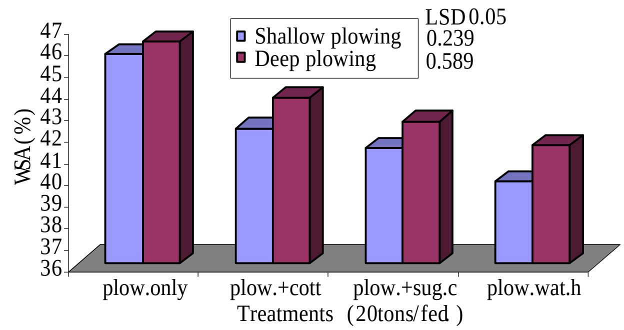

Fig. 3b: Water stable aggregates (<0.25mm) of clayey soil as affected by plowing and compost.

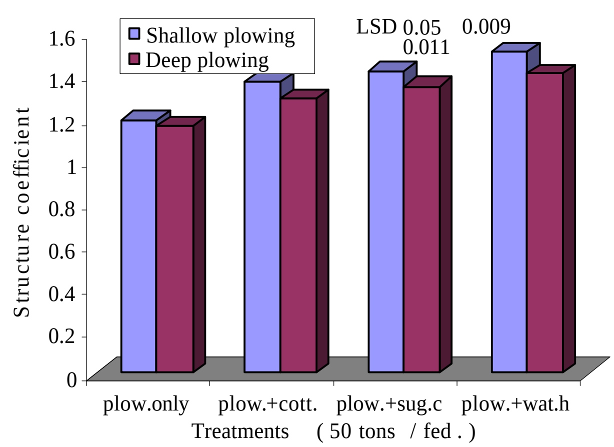

Fig. 3c: Structure coefficient of clayey soil as affected by plowing and compost.

Water stable aggregates (WSA) and structure coefficient (SC): The percent of water stable aggregates>0.25 mm were taken as a reflection of soil aggregate stability. In order to find out the aggregating capacity and to compare quantitatively among the different treatments, structure coefficient (SC) was calculated. Fig (3a) illustrated that the WSA (> 0.25 mm, <0.25 mm) and structure coefficient at the end of corn season were significantly changed under used treatments. It is evident that WSA markedly influenced by plowing accompanied by composts addition compared to the control treatments (plowing only) irrespective of the depth of plowing. Slight differences were noticed for the aggregates >0.25 mm for the two levels of plowing. The same position was found between the aggregates < 0.25 mm. Fig (3b) depicted generally that the shallow plowing had the highest values of the aggregates> 0.25mm but the opposite was true for the aggregates < 0.25 mm. relative to that of deep plowing. An increase in the values of aggregates >0.25 mm was occurred at the expense of that <0.25 mm for both shallow and deep plowing treatments.

It was observed also that the aggregates < 0.25 mm in shallow plowing slightly less than that in deep one. The plowing + composts treatments of shallow plowing achieved an increase in WSA >0.25 mm amounted to 6.29, 7.99 and 10.77% while reached 4.84, 6.87 and 8.87% for deep plowing for cotton, sugar cane and water hyacinth, respectively compared with the control treatment (plowing only). With respect to the WSA <0.25 mm, a decrease in the values of the aggregates took place which reached 7.49, 9.51 and 12.81% for shallow plowing and 5.62, 7.98 and 10.31% for deep ones for the same treatments mentioned before compared with the plowing only. As demonstrated in Fig (3c), an increase in the values of structure coefficient (SC) reached 15.13, 19.33 and 26.89% for shallow plowing while the increase was 11.21, 16.38 and 21.55% for deep plowing for cotton, sugar cane and water hyacinth, respectively relative to plowing only. It is evident that composts differ in their ability on increasing aggregate stability. The greatest action of the treatments in shallow plowing could be attributed to the initial high content of organic matter in the surface layer relative to the subsurface one, in addition to the dilution effect resulting from distributing applied composts on a wide range (40 cm) in deep plowing against narrow depth (20 cm) in shallow one. The trend of WSA and SC values supports the vital role of composts for maximizing the efficiency of plowing as considered one of the major tillage operations in soil management.

Soil pores: The obtained results concerning with drainable pores(DP)as percent from total volume of the studied soil are shown in Fig (4a). The values of DP under the treatments of plowing + composts significantly exceeded that of plowing only treatment either in shallow plowing or deep one. The values of DP were higher in shallow plowing compared with that of deep plowing where the former recorded an increase in the values reached 22.18, 25.04 and 26.98% for plowing + cotton, sugar cane and water hyacinth composts, respectively relative to the plowing only treatment. Regarding the deep plowing level, the increase amounted to 16.84, 20.80 and 29.06 % for the same previous treatments as formerly mentioned. Concerning water holding pores (WHP), Fig. (4b) showed that the treatments had the same trend as occurred in DP but the percent of increase was much less than that of DP. The trend of WHP may be due to the migration of fine clay particles to subsoil layer with irrigation water throughout growing season causing clogging in soil pores in that layer and the dilution effect earlier mentioned. The increase in the values of WHP was 3.00, 6.23 and 6.73% for shallow plowing level, while reached 1.33, 1.33 and 4.09% for deep plowing level for

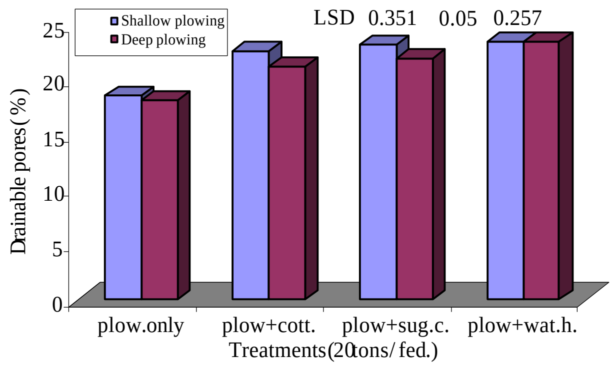

Fig. 4a: Soil porse of clayey soil treated with plowing and compost.

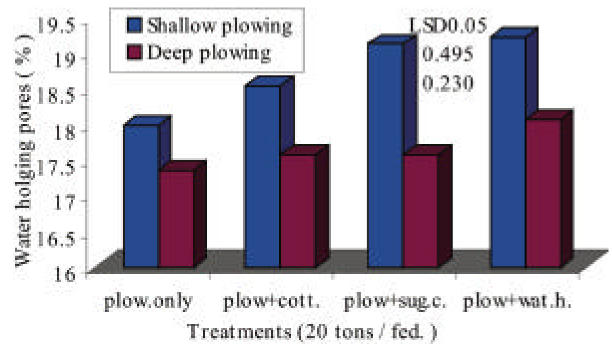

Fig. 4b: Soil pores of clayey soil treated with plowing and compost.

treatments of plowing + cotton, sugar cane and water hyacinth, respectively compared with the plowing only treatment.

Generally, soil pores were in harmony with the obtained results of water stable aggregates. The results proofed that plowing + composts treatments were capable of modifying soil pores where the treatments led to creating an adequate conditions through increasing the percentage of DP which its existence represents necessity for saving favorable level of air in the clayey soil which mainly suffers from lack of air where the fine pores ordinarily predominant, besides the light increase in WHP necessary for more retained water in the soil.

Soil hydraulic conductivity: Fig. (5) indicated the influence of plowing without composts (plowing only) and plowing accompanied by composts on soil hydraulic conductivity (SHC). The trend of treatments clarifies a distinct increase in the values of SHC under plowing + composts compared with the plowing only. For shallow plowing, all types of applied composts achieved a significant increase on SHC. Plowing + composts of cotton, sugar cane and water hyacinth had an increase reached 1.93, 2.29 and 4.6 times that of plowing only. As

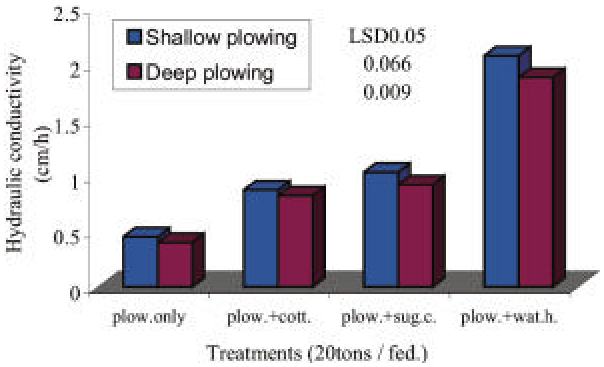

Fig. 5: Saturated hydraulic conductivity of clayey soil under plowing and compost treatments.

Table 2: Regression equation and correlation coefficient (r) of some studied parameters related to soil hydraulic conductivity.

Variables		Regression equation	r
X	Y		
SHC1*	SC1*	Y= - 5.199 + 4.596 x	0.903
SHC2	SC2	Y= - 5.938 + 5.317 x	0.893
SHC1	DP1	Y= - 3.569 + 0.212 x	0.725
SHC2	DP2	Y= - 4.212 + 0.246 x	0.888
SHC1	WHP1	Y= - 10.279 + 0.608 x	0.658
SHC2	WHP2	Y= - 13.531 + 0.823 x	0.617

*SHC1, SC1, DP1, WHP1, SHC2, SC2, DP2 and WHP2 = saturated hydraulic conductivity, structure coefficient, drainable pores, and water holding pores for shallow and deep plowing, respectively.

for deep plowing, the previous treatments in the same order had an increase in the values of SHC greater than plowing only treatment by 2.05, 2.03 and 4.70 times. The values of SHC for deep plowing were less than that of shallow one because of what is earlier mentioned and concerning with the dilution effect and clogging soil pores which tending to slowing water movement through soil profile. The obtained results may be due, partly or totally to the positive changes occurred on soil aggregate stability and consequently the change in soil pores related to water flow in the soil. Many researchers have found a net increase in SHC of various types of soils after application of organic amendments[1,6].

Regression equation and correlation coefficient (r) of SHC and structure coefficient (SC), drainable and water holding pores (DP; WHP) for shallow and deep plowing are shown in Table (2).

Yield of corn: The results included grain yield of corn (tons / fed.) as affected by the studied treatments are depicted in Fig (6) It is evident that a significant increase in yield of corn grains under the treatments of plowing with composts was achieved compared to the treatment of plowing only, regardless the level of plowing (i.e., shallow, deep). It was noticed also that the percentage of increase in deep plowing exceeded that of shallow one.

Table 3: Rregression equation and correlation coefficient (r) concerning with some chosen parameters related to yield of corn.

Variables		Regression equation	r
X*	Y*		
GY1	SC1	Y = - 0.913 + 2.406 x	0.899
GY2	SC2	Y = - 3.376 + 4.716 x	0.911
GY1	FC1	Y = - 8.994 + 0.306 x	0.801
GY2	FC2	Y = - 33.140 + 0.996 x	0.651

*GY1, SC1, FC1, GY2, SC2 and FC2 = grain yield, structure coefficient and field capacity for shallow and deep plowing, respectively.

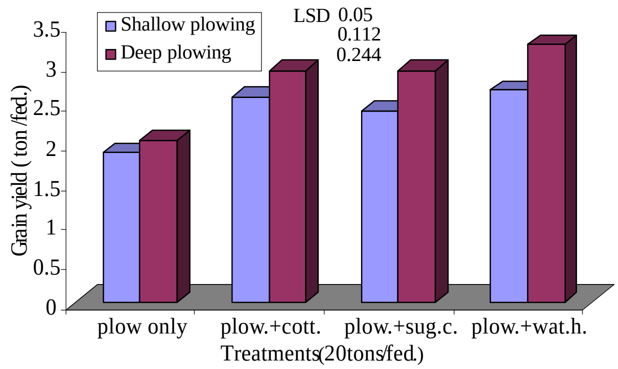

Fig. 6: Grain yield of corn cultivated in days soil as affected by plowing and compost.

The water hyacinth compost owned the highest value while sugar cane compost came last in this respect. For shallow plowing level, the increase in corn grain yield was 37.23, 28.72 and 42.02 while reached 43.14, 43.14 and 59.31% for deep plowing for composts of cotton, sugar cane and water hyacinth accompanied by plowing, respectively compared with the plowing only. The yield of corn grains increased by more than 20% when grain yield for deep plowing compared with shallow one. The increase in grain yield of corn under deep plowing may be due to the significant of plowing and applied composts on hydro-physical properties of clayey soil which acted upon corn yield via increasing the ability of corn roots to spread deeply as a result of loosening subsurface layer and consequently saving more soil air, water and nutrients necessary for corn growth. Ramadan[8] found that grain crop production of wheat and maize has significantly increased from 2. 71 and 7. 90 tons/ ha at zero tillage to 3. 80 and 10. 59 tons/ ha at 40 cm plowing depth in wheat and maize, respectively.

According to the results of the study, one can suggest the necessity of using compost simultaneously with the plowing for achieving maximum advantage for improving the physical properties of clayey soil for increasing crop production.

REFERENCES

1. Wanas, Sh.A., 2002. A comparison study about the influence of inorganic fertilizers and organic composts on the structure and water characteristics of sandy soil cultivated with cowpea plants. Egypt. J. Appl. Sci. 17 (4):362-375.
2. Wanas, Sh.A., 2002. The role of organic composts in alleviating soil compaction. Egypt. J. Appl. Sci. 17 (6): 363-372.
3. Reynolds, W.D, B.T. Boman, C.F. Drury, C.S. Tan and X. Lu., 2002. Indicators of good soil quality: density and storage parameters. Geoderma 110: 131-146
4. Seker, C., 2003. Effects of selected amendments on soil properties and emergence of wheat seedlings. Can. J. Soil Sci. 839 (2): 616-621.
5. Carter, M.R, J.B. Sanerson and J.A. MacLeod, 2004. Influence of compost on the physical properties and organic matter fractions of a fine sandy loam throughout the cycle of a potato rotation. Can. J. Soil Sci. 84 (2):211-218.
6. Nusier, O.K., 2004. Influence of peat moss on hydraulic properties and strength of compacted soils. Can. J. Soil Sci. 84 (2):115-123.
7. Ibrahim, S.M. and S.A. Gaheen, 1999. Improvement of compacted layers of the upper subsoil in a clayey soil. Egypt. J. Soil Sci. 39 (3): 373-381.
8. Ramadan, H.M., 2003. Effect on tillage on spatiotemporal variability of soil hydro- physical properties and productivity of wheat-maize under calcareous soil conditions at el-Nubaria. Minufiya J. Agric. Res. 28 (1): 331-354.
9. El-Barbary, S.M., 2003. Some techniques of water and soil management for sugar beet productivity at north Nile Delta. J. Agric. Sci. Mansoura Univ. 28 (5): 4207- 4217.
10. Dalzell, H., A.G., Bidlestone, K.R Gray and k. Thurairajan, 1987. Soil management: compost production and use in tropical and sub tropical environment. FAO, soil Bull. 51. 8.
11. Abdel-Moez, M.R. and Wanas, Sh.A., 2001. Some chemical and physical characteristics evaluation of composts prepared from different organic materials. J. Agric. Sci. Mansoura Univ. 26 (9): 5881-5891.
12. Majumdar, S.P. and Singh, R.A., 2000. Analysis of soil physical properties. Agrobios, New Delhi, India
13. Black, C.A (Editor), 1965. Methods of soil analysis (Part1). American Society of Agronomy. In Madison. Wisconsin, USA.
14. El-shafei, Y.Z. and R.A. Ragab, 1975. Soil surface sealing caused by rain drop impact. Egypt. J. Soil Sci. 16: 47-68.
15. Klute, A.A., Editor, 1986. "Methods of soil analysis" 2nd edition, American Society of Agronomy. Inc., publisher, Madison, Wisconsin, USA.
16. De Leenher, L., and M. De Boodt, 1965. Soil physics: International Training Center for Post - graduate. Soil Scientist, Ghent. Belgium.
17. Jackson, M.L., 1967. Soil chemical analysis. Prentice Hall, Inc., Englewood Cliffs. USA.
18. Costat, 1985. "User's manual version 3. " CoHort Tusson Arisona. USA.
19. Bledsoe, L., E.C. Versa, S.K. Chong, F.G. Olsen, B.P. Klubekandand and D.J. Stucky, 1992. The effect of deep tillage of reclaimed mine soils on corn root development. P. 51-58. In: Proc. of the Nat Symp. Prime Farmland reclamation, St Louis, 10-14 Aug. 1992. USA.