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SOIL RESPONSE TO TILLAGE TREATMENTS

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ABSTRACT

Soil structure is an important measure of soil quantity that is significantly affected by tillage systems. The investigation was carried out on the suggested system of tillage to get the best soil structure for achieving a high production. To fulfill this aim, five tillage systems were investigated. The combination between the primary tillage, (moldboard plow, 20 cm in depth; chisel plow, 20 cm; disk plow, 10 cm; disk harrow, 10 cm and control without tillage), and two secondary tillages (disk harrow followed with rotary and control) as tillage systems are identify. Clod size distribution, main weight diameter, soil roughness, tillage degree, soil resistance, soil shearing, bulk density, and mechanical measurements such as rolling resistance, slippage, draft and fuel consumption were measured as independent variable. The results indicated that, the soil surface after using moldboard plow or disk plow were more response to pulverization. The lowest mean weight diameter (34.81 mm) was recorded at “disk harrow” followed with rotary. Increasing the mean weight diameter (MWD) increased the soil roughness. Moreover, decreasing the “MWD” values because of increasing soil pulverization consequently increases the number of impacts and then decreases the penetration values. Bulk density, rolling resistance, slippage, and draft were affected by tillage systems.

INTRODUCTION

Tillage operations for seedbed preparation are often classified as primary or secondary tillage operations although the distinction is not always straightforward. It is carried out for many objectives; the most important one is to improve the soil physical properties that are beneficial to the growth of plants. Primary tillage consumes about 50 % of the power used for all production and harvesting operation. Different types of tillage tool are used for preparing the soil, such as chisel, moldboard disk, and rotary plows. In Egypt the chisel plow is locally manufactured and is widely used for preparing the soil for different crops (Korayem *et al*., 1985). About 5-6 billion tons of soil covering about 6 million feddans in Egypt are tilled 4-8 times each crop rotation per year. This would in fact turn about 24-48 billion tons of soil and consume 5×10^{12} litter of diesel oil (El-Sheikha, 1989). The land preparation for rice in Egypt is carried out by tillage with a chisel plow twice and wet leveling which gave low rate of yield / fed compared with other methods used by El-Serafy (1986).

Abo-Habaga (1992) reported that the suitable seedbed for using the drill machine must contain different aggregate size having diameters, not greater than 50 mm. The percentage of greater aggregates (ϕ 20-50 mm) and likewise the small aggregates (ϕ < 2 m) must be kept to a minimum value of total aggregates. The effect of tillage on surface roughness was studied by Romkens and Wang *et al*. (1986).

The amount of energy required to produce a given degree of pulverization depends primarily upon the soil strength and the energy utilization efficiency of the implement. Soil strength is related to the nature of the soil and to its physical condition (El-Banna *et al*., 1987). Clay soils need higher breakup-energy requirements than sandy soils. Loams, climate, cropping practices, cultural practices, and other factors influence the soil physical condition. Depth of cut, width of cut, tool shape, tool arrangement, and travel speed are factors that may affect draft and the energy utilization efficiency for a specific soil condition. Kenneth (1977) reported that the energy requirement is a function of the draft of the implement. The draft of plow is commonly expressed as units of weight per units of area of furrow cross-section. The draft is extremely variable from one place to another and on a same place from year to year.

The objectives of this study were to evaluate the performance of five methods of primary and two of secondary tillage systems. The evaluation includes tillage quality, some of soil physical properties and mechanical performance for primary tillage implements. Draft force, fuel consumption were conducted as mechanical performance.

MATERIALS AND METHODS

The experiment was carried out in Sakha research farm (Kafr El-Sheikh Governorate) at the summer season (May 1990). Clover was the previous crop. The land preparation for clover was done by chisel twice in the two directions and then disked and dry leveling. The strip-split plot design was used to evaluate the factors affecting the different parameters as soil physical properties. The five primary and two secondary tillage operations were first arranged according to a strip plot design. Then each of the 10 plots at three replicates was divided into subplots. The primary tillage operations as the main factor done in one direction for one trip and included five operations in every replicate as main factors. The moldboard plow (20 cm in depth) “M”, chisel plow (20 cm) “C”, disk plow (20 cm) “dp”, disk harrow (10 cm) “dh” and without primary tillage “Non” were considered as primary tillage operation. The secondary tillage operations were done in the perpendicular directions as subplot treatments. The offset disk harrow two trips (10 cm depth) followed with rotary (10 cm depth) “d2-r” were considered as secondary tillage operation.

The penetration (compaction) and shear of soil, and bulk density were measured during harvesting time, after sowing with 6 days for depth (0-10 cm). The measurement after primary tillage was infiltration rate and tillage degree, while the clod size; mean weight diameter and soil roughness was measured after secondary tillage. All experiments were conducted to study the effect of different combinations of secondary and primary tillage factors on the soil mechanical and physical properties.

The clods sizes were measured by traditional method. The sieves have holes with different diameter (100 – 75 – 50 – 25 – 19 – 12.5 mm). The sample were taken from three different locations secondary tillage within 3 days in each tillage system, the mean weight diameter (MWD) of the soil clods was calculated using the following equation:

$$MWD = \frac{W_1\ S_1 + W_2\ S_2 + \dots\dots\dots + W_n\ S_n}{W_1\ + W_2 + \dots\dots\dots + W_n} \quad (1)$$

Where:

W_1, W_2, ….. W_n = Weight of soil above each sieve.

S_1, S_2, …….. S_n = Medium of size range for each sieve.

n = Number of observations.

A reliefmeter apparatus is used to measure the soil surface profile along a line perpendicular to the plowing travel after secondary tillage operations. The reliefmeter was 150 cm in length. Soil profile was measured according to Gaheen *et al*. (1978). While the soil surface roughness (SR%) was measured by the following equation:

$$SR = 100 \log \delta$$

The standard deviations (δ, cm) were estimated according the following equation:

$$\delta^2 = \frac{\sum (x - \bar{x})^2}{n}$$

Where:

$\bar{x}$ = The average treatment of observation number, cm

x = The value of observation, cm

The compaction was carried out by using an impact penetrometer types (Singh, 1967), before primary tillage and after seeding with 6 days.

A torque wrench and a wing borer according to (Singh, 1967) measured the shearing resistance of the soil. The shear strength of the soil could be determined by using the following equation:

$$T = \pi T_f \left(\frac{d^2 H}{2} + \frac{d^3}{6}\right)$$

Where:

T = The torque at failure, kg. cm,

T_f = The unit shear strength of the soil, kg/cm^2,

H = The height of van, cm,

d = Diameter of van, cm.

The bulk density was determined by using the traditional methods, while the percentage of slippage can be determined as follows:

$$S = \frac{(V_1 - V_2)}{V_1} \times 100$$

Where:

S = Slippage percentage, %,

V_1 = Forward speed without load, m/sec,

V_2 = Forward speed with load, m/sec.

The draft force was measured by using two tractors and a calibrated hydraulic force dynamometer (5000 kg) by (Ismail,1980). The specific draft was calculated by the following equations:-

$$\sin\theta = \frac{Y_1 - Y_2}{L}$$

Where:

θ = Angle of inclination of line of pull,

Y_1 = Height of the front tractors drawbar above the soil surface,

Y_2 = Height of the hitching point of the rear tractor above the soil surface,

L = The length of chain and dynamometer.

Then; the draft can be calculated as follows:-

$$D = P \times \cos\theta$$

Where:

D = Draft force,

P = Pulling force along the chain, the dynamometer reading.

The fuel consumption per unit time or unit area can be worked out as follows:

$$F.C_t = \frac{F}{t} \qquad \text{and} \qquad F.C_a = \frac{F}{a}$$

Where:

$F.C_t$ = the fuel consumption rate per unit time,

$F.C_a$ = the fuel consumption rate per unit area,

F = the quantity of fuel consumed throughout the work,

t = Time of work,

a = The plowing area.

The data of this paper was provided from the "M. Sc." of “Mechanization of seedbed preparation and planting of rice crop”. Whose supervisor is Prof. Dr. Ismail, (1994).

RESULTS AND DISCUSSION

The quality of tillage may be judged by measuring the soil mechanical properties such as clod size distribution (CS %), mean weight diameter (MWD), soil roughness (SR %) and tillage degree.

1- Clod Size Distribution:

The relation between the tillage systems and the distribution of clod sizes were illustrated in Fig. (1). At using the moldboard plow (m), as primary tillage operation, the data indicated that the maximum percentage "54.1%" of clod size more than 100 mm was recorded for “m-no” tillage system. But using disk twice followed with rotary “dh- d2r” recorded the best situation of soil pulverization (the distribution tend to normal distribution) because it gave the minimum of the clod size > 100 mm (9.1 %). It is easy to note that the decrease of the percentage of clod size categories > 100 and (75-100 mm) increase of clod size categories < 12.5 and (12.5-19 mm). Generally, the differences between clod size percentages for tillage treatments (m, C and dp) were clearly decreased after using "d2r", as secondary tillage systems.

It may be concluded that the land after using moldboard plow or disk plow were more response to pulverization by different systems of secondary tillage compared with chisel plow (C) (Fig. 1-A). The secondary tillage treatments "d2r" recorded 4.3 % of clod size > 100 mm at using the (dh) as a primary tillage (Fig.1-B).

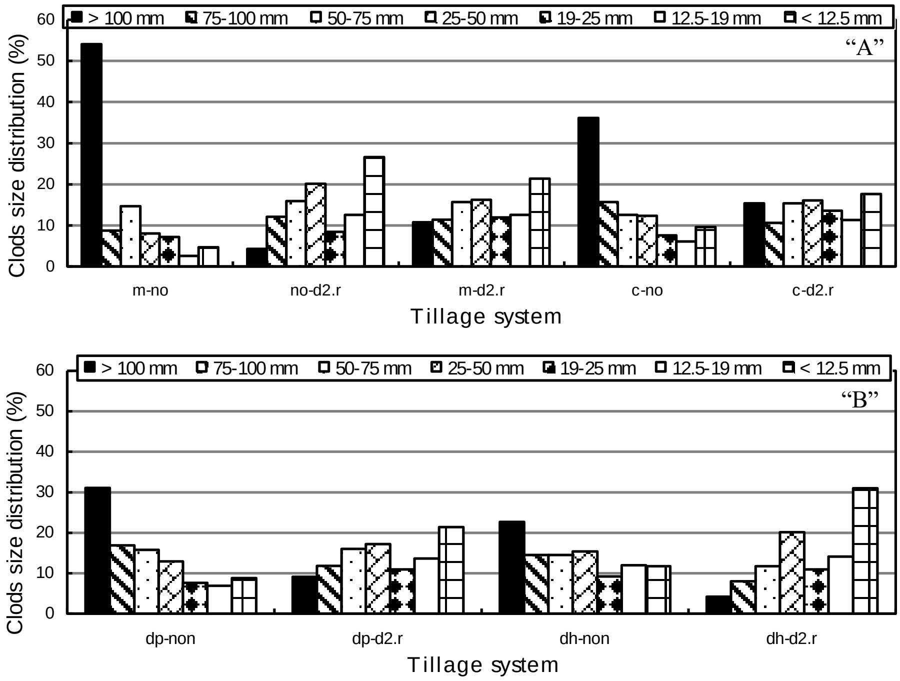


Fig. 1: Clods size distribution as affected by different tillage systems (m).

2- Mean Weight Diameters (MWD):

Data in Fig. (2) showed that the lowest mean weight diameter (34.81 mm) was recorded at "dh-d$_2$r", while the tillage system "m-non" recorded the maximum of mean weight diameter (103.31 mm) but, the "c-d$_2$r"; "dp-d$_2$r" and "non-d$_2$r" tillage systems recorded 54.04, 46.41, and 40.09 mm of mean weight diameter (MWD) respectively.

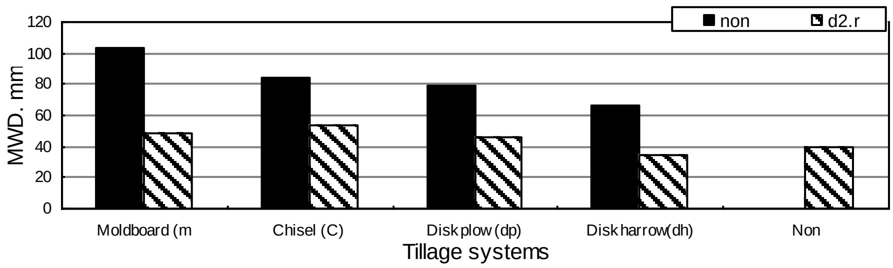


Fig. 2: Mean weight diameter for different tillage systems.

Generally, using the secondary tillage operations lead to decrease the "MWD". For example the "MWD" decreased from 103.31 mm to 48.12 mm as a result of using disk harrow two trips followed with rotary "r" instead of "non" with constant primary tillage (moldboard plow). The analysis of variance for data of "MWD" for primary and secondary tillage factors were highly significant. But the secondary tillage factors were more effective on the "MWD".

3- Soil Roughness:

The effects of tillage systems on the soil surface profile were illustrated in Fig. (3). From figure, the results showed that the "m-non" tillage system left soil surface very rough (SR = 89.8%) while, soil roughness (SR%) redacted to 80.29% after "c-non" tillage system. This may be due to the clod size on the soil surface; at "m-non" tillage system produces the greatest number of aggregates large than 100 mm. The effects of using the "d2r" as secondary tillage on (SR %) are great at "c" than at "dp".

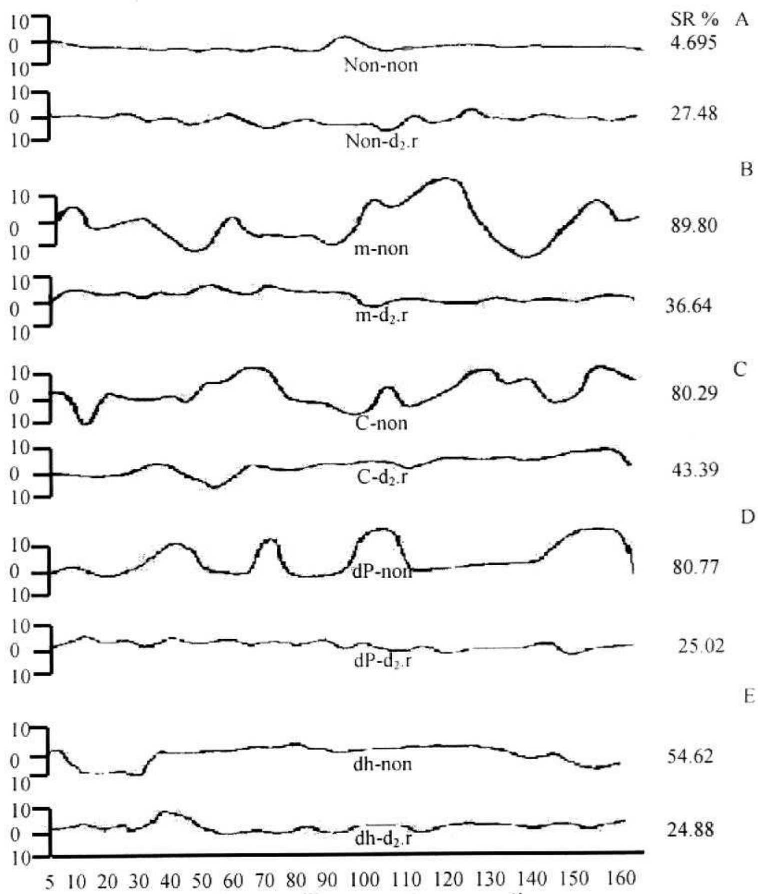
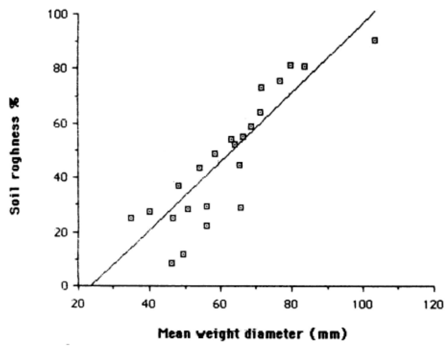


**Fig 3: The effect of different tillage systems on the soil surface profileat:
A: Non-primary tillage B: Moldboard plow C: Chisel plow
D: Disk plow E: Disk harrow**

The relationship between soil surface roughness and mean weight diameter is illustrated in Fig. (4). Generally, increasing the mean weight diameter increases the soil roughness. For example increasing the mean weight diameter from 60 to 80 mm increases the soil roughness "SR %" by 1.54 time.

The best fitted curve for the relationship between clod sizes and soil roughness is illustrated in Fig. (5). It is observed that the large size of clod > 100 mm had a bad effect on soil roughness, but the small size < 12.5 mm had the opposite effect on the soil roughness.



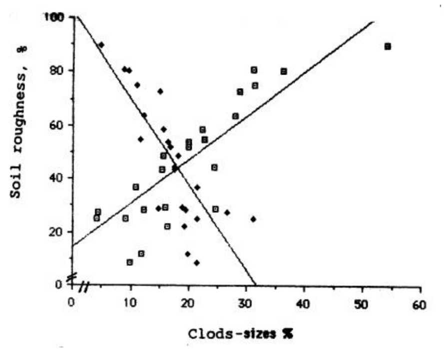


Fig. 4: The effect of mean weight diameter on soil roughness.
SR = -29.3878 + 1.2518 MWD
R^2 = 0.81

Fig. 5: The effect of mean clods sizes on soil roughness.
SR = 14.4705 +1.6386CS R^2 = 0.78 □ > 100mm
SR = 101.834 - 3.2178CS R^2 = 0.78 ◆ < 12.5mm

4- Soil Resistance:

The term of soil resistance is important for describing their susceptibility to apple pressure from farm machinery and tillage system. It could be divided into soil penetration (compaction) and soil shearing.

4-1- The soil penetration:

The soil resistance is illustrated in Fig. (6) for all treatments 6 days later from sowing. Generally, the experimental results of all tillage systems showed an increase in the penetration resistance with the increase in soil depth. The soil penetration recorded (14 impacts) the highest values with the "d2h" of secondary tillage systems. While the lowest values of resistance of penetration recorded 6 impacts at constant, chisel-plow with "non" as secondary tillage system. Moreover, decreasing the "MWD" values because of increasing soil pulverization (non – d1 – d2 – d2h – d2r) increases number of impacts and then decreases the penetration values. These results agreement with Chaplin *et al* (1986); Abo-Habaga (1992) and Saffan (1975).

4-2- Torque required for soil shearing:

The values of torque (N.m) required shearing soil at depths (0-10 cm) and at 6 days later from sowing. Moreover, during harvesting time for all the treatments under this study, the soil shearing was recorded 38.1 N.m, 38.8 N.m, 39.8 N.m, 41.6 N.m and 40.5 N.m for tillage systems "m-d2r", "c-d2r", "dp-d2r", "dh-d2r" and "Non-d2r" respectively as indicated in Fig. (7) after sowing with 6 days. But it recorded the highest values of torque required to shear soil in case of non-non (42.4 N.m) during harvesting time the system non-non (Fig. 7) recorded the highest values of torque required to shear the soil and the values of torque increases with increasing the secondary tillage action.

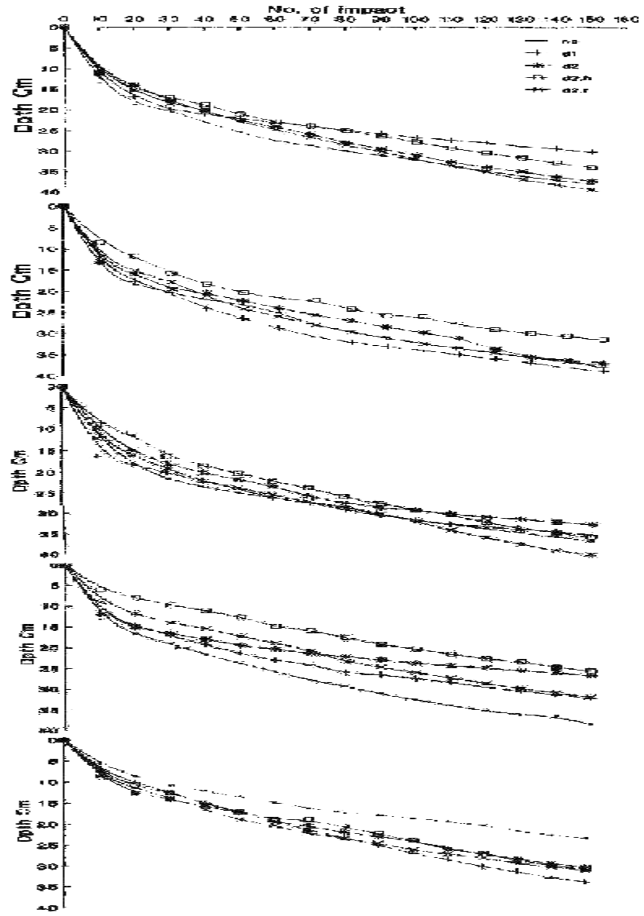


Fig 6: The soil penetration as affected by tillage systems at:
A: Non-primary tillage B: Moldboard plow C: Chisel plow D: Disk plow E: Disk harrow

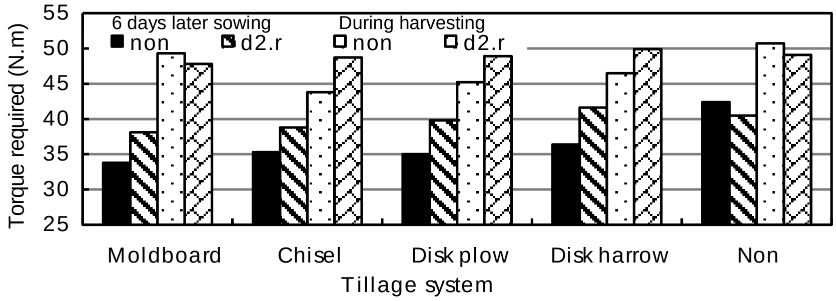


Fig. 7: The relationship between the tillage systems and the values of torque to shear soil at 6 days later from sowing and at harvesting time.

5- Bulk Density:

The bulk density was 1.30 g/cm^3 before carrying out the primary tillage operations but after sowing with 6 days, the bulk density tended to decrease more to reach 1.05 g/cm^3; 1.06 g/cm^3; 1.07 g/cm^3 and 1.15 g/cm^3 with the systems “m-non, c-non, dp-non and dh-non” respectively (Fig. 8). Whereas, it is shown that the differences in bulk density values is not clear in the harvesting time which were 1.33; 1.32; 1.34 and 1.34 g/cm^3 with the systems “m-d_2r”; “c-d_2r”; “dp-d_2r” and “dh-d_2r” respectively as shown in Fig. (8). Its clear that the bulk density is going to be higher and it may be related to the system used in irrigation as low land rice.

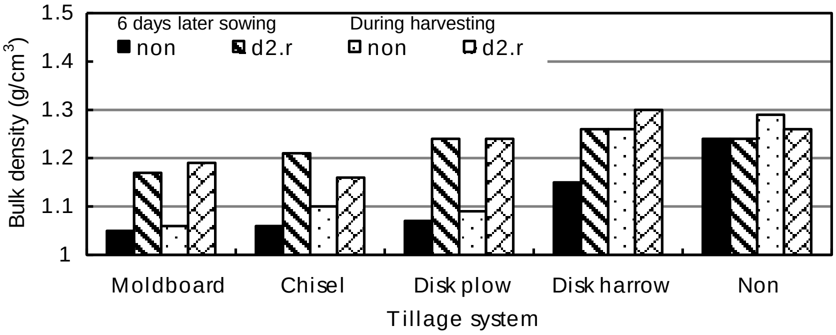


Fig. 8: The effect of tillage systems on the bulk density at 6 days from sowing and at harvesting time.

6- Mechanical Measurements:

The draft (kg$_f$) was determined and the data as shown in table (1) that “m”; “c”; “dp” and “dh” implements required 2361; 1723; 1610 and 1883 kg to be pulled respectively and the corresponding slippage were 14.2 %; 10.3 %; 8.7 % and 11.5 %. On the other hand, the corresponding rolling resistance (kg) was 253; 241; 225 and 298 kg respectively. The chisel plow recorded the lowest specific draft 0.448 kg/cm^2 whereas the moldboard recorded 0.894 kg/cm^2 as the maximum. On the other hand, “dp” and “dh” recorded 0.719 and 0.553 kg/cm^2 respectively.

Table 1: Mechanical measurements.

Measurements / Primary tillage Implements	Rolling resistance (kg)	Slippage (%)	Draft (kg$_f$)	S. draft (Kg/cm^2)	Fuel cons. (L/hr)	Fuel cons. (L/fed.)	Field capacity (fed./hr)	Width of cut (cm)
Moldboard plow “m”	253	14.2	2361	0.894	19.2	18.28	1.05	132
Chisel plow “c”	241	10.3	1723	0.448	15.4	9.57	1.61	192
Disk plow “dp”	225	8.7	1610	0.719	13.7	16.17	0.847	112
Offest disk harrow “dh”	298	11.5	1883	0.553	18.1	6.41	2.82	340

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إستجابة التربة لمعاملات الحرث

زكريا إبراهيم إسماعيل
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إن إتباع نظام للحرث يؤثر بشكل ملحوظ على بناء التربة، هذا البناء يؤثر بدوره على الإنتاج، لذلك تناول البحث خمس نظم خرث مختلفة وتوليفات تجمع بين الحرث الإبتدائى والحرث الثانوى، وتوصل الباحث إلى أن أهم المعاملات التى تؤثر على جودة الحرث ترجع إلى إنتظام جيد لسطح التربة (SR)، وحجم حبيبات يتراوح من ١٢,٩ إلى ١٩ مم يتحقق مع نظم حرث بإستخدام المحراث القرصي وجهين يتبعه المحراث الدورانى. كما أن متطلبات القدرة لكل نظام حرث مرتبط أيضاً بالمقاومة النوعية والكثافة الظاهرية وكذلك معامل التدحرج والإنزلاق. حيث كانت فى ظروف التجربة عبارة عن ٠,٨٩، ٠,٤٤، ٠,٧١، ٠,٥٥ كجم/سم[٢] عند نظم حرث على الترتيب محراث قلاب مطرحى، محراث حفار، محراث قرصى، محراث دورانى.