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TILLAGE MACHINERY PERFORMANCE AS AFFECTED BY ADDING SOME ORGANIC AND CHEMICAL MATERIALS

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ABSTRACT

The effects of three different soil additions on soil strength and also on machinery platform roughness were illustrated. The addition materials were organic manure, calcium sulfate, and calcium super phosphate. Two different doses of each addition were added to the soil during tilling for the pre-seeding crop using two different chiseling mixing methods. While, a tractor-chisel plow performance was tested during tilling for the next crop

The changes in soil properties were evaluated during the growing season through sequential measurements for both soil shear and penetration resistance, and also soil profile. While, the performance of the tractor-plow combination was evaluated by measuring draught force, wheel slip, and fuel consumption.

The gained results may be summarized as follows:

Adding organic manure (40m^3/fed) or calcium super phosphate (500 kg/fed), caused reduction in both soil penetration and shear resistance by about 20 and 10% respectively. While in construct calcium sulfate addition (Gypsum) led to increase these resistances.

- Using twice-chiseling mixing method reduced soil resistance, than the only once chiseling mixing method by about 3-5%.
- In general organic manure (cattle manure) additions can cause sensitive reduction in draught force, tractor wheel slip and fuel consumption by about 7.2, 3.1, and 18.1 % compared with control treatment.

1. INTRODUCTION

Soil distinguishes itself by high resistance, to be overcome by the multiplied, or large width plowshares. Nevertheless, the major task, that facing, tillage machinery manger is to apply faster forward speed, or more working width and depth during the field operations. Thus it was thought that it is necessary to increase the tractor power to match more selected tillage depth, width, and speed. **FMO (1989)** reported that the pre- tilling soil condition is the most important parameter for determines the consumed tractor power. Hence, soil strength and soil roughness are important factors, for limiting the used machinery required power and work rate performances.

In fact, many authors reported that, the soils treated with some organic or chemical additional materials, a sensitive change in their strength properties, were observed. **Ohu et al. (1986)** examined in the laboratory the shear strength of soils under three levels of organic matter (3, 10,and 17%). They indicated

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that, the addition of organic matter to sandy, clay loam, and clay soils, resulted in decreasing shear strength at different moisture content levels (ranged from 5 - 30%). They showed that shear strength values in the sandy loam soil, were 0.55 MPa (at moisture content of 17.5%), 0.5Mpa (at moisture content of 20%,) and 0.44 MPa (at moisture content of 27%) at the additions of 3, 10, and 17% organic matter contents respectively. They concluded that, the maximum shear strength reduction ratio in the clay loam soil were about 91, 71, and 33% due to three levels of organic matter (17, 10,and 3 %). While the corresponding reduction ratios in the clay soil were about 50, 38, 27and % respectively. **Cook and Nelson (1986)** used different rates of granular and soluble PAM (as a polymer) started from 0 to 90kg/ha on artificial and Matura soil. The results showed that, adding polymer to soil was significantly lowering the soil resistance. **Terry and Nelson, (1986),** indicated that the benefits of the soil addition could be translated into lower soil bulk density and decreased energy requirements for tillage **Helalia and Letev (1989)** reported that as PAM as a solution was applied at 0, 10 and 50 mg/L on loamy soil. The penetration resistance was significantly higher in non-treated than PAM-treated soil. They added that aggregate stability was much better for PAM-treated soil than for non-treated soil. **El-Banna, (1992),** and **El-Hady and Abdel–Hady, (1989)** reported that mixing plant nutrients with polymer before conditioning soil was a promising method for improving the mechanical strength and stability of soil structure. **Ali and Abo-Habaga (1995)** cleared that the addition of organic materials always decreased the soil shear strength at any moisture content for all employed compaction soil levels. They said that in general organic materials influence the physical, chemical and biochemical characteristics of soil, which in turn influence the growth and development of plants. **Ismail (1998)** reported that polymer addition significantly decreased both soil penetration resistance, and, soil shear strength parameters.

On the other side, the correlation between soil surface conditions and machinery energy consumption, was investigated by many researchers **{Soane (1970), Swan et al. (1987), Siemns (1989), and Matouk et al. (1998)}**. They indicated that the more roughness or the more soft soil conditions the greater amount of power that will be consumed. That is because, more roughness of soil surface, gives greater draft resistance, while looser soil gives greater rolling resistance.

However, the majority of tillage studies have been carried out to evaluate the soil properties resulting from different tillage implements systems, the literatures relating that implement performances to the pre-tilling soil condition are almost negligible. Consequently, the aim of the present study is to relate some soil strength parameters to some organic and chemical additions. In addition, to relate the energy required for tillage, the tractor-plow slip, and fuel consumption to the resulted soil properties.

3- MATERIALS AND MEASUREMENTS

3-1 Organic and Chemical Additions:

The three investigated additions, and their added rates per feddan are shown, in Table (1).

Table (1) The tested additions types and their dose per feddan

Addition type	The illustrated additions dose (added rates)		
	Datum	Recommended (R)	Suggested dose (S)
1- Organic manure (cattle manure) (m^3)	-	Or=30	Os=40
2- Calcium sulfate ($CaSO_4$ $4H_2O$); (ton)	-	Gr=4	Gs=5
3- Calcium super phosphate 15.5% (kg)	-	Sr=300	Ss=500

3-2 The tested tractor-tillage implement combination:

A 47.8 kW (65 hp) Universal tractor model D.110 was used as the power source in this study. While, a locally manufactured seven shares chisel plow was used to accomplish the tillage work. The plow weight was 2.94 KN. In addition, the plow was adapted to be operating at 1750 mm width, and up to 250mm depth.

3-3 Site, Soil, and Growing Crop:

The present work was carried out, in Sinbellaween region (Dakahlia Governerate). Table (2) shows the mechanical analysis of the tested soil samples, which were collected from the experimental field through the depth from 0 - 75 cm with 15 cm intervals. The planted crop in this work was zea-maize (corn), while its variety was fodder.

Table (2) Soil mechanical analysis of the experimental field.

Clay %	Silt %	Sand %		Soil Texture
		Fine	Coarse	
48.32	27.83	20.98	2.87	Clay

3-4 The experimental design:

The experimental field was divided into two equal parts. Each part was allocated for a mixing method of the two proposed ones. At the first part, the additives was added followed by chiseling once, while, at the second part, chiseling twice was adopted after adding the additives. Each part was divided latterly into 4 rectangular main plots of 16*120m (Fig. 1). Three plots of them were divided into 6 sub-plots for adding respectively the following addition rates: - organic mature of 40m^3/fed. (Os), organic mature of 30 m^3/fed. (Or), calcium sulfate of 5 ton/fed. (Gs), calcium sulfates of 4 ton/fed. (Gr), supper phosphates of 500 kg/fed. (Ss), and super phosphate of 300 kg/fed. (Sr). The remaining fourth plot was allocated for applying the datum treatment. The layout of the experimental treatments is shown in Fig. (1).

3-5 Measurements:

The measurements covered the two following points: -

-Quantifying the consecutive changes of the soil properties due to (from the second irrigation till after harvesting time).

Estimating the tractor-plow work rates, and energy consumed during the next crop tilling operation.

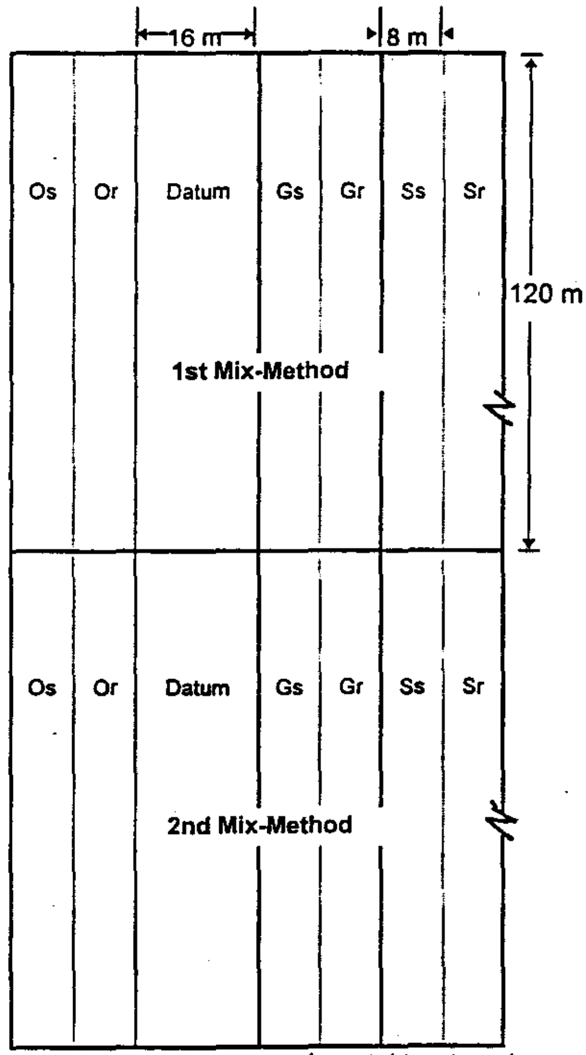


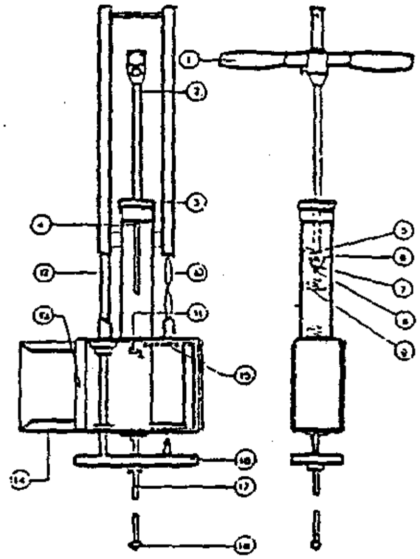
Fig: (1) Layout of the experimental treatments.

3-5-1 Soil measurements:

A- Soil penetration and shear resistance measurements:

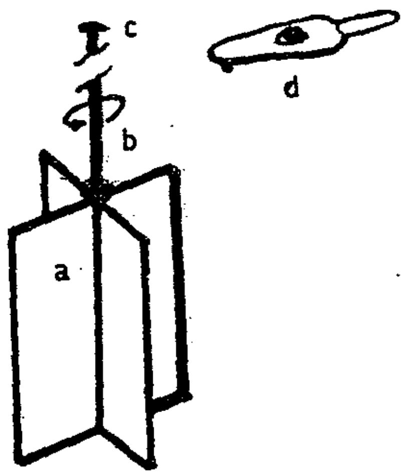
The soil penetration and shear resistances were measured at four consecutive periods. Those were immediately before the second and the third irrigations, before harvesting and the next crop. The penetration resistance was measured using penetrograph, as shown in Fig (2) according to **Eijkelkamp (1979)** While, shear resistance was estimated according to **Schaffer et** al.

(1968) using shear apparatus Fig. (3), and (Eq. 1). Both resistances were measured at 5, 10, 15, 20, 25 and 30 cm depth.



1- Dismounting grips
2- pressing-rod
3- springhouse-nut
4- pressing-rod guide
5- contranut
6- spmgring
7- contranut
8- writing-rod
9- spring
10- turned-rod
11- writing-pin holder
12- square rod-guide
13- magnetic coverlosing
14- card guide
15- driving-roller
16- ground plate
17- probing-rod
18- cone

Fig. (2) The used penetrograph construction.



a- Van blade
b- Van rod
c- Horizontal sheared surface (top)
d- Torque wrench

Fig. (3) The shear van device components.

$$\tau = \frac{T}{\pi . d^2 (\frac{h}{2} + \frac{d^3}{6})} \quad (1)$$

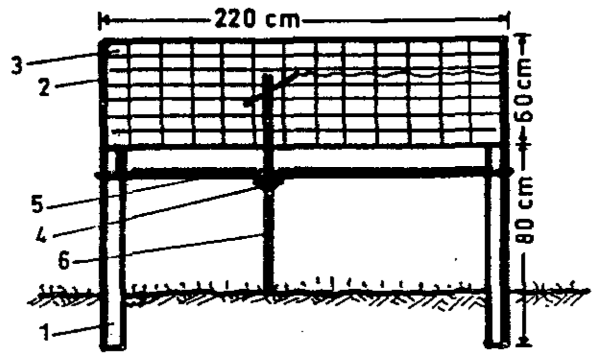
where:

τ = Shear stresses, N/cm^2

d = Diameter of the wing borer, cm
h = Length of the wings, cm
T = Torque, N/cm^2

B- Soil profile and roughness:

Soil surface profile was measured after harvesting, and directly before tillage using a locally manufactured profilemeter Fig. (4). That profilemeter consists of two L-shape iron supports (1), which are inserted at 220cm horizontal distance. A graph paper (3), which is fixed on a wooden board (2). A movable steel rod (6) that is allowed to run laterally on the soil surface by means of double joint sliding rings (4) and fixed steel rod (5). The rod (6) is also permitted to move ups and downs inside a fixed tube. The lower cone end of the rod (6) follows the contour of the soil and a pencil, which is fixed on the top of the rod (6), can take measurement drawings. Thus the results can be directly drawn graphically.



1- Iron L shape support
2- Wooden board
3- Graph paper
4- Double rings sliding
5- Horizontal steel rod
6- Vertical steel rod

Fig (4) The local manufactured soil profilemeter.

In each profilemeter positions, the standard deviation (S_d) of the graph paper readings could be estimated by using the following equation:

$$S_d = \left[\frac{\sum x^2 - (\sum x)^2}{N-1} \right] \qquad (2)$$

where:

x = distance between the horizontal surface and soil surface, cm,
N = Number of readings.

Then the soil surface roughness (R·%) could be calculated using the following equation according to **Kuipers (1957).**

$$R = 100 \log S_d \qquad (3)$$

To compare the soil roughness of the treatments treated by addition with that of non-addition treatment (control), the change in soil roughness percentage Ch% could be estimated as follows:

$$Ch\ \% = \frac{Rb - Ra}{Rb} \times 100 \qquad (4)$$

where:

Rb = Soil roughness of the control at any measuring time,
Ra = The corresponding soil roughness of soil treated by additives.

3-5.2 Machinery measurements:

A- Draught force measurements:

Draught data were obtained by the method suggested by **ASAE (1983)**. Hence in each plot of each experimental treatment the tested plow was mounted on tested tractor (as a dummy tractor). Then an auxiliary tractor of 51.5 kW pulled the whole combination. The draught force "D" was then measured as the horizontal component of the force between the driving tractor and tested tractor-plow combination (towed). A spring dynamometer developed by **El-Sheikha (1995)** ,

B- Measurements of slip (SL%):

The 47.8 kW Universal tractor wheels slip ratio (S_L %) was calculated using the following equation: (ASAE D230.3)

$$S_L\ \% = \frac{D - d}{D} \times 100 \qquad (5)$$

where:

D = The theoretical traveling distance for 10 rev. of a wheel on the road, (m).
d = The actual traveling distance for 10 rev. of a rear wheel on the field, (m).

C- Measuring the fuel consumption:

The fuel consumption was measured by using a small auxiliary tank of about 4-L content Fig. (5). The tank is a bottle closed with a rubber stopper. There are three holes in the stopper. Metal has been inserted in two holes; one reaches to 0.5 cm above the bottom of the tank and the second for filling the fuel by means of an attached funnel. The third hole serves as ventilator for the tank during filling.

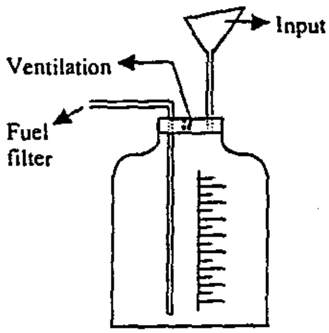


Fig (5) The fuel measuring tank.

The rate of fuel consumption FCR was calculated for each treatment by dividing the volume over the time recorded as follows:

$$FCR\ (l/h) = \frac{FCV\ (ml)}{1000} \times \frac{60}{Time\ of\ operation\ (min)} \qquad (6)$$

The fuel consumption per unit of area was determined by dividing the fuel consumption rate (in L/h) on the actual field capacity in feddan/h as follows:

$$Fuel\ consumption\ (l\ /\ fed.) = \frac{fuel\ consumption\ (l\ /\ h)}{actual\ field\ capacity\ (fed./h)} \qquad (7)$$

Also, the specific fuel consumption (L/kW.h) was determined by dividing the fuel consumption rate in L/h on rated power in (kW) as follows:

$$Specific\ fuel\ consumption\ (l\ /\ kW.h.) = \frac{fuel\ consumption\ (l\ /\ h)}{rated\ power\ (kW)} \qquad (8)$$

4- RESULTS AND DISCUSSION

4-1 Changes in the Soil Properties:

A- Soil penetration and shear resistance changes:

The typical soil penetration and shear resistance values as they measured at successive times and depths for the addition and control treatments are shown in Figs from 6 to 9. However, the data plotted in Figs 6 and 8 show the effect of the addition treatments, when they were mixed by the first mixing method. While Figs 7 and 9, show that effect, when they were mixed by the second method.

In general, it can be noticed that the two tested doses of the organic leads to weaken the soil penetration resistance at any measuring time and depth, when compared to the control treatment (without addition). While, the calcium super phosphate additions decreased slightly this property only before and after harvesting times. Since, it should be denoted that the penetration resistance reduction rates were higher (in favor of the manure) than calcium super phosphate by about 15 - 19%. Vise versa the two-calcium sulfate doses (gypsum), caused increase in the value of that soil property by about 3-16% when compared to the control treatment.

The effects of the two tested chiseling mixing methods on the soil penetration with respect to the organic addition were compared. Data show that a higher reduction in the soil penetration resistance by about 8% was achieved, in favor of the two chiseling mixing method. While, with calcium sulfate addition, the data show that the only once chiseling mixing method has less penetration values than the twice chiseling method by about 9 %. Consequently, it may be recommended to prevent the addition of calcium sulfate (gypsum) to the clay soil.

From data in Figs (8 and 9) it can be realized that the effects of the tested additions on soil shear resistance, exhibited approximately similar trend to those of penetration resistance data. But it should be denoted that data at shear resistance given by gypsum mixed by once contradict the data of penetration. With respect to construct, the addition with twice chiseling leads to decrease the shear resistance.

Thus, it can be stated that, the low shear resistance could be obtained by adding 40 m^3 /fed manure.

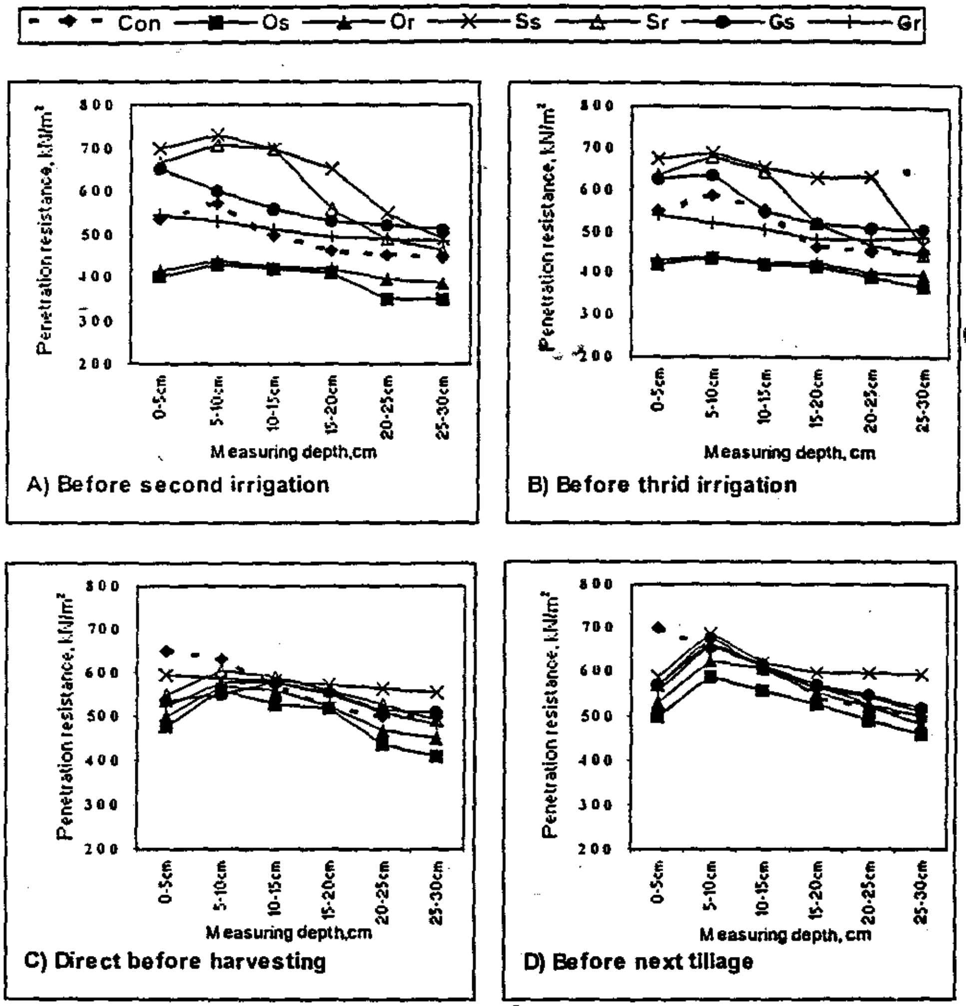


Fig 6: Soil penetration resistance (kN/m^2) at different measuring times and depths as affected by the additions mixed by only once chiseling.

Moreover, the soil penetration and shear resistance values exhibited regular increments with increasing depth down to 15 – 25cm. But it should be denoted that the increment rates were found very high in the case of calcium sulfate addition. However starting from 25 cm depth, the soil resistance is becoming weaked and decreased. This result may be due to the higher soil moisture content values.

B- Soil profile and roughness:

Fig (10) shows the sequence changes of the soil profiles, due to the addition rates as they were mixed with the 1st mixing-method. While Fig (11) shows these changes as they were mixed by 2nd mixing-method. Moreover, the estimated soil roughness data (R %) according Eq.(5) are tabulated in Table (3).

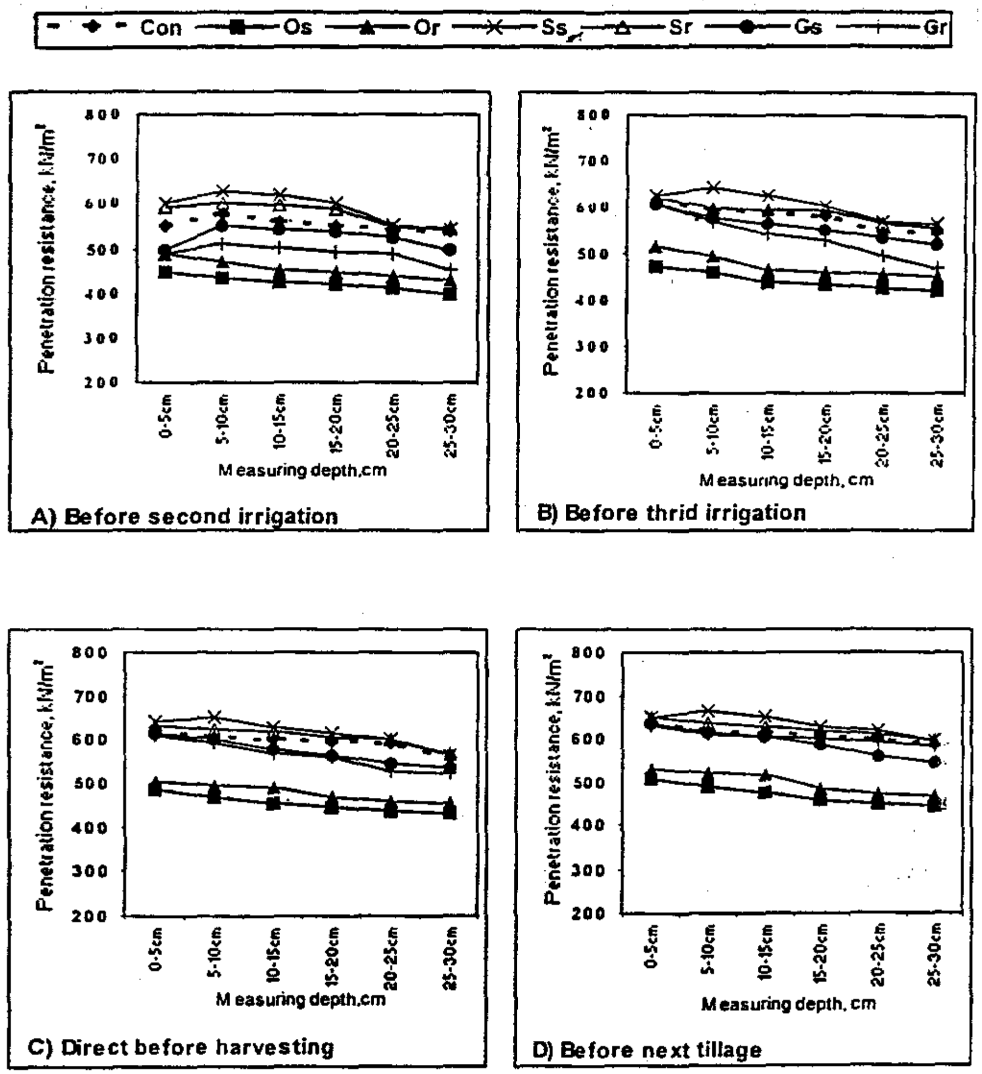


Fig (7) Soil penetration resistance (kN/m^2) at different measuring times and depths as affected by the additions mixed by twice chiseling.

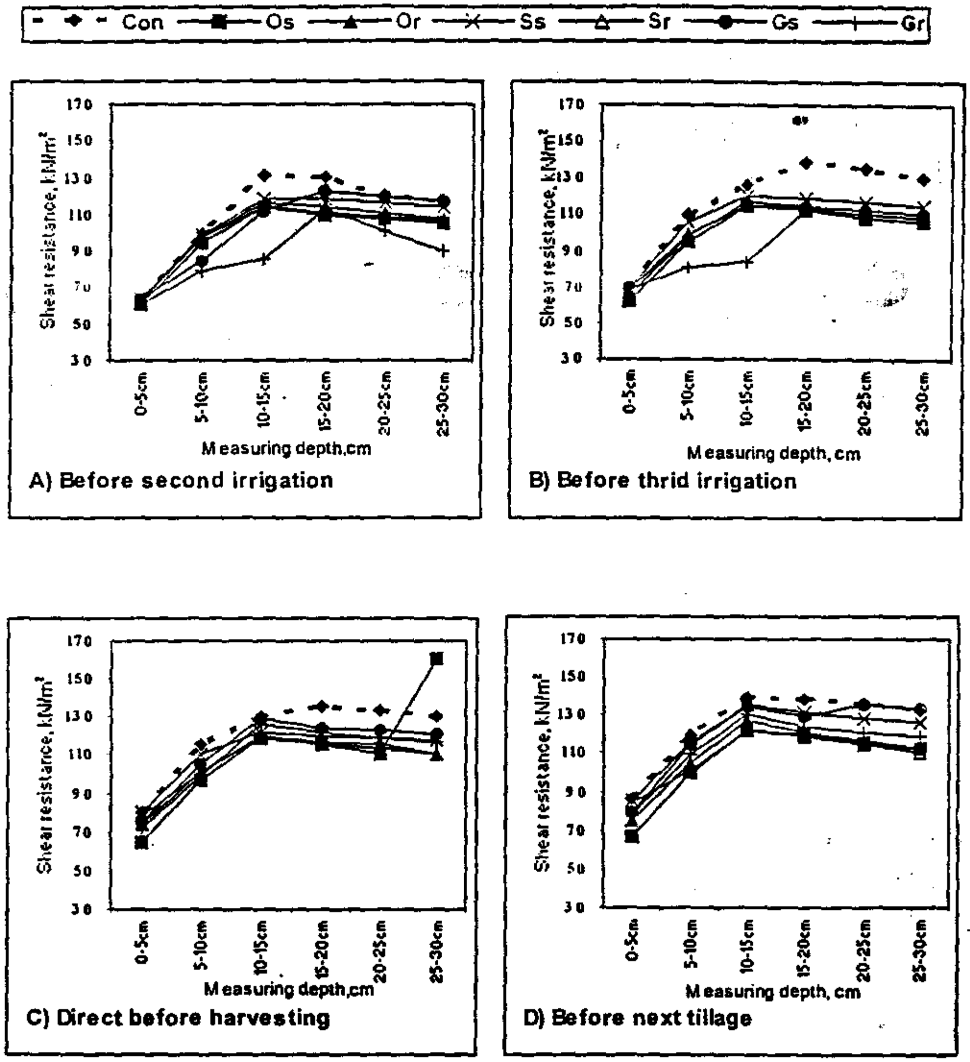


Fig (8) Soil shear resistance (kN./m^2) at different measuring times and depths as affected by the additions mixed by only once chiseling.

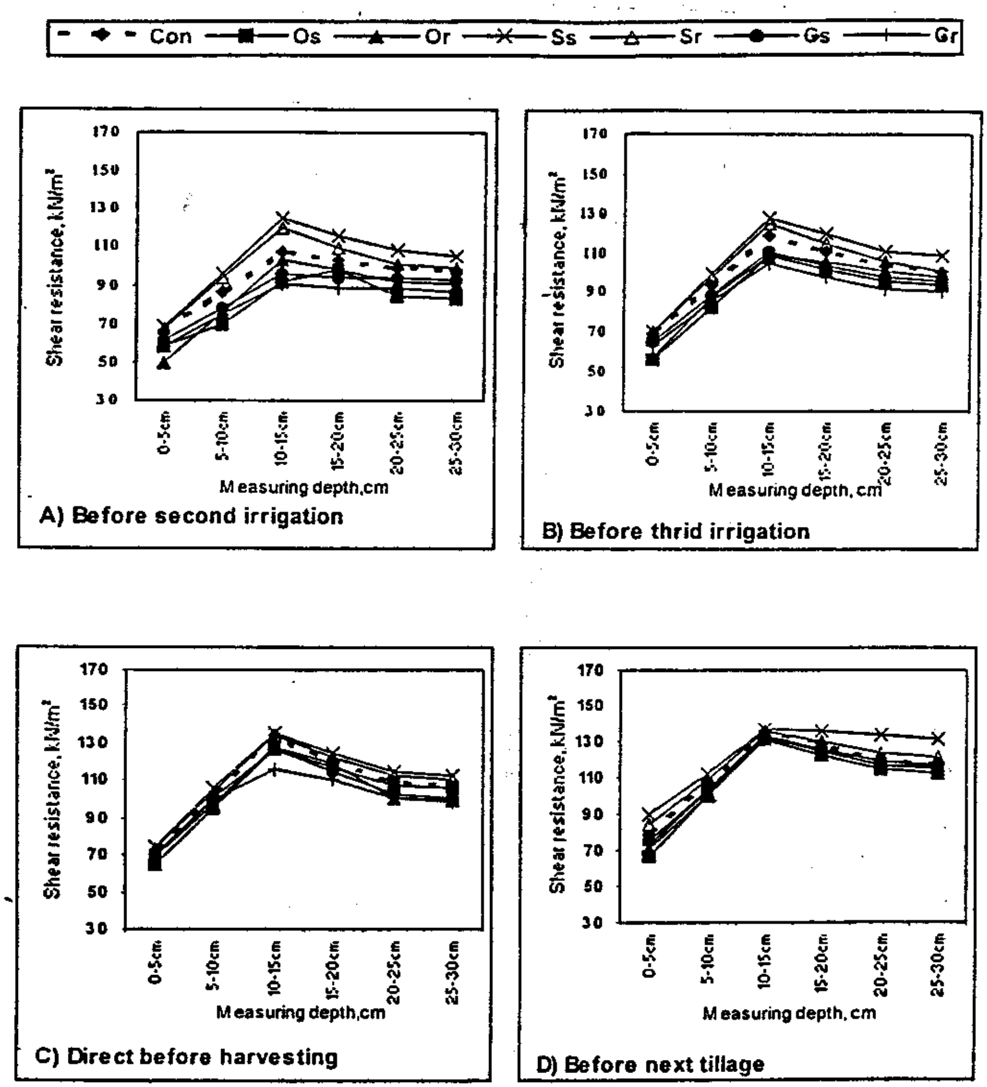


Fig (9) Soil shear resistance (kN/m^2) at different measuring times and depths as affected by the additions mixed by twice chiseling.

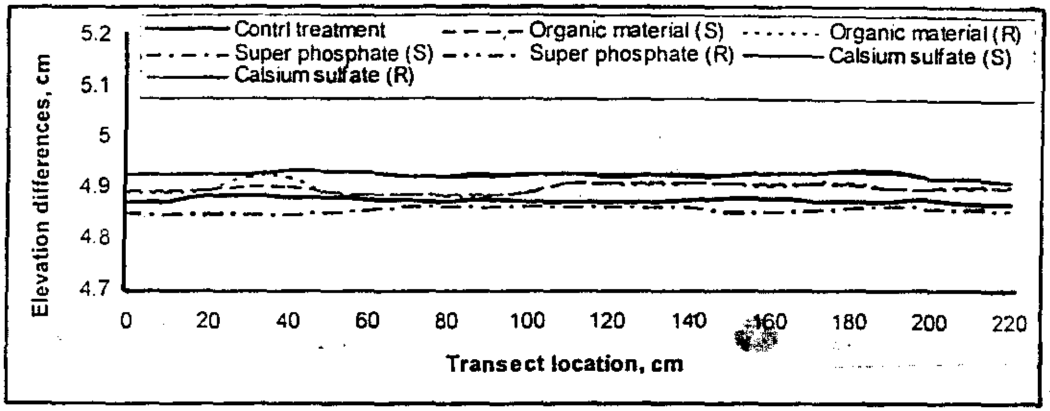


Fig (10) The typical soil profiles measured after maize harvesting as affected by the tested addition under the 1st mixing-method.

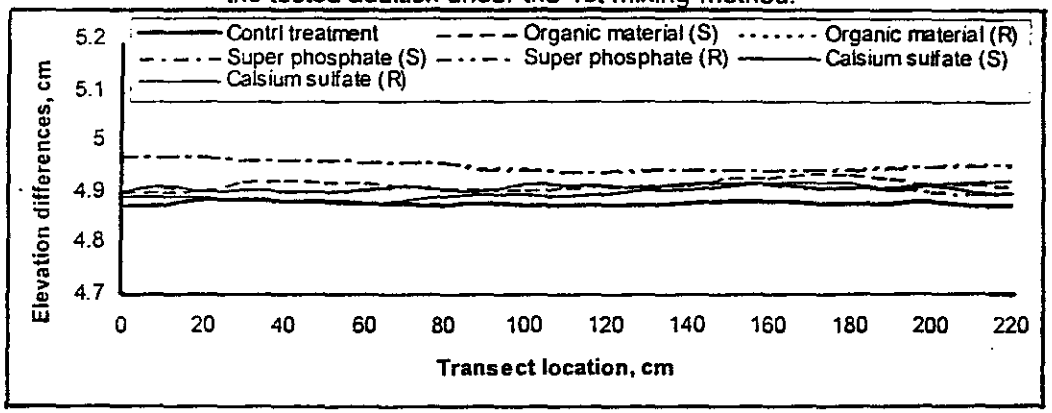


Fig (11) The typical soil profiles measured after maize harvesting as affected by the tested addition under the 2nd mixing-method.

Table (3) Average soil roughness (R%) resulted from the tested addition treatments.

Addition Treatment		Mix-Method (1)			Mix-Method (2)		
		Soil leveling accuracy L.C.%	Soil roughness R%	Change in soil roughness %	Soil leveling accuracy L.C.%	Soil roughness R%	Change in soil roughness %
Organic	Os	79.57	20.43	67.83	84.02	15.98	74.83
	Or	81.00	19.00	70.08	86.16	13.84	78.20
Calcium Sulfate	Gs	78.36	21.64	65.92	79.98	20.02	68.47
	Gr	69.14	30.86	51.40	76.79	23.21	63.45
Super Phosphate	Ss	77.81	22.19	65.06	78.91	21.09	66.78
	Sr	77.20	22.80	64.09	77.71	22.29	64.9
Control		70.0	30.0	52.76	77.59	22.41	22.41

It could be easily noticed that calcium sulfate accomplished the lowest changes in soil roughness (51 %). With the 1st chiseling mixing method, the soil pattern leveling accuracy were 80, 74, and 78 %, for the organic, calcium sulfate, and calcium super phosphate additions, respectively. These above shown values were 85, 78, and 78 % when replacing with mixing by chiseling once compared with chiseling twice.

4-2 Evaluation The Tractor-Plow Performances: -

A- Draught force evaluation (D):

From data in Tables 4 and 5 it can be noticed that, the highest draught (D) values, were recorded when the tractor-plow combination was operated on the datum soil pattern. That followed by operating on the soil treated by gypsum. Then, the soil treated by Super Phosphate addition. At the end the organic pattern came as the lowest draught pattern. Comparing between the tested additions, and the control on the base of the collecting draught force data, it can be stated that average draught reduction rates were 18.7, 16.4 and 10.1 % for organic, Super Phosphate and gypsum respectively.

Table 4: The effect of the investigated parameters on the tractor-plow performance as the addition mixed by 1st Mix - Method.

Parameters			Field performance			Draft	Draw	Actual	Specific
Addition type	dose	Missed gear	speed (m/s)	Filed capacity (Fed/h)	Slip %	force (kN)	bar power (kW)	fuel cons. (L/h)	fuel cons. (L/kW.h)
Organic	Os	2nd	0.61	0.92	8.80	29.55	17.73	7.15	0.40
		3nd	0.69	1.04	9.20	29.85	20.30	7.25	0.36
	Or	2nd	0.60	0.90	9.00	29.65	17.80	7.65	0.43
		3nd	0.68	1.02	9.50	29.95	20.40	7.95	0.39
Gip sum	Gs	2 nd	0.56	0.83	10.00	30.02	18.00	8.25	0.46
		3 nd	0.61	0.92	11.00	30.25	20.60	8.50	0.41
	Gr	2 nd	0.59	0.88	9.50	30.65	18.40	8.49	0.46
		3 nd	0.65	0.98	10.30	30.95	21.10	8.69	0.41
Super	Ss	2 nd	0.52	0.78	10.50	30.15	18.10	8.10	0.45
		3 nd	0.56	0.83	11.90	30.65	20.80	8.25	0.40
	Sr	2 nd	0.58	0.88	9.50	30.47	18.30	8.50	0.46
		3 nd	0.66	1.00	9.90	30.45	20.50	8.65	0.42
CONTROL		2 nd	0.49	0.74	11.50	30.69	18.40	8.60	0.47
		3 nd	0.56	0.83	12.40	30.99	21.10	9.10	0.43

B- Evaluation the slip (SL%) and work rate performance:

The slip data are also plotted in Tables 4 and 5. The data was collected when the tractor was running at two different gears settings and constant fuel throttle. It can be seen that operating on the soil treated with organic additions exhibited the lowest average of slip (8.4 %). While the average slip data were 9.8, 10.1 and 11.5 % when operating on the soil of gypsum, super phosphate and control treatments respectively. Comparing the slip data with respect to the addition mixing method, it can be noticed that, a slip % reduction ranges from 0.5 to 2 % in favor of chiseling twice mixing method. The highest slip value was about 12.4 % at the control treatment at forward peed 0.56 m/s (2.0 km/h). The lowest slippage 7.9% was recorded by Os addition at speed of 0.8 m/s (2.88 km/h). It can be stated that the same tractor type can do the work at faster forward speed (by about 31 %), with lower slip (by about 4.5 %), if the soil pattern was treated by 40 m^3/fed of organic manure.

Table 5: The effect of the investigated parameters on the tractor-plow performance as the addition mixed by 2nd Mix - Method.

Parameters			Field performance			Draft	Draw	Actual	Specific
Addition type	Dose	Missed gear	speed (m/s)	Filed capacity (Fed/h)	Slip %	force (kN)	bar power (kW)	fuel cons. (L/h)	fuel cons. (L/kW.h)
Organic	Os	2nd	0.70	1.05	7.90	29.25	19.60	7.10	0.36
		3nd	0.80	1.20	8.00	29.95	21.86	7.80	0.35
	Or	2nd	0.68	1.02	8.30	29.75	19.93	8.15	0.41
		3nd	0.74	1.10	9.20	30.10	21.97	8.25	0.38
Gip sum	Gs	2 nd	0.65	0.90	9.50	30.41	20.10	8.52	0.42
		3 nd	0.71	1.10	8.50	30.75	22.45	8.79	0.39
	Gr	2 nd	0.66	1.00	8.60	30.65	20.54	8.20	0.40
		3 nd	0.72	1.10	9.50	30.95	22.59	8.52	0.38
Super	Ss	2 nd	0.58	0.90	9.80	30.78	20.62	8.40	0.41
		3 nd	0.69	1.04	9.90	31.45	22.96	8.50	0.37
	Sr	2 nd	0.63	0.94	9.40	30.25	20.27	8.49	0.42
		3 nd	0.74	1.10	9.70	30.95	22.59	8.55	0.38
CONTROL		2 nd	0.63	0.84	10.65	31.00	20.77	8.94	0.43
		3 nd	0.65	0.93	11.25	31.95	23.32	9.33	0.40

The actual field capacity (work rate) was by multiplying the plough width by the actual speed. In general, it can be seen that, operating at a soil treated with organic manure gave the highest work rate performance 1.2 Fed/h compared to 1.1, 1.04 and 0.932 Fed/h for gypsum, super phosphate and the control treatments respectively.

Moreover, from these tables, it can be easily noticed that, higher field capacity was recorded in favor of mixing twice method by about 19.5 % (0.25 Fed./h), when compared to mixing once method.

C- Evaluation the fuel consumption:

Data in Tables 4 and 5 show the effects of the tested treatments on fuel consumption rates (L/h). These effects were highly differ according to the type of addition, than with respect to the speed level. For example, a fuel consumption reduction of about 10.4 % was obtained, when comparing the fuel consumption rates associated with the suggested dose, and the datum treatments at high speed missing. While the fuel consumption reduction was about 9 % by decreasing the speed from 0.8 to 0.7 m/s in the organic treatment.

It can be seen also that the organic manure addition achieved the lowest specific fuel consumption values followed by the gypsum, came at the end the Super Phosphate addition. The exhibited average specific fuel consumption reduction were 12.1, 9.2 and 7.2 % compared to the control treatments (soil without addition).

5. CONCLUSION

Adding organic, or super-phosphate, or calcium-sulfate materials were assumed methods to achieve soil resistance weaken. Hence the aim of percent work was to illustrate the effects of these materials on specific resistance of soil. In the same time some agricultural machinery power and work rate performances were deduced on the resulted soil platforms. The degree of soil weakness was evaluated through subsequent periodical measurements for the soil surface layer (0-30 cm). While the machinery performance improvement were tested through evaluating slippage, work rates (fed/hour), specific fuel consumption (L/kWh), draught force (KN.), and power requirements (kW).

The gained results could be summarized in the following points:-

At any measuring time and depth both tested dose of the organic, or calcium super phosphate additions, caused weaken in both soil penetration and shear resistance when compared to the control treatment (without addition). The reduction rates reached about 21% in penetration, and 13% in soil shear resistance. Inverse trend was accomplished the Gypsum addition, whereas, these resistance were increased by about 10%.

The weak in the soil resistance due to the mixing method was by about 3-5%, in favor of the two chiseling mixing method less than the only once chiseling mixing method

Operating the tractor-plow combination at a soil pattern reveled from the organic manure coincided the highest work rate performance 1. 2 Fed/hr versus 1.1, 1.04, and 0.932 Fed/hr for Gypsum, super phosphate, and the control treatments respectively. Also, higher field capacity by about 19.5% (0.25 fed/h), was recorded in favor mixing method two by about when compared to the first mixing method .

The same tractor type can do the work at faster forward speed by about 31%, with lower slip by about 4.5% if the soil pattern was treated by organic manure dose of 40 m^3 /fed .

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الملخص العربي

تأثير إضافة المواد العضوية والكيمانية على أداء آلات الحرث

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يهدف هذا البحث إلى دراسة تأثير إضافة بعض المركبات العضوية والكيمانية على المقاومة النوعية للتربة ودراسة مدى تأثير تلك الإضافات على خواص التربة وبالتالي على أداء الجرار والمحراث لاتمام عملية الحرث الأولى للتربة وكذلك على قوى الجر واستهلاك وقود الجرار.

وقد تم إجراء التجارب الحقلية بمنطقة السنبلاوين بمحافظة الدقهلية وكانت معاملات الدراسة:

- المواد المضافة: تم إضافة المادة العضوية (٣٠، ٤٠ م^{3}/ف) سلفات الكالسيوم (جبس زراعى) (٤، ٥ طن/ف)، سوبر فوسفات الكالسيوم (٣٠٠ - ٥٠٠ كجم/ف)
- طريقة الخلط: حيث تم استخدام معاملتين أحدهم عن طريق الحرث مرة واحدة بالمحراث الحفار والثانية عن طريق الحرث بالمحراث الحفار مرتين متعامدتين.

أهم النتائج المتحصل عليها:

- إضافة السماد البلدى للتربة أدى إلى انخفاض ملحوظ فى مقاومتى التربة للاختراق والقص بمعدلات تتراوح ١٠ ؛ ٢٠ ٪ أثناء موسم النمو ووقت الحصاد. كما أدى إلى انخفاض قوى الجر ونسبة انزلاق عجلات الجرار واستهلاك الوقود بمعدلات ٧,٢ ؛ ٣،١ ؛ ١٨،١ ٪ على الترتيب مقارنة بالمعاملة بدون إضافات.
- خلط الإضافات بالتربة باستخدام المحراث الحفار مرتين (متعامدتين) أدى إلى زيادة فى معدلات أداء الآلات الزراعية بالمقارنة باستخدام المحراث الحفار مرة واحدة.
- إجراء عملية الحرث لحقل مضاف إلية السماد البلدى فى الموسم السابق بمعدل ٤٠م^{3}/فدان أدى إلى زيادة سرعة الجرار بنسبة ٣١٪ وكذلك انخفاض فى معدل انزلاق عجلاتة بنسبة ٤,٥ ٪ وذلك مقارنة بحرث الحقل بدون إضافة.

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