J. Soil Sci. and Agric. Engineering, Mansoura Univ., Vol.1 (7): 723- 738, 2010

CLAY ANA HEAVY CLAY SOILS IMPROVEMENT WATER MOVEMENT BY APPLICATION OF SUB-SOILING METHODS

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ABSTRACT

Drainage is the most important component of the soil moisture balance equation for the soils and geographical area for which this study is carried out. An accurate estimate of the rate of water removed *from* a soil profile by deep percolation and seepage to subsurface drains or water reservoirs *forma* an essential part of a soil water balance equation especially in temperate and humid regions where evaporation is not the most influential factor. Consequently, deep tillage techniques will accomplished a sensible soil character improvements. Soil science technology and agricultural engineering were applied many methods to improve soil surface layers and their structures. Normal and deep tillage or sub-soiling were usually beneficial in conserving moisture in the sequence soil layers.

An empirical drainage equation was developed to predict declination of soil moisture movement after applying sub-soiling system before traditional tillage. Even this procedure improvement clay and heavy clay soils by improving their properties and porosity, increase wheat crop yield in both soils by 9-10%.

For various soil types (Clay ration (Cr)=: 0.12 sandy, 0.28 sandy loam, 0.43 silty loam, 0.86 clay, 1.66 heavy clay soil), Elbanna (1993) drainage equation was simplified validated to predict water flux, mm/day, as exponential function of soil moisture content mm at previous day to profile with high explanation coefficient..

INTRODUCTION

Elbanna (2001) and Elbanna and Witney (1987) developed soil strength equation as a function of the soil type (in terms of the clay ratio), soil specific weight and soil moisture content, the developed soil strength equation was:

$$\mathbf{CI = [3.63.Cr.e^{-n\theta\theta/(+Cr)} + 0.0066\frac{\gamma}{1+2Cr}]e^{\pi(1+Cr)}} \quad .....1$$

where Cr = clay ratio= %clay/ (%silt +%sand);

ϕ =soil internal shearing frictional angle, deg.

The proctor penetrometer is used to determine soil moisture penetration resistance relationship of fine-grained soils using penetration needles. The penetrometer is used to determine penetration resistance of the mortar content concrete (road off vehicles). The soil specimen must be penetrated at the rate of 13-mm/ sec. (0.5 in./sec) for a distance of not less than 75 mm. (3 inches). The corrected size of needle used should have an end area which is suitable for the condition e.g. dryness or witness, (Söhne, 1960). He reported that at least six penetration resistance determinations are to be made in each rate of hardening tests, the time intervals between penetration tests shall be as such to provide satisfactory rate of hardening curve, as indicated by equally spaced points.

The vane shear test has been used to measure the strength of the soils near the surface and at considerable depth (American society for test-materials, ASAE (1957). The vane usually is constricted so that the height of the blades is from 2 to 3 times the radius. However, Schafer, et al. (1968) stated that the height of the blades is usually 1.5 to 2 times diameter of the vanes. The soil shear resistance was in the same of measuring penetration resistance and at the same depth measured. In that measuring process, the vane is driven into the soil to the desired depth, and then the vane is rotated at a constant angular velocity and thus the volume of soil contained within the blades is sheared off. Schafer et al. (1968) Showed that the soil shear stress τ, (N/m^2) could be estimated from the following form:

$$\tau = \frac{T}{\pi d^2 (h/2 + d/6)} \quad \text{.........} 2$$

where :

T = torque reading by the device, N.m;

d = vane diameter, m; h = vane length, m

In comparative studies made by Elbanna (2001) on three soil strength force methods of cone index (penetrometer), proctor test (proctor penetrometer) and soil vane shear. He concluded that the readings obtained by cone penetrometer equal 10 times of soil vane shear reading. While the reading obtained by using proctor peterometer was equal 1.5-1.75 times the once taken by cone penetrometer.

Sub-soiling by using chisel plough is suitable to break through and shatter compacted or otherwise impermeable soil layers chisel plough might break hard layers up to 35 cm, and this surface layers suitable for grown cereal crops, (Michael, and Ojha. (1981). Others plant crops a deep sub soiling up to 70 cm is needed. Madeira; *et al.* (1989) compared the effects of minimal (surface disc harrowing) and intensive (deep ploughing) site preparation techniques on various soil properties. Their results covered the first 30 months after planting. They showed that, disc harrowing caused a significant decrease in bulk density up to 30-cm depth, whereas, a decrease in soil compaction to 10-cm depth, and also an increase in porosity in the 0 to 10-cm layer. They showed that, the infiltration was greater with disc harrowing. In both treatments the chemical properties of the soil were only affected within the top 20 cm. Since significant decreases in organic carbon, pH, exchangeable Ca, sums of bases and caution exchange capacity were occurred in both treatments. They concluded that decreases in all variables except pH were significantly higher in deep ploughed than in disc-harrowed plots. Biomass production and partitioning, measured 18 and 30 months after planting, were not affected by the tested treatments. However, roots were concentrated in the 0 to 20-cm layer in the disc-harrowed plots and in the 20 to 75-cm layer in the deep-ploughed plots

It was conducted that deep tillage experiments for many years in West Africa. Nicou; *et al.* (1993) evaluated deep ploughing techniques involved motorized equipment or animal powered tools using fined equipment and ridges for earthing up. They evaluated the soil properties plant characteristics, soil porosity, root development, microbial life, soil-water reserves, and crop yields. They also discussed the results of no-tillage and minimum-tillage. They reported that, application of reduced deep tillage techniques did not produce satisfactory results. They concluded that, deep tillage is an excellent means of improving soil physical properties and crop yields in the semi-arid regions of West Africa. They recommended that, motorized equipment technique for resource-poor small farmers to solve their logistical problems.

V-shaped subsoil blade ripper has been shown to be most effective implement for the deep tillage applications. Shumakov; *et al.* (1993) successfully used that blade shape in Kazakhstan, for deep cultivation of the arable layer to 40-50 cm, when livestock wastes and 100-120 t/ha decomposed manure were applied in the treated layer and during the basic soil treatment, respectively.

The performance of a single shank, tractor-mounted oscillating sub-soilers in sandy clay soil with an average moisture content of 16.4% (dry basis) and dry bulk density of 1.57 g/cm^3, and also at 10.17% (dry basis) and dry bulk density of 1.6 g/cm^3. Their tests were also conducted with and without vibration at three forward speeds of 0.62, 0.74 and 1.25 m/s. The used oscillating amplitude was of 15 mm, while the oscillating frequency was of 4.86-10.54 Hz for all tests, (Niyamapa; *et al.* (1994). They tested tillage depths of 30, 35 and 40 cm. The boundary of soil disturbed area was found by a micro relief-meter. They showed that, the soil disturbance area decreased with an increase in the oscillating frequency for the same forward speed. Also the soil disturbance area was increased with the increase in forward speed for the same oscillating frequency.

Prinzio; *et. al* (1996 and 1997) compared three sub soiling techniques (conventional sub soilers, winged subsoil, and rigid tine sub soilers followed by conventional subsoil). Their evaluation parameters were: the increase in the soil volume, disturbed soil area, specific resistance and bulk density. They found that at a depth of 55 - 60 cm, the winged sub soilers gave a greater increase in soil volume with a larger disturbed soil area. The previous passage of rigid tines showed similar results with improved work quality. They concluded that, at a depth of 25 - .30 cm, the 3 three tested sub soiling techniques produced similar results.

The soil moisture retained at a given tension was expressed in terms of grams of soil in 100 grams of dry density. The conventional unit of bar was used to expressed soil tensions. Using soil moisture characteristics and bulk density (Elbanna, 1993). Soil water drained rapidly for values of low tension and more slowly with higher tensions. A logarithmic equation in the following form was fitted to specific soil type at three horizons of four soil moisture tensions data and a very high degree of explanation was obtained for each soil type all data

Elbanna (1993) concluded different types of relationships were tried in order to develop a general productive drainage equation. In theory, hydraulic conductivity and drainage, is constant when soil is at saturation, and either ceases or reaches to a negligible value when the soil moisture content approaches to the field capacity. Of the numerous equations examined the following two forms of equations (3 and 4) were found to yield the best results. First, a log-linear relationship was assumed, (equation 3). Secondly, a log-log relationship (equation 4)

$$\ln \theta_m = -21.215 \ln P_h \qquad \therefore \theta_m = e^{-21.215 \ln P_h} \qquad ....3$$

where:
θ_m = soil moisture content, mm/ mm depth;
Ph=soil moisture tension head, mm.

Drainage equation (4) was simplified validated in the present study after Elbanna (1993) to predict water moisture movement mm/day, as an exponential function of soil moisture content , mm at previous day to profile depth, mm as in the form of:

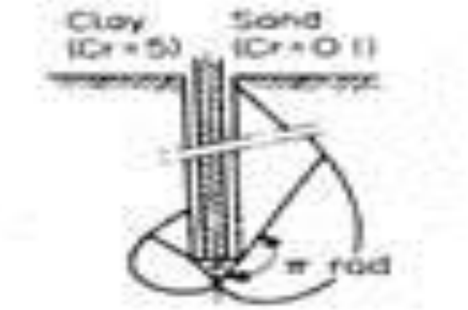
$$\ln Q_D = 5.65\{\theta_{m-1}\}\backslash h \qquad \therefore Q_D = e^{5,65\{\theta_{m-1}/h\}} \qquad ....4$$

where Q_D = drainage flow, mm/day; h=soil profile depth, mm.
θ_{m-1}=soil moisture content on previous day, mm/day

MATERIALS AND METHODS

Soil mechanical analysis and sites

Two field sites were chosen for carrying the soil tests and field data. The first field was sited at 75-Village, El-Hamool, Kafr El-Sheikh Governorate. Whilst, the second field was chosen at El-Sorow station, Domitta Governorate. Five randomized soil samples were taken from each field at 30 cm surface layer and carried to soil laboratory at Fac. of Agric., Mansouara, Univ. The average soil mechanical analysis for each soil samples were average to represent soil type in each filed depends on clay ratio and each soil frictional angle (Elbanna and Witney 1987) as in the from:

$C_r = \dfrac{clay(\%)}{silt + sand,(\%)}$ $r = r_o e^{\pi \tan\varphi}$ $\tan\varphi = \dfrac{1}{1 + 2c_r}$	 Relative size of the pressure bulb formed at the base of cone penetrometer for clay and sand

C_r =clay ratio (soil type); φ = internal soil frictional angle, deg;
r, r_o = initial and final slopes radius of failure logarithmic spiral curves.

Field data of soil mechanical analysis of both fields were represented in Table 1

Table 1 : 75-Village, El-Hamool and Serow soils mechanical analysis

Site	Sand, %			Silt, %	Clay,%	$C_{r,}$	φ, deg
	Coarse	Fine	total				
75-Village	4.95	10.48	15.43	30.77	53.80	1.165	16.70
El-Serow	1.55	8.95	10.50	27.12	62.38	1.658	14.25

Cone Penetrometer (cone index)

Soil strength was measured empirically in terms of the cone index, which is the force that may be applied to the handle of the cone penetrometer (Fig.1a) per unit area of its cone tip in order to force it into the ground. The right circular is 30-deg cone, has an end area of 0.2 or 0.5 sq. in. (1.29 or 3.226 cm^2). The cone is pushed slowly downward, and readings of the dial gauge are made at desired vertical increments which are shown by graduations on the instrument's shaft.

Proctor Penetrometer

The proctor penetrometer is used to determine soil moisture-penetration resistance relationship of fine-grained soils using penetration needles. It consists of a special spring dynamometer with a pressure indicating scale on the stem of the handle. The scale is calibrated from 10 to 150 lbf., in 2 lbf. increments (0.0445 to 667.23 kN in 8.9 N interval) and a sliding ring indicate the applied load, which is read off at the top face of the sliding ring. The sliding stem can be connected, screwed with one of sectional circular plate of 1/20", 1/10", 1/5", 1/3", 1/2", 3/4" and 1 in^2. The proctor strength was calculated in MPa by dividing the sliding manometer reading by plate sectional area, (Fig. 1b) shows the standard British proctor penetrometer.

Vane Shear Strength

The inspection vane borer is used to measure the in situ untrained shear strength in soil. It is primarily intended for use in trenches and excavations at a depth not influenced by drying and excavation procedure. The range of the instrument is from 0 to 26 t/m^2 when three different sizes of vanes are used. The accuracy of the instrument should be within 10% of the reading. The measuring part of the instrument is a spiral-spring (max. torque transmitted 30 kg.cm). When the handle is turned, the spring deforms and the upper part and the lower part of the instrument get a mutual angular displacement. When torque is applied, the scale-ring follows the upper part of the instrument, and when failure in the soil is obtained, the scale ring will remain in its position due to the friction in the threads. The size of this displacement depends on the torque, which is necessary to turn the vane. By means of a graduated scale, the shear strength of the soil is obtained.

Three sizes of four blades vanes are used: 16x32 mm (extra) multiply readings with 2, 20x40 mm (standard-direct readings) and 25.4x50.8 mm (extra) multiply readings with 0.5, which makes possible to measure shear strength of 0 to 26, 0 to 13, and 0 to 6.5 t/m^2 (254.98, 127.49 and 63.75 kN/m^2), respectively. The "area ratio" of the vanes is 14, 16.5 and 24% (ratio of cross sectional area of vane to the area to be sheared). The vane blades are soldered to a vane shaft, which is extended by one or more 0.50 m rod (Fig. 1c). Threads make the connection between the shaft-rod and the instrument, to make the connections as straight as possible, the rod have to be screwed tight together and threads cleaned for dirt.

a-cone penetrometer (ELE20-088 British standard).
b-proctor penetrometer (ELE 24-651 British standard)
c-vane shear strength; (GeoNorA/S Vane tester H-60).

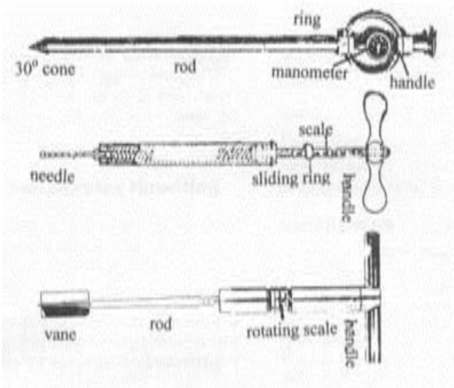


Fig. 1: Three instruments used to measure soil strength forces in clay and heavy clay soils

Tractor and Implement

A 73.5 kW (110 hp) Romania tractor was used to perform all tillage depth treatments with the truckled sub soiling implement. While a 44.12 kW (60 hp) Nasr tractor was chosen as dummy or auxiliary tractor only when implement draught force was tested, Table 2 and Fig. 2 show the used sub-soiler machine.

Table 2: Trailed sub-soiller specification .

Model	**UK., MLTL**
Mass, kg, No of shares	740, Single share
Dimension: length, m	2.75
width, m	1.65
height, m	1.40
Power required, kW	73.5 (110 hp)
Share dimensions: length, cm	30.0
width, cm	80 at its front edge
	120 at its end 30

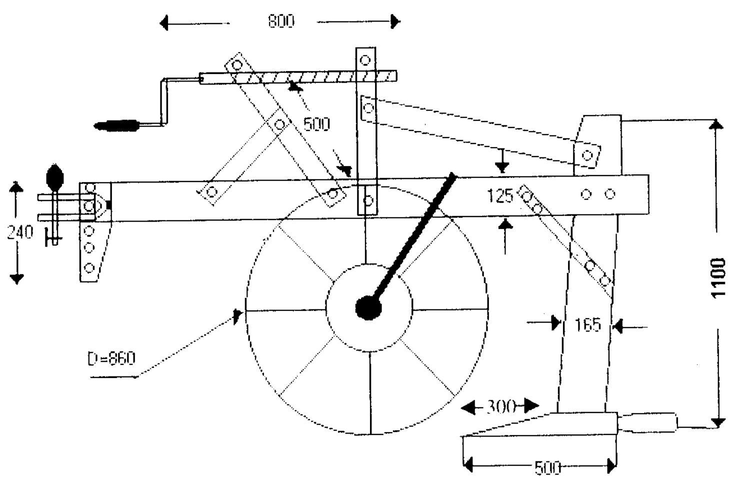


Fig. 2: Trailed sub-soiler with its design specification parameters.

Both fields (experimental data) were under subsurface drainage and surface irrigation systems. Farmers in both field trails were applied traditional tillage system using a 7 mounted chisel plough with an average 20 cm tillage depth. Each field was divided into three main plots, within two-irrigational and one- drainage channels. Each individual plot was treated with three sub-soiling drain channels' spacing of 2, 4 and 8 m. (Fig. 3). Trailed sub soiling treatment criteria were summarized as follows:

x= drain channel spacing: 200, 400 and 800 cm;

d=sub-soiling operating depth: 30, 45 and 60 cm.;

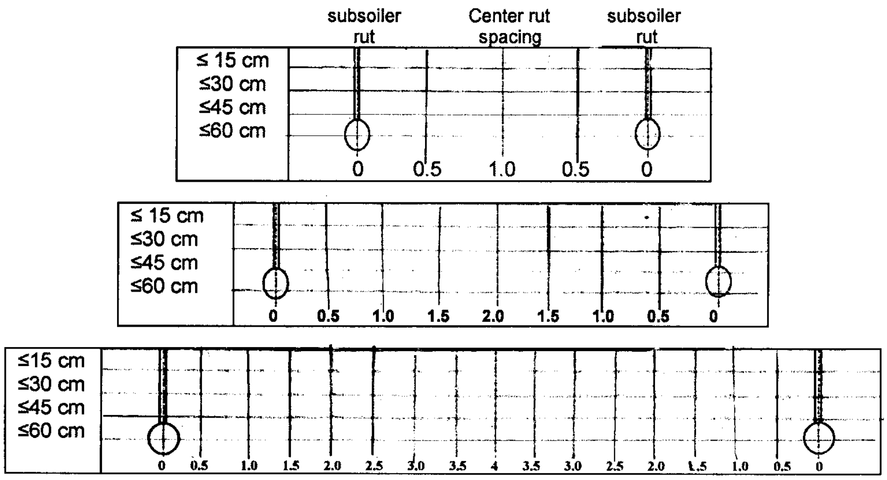


Fig. 3: Horizontal and vertical position of soil moisture samples lies between sub-soiling channels

The above two treatments were applied at both 75-Village and El-Serow station. The sub-soiling experimental readings were carried out after traditional tillage system (by twice perpendicular of chiseling plough and harrowing) and before growing wheat crop. The same seed drill machine and Giza 171 variety were used to grow winter wheat in both fields.

RESULTS AND DISCUSSION

Irrigation or rainfall alone is of little help in determining the moisture content of the soil because drainage of water through the soil varies markedly from site to site. Both evaporation of moisture from the soil and transpiration of water vapor by the crop are also affected by the ambient temperature, with warmer intervals favoring a more rapid moisture loss. In addition, the existing moisture status of the soil governs the rate of drainage and the rate of evapotranspiration. As the soil dries out, the removal of additional water becomes progressively more difficult. Not accounting for this fact in the past has led to excessively high estimates of soil workdays. Lastly, during periods of high intensity or prolonged irrigation or rainfall, the percolation of water through the soil is too slow to meet the deluge imposed upon it and the excess flows over the soil surface to the nearest waterway as runoff.

In order to evaluate the soil moisture content on a daily basis, it is necessary to consider: (a) soil moisture content on the previous day; (b) precipitation; (c) runoff; (d) drainage; (e) evapotranspiration. These factors are combined to form the soil moisture balance equation for the top 300 mm of the plough layer:

$$m_a = m_p + Q_p - Q_r - Q_d - Q_e \quad \text{.......(1)}$$

By means of this equation, the soil moisture content on the previous day is adjusted for soil moisture gains and losses to provide a revised soil moisture content on a cumulative basis.

For simplicity, only water entering the soil as precipitation (snow, sleet, rainfall and/or irrigation) need be considered because worldwide meteorological data are readily available. In temperate climates, the amount of water condensing onto the soil from the air entering the soil may be neglected, although this moisture source is important in some parts of the world where dry farming is practiced. Equally, the transfer of water from adjacent areas either as surface runoff or subsurface flow only can be ignored for non-sloping sites and homogeneous soil profiles. The differential transmission of water vapour through the soil is negligible in comparison with the evapotranspiration and, at the early stages of plant establishment, the moisture directly intercepted by vegetation can be discounted. Any soil moisture content can be converted into an equivalent depth of water by multiplying its decimal value by the depth of the soil profile and the ratio of the soil bulk density to the density of water (1 g/m^3). Despite these provisos, the moisture content can be predicted with a high degree of accuracy. So drainage factor Q_f can be evaluated from predicted regression equation with high degree of explanation as in the form:

$$Q_f = k_i Q_{ir} + k_\theta \left(\frac{Q_m - Q_c}{100} \right) \frac{\rho_b}{\rho_w} h + k_{sd} \frac{Sd}{Dd} \quad ....2$$

where:
Q_f = drainage factor, mm/day;
Q_{ir}=irrigation/ or precipitation, mm/day;

θ_m= %, soil moisture at middle spacing between two drained sub-soiler ruts; θ_c= %, soil $_{moisture}$ at center of drained sub-soiler rut; ρ_d and ρ_w=soil and water density, gm/cm^3; S_d and D_d = draine sub-soiling drain spacing and depths

Table 3: Values of the clay ratio, drainage coefficients, their standard errors and percentage of explanation in the two tested field.

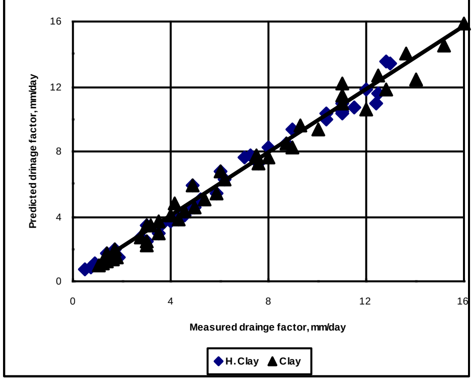
Soil Type	Clay ratio	Drainage coefficients*10^{-2}			Standard errors*10^{-3}			Expl, %	DF.
		K_i	k_θ	K_{sd}	K_i	k_θ	k_{sd}		
75-village, Kafr El-Sheikh	1.165	162.6	1.1256	0.9061	10.041	1.256	5.422	99.15	44
El-Serow, Domitta	1.658	147.6	4.247	-4.088	6.058	26.921	-2.056	98.48	44
Combined		169.57	4.150	-2.794	3.153	34.198	-2.178	99.06	88

Expl. = explanation, r^2; DF. = degree of freedom

Drained sub soiler data in two soil types were normalized and analyses to obtain drained water (infiltration) factor. Exploring the effects of the investigated sub-soiling treatments on a sequence changes of the drain channels at nine treatments (three sub-soiling depths of 30, 45 and 60 cm x three sub-soiling spacing of 2, 4 and 8m), (Fig. 1). Both fields were under subsurface drainage and surface irrigation systems.

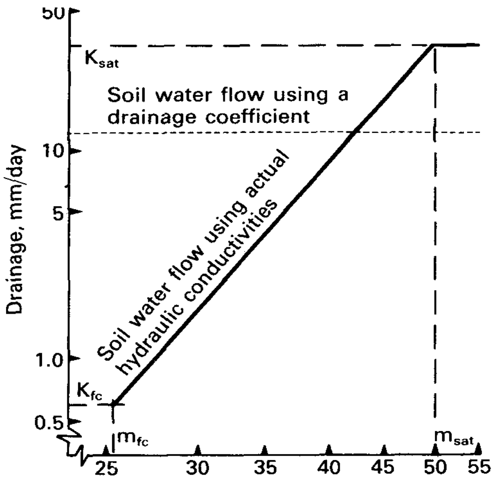
Farmers in both field trails were applied traditional tillage system using a 7 mounted chisel plough with an average 20 cm tillage depth. Wheat crop is grown in both fields and was irrigated 5 times. Soil moisture content, strength (cone index) and soil specific weight data were measured with an interval of 0.50 m lateral spacing from the center sub-drained rut to the middle between the two main sub-drained ruts. These soil properties data were replicated with 15 cm interfere

Fig. 1 Predicted against mesured of clay and heavy clay soils drinage factor fron saturation to wilting point.



depths from the soil surface upto 60 cm profile depth at the three sub-soiling spacing.

Soil water movement is governed by the hydraulic conductivity. Whilst there are substantial fluctuations in the rate of soil water movement, various approximations are appropriate *for particular* applications, but these approximations cannot be transferred from one application to another. For the design of field drainage systems, for example, it is only essential to identify the maximum flow rate for the selection of an adequate system capacity and it is quite acceptable to adopt the concept of a *drainage coefficient* (Fig. 2)



Soil moisture content, mm/300 mm

Fig. 2 Hydraulic conductivities, K, for the soil moisture contents, m, at saturation and field capacity used in the determination of drainage flow.

The soil moisture content distribution data provided strong evidence for both lateral and deeply infiltration rates in each drained treatments. Figs. 3a, b, c, d, e, f and Figs 4a, b, c, d, e, f showed the moisture content data were measured from topsoil 15 cm to 60 cm soil profiles for three sub-drained spaces of 2, 4 and 8 when sub-soiling depth 60 cm. The soil moisture, cone index, proctor test and soil vane shear were taken from the central or middle spacing between two sub-soiling ruts just before 5 sequential irrigations (Table 4).

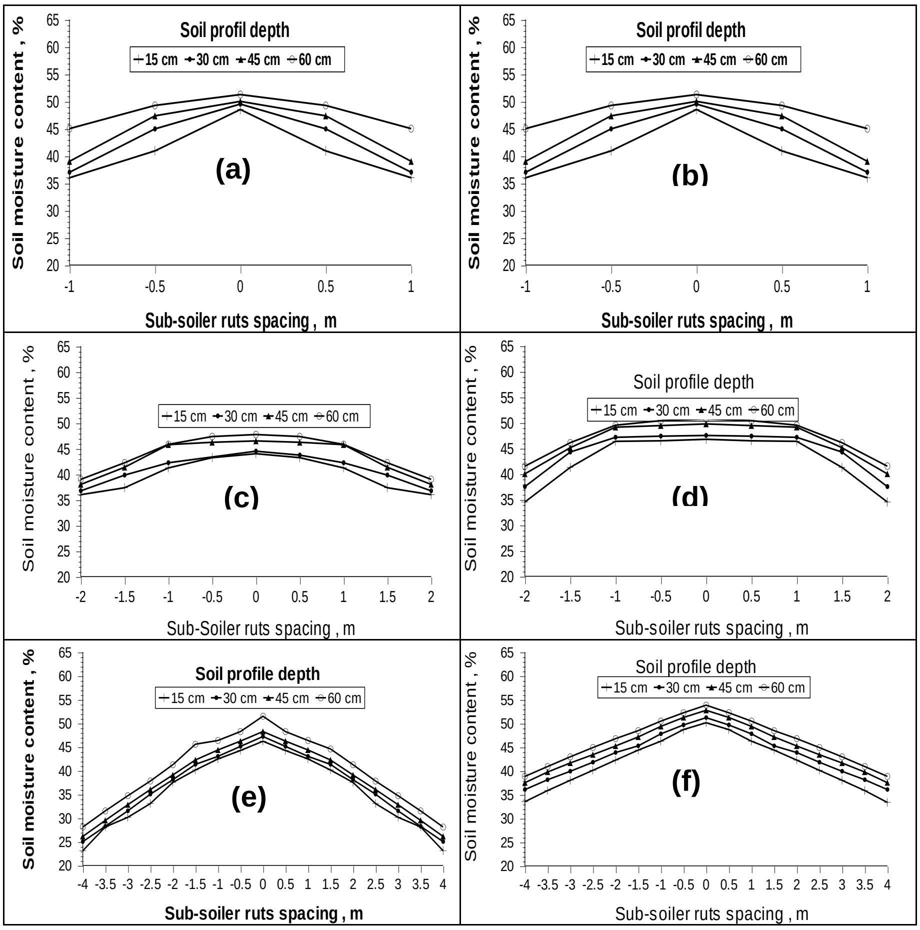


Fig. 3a, b, c, d, e, f. Fluctuations of clay loom (75-Village) water movement from middle to sub-soiler ruts at 60 cm depth with 2, 4, 8 m rut spaces.

From Figs 3.and 4 it can be concluded that, as sub-soiling drain ruts increase from 30 to 60 cm, the level of moisture content decline from the middle to the sub-soiling rut. Previous figures show a complicated situation with increasing sub-soiling spaces found more holding soil moisture contents. So with increasing the sub-soiling rut spaces or decreasing rut depths, the more holding level of soil moisture contents. From previous figures it can be concluded sub-soiling 60 cm depth with 2 m rut spacing gave more infiltrated or drained water after 5 applied irrigated times in both wheat crop fields and gave more grain yield compared with the other two systems.

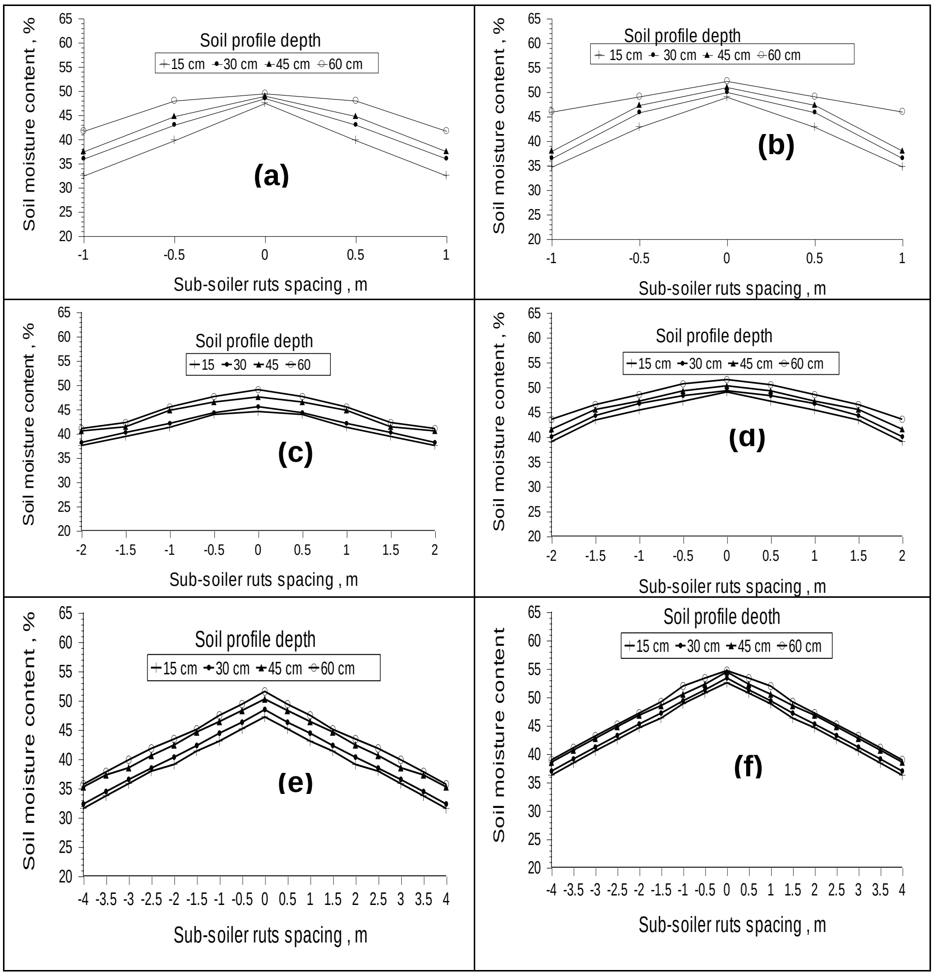


Fig. 4a, b, c, d, e, f. Fluctuations of heavy clay loom (El-Serow) water movement from middle to sub-soiler ruts at 60 cm depth with 2, 4, 8 m rut spaces .

Different types of relationships were tried in order to develop a general productive drainage equation. In theory, hydraulic conductivity and drainage, is constant when soil is at saturation, and either ceases or reaches to a negligible value when the soil moisture content approaches to the field capacity. Of the numerous equations examined the following two forms of equations were found to yield the best results. First, a log-linear relationship was assumed, (equation 4). Secondly, a log-log relationship (equation 4) simplified to equation form 3.

The average of four replications of soil water flux for 10 days duration from saturation was calculated from the moisture content values, for sandy, sandy loam, silty loom, clay and heavy clay soils (clay ratios, Cr=0.12, 0.28, 43, 0.86 and 1.66). are shown in Fig. 5, Using (Elbanna, 1993 equation 4) which has a theoretical backing, such as:

$$\ln Q_D = 5.65\left\{\theta_{m-1}\right\} \backslash h \qquad \therefore Q_D = e^{5,65\left\{\theta_{m-1}/h\right\}} \qquad ....3$$

where Q_D = drainage flow, mm/day; h=soil profile depth, mm.
θ_{m-1}=soil moisture content on previous day, mm/day

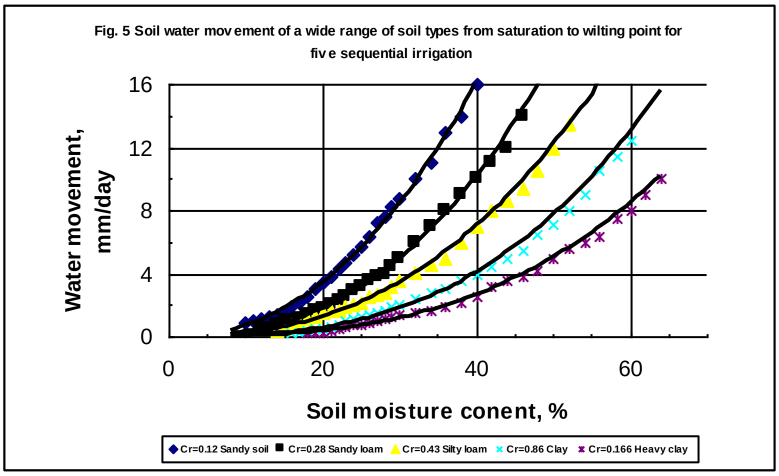


Fig. 5: showed soil properties, soil strength, proctor penetrometer and soil vane shear forces just previous day of sequential 5 times of irrigation in two wheat crop fields compared with the predicted values using Elbanna equation (2002).

Table 4: Average values of soil strength (measured with cone penetrometer), proctor needle and vane shear) together with their predicted values and soil moisture content and specific weight in the two tested soils before sequences irrigation.

Irrigation sequence	Soil specific weight, kN/m^3	Soil moisture content, %	Cone index, MPa		Proctor strength, MPa		Shear strength, kPa	
			Meas.	Pred	Meas.	Pred.	Meas.	Pred.
Light clay soil (Cr=1.161) at 75-Village, Kafr El-Sheikh								
1	14.04	24.02	1.449	1.346	3.321	3.492	156.55	167.58
2	13.99	23.04	1.487	1.460	3.544	3.508	177.23	172.86
3	13.64	22.50	1.509	1.507	3.701	3.681	187.15	181.12
4	13.44	21.50	1.559	1.651	3.851	3.740	198.33	186.35
5	14.07	20.54	1.561	1.708	3.902	3.716	204.33	193.76
Mean	13.84	22.23	1.513	1.533	3.664	3.567	184.70	180.33
Heavy Clay soil (Cr=1.881) at El-Serow Domitta								
1	13.36	24.14	1.655	1.555	3.885	3.558	177.08	178.61
2	13.10	23.61	1.725	1.678	4.415	4.328	190.70	199.77
3	13.41	23.60	1.814	1.783	4.554	4.422	198.65	189.55
4	13.64	24.06	1.775	1.801	4.720	4.600	210.53	206.88
5	13.93	23.96	1.881	1.891	4.867	4.719	230.22	215.60
Mean	13.49	23.89	1.769	1.742	4.488	4.325	201.44	198.08

CONCLUSION

Soil water movement is governed by the hydraulic conductivity. However, it is only essential to identify the maximum flow rate for the selection of an adequate system capacity and it is quite acceptable to adopt the concept of a *drainage coefficient*. So the drainage factor was predicted for heavy clay soils with high explanation as a function of irrigation or rainfall precipitation, fluctuations of soil moisture content between drainage ruts and ratio of rut space/ depth.

Using the sub-soiling methods in clay and heavy clay soils is acceptable and improvement of water movement to drained ruts and improve soil prosperities and it conditional status in a comparison with normal tillage. Applying the sub-soiling methods before growing wheat crops increase yield by 10% in both tested fields.

Cone index "soil strength", proctor test and soil vane shear are another aspect of root growing or elongation which lead to high inflict of crop yield. Therefore, the soil strength properties were evaluated during and at the end of the growing seasons in two tested fields, just before each of 5 irrigations during winter crop growing season. It is concluded that measurement one of them that enough to give an indication of soil strength. Hence from a wide range of soil type (Elbanna, 2001) and as aid of this presentation, the cone penetrometer readings is equal 10 times of soil vane shaer readings, whilst the proctor penetrometer (proctor needle) readings is equal 1.5-1.75 times of cone index readings.

Drainage equation was simplified validated to predict water flux, mm/day, as exponential function of soil moisture content mm at previous day to profile depth, mm, using with high correlation coefficient of 98%.

Soil water movement can be predicted also using sub-soiling method before traditional tillage improves clay and heavy clay soils propertied and their porosity, and the declination of water movement from middle spacing between sub-soiling ruts was predicted as a function of water precipitation or irrigation, mm/day, difference moisture, mm and ratio of horizontal/depth of sub-soiling ruts.

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تحسين حركة المياه بالتربة الطينية والطينية الثقيلة بتطبيق الحراثة تحت التربة فيهما

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في موسم زراعة محصول القمح 2010/2009 أجريت تجارب حقلية باستخدام محراث تحت التربة بثلاث أعماق 30، 45، 60 سم لعمل أخاديد تحت التربة الطينية بقرية 75 بمحافظة كفر الشيخ، والطينية الثقيلة بمحطة السرو بدمياط لتحسين خواص التربة الطبيعية وصرفها.

حيث أجريت عملية إعداد الأرض للزراعة بنفس الأسلوب باستخدام محراث حفار معلق 7 سلاح (حرثتان متعامدتان لعمق 20سم ، يليهما تمشيط بمشط قرصي مزدوج) وقبل عملية الحراثة استخدم محراث تحت التربة على مسافات 2، 4 ، 8 متر لأعماق 30، 45، 60 سم في الحقلين.

وقد أظهرت النتائج أن استخدام محراث تحت التربة حسن معامل الصرف في المعاملة 60 سم عمق ومسافات بينية 2متر بالمقارنة بالمعاملتين (45سم ، 4م ؛ 30سم عمق، 4م مسافة بينية) وقد تأثرت إنتاجية المحصول في الحقلين بعملية تحسين معامل الصرف حيث أعطت زيادة 9، 10% في إنتاجية محصول القمح (فى التربة الطينية والطينية الثقيلة) بالمقارنة بنتائج الكنترول أو الزراعة بالطرق التقليدية.

باستخدام ثلاثة أجهزة لقياس مقاومة التربة (soil strength) وهى cone index, proctor (needle) and vane shear test لاختبار مقاومة التربة قبل الري لمحصول القمح مباشرة (5 ريات) وتأكيد استخدام العلاقة كعلاقة عامة تغنى عن إستخدام ثلاثة أجهزة إختبار:

$$C_S = k_C[Cr.e^{-n\theta\theta/(+2Cr)}] + k_\varphi[(\frac{\gamma}{1+2Cr})e^{\pi(1+Cr)}]$$

where CI = cone index, MPa; θ = soil moisture content, %:
γ = soil specific weight, kN/m^3; Cr = clay ratio= %clay/ (%silt +%sand);
ϕ =soil internal shearing frictional, deg: $\tan\phi$ = tangential friction angle=1/(1+2Cr).

حيث أنه من القياسات الحقلية والمتنبأ بها من المعادلة السابقة أعطى Cone index قراءة تعادل 10 أمثال vane shear بينما قراءة Proctor Needle تعادل 1.75-1.5 مرة Cone index.

وبصفة عامة ينصح باستخدام عملية (Sub-soiling) في التربة الثقيلة على مسافات متقاربة 2-4 متر لتحسن معامل الصرف أو التسرب سواء في مناطق الصرف المكشوف أو المغطى خصوصا في مناطق الري السطحي. حيث أنه بالإضافة لتحسين معامل الصرف، قلل من مقاومات التربة فى منطقة نمو جذور النبات مما يحسن من إنتاجية المحصول.

قام بتحكيم البحث

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