RESULTS AND DISCUSSION

4. Results and Discussion

The present study was executed to evaluate the role of some soil parameters and their interactions in soil compactain and the effectiveness of some management measures for solving or alleviating this problem. The considered soil parameters included the particle size separates, content and size distribution of $CaCO_3$, gypsum, organic matter content and soil wetness. Meanwhile, the remedial measures included plaughing to different depth using different types of plows and the application of composted organic matter.

4.1 . Characteristics of soils under study :-

Taking the variations of soil constituents and the applied management practices into consideration when assessing compaction problem, seven sites were chosen along a transect starting from Nubaseed and extending to Al Gharbaneiat. These sites are Nubaseed, the mechanized farm (2 sites), the Agricultural experimental station of Desert Research Center DRC (2 sites), Burg El Arab and Al Gharbaneiat. Generally the soils of these sites, except few cases, are belonging to typic torriorthents carbonitic thermic, El Kady and Harga (1983) and Erian et al (1989).

4.1. a. Morphological description :

Morphological study of soil profiles representing these sites was undertaken according to the criteria outlined by FAO (1970). In general, the data given on the following pages indicate that the area is nearly flat and the soil is very deep as the water table and the soil bedrock are not present in less than 150 cm depth, except the case of Nubaseed site where water - table is detected at 115 cm depth.

Profile No (1)

Location : Nobaseed

Date of Description : 18th October 1995

Topography : Level plain

Parent Materials : Calcareous sediments

Vegetation : uncultivated, udner preparation for wheet cultivation.

Depth	Description
0-30	Light yellowish brown (10 YR 6/4, dry), yellowish brown (10 YR 5/4, moist); loamy sand, massive,weaky cemented, non sticky, non plastic; abrupt smooth boundary.
30-75	Reddish yellow (7.5 YR 6/6, moist); loamy sand, massive; slightly hard; slightly sticky, non plastic; clear smooth boundary.
75-100	Reddish yellow (7.5 YR 6/6, moist); sandy loam, massive, friable, slightly sticky, slightly plastic; many lime segregations, gradual smooth boundary.
100-115	Do as (75-100) layer, but wet.
115 +	Water table.

Profile No. 2: Parcel (2)

Date of Description : 18th October, 1995

Location : West Noubaria Agric. Company, km 62 from Alex, =1 km east of Cairo -Alex. Desert Road.

Topography : Nearly level.

Parent Material : Calcareous sediments

Vegetation : Plowed field

Depth	Description
0-29	Pale brown (10 YR 6/3, dry), yellowish brown (10 YR 5/4, moist); sandy clay loam; massive; hard; sticky, plastic; clear smooth boundary.
29-50	Brown (10 YR 5/3, dry), dark brown (10 YR 4/3 moist); sandy clay loam; massive strongly cemented, very hard to extremely hard; sticky, plastic, abundant white powdery and crystals of gypsum, gradual smooth boundary.
50-80	Yellowish brown (10 YR 5/4 moist), sandy clay loam mottled with brown (7.5 YR 5/4) and olive gray (5 Y 5/2) of clay bockets; hard; sticky, plastic; many fine gypsum crystals; abrupt smooth boundary.
80-150	Light olive brown (2-5 /Y 5/4); loamy sand; massive; non sticky, non plastic; friable; many rusty mottles.

Profile No (3) : Parcel (5)

Date of Description : 18th October, 1995

location : West Noubaria,Agric. Company, Km 62 from Alex ~ 5 km east of Cairo - Alex. Desert Road

Topography : Nearly level

Parent Material : Calcareous Sediments

Vegetation : Plowed field.

Depth	Description
0-22	Very pale brown (10 YR 7/3, dry), yellowish brown (10 YR 5/4, moist); sandy loam; massive; slightly hard; slightly sticky, slightly plastic, abrupt smooth boundary.
22-50	Brownish yellow (10 YR 6/6, dry), yellowish brown (10 YR 5/6, moist); sandy loam; massive, hard, slightly sticky, slightly plastic, many distinct hard lime segregations, gradual smooth boundary.
50-110	Brownish yellow (10 YR 6/6, dry), yellowish brown (10 YR 5/6, moist); sandy loam, massive, slightly hard; slightly sticky, slightly plastic; scattered gravel- sized fragments; clear smooth boundary.
110-150	Brownish yellow(10 YR 5/4, moist), sandy loam; friable; slightly sticky, slightly plastic; few bockets glayzed clays.
+160	W.T.

Profile No. (4) Parcel (15)

Location : DRC; Maryout Experimental Station 40 km from Alex, 2 Km west of the Cairo -Alex. desert road.

Date of Description : 19th October, 1995

Topography : Nearly level

Parent Material : Calcareous sediments.

Vegetation : Olive trees

Depth	Description
0-15	Very pale brown (10 YR 7/4, dry), yellowish brown (10 YR 5/6, moist), sandy clay loam fine subangular blocky; hard; sticky; plastic, numerous fine and coarse roots; abrupt smooth boundary.
15-30	Yellowish brown (10 YR 5/4, dry), yellowish brown (10 YR 5/6, moist); clay loam; subangular blocky; very hard; sticky plastic, clear smoth boundary.
30-80	Yellowish brown (10 YR 6/4, dry), yellowish brown (10 YR 5/6 moist); sandy clay loam, fine subangular blocky, very hard, sticky, plastic; abrupt smooth boudnary.
80-110	Yellowish brown (10 YR 5/6, dry and moist) sandy clay loam, subangular blocky; hard; sticky, plastic; many lime segregations; abrupt smooth boundary.
110-150	Yellwish brown (10 YR 5/6, moist); sandy clay loam; hard; sticky, plastic; common hard fine lime segregations.

Profile No. (5): Parcel 16

Location	: DRC; Maryout Experimental Station
Date of Description	: 19th October, 1995
Topography	: Nearly level
Parent Material	: Calcareous sediments
Vegetation	: Cultivated with berseem

Depth	Description
0-30	Light yellowish brown (10 YR 6/4, dry), yellowish brown (10 YR 5/4, moist) sandy loam; fine subangular blocky slightly sticky, slightly plastic; many fine roots, abrupt smooth boundary.
30-60	Brownish yellow (10 YR 6/6, dry); yellowish brown (10 YR 5/6, moist); clay loam; fine subangular blocky; very hard to extremely hard; sticky; plastic, common medium and fine lime segregations; clear smooth boundary.
60-90	Brownish yellow (10 YR 6/6, dry), yellowish brown (10 YR 5/8, moist); clay loam; subangualr blocky; very hard; sticky, plastic; few gypsum threads; clear smooth boudnary.
90-115	Yellowish brown (10 YR 5/8, moist), sandy clay loam, subangular blocky, very hard, sticky, plastic, gradual smooth boundary.
115-150	Brownish yellow (10 YR 5/6, moist); clay loam, subangular blocky, very hard, sticky; plastic, common lime segregations.

Profile No. (6)

Date of description 19th October 1995

Locatin : Burg El-Arab, 2 km east of Burg El Arab City.

Topography : level plain

Parent Material : Calcareous sediments.

Vegetation : Uncultivated

Depth	Description
0-42	Very pale brown (10 YR 7/3, dry) to brownish yellow (10 YR 6/6, moist) sandy clay loam, moderate medium subangular blocky, hard, sticky, plastic, few fine roots, gradual smooth boundary.
42-70	Very pale brown (10 YR 7/3, dry) to brownish yellow (10 YR 6/6, moist) sandy clay loam, moderately medium subangulr blocky, extremly hard, sticky, plastic, some fine lime dules, clear smooth bounary.
70-150	Light gray (10 YR 7/2, dry) to yellowish brown (10 YR 5/4, moist) sandyloam, moderate fine subangular blocky, hard, sticky, plastic, some fine lime.

Profile No. (7)

Loation : Al-Gharbaniate

Date of Description : 19th October, 1995

Topography : level plain

Parent Material : Calcareous sediments

Vegetation : Uncultivated, plowed field.

Depth	Description
0-35	Very pale brown (10 YR 8/3, dry) to very pale brown (10 YR 7/3, moist); sandy loam; massive; slightly hard, slightly sticky; slightly plastic; clear smooth boundary.
35-67	Yellow (10 YR 7/6, dry) to brownish yellow (10 YR 6/6, moist) sandy clay loam; massive; hard; slightly sticky, slightly plastic; common lime segregations; diffuse smooth boundary.
67-150	Pink [(7.5 YR7/4, dry), (7.5 YR 6/4, moist)]; sandy clay laom; massive; very hard slightly sticky; slightly plastic; common lime segregations.

4.1.b Physical properties :

The physical characteristics of the different layers of soil profile representing the studied sites are given in tables (2 a and b). These data point out that the chosen sites represent almost all the textural classes prevailing in the study area. For the profile No.1 representing Nubaseed site, it is evident that it is characterized by loamy sand texture in the upper most 0-30 cm and 30-75 cm layers and sandy loam texture in the deepest layers. In the top layers, total sand content constitutes more than 86% of the soil matrix, therefore the values of soil moisture retained at pressures equivalent to 0.1 and 15 bars, i.e field capacity (FC) and permanent wilting per centage (PWP) in sequence, are very low, (Table 2b). Likewise, the total aggregates and their mean weight diameter (MWD) are extremely low, whereas the saturated hydraulic conductivity of such layers varies from 15.6 cm/hr in the top 0-30 cm to 11.73 cm./hr in the underneath 30-75 cm layer. This indicates that the ability of such layers to transmit water ranges from rapid to moderately rapid, in the same sequence, according to O"Neal (1952). Nevertheless, in the rest of soil profile, silt + clay constitutes about 30% of the soil matrix, thereby the percentages of different aggregate size fractions, total aggregates and the mean weight diameter relatively increased, compared to their corresponding values in the top layers. Also, the moisture retention of such underlaying layers is relatively high and the hydraulic canductivity is moderately rapid (Table 2b).

Considering the profiles representing the mechanized farm at West Nubaria agricultural company, i.e. profiles No 2 and No, 3, the data given in Table (2a) reveal that the profile No.2 is characterized by sandy clay

Table (2a) Particle size distribution, field capacity (FC%), and permanent wiliting point (PWP%) and organic matter (OM%) of the studied soil profiles.

Profile No.	Depth (cm)	Particle size distribution				Text. class	FC%	PWP%	OM%
		C. Sand %	F. Sand %	Still, %	Caly, %				
(1)	0-30	31.58	54.48	5.38	8.56	LS	9.34	4.11	0.41
	30-75	28.20	59.37	2.28	10.55	LS	10.20	4.72	0.28
	75-100	26.40	43.01	14.24	16.35	SL	12.50	5.36	0.13
	100-115	27.31	43.26	14.31	15.12	Sl	12.11	5.27	0.11
(2)	0.29	21.43	45.90	11.77	20.90	SCL	19.63	11.27	1.31
	29-50	13.65	36.82	16.57	32.96	SCL	27.18	14.21	0.67
	50-80	11.34	39.58	24.12	24.69	SCL	21.85	11.96	0.37
	80-150	15.60	71.53	2.21	10.66	LS	13.21	6.35	0.34
(3)	0-22	23.94	42.95	16.21	16.90	SL	15.52	7.34	1.16
	22-50	22.19	40.16	20.72	16.95	SL	17.43	8.49	0.67
	50-110	18.25	45.22	19.42	17.11	SL	14.98	7.57	0.37
	110-150	20.45	55.05	9.02	15.48	SL	13.17	6.93	0.34
(4)	0-15	2.31	54.33	21.68	21.68	SCL	19.14	10.64	1.46
	15-30	0.70	42.96	26.02	30.32	CL	27.42	14.82	0.93
	30-80	1.55	94.48	22.10	26.17	SCL	23.00	12.05	0.35
	80-110	3.76	43.48	28.53	24.23	SCL	20.56	11.93	0.21
	110-15	9.25	41.16	26.87	22.72	SCL	18.04	9.85	0.21
(5)	0-30	3.65	56.32	22.22	17.81	SL	17.71	8.94	1.69
	30-60	0.46	35.13	29.38	35.08	CL	31.08	15.11	0.71
	60-90	0.21	44.98	23.52	31.29	CL	29.47	14.05	0.60
	90-115	0.35	55.87	18.13	25.65	SCL	22.39	11.79	0.31
	115-150	0.84	36.26	28.10	34.78	CL	30.80	14.62	0.12
(6)	0.42	8.34	44.04	19.36	28.26	SCL	25.90	12.61	0.83
	42-70	5.84	45.15	23.98	25.03	SCL	24.34	11.87	0.58
	70-150	7.55	45.59	32.93	13.93	SL	16.50	9.21	0.16
(7)	0-35	17.55	52.56	15.46	14.43	SL	14.81	7.80	1.13
	35-67	13.98	40.61	20.94	24.47	SCL	23.48	12.22	0.64
	67-150	7.84	48.60	20.24	23.32	SCL	21.89	12.09	0.12

Table (2b) Real density (RD), bulk density (BD), total porosity (TP), Water stable aggregates %, Agg. parameters and hydraulic conductivty (K) of the studied soil profiles.

Profile No	Depth (cm)	RD $Mg.m^{-3}$	BD $Mg.m^{-3}$	TP %	Water stable aggregates %				Agg. parameters		K d Cm/hr	Perm. class
					5 - 2 mm	2-0.85 mm	0.85-0.425 mm	0.425-0.25 mm	MWD	T.Agg.		
(1)	0-30	2.69	1.61	39.69	0.39	1.61	2.25	4.80	0.11	9.05	15.61	R
	30-75	2.67	1.63	39.02	0.53	1.23	2.99	2.86	0.13	7.61	11.73	M.R
	75-100	2.65	1.59	40.11	0.74	3.28	3.81	7.13	0.18	14.96	7.55	M.R
	100-115	2.66	1.6	40.08	0.56	1.72	3.89	5.92	0.15	12.09	6.75	M.R
(2)	0-29	2.62	1.37	47.81	6.50	2.75	11.56	16.20	0.46	37.01	0.428	S
	29-50	2.61	1.44	44.65	2.13	2.43	2.56	2.56	0.22	9.68	0.101	V.S
	50-80	2.62	1.43	45.48	3.52	3.27	6.05	2.65	0.29	15.49	0.219	S
	80-150	2.65	1.6	39.77	0.25	3.36	2.72	4.86	0.20	11.19	4.037	M
(3)	0-22	2.64	1.56	40.85	3.51	5.24	9.74	11.80	0.37	30.29	3.378	M
	22-50	2.63	1.58	36.26	2.84	3.06	7.16	10.78	0.28	23.84	0.938	M.S
	50-80	2.64	1.57	40.34	4.00	3.26	7.46	13.12	0.35	27.84	2.64	M
	80-150	2.64	1.60	39.52	3.52	4.42	5.30	19.08	0.36	32.32	2.326	M
(4)	0-15	2.61	1.37	47.78	2.83	3.86	6.97	5.80	0.27	19.46	1.841	M.S
	15-30	2.62	1.41	46.31	2.16	2.36	4.66	3.64	0.20	12.82	0.151	S
	30-80	2.63	1.39	47.11	1.20	4.62	5.11	7.17	0.25	18.10	0.385	S
	80-110	2.64	1.38	47.39	1.80	3.56	2.13	10.10	0.24	17.59	0.706	M.S
	110-150	2.62	1.37	47.59	1.99	2.02	3.01	6.78	0.22	13.80	0.756	M.S
(5)	0-30	2.63	1.4	46.90	2.13	4.49	9.14	8.21	0.31	23.97	2.705	M
	30-60	2.62	1.45	44.76	1.39	2.26	3.61	2.46	0.18	0.72	0.051	V.S
	60-90	2.62	1.44	45.25	0.81	2.86	3.21	9.18	0.21	16.06	0.304	S
	90-110	2.61	1.43	45.54	1.76	2.11	4.96	9.74	0.25	18.57	0.329	S
	115-150	2.63	1.45	44.73	1.99	3.34	7.47	7.25	0.28	20.05	0.130	S
(6)	0-42	2.65	1.52	42.61	5.14	1.93	6.98	15.30	0.38	29.35	2.811	M
	42-70	2.61	1.67	35.88	1.32	1.83	1.76	17.53	0.16	22.44	0.054	V.S
	70-150	2.62	1.54	40.95	8.05	4.83	3.18	10.95	0.43	27.01	1.565	M.S
(7)	0-35	2.64	1.46	44.54	2.87	5.04	11.54	8.68	0.34	28.13	3.292	M
	35-67	2.63	1.53	41.66	2.48	4.58	8.08	3.18	0.28	18.32	1.885	M.S
	67-150	2.61	1.6	38.63	1.32	2.69	4.31	4.33	0.21	12.65	1.295	M.S

LSD at 5%

Profile No	BD	TP	MWD	T.Agg	K
1	0.012	0.0736	0.0619	0.7593	1.6763
2	0.051	0.1915	0.01225	0.7896	0.1233
3	0.057	0.2184	0.0709	1.004	0.4060
4	0.058	0.8889	0.0520	0.7224	0.1286
5	0.047	0.1742	0.0071	1.1997	0.2288
6	0.038	0.1393	0.0393	5.6727	0.3381
7	0.084	0.3222	0.0257	1.0748	0.3179

Perm class
R= Rapid
MR = Mod. repid
M= Moderate
MS = Mod. slow
S= Slow
VS= Very slow.

loam texture in the top three layers and loamy sand in the bottom. Silt plus clay in the top layers of such profile ranges between 32.67 and 49.5% of the total mechanical separates therefore the values of FC and PWP are remarkably high. It is also evident that in spite of the relatively high content of silt plus clay in the subsurface 29-50 cm and 50-80 cm layers, yet the total water stable aggregates and the mean weight diameter are very low. Likewise water permeability of such layer is slow (Table 2a), indicating undesirable conditions for plant root growth.

In case of profile 3, the data presented in Table (2a) indicate that the site represented by such profile is characterized by sandy loam texture throughout the studied soil depth. The clay content of the various soil layers is more or less constant; therfore, the values of moisture at field capacity and PWP vary within very narrow range. The percentage of different water stable aggragate size units as well as the mean weight diameter of stable aggregates are relatrively high, thereby the ability of such soil to conduct water expressed by hydraulic conductivity values is moderate. Exceptional being the case of 22-50 cm layer where hydraulic conductivity is moderately slow. However, it is striking to notice that in spite of the fact that such site represent well aggragated sany loam soil, yet the values of bulk density, especially of the subsurface soil layer are appreciably high indicating high soil compactness in the crop-root-zone (Table 2b). Need to mention that this site was chosen to execute a field experiment for evaluating the effectiveness of some tillage treatments and organic matter application on reducing campaction problem, which will be discussed afterwards.

With respect to the soil profiles representing the agricultural experimental station of DRC, i.e. profiles No.4 and No.5, the obtained results indicate that profile No.4 is characterized by sandy clay loam texture, except the 15-30 cm layer where the texture is clay loam. Its clay plus silt ranges between 43.36 and 56.34% of the total soil mechanical separates consequently the retained moisture either at field capacity or permanent wilting percentage is relatively high. Bulk density, except of the upper most layer, (0-15cm) slightly decrease with depth. The amount of total water stable aggregates varies from 12.8 to 19.46%. The data also reveal that the ability of the different layers of the soil profile to transmit water varies from moderate to slow.

As regard to profile 5 the data point out that it is characterized by sandy loam top 30 cm, overlying two sandy clay loam layers (30-60 cm and 60-90 cm) and sandy clay loam layer (90-115 cm). The bottom layer is clay loam in texture. The content of silt plus clay of the different layers of soil profile, except few cases, is relatively higher than the corresponding values in profile No.4. Total aggregates, MWD and the saturated hydraulic conductivity are nearly similar to those of profile No.4. Nevertheless, the bulk densities of the different soil layers are higher in case of profile No.5 compared to profile No.4.

As to Burg El-Arab site, (profile No.6), the data reveal that the soil texture is sandy clay loam in the upper most two layers, (0-42 cm and 42-70 cm) and sandy loam in the deepest layer, (70-150 cm). Silt plus clay in the different layers constitutes about 48% of the total soil matrix. The moisture content at field capacity ranges between 16.5 and 25.90% while PWP varies from 9.21to 12.61%. Such behaviour seems to be related to the clay content of soil.

It is striking to notice that the bulk density of the subsurface layer of profile No.6.(42-70 cm) is very high and thus porosity of such layer is extremely low, compared to the other studied sites. Therefore water permeability of this layer is very slow (0.054 cm/hr).

With respect to Al-Gharbaneiat site, it is evident that the texture of the top soil layer, i.e. 0-30 cm is sandy loam overlying two sandy clay loam layers, viz. 35-67 cm and 67-150 cm. Silt plus clay vary from about 30% in the top soil layer to about 45% in the underneath layers. Consequently the values of the retained soil moisture at field capacity varies from about 15% in the topsoil to about 23% in the bottom soil layers. The data of saturated hydraulic conductivity indicate that the readiness of such soil to conduct water is moderate; Table (2b). Total water stable aggregates ranges from 12.65 to 19.78%. Bulk density progressively increases with depth.

4.1.c: Content and distribution of $CaCO_3$:-

Table (2c) shows that the content and the size distribution of $CaCO_3$ in soil considerably vary within the studied soil profiles. For profile No.1 representing Nubaseed site, the data indicate that $CaCO_3$ content of the different layers of the soil profile ranges between about 16% and 24% of the soil matrix. It is also evident that $CaCO_3$ contents in the middle soil layers, i.e. 30-75 cm and 75-100 cm depths are higher than those of the top and bottom ones.

As to the particle size distribution of $CaCO_3$ in Nubaseed site, the obtained result substantiate that in the top soil layers, where the integrated soil texture is coarse, i.e. loamy sand, $CaCO_3$ dominates the sand fraction.

Table (2c) Content and distribution of $CaCO_3$ in the different layers of the investigated soil profiles.

No. profile	Soil depth, cm	Total carbanate %	% $CaCO_3$ in soil mechanical fractions				$CaCO_3$ distribution (% of the total $CaCO_3$)			
			C. sond	F.sand	silt	clay	C.sand	F.sand	silt	clay
1	0-30	16.27	6.16	5.39	3.25	1.47	37.86	33.13	19.98	9.03
	-75	21.38	4.51	11.84	0.57	4.46	21.09	55.38	2.67	20.86
	-100	24.90	5.93	1.96	7.20	9.81	23.82	7.87	28.91	39.40
	-115	19.38	6.43	1.25	4.17	7.53	33.18	6.45	21.52	38.85
2	0-29	27.58	6.70	4.15	3.43	13.30	24.29	15.05	12.44	48.22
	-50	46.58	5.40	7.49	6.86	26.83	11.59	16.08	14.73	57.60
	80	32.05	1.21	3.73	7.14	19.97	3.78	11.64	22.28	62.30
	150	20.28	3.12	9.44	0.56	7.16	15.38	46.56	2.76	35.30
3	0-22	33.95	8.1	5.18	10.91	9.76	23.86	15.26	32.14	28.74
	50	42.42	6.45	11.06	15.46	9.45	15.21	26.07	36.45	22.27
	110	27.76	2.97	4.96	6.67	13.16	10.72	17.87	24.00	47.41
	150	15.25	3.73	1.05	1.53	8.94	24.46	6.88	10.03	58.63
4	0-15	40.03	1.95	4.13	16.97	16.98	4.87	10.32	42.39	42.42
	-30	40.82	0.56	4.91	10.07	25.28	1.37	12.03	24.67	61.93
	-80	31.19	1.47	1.80	6.44	21.48	4.71	5.77	20.65	68.87
	-110	44.67	3.60	7.20	14.62	19.25	8.06	16.12	32.73	43.09
	-150	49.24	9.11	10.83	13.74	15.56	18.51	21.99	27.90	31.60
5	0-30	36.12	2.40	12.45	8.52	12.75	6.64	34.47	23.59	35.30
	-60	45.60	0.40	5.92	10.18	29.10	0.88	12.98	22.32	63.82
	-90	35.88	0.13	2.98	6.68	26.09	0.36	8.31	18.62	72.71
	-115	31.12	0.29	6.69	2.74	21.40	0.93	21.50	8.80	68.77
	-150	46.67	0.81	3.10	15.54	27.22	1.74	6.64	33.30	58.32
6	0-42	42.72	7.62	9.59	8.01	17.50	17.84	22.45	18.75	40.96
	-70	54.21	5.56	12.22	15.98	20.45	10.26	22.54	29.48	37.72
	-150	73.26	7.24	33.63	23.25	9.14	9.88	45.90	31.74	12.48
7	-35	46.03	16.56	14.70	4.57	10.20	35.97	31.94	9.93	22.16
	-67	55.85	9.93	16.82	18.01	11.09	17.78	30.12	32.25	19.85
	-150	57.27	7.46	19.65	12.74	17.42	13.03	34.31	22.25	30.41

Meanwhile, in the subsurface layers, i.e. 75-100 cm and 100-115cm depth, where the integrated soil texture is relatively fine, i.e. sandy loam, $CaCO_3$ is found to dominates the clay fraction.

Considering the two locations situated in the mechanized farm at West Nubaria Agricultura Company, the obtained results indicate that $CaCO_3$ content is appreciably high, compared to Nubaseed site (profile No.1). Its content varies between 20% and above 46%. In the two locations, $CaCO_3$ content in the subsurface soil layers (i.e. 29-50 cm in profile No.2 and 22-50 in profile No.3) are relatively high compared to the top and deeper layer in the same profile. Nevertheless, below such layers, $CaCO_3$ gradually decreases with depth.

Regarding the size distribution of $CaCO_3$ in the mechanized farm site, the data given in Table (2c) point out that in the surface soil layers, (i.e. up to 80 cm depth) where the soil textural class is sandy clay loam, $CaCO_3$ dominates the clay fraction. But in the loamy sand bottom layer (80-150 cm), $CaCO_3$ dominates the fine sand fraction, Likewise, in case of profile No.3, where the soil texture is sandy loam throughout the studied depth, $CaCO_3$ is found to dominate either the silt fraction in the top soil (0-50 cm) or clay fraction in the subsurface layers (50-150 cm).

With respect to Maryut area, (profiles No.4 and No.5), $CaCO_3$ content in the different layers of soil prafile varies from about 30% to 50% of the soil matrix. In these two sites, where the textural classes of the different layers of soil prefiles vary from sandy loam, to sandy clay loam and clay loam, $CaCO_3$ dominates the clay fraction. It is also evident that appreciable amounts of $CaCO_3$ are found in silt fraction. The data reveal that about 60% to more than 90% of the total $CaCO_3$ in such area are present in silt + clay fractions.

For Burg El-Arab site, i.e. profile 6, the obtanied data reveal that $CaCO_3$ of the different layers of soil profile is very high, as its level ranges from 42.7 to 73.26% of the total soil mechanical separates. Apparently, $CaCO_3$ content in such profile gradually increases with depth. The data also point out that $CaCO_3$ in the sandy clay loam top layers dominates the fine fractions, i.e. silt + clay where 60% of its content is found in such size fractions. Meanwhile, in the sandy loam bottom layer (70-150cm), $CaCO_3$ dominatoes the medium size fractions, i.e. fine sand and silt fractions.

Concerning the soil profile representing Al Gharbaneiat site (profile No.7) the obtained results indicate that the content and size distribution of $CaCO_3$ are nearly similar to those manifested in Maryout site (Profile No. 5).

The foregoing results show that the mean values of total $CaCO_3$ content in soil profiles increases along the studied transect, i.e. from Nubaseed (profile No.1) to Al Gharbanieat (profile No.7). It is also evident that the particle size distribution of $CaCO_3$ among the mechanical soil separates generally follows the integrated soil texture or the textural class. In other words when the soil texture is coarse, $CaCO_3$ dominates the sand fraction. These findings are in agreement with those reported by Afifi (1968), who found that most of the $CaCO_3$ was found in the sand fraction in the foreshore soils and inland dunes whereas in the cultivated depression and the alluvial fans, $CaCO_3$ was present in finer fractions.

4.1.d. Chemical properties :

The relevant chemical properties of the studied soil sites are presented in Table (2d). The obtained data show that Nubaseed site, (profile No.1) is a salt - affected soil where the values of electrical

Table (2 d) Some Chemical Properties of the Studied Soil Profiles

Profile No	Soil depth cm	PH	EC ds/m	Soluble Cations me/1				Soluble Anions me/1				$CaCO_3$ %	Gyps %
				Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3^-	CO_3^{--}	$SO4^{--}$		
(1)	0-30	7.50	8.45	68.04	0.557	16.15	11.75	76.50	5.21	-	14.80	16.27	0.05
	30-75	7.95	4.30	37.96	0.42	7.69	3.12	40.15	2.50	-	6.44	21.38	0.05
	75-100	8.05	4.20	31.58	0.29	6.41	4.92	36.02	1.23	-	5.95	24.36	0.27
	100-115	7.80	4.62	42.69	0.31	6.86	7.12	45.39	1.92	-	9.67	19.38	0.23
(2)	0-29	8.15	2.25	12.13	0.71	11.75	3.31	14.25	2.79	-	1.86	27.54	0.82
	29-50	8.00	3.60	16.171	0.34	18.45	9.55	28.21	2.65	-	26.50	46.58	1.98
	50-80	8.05	3.80	18.13	0.26	16.97	5.16	20.77	1.89	-	17.86	32.05	1.27
	80-150	8.05	2.91	19.71	0.29	9.75	7.93	23.95	2.10	-	11.63	20.28	0.23
(3)	0-22	7.80	1.14	6.86	0.24	4.45	1.76	8.18	1.39	-	3.75	33.95	0.07
	22-50	8.10	1.24	16.71	0.34	18.45	9.55	28.21	2.65	-	26.50	42.42	0.05
	50-110	8.25	1.07	18.13	0.26	16.97	5.16	20.77	1.89	-	17.86	27.76	1.18
	110-150	7.95	1.75	19.71	0.29	9.75	7.93	23.95	2.10	-	11.63	15.25	0.04
(4)	0-15	8.15	2.98	18.31	0.65	8.21	6.93	21.27	2.80	-	10.03	40.03	0.08
	15-30	8.25	2.07	11.61	0.52	8.14	5.26	15.93	2.21	-	7.39	41.82	0.23
	30-80	8.05	2.31	12.28	0.56	9.05	7.12	18.34	2.71	-	8.50	31.19	0.22
	80-110	7.90	2.64	14.13	0.43	7.95	8.41	20.09	3.26	-	7.47	44.67	0.27
	110-150	8.20	3.21	22.06	0.46	9.32	8.16	26.34	1.79	-	11.87	49.37	0.15
(5)	0-30	7.95	3.11	25.13	0.96	11.30	6.70	29.10	3.08	-	11.91	36.12	0.28
	30-60	7.85	2.85	16.68	0.73	8.79	7.28	21.05	2.24	-	10.19	45.60	0.34
	60-90	8.10	1.84	11.88	0.45	7.07	5.39	14.09	1.96	-	8.74	35.88	0.54
	90-115	8.15	1.73	10.27	0.52	6.49	6.81	12.37	1.84	-	9.88	31.12	0.40
	115-150	8.10	1.93	14.11	0.39	8.16	6.95	17.91	1.76	-	9.94	44.67	0.25
(6)	0-42	8.10	4.98	36.91	0.43	10.03	6.94	41.33	5.80	-	7.18	42.72	0.07
	42-70	8.25	1.30	9.36	0.27	5.06	2.59	10.74	2.30	-	4.24	54.21	0.08
	70-150	8.20	3.30	22.58	0.32	7.80	3.05	25.10	3.30	-	3.35	51.60	0.23
(7)	0-35	8.05	1.98	11.91	0.28	7.41	3.84	13.25	2.79	-	7.40	46.03	0.15
	35-67	8.20	1.12	9.06	0.22	6.18	5.43	11.62	2.83	-	6.44	55.85	0.21
	67-150	8.25	1.17	10.13	0.19	6.86	5.71	11.96	2.58	-	8.35	75.27	0.30

conductivity of the saturation extract of the different soil profile layers exceed 4 $ds.m^{-1}$. Undoubtedly this behaviour is attributed to the presence of high water table (at 115 cm depth) which contributes to the gradual salt accumulation in soil profile. The major soluble ions are sodium and chloride followed by calcium and sulphate. Gypsum content in the top soil layers (i.e. 0-30 cm and 30-75 cm) is very small but it shows an abrupt increase in the underlying layers. Organic matter is low and exhibits a gradual decrease with depth.

Considering the two locations of the mechanized farm, i.e. profiles No.2 and No.3, the data reveal that they are non-saline. However the magnitude of soil salinity is relatively higher in case of profile No.2 than that of profile No.3. In the two sites, sodium and calcium are the predominant soluble cations while the chlorides and sulphates are the cheif anions. It is enteresting to notice that gypsum contents in the middle layers of the two profiles are pronouncedly higher than those of the top and bottom layers of the same profiles indicating a sort of gypsum accumulation in such layers. Organic matter content which is quite similar in the different layers of soil profile, progressively decreases with soil depth.

Table (2d) also declares that the chemical properties of the chosen sites of Maryout area, i.e. profiles No. 4 and No. 5 are more or less similar to those manifested for the mechanized farm. Exceptional being the gypsum content which is approximately constant throughout the studied depth of soil profiles. It is also evident that organic matter in Maryout top soil is appreciably high (~ 1.50%), but its content progressively diminishes with depth.

Regarding the chemical properties of Burg El Arab and Al Gharbaniat soils, prefiles No.6 and No.7, Table (2d) clarifies, except the top layer of profile No.6 (0-42 cm), that both soils are non-saline where the electrical canductivity of saturation extract of the different layers of soil profiles are less than 4 $ds.m^{-1}$. PH values are relatively high, as they ranges from 8.05 to 8.25. The predominant soluble ions are chlorides and sodium followed by calcium and sulphate.

In conclusion, the chosen soil sites differ in their textural classes, content and size distribution of calcium carbonate, salinity, gypsum and organic matter as well as the bulk density, total and size distribution of soil aggregates. It is excepted that these wide variation in soil parameters and their magnitude will allow better evaluation of the most important variable or variables affecting soil compaction in the study area.

4.2. Influence of soil parameters on compaction :

As the soils widely differ in their ability to withstand mechanical load, there is, however, no complete assessment of soil factors and their role in soil compaction process. In the current study, a number of soil parameters affecting the mechanical compressibility of calcareous soils were investigated. These included the percentage of soil moisture silt, clay, gypsum and organic matter as well as $CaCO_3$ either total or its content in clay and silt size fractions.

4..2.1. Moisture content :

To study the influence of soil water on compaction, soil samples were taken from each soil depth at time of measuring its penetration resistance. In these samples soil moisture content was determined. The obtained results given in Table A (in the appendex) and illustrated in Figs. (2a and b) reveal, irrespective to soil constituents; that soil strength; expressed by the values of penetration resistance in MPa; appreciably decreases with increasing the soil moisture content. However, the magnitude of decrease with increasing soil water content is not consistent in the different layers of the studied soil profiles. This may indicate that factors other than soil moisture content are involved in understanding compactability of the different soils.

To express mathematically the effect of moisture content on soil compaction, the weighed values of soil moisture content in each of the morphologically identified layers of the studied soil profiles (x) and its weighed penetration resistance (y) were statistically correlated. The data indicated higly significant correlation between the two variables, therfore regression analysis was established and the obtained formulae are presented in Table (3). These equations show highly significant negative linear

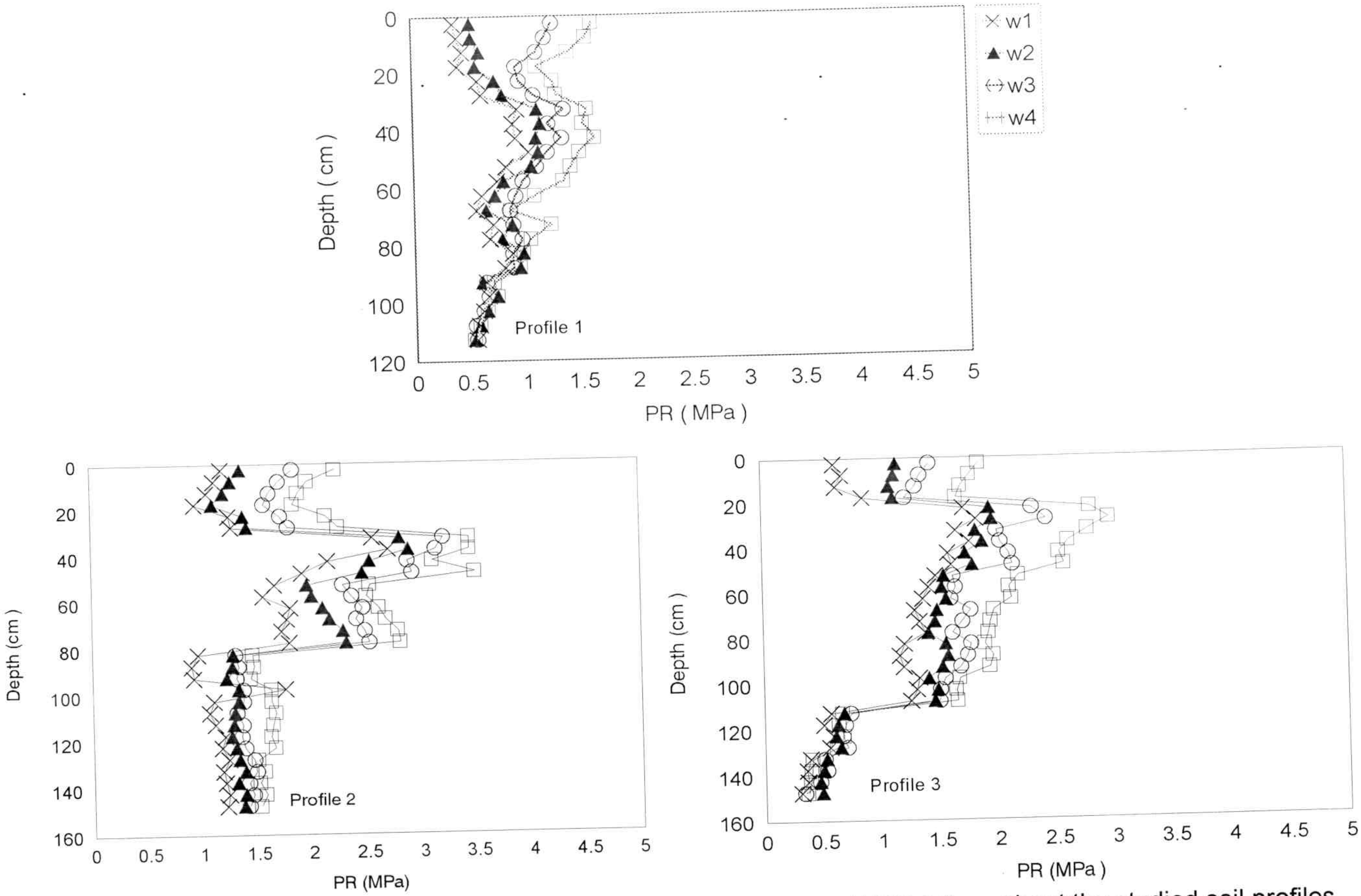

Fig (2 a) Penetration resistance (PR) at different moisture content (W %) throughout the studied soil profiles .

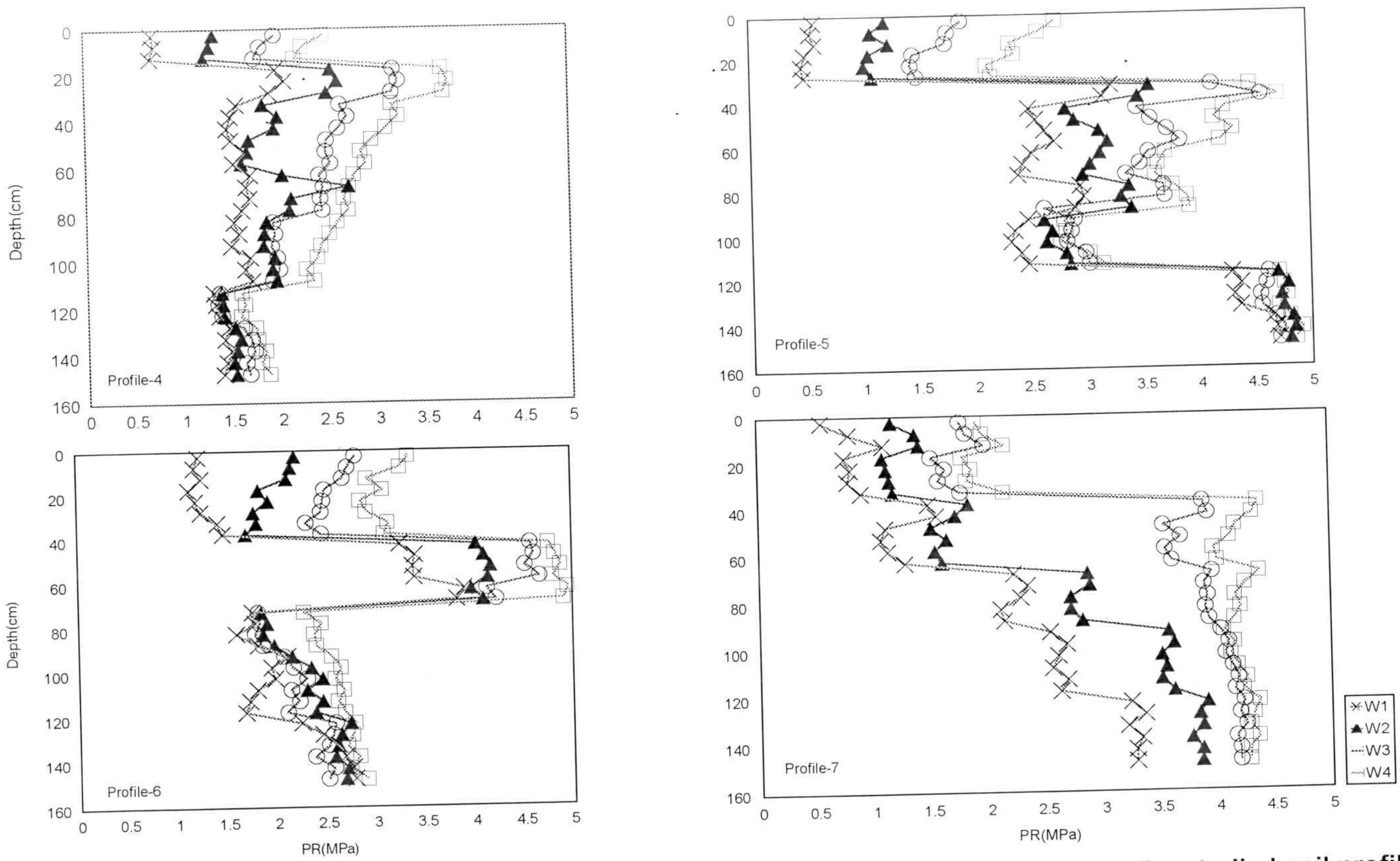

Fig (2 a) Penetration resistance (PR) at different moisture contents (w%) throughout the studied soil profiles.

Table (3) Mathematical formulae describing the relationship between soil moisture content and penetration resistance of different layers in the studied soil profiles.

Profile No	Depth cm	Equation model	r
1	0-30	y = 1.9400 - 0.1316 x	- 0.8947 **
	30-75	y = 2.3998 - 0.1132 x	- 0.9144 **
	75-115	y = 2.8379 - 0.1377 x	- 0.9565 **
2	0-29	y = 5.8260 - 0.2374 x	- 0.9038 **
	29-50	y = 7.1758 - 0.2079 x	- 0.9694 **
	50-80	y = 5.7855 - 0.1834 x	- 0.9755 **
	80-150	y = 3.1175 - 0.1152 x	- 0.9512 **
3	0-22	y = 2.9285 - 0.143 x	- 0.9722 **
	22-50	y = 4.2129 - 0.1586 x	- 0.9763 **
	50-110	y = 3.5840 - 0.1843 x	- 0.9639 **
	110-150	y = 2.9783 - 0.1486 x	- 0.9564 **
4	0-15	y = 4.95514 - 0.2067 x	- 0.9961 **
	15-30	y = 7.3817 - 0.2238 x	- 0.9924 **
	30-80	y = 6.5758 - 0.02261 x	- 0.9854 **
	80-110	y = 7.536 - 0.2844 x	- 0.9642 **
	110-150	y = 6.2495 - 0.2840 x	- 0.9662 **
5	0-30	y = 4.2168 - 0.1469 x	- 0.9196 **
	30-60	y = 7.7924 - 0.2082 x	- 0.9448 **
	60-90	y = 6.5196 - 0.1724 x	- 0.9843 **
	90-115	y = 6.8611 - 0.2461 x	- 0.9636 **
	115-150	y = 9.2301 - 0.2887 x	- 0.9491 **
6	0-42	y = 7.0574 - 0.2774 x	- 0.9845 **
	42-70	y = 9.4687 - 0.3144 x	- 0.9811 **
	70-150	y = 6.7465 - 0.3197 x	- 0.9260 **
7	0-35	y = 3.038 - 0.1232 x	- 0.9558 **
	35-67	y = 7.6347 - 0.076 x	- 0.9863 **
	67-150	y = 8.0781 - 0.3168 x	- 0.9749 **

functions between penetration resistance of soil and its moisture content. Nevertheless, the slopes of these equations are relatively small indicating that the decrease in soil strength upon increasing soil moisture is gradual. Such effect could be attributed to the associated decrease in the points of contact among soil particles upon increasing soil moisture as the soil particles will be enveloped by water films. Another reason could be ascribed to the decrease in bulk density upon raising soil moisture content, consequently soil strength decreases. These findings are in quite agreement with those reported by Bennett et al. (1964) and Afifi (1974) who found that maintaining the soil moisture content at high levels by using different treatments to prevent drying of soil surface caused considerable decrease in soil strength, thereby seedling emergence significantly increased.

In order to compare the degree of compactness in the different layers of the studied soil profiles, each of the previously obtained equations was used for estimating soil strength of the corresponding soil layer. Need to mention that such estimation was performed at constant soil moisture content viz.; 20% of the available water of each soil layer. Such value is supposed to be the lower permissibe content of soil moisture for the growing plants and thereat irrigation becomes a must. Consequently, it is assumed that the calculated values of penetration resistance given in Table (4) represent the maximum soil mechanical impedance facing the root growth. These data point out that Nubaseed soil (profile No. 1) generally has the lowest penetration resistance throughout the studied soil depth compared with the other sites. This behaviour could be attributed to the sandy nature of Nubaseed soil.

Table (4) : Calcutated soil penetration resistance (PR) at moisture content equal to 20% of the available water in each layer of the studied soil profiles.

profile No	Depth cm	PR MPa	profile No	Depth cm	PR MPa
(1)	0-30	1.27	(4)	0-15	2.40
	30-75	1.74		15-30	3.50
	75-100	1.90		30-80	3.36
	100-115	1.92		80-110	3.17
(2)	0-29	2.75		110-150	2.99
	29-50	3.68	(5)	0-30	2.65
	50-80	3.23		30-60	3.98
	80-150	2.23		60-90	3.57
(3)	0-22	1.64		90-115	3.44
	22-50	2.58		115-150	4.07
	50-110	1.92	(6)	0-42	2.82
	110-150	1.76		42-70	4.95
				70-150	3.34
			(7)	0-35	1.90
				35-67	3.18
				67-150	3.63

Regarding West Nubaria site, Table(4) indicates that the penetration resistance of the profile No.2 display an abrupt increase from 2.75 MPa in the top layer to 3.68 and 3.22 MPa in the middle layers (i.e 29-50 cm and 50-80 cm) in spite of the similarity of their texture. Nevertheless in the deepest layer (80-150 cm) penetration resistance decreases to 2.23 MPa due to the sandy nature of this layer. Likewise, in case of profile No. 3 which it is homogenous sandy loam texture, the penetration resistance in the subsoil layer (22-50 cm) is very high relative to the top and bottom layers of the same profile. Apparently the compaction of these layers was not a consequence of their textural composition but most probably induced by improper tillage or agronomic practices or by combination of the two, i.e. anthropic pans. In this respect, Grimberger (1972) showed that the anthropic pan which developed as a result of compacting forces, is commonly found just below the zone disturbed by normal tillage operation and is similar in texture and chemical properties to those of layers immediately obove and below.

On the other hand, in case of Maryout and Al-Gharbaniate soils, the data in Table (4) reveal that, except the surface layer, the penetration resistance is very high and, more or less, unchanged throughout the entire depth of soil profile. This may indicates that such layers have been naturally or pedogenetically formed in the profile.

With respect to Burg El Arab soil, the obtained data substantiate that the values of penetration resistance of the middle layer are extremely higher than those of the top and bottom layers, indicating excessive compaction in such layer, (4.95 MPa). Obviously such state of compaction seems to be a consequence of higher $CaCO_3$ content in this layer compared to the other layers in the profiles. In other words, the compacted layer in Burg El- Arab soil may be of Natural origin.

In this context, it is worth to mention that the previous studies on the effect of mechanical impedance on root growth have showed that the probable maximum penetration resistance at which root growth decreses to about 80% of its maximum elangation rate, ranges between 20 and 30 bar (Taylor and Ratliff 1969 and Eavis et al 1969). Accordingly the presence of natural or anthropic compacted layers underlying the ordinary tillage zone in the studied sites, particularly whenever the soil moisture approaches the lower limit of its available range, can drastically inhibit the root penetration and development. Exceptional being Nubaseed soils where their penetration resistance may cause little side effects on root development.

4.2. 2 Clay content :

Due to the fact that clay has far greater surface area per unit mass and ion exchange phenomena, it is the decisive fraction which has the most influence on soil behaviour. As it tends to absorb and retain much more water and to become plastic and sticky when wet, as well as tight and cohesive when dry thereby it extremely affect compressibility and strength of soils.

To evalute the contribution of clay to soil strength, the obtained values of clay content in the different layers of soil profiles representing the studied sites given in Table (2a) were statistically correlated with the calculated values of penetration resistance at moisture content equivalent to 20% of the available water in each soil layer. The data indicated highly significant positive correlation between the two variables where $R^2 = 0.4819$ at $n = 112$ therefore, the simple regression analysis was carried out and the obtained formula is as fallows;

$$Y = 0.8943 + 0.0846\ X$$

Where Y= adjusted penetration resistance (PR) at moisture content equal 20% of the available water range in MPa and X = clay content (%).

This equation clarifies that soil penetration resistance lineally increases with increasing its clay content. It is also evident that each increment of 1.183% clay will result in an increase in soil penetration resistance by 0.1 MPa or one bar at the dry end of the available water range. This indicates that clay plays very important role in soil hardness. These findings are align with those reported by Horn and Lebert (1994) who stated that soil strength depends mainly on the grain size distribution, kind of clay mineral and kind and amount of exchangeable cation. They further added that coarse textured soils are less compressible than the fine - textured ones.

4.2.3 Silt content :

The single contribution of silt fraction on soil compressibility was established by correlation analysis between the adjusted values of penetration resistance of each soil layer in the studied profiles ($PR_{20\%Aw}$) and its silt content. The obtained data substantiate that there is a highly significant positive correlation between the level of silt in soil and its penetration resistance, where $R^2 = 0.447$ at n= (112). Therefor, the simple regression analysis between the two variables was conducted and the derived formula is as follows;

$$Y= 1.3286 + 0.0693 X$$

Where Y= the adjusted $PR_{20\%AW}$ in MP_a

and X = silt content (%).

This linear equation suggest that every increment Of 1.443% silt will result in an increase of soil penetration resistance, at wetness corresponds 20% of available range; by 0.1 MP_a (= 1 bar). These result stands in agreement with that reported by Tackett and Pearson (1965) in their studies on a reconstituted soil material, that increasing silt content from 5% to 22.6% caused a sharp rise in soil strength.

4.2.4. Content and size - distribution of $CaCO_3$:-

It is commonly known that the calcareous soils are those arbitrary having more than 10% $CaCO_3$. Their properties are remarkably affected not only by the total carbonate content but also by its particle size distribution. Therefore the obtained values of total $CaCO_3$ content and its size - distribution either in silt or clay fractions (Table 2c) were separately correlated with the adjusted values of PR $_{(20\%AW)}$ at moisture content equals 20% of the available moisture range .

Highly siginificant correlation was found between adjusted PR and each of such variables where $R^2y\ x_1 = 0.2982$ at $n = 112$, $R^2y\ x_2 = 0.1966$ at $n = 112$ and $R^2y\ x_3 = 0.5531$ at $n = 112$. Therefore simple regression analyses were made and the obtained formulae are as follows;

$$Y = 1.3333 + 0.0351\ X_1,$$

$$Y = 2.0791 + 0.0587\ X_2$$

and $$Y = 1.3048 + 0.0915\ X_3$$

Where Y = the calculated PR $_{(20\%AW)}$ in MP_a

X_1 = total $CaCO_3$ (%)

X_2 = $CaCO_3$ content in silt fraction (%)

X_3 = $CaCO_3$ content in clay fraction. (%)

These formulae show highly significant positive linear relationship between soil $PR_{20\%AW}$ and its $CaCO_3$ content either total or in the size of silt and clay fraction.The ratios between the slopes of thes variables i.e total $CaCO_3$ and it content either in silt or clay fraction approache 1, 1.67 and 2.61 in the same requence. These findings. substantiate that $CaCO_3$ present in the clay fraction is undoubtedly more effective than that in silt fraction on increasing soil hardness. This is attributed to the fact that $CaCO_3$ in clay size fraction could be considered a highly cementing agent thereby increases soil hardness. This conclusion is quite in agreement with those of Hemwall and scott (1962), and Afifi (1974) who found that the net cohesive forces of soil particles, measured by modulus of rupture were directly functioned by the quantity and type of clay and $CaCO_3$ in the clay size fraction. Also Patricia (1985) and El-Nawawy et al (1990) were in confirmation with these conclusions.

4.2.5. Organic matter :-

The contribution of organic matter content on soil compressibility was evaluated by the correlation analysis between the calculated penetration, resistance at soil wetness equal 20% of availble water for layer in the studied profiles and its organic matter content (Table 2a). The data indicate that there is a highly significant negative correlation between the two variables, where $R^2 = 0.0685$ at $n = 27$. Therefore, simple regression analysis was carried out and the derived equation is as follows;

$$Y = 3.0358 - 0.5358\ X$$

Where Y = penetration resistance at soil wetness equivalent to 20% of available range, MP_a.

X = organic matter (%).

This negative linear relationship indicates that organic matter is an effective mean for minimizing or preventing compaction. It is evident that every increase of 1.86% organic matter content will result in a decrease of penetration resistance by 1 MP_a (= 10 bar). This result confirms the conclusion of Soane (1990) who pointed out that soil compactability diminishes as organic matter content increases.

He attributed the beneficial effect of organic matter to the improvement of the internal and external binding of soil aggregates and to the reduction in bulk density as well as the lubrication effect of organic matter.

4.2.6 : The combined effect of soil constituents on compaction :

Due to the fact that soil constituents do not behave independently, and their physical, chemical and biological interactions may play a role in soil compaction process, therefore multiple regression alaysis was conducted between the percentages of clay (x_1), silt (x_2), total $CaCO_3$ (x_3) , $CaCO_3$ in clay size fraction (x_4), $CaCO_3$ in silt size fraction (x_5) and organic matter (x_6) against the calculated penetration resistance (y) in MP_a.

The abtained equation is highly significant where R^2=0.7593 at n=112 . It can be presented as follows :

$$Y = 1.212 + 0.0483X_1 + 0.0242X_2 + 0.0139X_3 + 0.1128\,X_4 + 0.0185\,X_5 - 0.6256\,X_6.$$

From this equation, it is clearly seen that any increase in silt, clay and the amount of $CaCO_3$ either total or in the sizes of silt or clay will result in a pronounce increase in soil hardness, whereas the opposite is true for organic matter content. It is also evident that the ratios between the slopes of these variables are; 3.47, 1.74, 1.0, 8.12, 1.33 and 45 for clay, silt, total $CaCO_3$, $CaCO_3$ in clay fraction, $CaCO_3$ in silt fraction and organic matter content, respectively. This indicates that organic matter content is a powerful factor controlling and avoiding soil compaction, whereas the amount of $CaCO_3$ in the size - fraction of clay plays a major role in increasing soil hardness, followed by the total clay content . Undoubtedly this behaviour is rendered to the tremendous surface area and thus the eminent cohesive forces of clay fraction as well as the cementing effect of $CaCO_3$, particularly wher present in finer sizes.

4.3. Amelioration of soil compaction :

In the preceding discussion, we have shown that the soils of the study area are commonly highly compact. Such soil attribute has arises either naturally owing to the presence of appreciable amounts of finer mechanical separates and CaCO3 especially in the clay-size fraction; or as a consequence of machinery - iduced stresses within the soil. Undoubtedly, these conditions negatively affect water movement, root exploration and nutrient uptake; all which have a direct bearing on crop production. From the standpoint of promoting crop production, it becomes necessary to minimize soil strenght and ameliorate the compacted soil layers.

In the current study, the effectiveness of chisel, moldboard, subsoil and subtiller plows as well as the application of organic matter, as measures for soil loosening and promoting corn yield were evalvated. The experiment was implemented on parcel (5) in the mechanized farm of West Nubaria Agriculltural Company where a machinery - induced compacted layer was found at depth of 22-50 cm, (profile No. 3). The obtained results can be discussed under the following subheadings :-

4.3.1. Effect of plowing on soil loosening :-

The effectiveness of the employed plows, i.e. moldboard, subsoil, and subtiller as compared to chisel on soil loosening and disruption of the compacted layers was assessed using many criteria such as corrected values of penetration resistance for moisture content equivalent either to 20% or 80% of the available moisture range of each soil layer under study. The assessement measures also included bulk density, pore-size distribution, saturated hydraulic conductivity and water infiltrability. Need to mention that these measurements were performed twice; i.e. at the end of seedbed preparation (after plowing, disking and application of preplanting irrigation) and immediately after harvesting.

4.3.1.1. Penetration resistance :

Table (5) elucidates the influence of the employed plows and organic matter treatments on penetration resistance of the different soil layers within the tillage zone. At the end of seedbed preparatory stage, the obtained data point out that the penetration resistance of the top, 0-10 and 10-22 cm layers of the control (unplowed site); as corrected to soil wetness corresponds to 20% of their available moisture range, approached 1.8 and 1.62 MPa, in the same sequence. It is also evident that tillage treatments has resulted in remarkable decrease in penetration resistance of these layers. Subsoiling using subtiller and subsoiler plows was particularly effective in reducing the penetration resistance of the top soil. However, moldboard plowing seems to be less effective in loosening and thereby reducing the penetration resistance of the soil, as compared to the other plowing treatment. Most probably, this behaviour can be attributed to the presence of unfractured soil clods under moldboard plowing , (Hadas et al, 1978 and soane and pidgeon 1975).

It is astonishing to note that, by the end of the seedbed preparatory, period, the application of organic matter has results in an appreciable increase in the penetration resistance of soil, under the different plowing treatments, (Table 5). This behaviour may by attributed to the repeated

Table (5) Effect of different plows and organic matter on penetration resistance of soil after seedbed preparation and after crop harvesting periods.

Depth cm	unplowed soil		CHo		CHw		MBo		MBw		SSo		SSw		STo		STw	
	80%	20%	80%	20%	80%	20%	80%	20%	80%	20%	80%	20%	80%	20%	80%	20%	80%	20%
1- After seedbed preparation																		
0-10	0.86	1.80	0.50	1.17	0.61	1.29	0.53	1.22	0.79	1.35	0.39	1.10	0.48	1.25	0.27	1.16	0.48	1.25
10-22	0.73	1.62	0.48	1.13	0.57	1.24	0.50	1.16	0.76	1.31	0.37	1.03	0.46	1.22	0.25	1.12	0.41	1.21
22-30	1.42	2.79	1.43	2.91	1.50	2.81	0.57	1.60	0.77	1.68	1.12	2.21	0.97	2.05	0.71	1.81	0.86	1.63
30-50	1.42	2.79	1.43	2.91	1.50	2.81	1.75	2.95	1.75	2.90	1.12	2.21	0.97	2.05	0.71	1.81	0.86	1.63
50-70	1.05	1.87	1.11	1.83	1.11	1.99	1.19	2.08	1.21	2.08	1.17	2.09	1.15	1.77	0.85	1.95	0.89	1.87
70-80	1.05	1.87	1.11	1.83	1.11	1.99	1.19	2.08	1.21	2.08	1.30	2.11	1.10	2.17	1.22	1.89	1.11	2.09
2- After crop harvesting																		
0-10	0.86	1.80	0.76	1.63	0.64	1.60	0.67	1.51	0.90	1.30	0.93	1.68	0.92	1.60	0.83	1.60	0.88	1.66
10-22	0.73	1.62	0.73	1.60	0.61	1.58	0.65	1.45	0.88	1.26	0.91	1.64	0.90	1.59	0.81	1.57	0.85	1.62
22-30	1.42	2.79	1.62	2.,87	1.75	2.78	1.18	2.42	1.26	2.32	1.21	2.40	1.14	2.22	1.09	2.15	1.04	2.04
30-50	1.42	2.79	1.62	2.87	1.75	2.78	1.67	2.78	1.82	2.72	1.21	2.40	1.44	2.22	1.09	2.15	1.04	2.04
50-70	1.05	1.87	1.10	1.94	1.09	1.91	1.24	1.96	1.09	2.08	1.0	2.10	1.07	2.05	1.18	1.85	1.03	1.80
70-80	1.05	1.87	1.10	1.94	1.09	1.91	1.24	1.96	1.09	2.08	1.0	2.10	1.07	2.05	1.18	1.85	1.08	2.03

passes over the treated plots during the application and mixing the organic matter with the surface soil layer. Needless to state that during such period, the biological decay of the applied organic matter and consequently the production of active organic substances which have eminent improvement of soil workability still at their initial stages.

Considering the impact of plowing treatments on the machinery induced - compacted layer (22-50 cm), the obtained data declaire that chisel plowing did not materially affect the degree of compactness of such layer. This is because the normal chiseling depth is confined within the top 20 cm soil layer. However, under moldboard, the penetration resistance of the upper part of the subsurface compacted layer (i.e. from 22 to 30 cm depth) appreciably decreased compared with the other treatments. This indicates that moldboard is the most successful treatment for rectifying soil compaction within the top 30 cm depth. This conclusion is in a quite agreement with that reported by El-Swaify et al (1985) who mentioned that moldboard plowing was particularly effective in reducing surface soil compaction in Alfisols of the semi - arid tropics.

With respect to the subsoiling treatments, the data in the same table show that subtiller plow is the most effective tool for loosening and disruption of deep compacted layers, as compared with the subsoiler plow. This behaviour could be explained on basis that subtiller has seven blades while subsoiler has only one, (Larson, et al, 1994).

Concerning soil strength after crop harvesting, Table (5) indicates that the values of penetration resistance of chiseled plots are quite similar to those of the control. This means that loosening effect of chiseling disappear by the expiry of one growth season. However, the effect of moldboard on reducing the penetration resistance of the top 30cm soil layer is more pronounced and tends to last more than one growing season. It is also evident that the influence of subsoilers on reducing the penetration resistance of the machinery- induced hard pan at the end of growing season still pronouced, and seems to persist for more than one season. Obviously, subtiller plow appeared more effective than subsoiler.

Unlike to its adverse effect on soil strength at the end of seedbed operations, organic matter at the expiry of growing season displayed an appreciably beneficial effect on the penetration resistance of soil,Table (5). This behaviour, in effect, is attributed to the influence of products of the microbial decay of organic matter. These products promotes soil aggregation with consequent improvement of soil mechanical properties. these findings are concomittant with those reported by soane (1990) and larson et al (1994).

4.3.1.2. Soil bulk density and porosity :-

Soil bulk density and its related properties, e.g. total porosity and void ratio are among the most important criteria for quantitative evaluation of soil compactness. Therefore, these properties were used for evaluating the effectiveness of the different employed plows and organic matter application on soil loosening.

The data of bulk density (BD) and total porosity (E) at the end of seedbed preparation and immediately after harvesting as affected by plowing and organic matter treatments are given in Table (6 a and b).

Table (6 a) : Effect of different plows and organic matter on soil bulk density ($Mg.m^{-3}$) after seedbed preparation and crop harvesting .

1. After seedbed preparation

Depth	Control	CH_o	MB_o	SS_o	ST_o	CH_w	MB_w	SS_w	ST_w
0-10	1.56	1.49	1.47	1.48	1.48	1.47	1.46	1.47	1.47
10-22	1.56	1.49	1.48	1.49	1.49	1.49	1.47	1.49	1.48
22-30	1.68	1.68	1.62	1.64	1.63	1.68	1.62	1.64	1.62
30-50	1.67	1.67	1.67	1.65	1.62	1.67	1.67	1.65	1.62
50-70	1.58	1.58	1.58	1.56	1.55	1.58	1.58	1.56	1.55
70-80	1.57	1.57	1.57	1.56	1.576	1.57	1.57	1.56	1.51

2. After crop harvesting

Depth	Control	CH_o	MB_o	SS_o	ST_o	CH_w	MB_w	SS_w	ST_w
0-10	1.56	1.56	1.56	1.56	1.55	1.56	1.56	1.56	1.56
10-22	1.56	1.57	1.56	1.55	1.56	1.56	1.57	1.56	1.56
22-30	1.68	1.68	1.66	1.67	1.67	1.68	1.66	1.67	1.67
30-50	1.67	1.68	1.67	1.67	1.66	1.67	1.67	1.67	1.66
50-70	1.58	1.58	1.58	1.57	1.57	1.58	1.58	1.57	1.57
70-80	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57

LSD (0.05)

	After seedbed Preparation	After crop harvesting
Depth	0.084	0.043
Organic matter	0.047	NS
Tillag	0.073	0.015

Table (6 b) : Effect of different plows and organic matter on soil total porosity (%) after seedbed preparation and crop harvesting .

1. After seedbed preparation

Depth	Control	CH_0	MB_0	SS_0	ST_0	CH_W	MB_W	SS_W	ST_W
0-10	41.00	43.46	44.22	43.65	43.77	44.15	44.75	44.33	44.26
10-22	40.74	43.43	34.96	43.50	43.73	43.73	44.22	43.73	43.96
22-30	36.11	35.99	38.54	37.63	38.27	35.99	38.50	37.55	38.27
30-50	36.41	36.41	36.41	37.36	38.31	36.41	36.91	37.32	38.35
50-70	40.91	40.15	40.04	40.65	41.10	40.08	40.23	40.76	41.18
70-80	40.94	4.53	20.65	40.76	40.42	40.53	40.57	40.72	40.55

2. After crop harvesting

Depth	Control	CH_0	MB_0	SS_0	ST_0	CH_W	MB_W	SS_W	ST_W
0-10	41.00	40.96	41.00	41.04	41.11	40.92	40.89	41.08	41.04
10-22	40.74	40.70	40.74	40.38	40.74	40.70	40.70	40.92	40.81
22-30	36.11	36.07	36.79	36.45	36.68	36.75	36.75	36.45	36.72
30-50	36.41	36.41	36.41	36.64	36.79	36.41	36.41	36.56	36.75
50-70	40.91	40.19	40.15	40.30	40.34	40.19	40.19	40.72	40.30
70-80	40.94	40.55	40.49	40.49	40.46	40.94	40.49	40.53	40.46

LSD (0.05)

	After seedbed Preparation	After crop harvesting
Depth	0.2033	1.539
Organic matter	0.0827	NS
Tillag	0.1164	0.932

These data reveal that soil tilting markedly decreases the values of soil bulk density (BD) after seedbed preparation as compared with the unplowed soil plots.

Comparing the effect of the employed plows on the values of bulk density in the ordinary tillage zone (0-22 cm depth), reveals similar tendency of decrease under the different plowing treatment. However the magnitude of decrease seems to be more pronounced under moldboard plowing. This indicates that such plow is the most effective tillage implement for loosening the surface soil layer (up to 30 cm depth).

As for organic matter, the same table point out that addition of 25 ton per feddan of composted organic matter has resulted in appreciable decrease of soil bulk density at the end of seedbed preparatory period, as compared to the untreated plots. Undoubtedly this behaviour is attributed to the dilution effect as a result of mixing organic matter with the top soil layer, (Larson et al 1994).

concerning the compacted plow pan (22-50 cm depth), the obtained results indicate that chiseling did not affect the bulk density of such layer, because it underlies the plowing depth of such implement. Meanwhile moldboard plowing resulted in appreciable decrease in bulk denisty of the 22-30 cm layer. Meanwhile subsoiling resulted in reducing the bulk density throughout the plowing depth, (i,e. 80 cm). However, the magnitude of reduction in the values of bulk density was of less pronounced with increasing soil depth.

4.3.1.3. Porosity and pore-size distribution :

a) Porosity:

Table (6b) delineates the influence of plowing treatments on total porosity of soil either after seedbed preparation or after crop harvesting. The obtained data indicate that soil plowing has resulted in a significant increase in total porosity of the top soil layer, (0-22 cm) as compared with the corresponding values of the control treatment. It is also evident that moldboard plowing causes the highest increase in the top soil porosity, relative to the other plowing treatments. This proves that moldboard is the most effective plow in creating a loose and highly porous tillage layer thereby favour rapid and complete germination and seedling establishment (Trouse, 1978).

The results given in Table (6b) also substantiates that subsoiling have a marked positive effect on soil porosity within the surface and subsurface compacted layers. However subtiller plow seems to be superior to the subsoiler in increasing soil porosity in a depth of 70 cm, whereas the beneficial effect of subsoil plow was confined within 50 cm depth.

As for the effect of plowing and organic matter treatments on soil porosity by the end of growing season, the obtained data reveal that such effects are not significant. This behaviour could explained on basis that soil loosening and improving porosity as a consequence of plowing operations may persist for a short period and the soil may resettle again to a relatively high bulk density. These results stand in agreement with those obtained by Orellana et al. (1990).

b) Pore-size distribution:

Due to the fact that compaction decreases soil porosity and in particular decreases the volume of the large interaggregate pores. In contrast it may result in a somewhat increase in the volume of the intermediate size-pores as some of the originally large pores have been squeezed into intermediate size upon compaction. Therefore, the effect of tillage on the volume of such pore-size was studied. Need to mention that the large or drainable pores includes the quickly drainable pores (QDP) which have pore-diameters above 28.4 μ and the slowly drainable pores (SDP) which have pore-diameters range from 8.62 to 28.4 μ (De Leenheer and De Boodt 1965).

The percentages of quickly and slowly drainable pores in soil at the end of seedbed preparation and after harvesting as affected by plowing and organic matter treatments are presented Table (7). The obtained data show that soil plowing results in appreciable increase in the volume of both quickly and slowly drainable pores in the tilted depth, as compared to the control. These results are in harmony with those arrived at Van Ouwerkerk and Boone (1970) who found that no-tillage not only reduced the total pore space but also radically change the pore-size distribution with larger pores disappearance. Likewise, Tollner et al. (1984) mentioned that plowing increased the number of drainable pores.

With respect to the organic matter treatments, it is evident that such treatments appreciably enhances the formation of macro-pores especially the slowly drainable pores . On percentage basis the increase of QDP and SDP in the surface layer of the untreated plots with organic matter approached 45% and 18% relative to the control as compared to 14 and

Table (7) : Effect of tillage and orgainc matter treatments on the quickly and slowly drainaple pores with-in the tilled depth of the the exprimental site.

Depth	Control		CH_o		CH_w		MB_o		MB_w		SS_o		SS_w		ST_o		ST_w	
cm	QDP	SDP	QDP	SDP	QDP	SDP	QDP	SDP	QDP	SDP	QDP	SDP	QDP	SDP	QDP	SDP	QDP	SDP
After seedbed preparation																		
0-10	10.73	5.89	15.38	6.09	12.15	8.47	16.69	6.76	12.78	8.54	16.05	6.87	12.24	7.76	15.71	7.67	12.60	8.16
10-22	10.69	5.71	15.19	6.18	12.63	7.75	16.61	6.45	12.62	7.86	15.59	7.11	12.34	7.26	15.94	7.63	12.84	7.79
22-30	2.38	4.57	2.14	4.97	2.00	5.02	7.59	7.25	7.86	6.68	4.80	7.97	4.89	8.26	6.87	7.86	7.22	8.62
30-50	2.59	4.65	2.39	4.97	2.32	5.24	2.23	4.80	2.31	4.85	4.57	6.50	4.87	6.70	6.61	8.27	7.08	8.27
50-70	9.65	6.59	9.00	6.56	9.60	6.46	9.45	6.62	9.73	6.60	11.37	6.43	11.19	6.96	10.70	7.40	10.92	7.38
70-80	9.85	7.40	9.86	7.50	9.94	7.55	10.01	7.48	10.00	7.42	11.22	7.01	11.32	7.06	4.67	7.31	9.99	7.34
After crop harvesting																		
0-10	10.73	5.89	11.74	5.87	11.49	5.42	11.37	6.34	11.53	6.38	11.31	6.01	11.24	6.27	11.78	6.09	11.52	6.27
10-22	10.69	5.71	10.79	5.72	11.90	5.90	11.22	6.38	11.11	6.42	10.76	6.27	11.41	6.41	11.64	6.09	11.23	6.68
22-30	2.38	4.57	2.06	4.40	2.20	5.08	4.67	6.07	4.66	5.75	4.24	5.27	4.83	5.79	5.68	5.95	5.56	5.95
30-50	2.59	4.65	2.32	4.38	2.13	4.62	2.27	4.27	2.18	4.47	4.44	5.68	4.24	5.83	5.23	6.12	5.41	6.09
50-70	9.65	6.59	9.90	6.15	9.98	6.26	10.04	6.05	9.94	6.18	10.64	6.26	10.69	6.25	11.57	5.90	11.34	5.99
70-80	9.85	7.40	9.95	7.39	10.07	7.13	10.05	7.17	9.92	7.18	10.50	7.52	10.53	7.33	9.38	7.73	9.72	7.25

Where
QDP = Quickly drainable pores (>28.4m)
SDP = slowely drainable pores (28.4 - 8.62 m)

LDS (0.05)

	After seedbed preparation			After crop harvesting		
	D	OM	Tillage	D	OM	Tillage
QDP	0.099	0.068	0.083	0.0304	ns	0.013
SDP	0.1021	0.0661	0.1008	0.080	0.045	0.070

37% for hte organic matter treated plots, in the same sequence. This behaviour could be attributed to the fact that during the early stages of organic matter application, it may lodge between the larger pores and/or encourage the formation of relatively finer aggregates, thereby the relatively small pores increases.

As regard to the compacted layer (22-50 cm), the same table indicates that subsoil plowing resulted in a remarkable incresase in the large pores. The increase of QDP in such layer reached 75 and 145% from the control, upon using subsoil and subtiller plowing, respectively. However, in case of SDP, the magnitude of increase is of less pronounced as it approached 55 and 77% for the two plowing treatments, in the same sequence. Below 50 cm soil depth, the effect of subsoiling on the drainable pores is inferior and can be neglected.

Considering the influence of plowing and organic matter treatments on the drainable pores at the expiry of growth season, Table (7) point out that the volumes of the QDP and SDP in the top soil layer under all treatments are more or less around the corresponding values of the control. This inconstancy of the pore-size distribution could be ascribed to the natural resettlement of the loose soil to a dense packing and the inherently unstable nature of soil structure.

For the subsoil layers, it is evident that the beneficial effect of subsoilers, i.e. subsoil and subtiller plows on the quickly and slowly drainable pores of these layers persists to the end of the growth season, and may last for another growing season. These resutls are in quite concomittant with those obtained by Larson et al. (1994) who reported that subsoiling gave the most evident results in dry season and may be necessary to be repeaed every 2 to 5 years.

4.3.1.4. Saturated hydraulic conductivity .

As soil compaction increases soil bulk density and decreases the total pore space, it significantly influences soil hydraulic properties, e.g. saturated hydraulic conductivity, infiltration and the related transport processes. In the present study, saturated hydraulic conductivity was used to evaluate the effectiveness of the applied rectifying treatments.

The obtained results of the saturated hydraulic conductivity (Ks) of soil layers to a depth of 80 cm, as affected by the various plowing and organic matter treatments are presented in Table (8). By the end of the seedbed preparation period, the obtained data point out that plowing treatments cause marked increase in the saturated hydraulic conductivity of the surface soil layer, as compared to the corresponding layer of the control. The data also reveal that the effect of organic matter on saturated hydraulic conductivity of the top soil layer immediately after seedbed preparation is minute.

As for the compacted subsurface layers, it is evident that subsoilers resutled in a pronounced increase in saturated hydraulic conductivity throughout the tilted depth, (i.e. 50 cm), as compared to the control. Exceptional being is the case of moldboard where the depth of plowing is limited to the 0-30 cm layer. On percentage basis, the increase in saturated hydraulic conductivity reached 123.47, 79.94 and 100.25% from the values of the corresponding depths of the control, upon using moldboard, subsoil and subtiller plows, respectively. Undoubtedly, such increase is rendered to the beneficial effects of plowing on soil loosening and the consequent increase in soil porosity and drainable pores.

Table (8): Effect of tillage treatments on saturated hydraulic conductivity (cm/hr) of the different depth in the experimental site.

	Without OM					With OM			
Depth	Initial soil	CH	MB	SS	ST	CH	MB	SS	ST
1 - After seedbed preparation									
0-10	5.129	8.329	9.171	8.709	8.813	7.116	8.050	7.556	7.793
10-22	5.632	7.710	8.301	7.833	8.115	7.531	8.103	7.651	7.814
22-30	0.982	0.969	2.195	1.751	1.972	0.859	2.194	1.783	1.961
30-50	0.987	0.973	0.898	1.634	1.905	0.921	0.886	1.627	1.895
50-70	2.950	2.802	2.811	3.246	3.861	2.814	2.793	3.197	3.902
70-80	2.891	2.744	2.766	2.983	2.718	2.752	2.751	2.989	2.704
2 - After crop harvesting									
	5.129	4.613	5.205	4.742	4.955	4.731	4.489	4.521	4.693
	5.632	4.780	5.819	4.814	5.160	4.796	5.193	4.924	5.073
	0.982	0.823	1.516	1.168	1.438	0.840	1.540	1.178	1.454
	0.987	0.919	0.876	1.152	1.417	0.862	0.869	1.249	1.486
	2.950	2.894	2.906	3.186	3.241	2.815	2.913	3.205	3.271
	2.891	2.872	2.842	2.971	2.713	2.792	2.847	2.746	2.695

LSD for (KS) (p = 0.05)

	1 - After seedbed prepartaion	2 - After crop harvesting
Depth	0.0354	0.0673
Organic matter	0.023	ns
Tillage	0.0366	0.064

By the end of growth season, the same table point out that the values of saturated hydraulic conductivity of the surface soil layer (0-22 cm) are approximately similar to those of the control, indicating that the beneficial effects of plowing on saturated hydraulic conductivity of the top soil layers are temporal and did not persist more than one growing season.

On the other hand, subsoiling increases the saturated hydraulic conductivity of the tilted subsurface soil layer as compared to the control. However, subtiller seems to be superior to the subsoil plows in improving the saturated hydraulic conductivity of the subsurface compacted layers.

In order to express mathematically the relationship between the corrected penetration resistance at soil moisture equivalent to 20% of the available moisture range (Y) and each of the above menhtioned variables, i.e. bulk density (X1), total porosity (X2), quickly drainable pores (X3), slowly drainable pores (X4) and saturated hydrualic conductivity (X5), simple and multiple regression analysis were carried out. The obtained simple and multiple regression equations are presented in Table (9). These equations indicate that there are highly significant negative linear relationship between each of the total porosity, quickly drainable pores, slowly drainable pores and saturated hydraulic conductivity and the penetration resistance of soil. Whereas, porosity exhibits highly significant positive linear relationship with penetration resistance. Howeve, the ratios between the slopes of the different variables in the multiple regression equation attained 9.71, 1.0, 3.98, 14.58 and 8.24 for X1, X2, X3, X4 and X5 repectively. This means that the volume of the slowly drainable pores (X4) is the most sensitive property to the changes in penetration resistance of the soils followed by bulk density, hydraulic conductivity, and quickly drainable pores. These findings are in accordance with those obtained by Dawidowski and Lerink (1990) and Campbell (1994).

Table (9) Regression equations describing the relationship between penetration resisatance against bulk density and haydraulic properties of soil under the different tillage treatments.

Soil Treatment	Soil Variable	Simple regression equation	r	R^2
All	$rY X_1$	$Y = -8.7463 + 6.7900 X_1$	0.8439 **	0.7121
Till (0)		$Y = -15.5049 + 11.0279 X_1$	0.9910 **	0.9821
(1)		$Y = -10.2684 + 7.7951 X_1$	0.9593 **	0.9203
(2)		$Y = -8.6941 + 6.7652 X_1$	0.8577 **	0.7356
(3)		$Y = -5.414 + 4.6665 X_1$	0.6683 **	0.4466
(4)		$Y = -3.4298 + 3.2507 X_1$	0.5876 **	0.3453
OM (0)		$Y = -10.1667 + 7.6624 X_1$	0.8864 **	0.7857
(1)		$Y = -7.6346 + 6.1095 X_1$	0.8131 **	0.6611
All	rY X2	$Y = 9.8402 - 0.1954 X_2$	- 0.8774 **	0.7699
Till (0)		$Y = 13.7397 - 0.2928 X_2$	0.9913 **	0.9827
(1)		$Y = 11.4103 - 0.2326 X_2$	- 0.9887 **	0.9775
(2)		$Y = 8.976 - 0.1724 X_2$	- 0.8275 **	0.6848
(3)		$Y = 8.3870 - 0.1610 X_2$	- 0.8677 **	0.7529
(4)		$Y = 5.668 - 0.0982 X_2$	- 0.6513 **	0.4242
OM (0)		$Y = 10.7034 - 0.2173 X_2$	- 0.9015 **	0.8127
(1)		$Y = 9.1207 - 0.1771 X_2$	- 0.8611 **	0.7415

Soil Treatment	Soil Variable	Simple regression equation	r	R^2
All	rY_1X_3	$Y = 3.0230 - 0.1193 X_3$	- 0.8694 **	0.7559
Till (0)		$Y = 3.4599 - 0.1602 X_3$	- 0.9958 **	0.9916
(1)		$Y = 3.0530 - 0.1254 X_3$	- 0.9053 **	0.8196
(2)		$Y = 3.1077 - 0.1213 X_3$	- 0.9003 **	0.8105
(3)		$Y = 2.6788 - 0.0872 X_3$	- 0.764 **	0.5837
(4)		$Y = 2.3421 - 0.0687 X_3$	- 0.6360 **	0.4045
OM (0)		$Y = 2.9638 - 0.1106 X_3$	- 0.8802 **	0.7748
(1)		$Y = 3.1564 - 0.1367 X_3$	- 0.8690 **	0.7552
All	rYX_4	$Y = 2.5424 - 0.2317 X_4$	- 0.4348 **	0.1891
Till (0)		$Y = 4.7193 - 0.4386 X_4$	- 0.7517 **	0.5651
(1)		$Y = 4.6769 - 0.4260 X_4$	- 0.7148 **	0.5109
(2)		$Y = 4.5892 - 0.4005 X_4$	- 0.72099 **	0.5198
(3)		$Y = 2.4177 - 0.0919 X_4$	- 0.1871 **	0.035
(4)		$Y = 3.0263 - 0.1812 X_4$	- 0.2148 **	0.0461
Om (0)		$Y = 3.9339 - 0.3147 X_4$	- 0.5693 **	0.3241
(1)		$Y = 4.4074 - 0.3605 X_4$	- 0.7822 **	0.6118
All	rYX_7	$Y = 2.6157 - 0.1832 X_7$	- 0.8517**	0.7254
Till (0)		$Y = 3.0635 - 0.2858 X_7$	- 0.8982 **	0.8068
(1)		$Y = 2.8655 - 0.2274 X_7$	- 0.9275 **	0.8603
(2)		$Y = 2.5637 - 0.1624 X_7$	- 0.8420 **	0.709
(3)		$Y = 2.4734 - 0.1641 X_7$	- 0.9637 **	0.9287
(4)		$Y = 2.0542 - 0.09996 X_7$	- 0.8034 **	0.6455
OM (0)		$Y = 2.6215 - 0.1843 X_7$	- 0.8622 **	0.7434
(1)		$Y = 2.6094 - 0.1822 X_7$	- 0.8390 **	0.7039

Multiple regression equation

$RY X_2 X_3 \; X_7 X_1 X_4$ $Y = 3.237 - 0.0119 X_2 - 0.0474 X_3 - 0.0981 X_7 + 0.1155X_1 - 0.1735X_4$

Y = Penetration resistance at moisture content equivalent 20% of available water
X_1 = B D; X_2 = TP , X_3 =QDP; X_4= SDP; X_5 = Ks
Till = Tillage treatment i.e. (0) untilled; (1) Chisel; (2) moldboard;
(3) Subsoiler and (4) Subtiller
OM (0) = Zero applied Organic matter
OM (1) = with organic matter

4.3.2. Effect of tillage on infiltratin rate:

Infiltration tests were carried out on the plots representing the different plowing and organic matter treatments, i.e. on the main and submain exprimental plots, at two periods viz., immediately after the preparation of seedbed and after the crop harvesting. All tests were conducted under 7.0 cm constant water head and each test lasted four hours. The volume of water entering a unit soil surface per unit time were processed using Kostiakov equation (1932). This equation can be presented in the form;

$$i = Kt^{-n}$$

where i is the infiltration rate; t is the time (minutes) and K and n are constants.

The obtained formulae of infiltration rate into the soil under the employed plowing and organic matter treatments are given in Table (10). These equations point out that the final or basic infiltration rates of the tilled soil are generally higher than those of the control. Nevertheless the tendency of increase in basic infiltration rate is of less pronounced under organic matter treatments.

Comparing the effect of plowing treatments on infiltration rate, the obtained data, reveal that subsoiling is the most effective tillage treatment for rectifying soil compaction and improving water infiltrability into the deep root-zone. While, Moldboard plowing is a successful cure for compactness and subsequent improvement of infiltration in the surface layer. The effect of chiseling on infiltration rate is inferior. On percentage basis the increase in the basic infiltration rate of the soil, without organic matter applications, approached 26.67%, 65.24%, 96.19% and 105.24%,

Table (10) : Infiltration rate (i) models for the various plowing and organic matter treatments at seedbed preparation and crop harvesting periods.

Treatment	Equation model	i cm/h	n	r
After seedbed preparation				
Control	$i = 3.6842\ t^{-0.5923}$	2.10	- 0.5923	- 0.9783
CHo	$i = 4.0360\ t^{-0.6040}$	2.66	- 0.6040	- 0.9576
CHw	$i = 4.0486\ t^{-0.6074}$	2.14	- 0.6074	- 0.9919
MBo	$i = 4.4596\ t^{-0.6158}$	3.43	- 0.6158	- 0.9951
MBw	$i = 4.3981\ t^{-0.6118}$	3.01	-0.6118	- 0.9940
SSo	$i = 4.3450\ t^{-0.5572}$	4.12	-0.5572	- 0.9932
SSw	$i = 4.2395\ t^{-0.5544}$	3.50	-0.5544	- 0.9953
STo	$i = 4.7825\ t^{-0.6055}$	4.13	-0.6055	- 0.9889
STw	$i = 4.66334\ t^{-0.6025}$	3.88	-0.6025	- 0.9920
After Crop harvesting				
Control	$i = 3.6842\ t^{-0.5923}$	2.10	-0.5923	- 0.9783
CHo	$i = 3.2761\ t^{-0.5232}$	1.98	-0.5232	- 0.9646
CHw	$i = 3.2199\ t^{-0.5071}$	1.94	-0.5071	- 0.9776
MBo	$i = 3.4542\ t^{-0.5475}$	2.09	-0.5475	- 0.9791
MBw	$i = 3.6560\ t^{-0.5507}$	2.10	-0.5507	- 0.9966
SSo	$i = 3.7887\ t^{-0.5968}$	1.91	-0.5968	- 0.9809
SSw	$i = 3.7586\ t^{-0.5852}$	1.93	-0.5852	- 0.9970
STo	$i = 3.5684\ t^{-0.5677}$	2.04	-0.5677	- 0.9796
STw	$i = 3.4500\ t^{-0.5423}$	1.98	0.5423	- 0.9813

relative to the control, upon using chisely moldboard, subsoil and subtiller plows, respectively. Meanwhile, under organic matter treatments, such increase reached 1.90, 43.33%, 66.67% and 82.38% from the control, in the same sequence. The adverse effect of organic matter on water infiltrability at the commencement of the growing season can be attributed to soil compaction of such plots owing to the transportation of vehicles loaded with organic materials.

As to the late season, the same table reveals that the basic infiltration rate did not display any trend pertaining the tillage tool nor the depth of plowing. Most likely this behaviour could be rendered to the resettlement of the loose soil to high densities with subsequent adverse effect on drainable pores. These results are align with those reported by Smith and Dickson (1990).

4.4. Effect of tillage on corn yield:

Due to the fact that soil compaction directly affect the system of macropores, it drastically affect the soil physical growth factors; i.e. soil moisture, soil aeration, soil temperature and soil mechanical resistance. Such effects are often clearly visual evident on the form of reduced crop establishment, growth and yield or quality. Therefore, corn yield as affected by the remedial measures, including different plowing and organic matter treatments was investigated. Need to mention that chiseling of the ordinary tillage layer (about 0-20 cm depth) followed by harrow disking to refine soil surface is the normal tillage practices in West Nubaria region, thereby chisel plowing has been considered the control treatment.

The data given in Table (11) and illustrated in Fig.(3) reveal that plowing has resulted in a considerable increase in corn grain yield, relative

Table (11) Effect of tillage and organic matter treatments on corn yield (ton / fed) under the conditions of the experimental site.

Treat	grain yield (ton / fed)		Cop yield (ton / fed)	
	Without OM	With OM	Without OM	With OM
CH	2.658	2.843	1.737	1.915
MB	2.455	3.202	1.512	2.168
SS	3.184	3.312	1.915	2.302
St	3.303	3.354	1.973	2.429

LDS (p = 0.05)

	Grain yield	cop yield
organic matter	0.00948	0.00697
Tillage	0.00689	0.01106

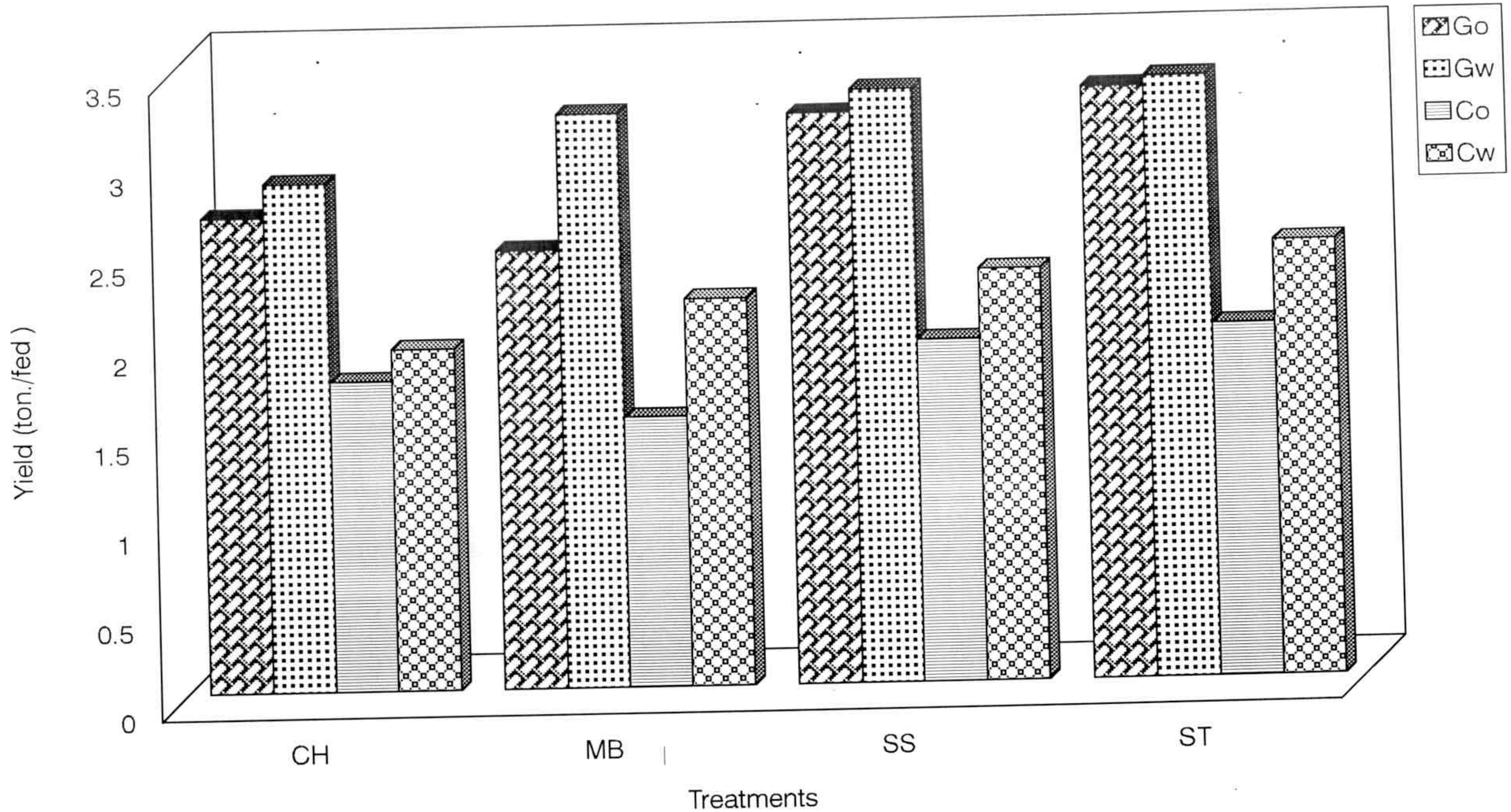

Fig (3) :Effect of tillage treatments on corn yield (ton / fed) in the studied soil

G=Grain;C=Cop;o=Without OM;W=With OM

to the contorl. Exceptioal being moldboard plowing without application of organic matter in which the grain yield was less than the contorl treatment. This behaviour may be attributed to the fact that moldboard plowing turns parts of the very inferior fertility and compacted subsoil to the surface, and thus unfractured clods may persist within the root-zone causing harmful effect for the growing plant, (soane and Pidgeon 1975).

Table (11) and Fig. (3) also show under organic matter treatment, that subsoil and subtiller plowing have increased the corn grain yield by 19.79% and 24.27%, as compared to the control respectively. Also, the cop yield has increased by 10.25% and 13.59% relative to the control, in the same sequence. Such increase may be related to the breaking up the compacted subsurface layer. Therefore it may be necessary, at times, to replace ordinary tillage by subsoiling so as to maintain soil productivity at highest levels.

Likewise organic matter applications at any plowing treatment has resulted in pronounced increase in crop yield as compared to the control. Such increase approached 6.96%, 30.43%, 3.86% and 1.25% for chisel, mold-board, subsoiler and subtiller, respectively. However, in case of cop yield, this increase reached 10.25%, 43.39%, 20.21% and 23.11% in the same sequence. This effect may be attributed to the beneficial impact of organic matter on the physical, chemical and nutritional properties of the soil.

the foregoing resutls prove that the subsurface compacted layer in the mechanized form of west Nubaria Agricultural company became a limiting factor for achieving highest level of soil producitivity.