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RESEARCH ARTICLE
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Performance of heavy disc harrow offset in medium texture soil.

Ahmed Abd Ali Hamid
Department of Dormitories Affairs - University of Baghdad., Baghdad, IRAQ.
*Corresponding Author: ahmed.hamid@uobaghdad.edu.iq.

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ABSTRACT

Factorial experiment carried out in 2024 in southern Baghdad, for the aim of evaluation the performance of heavy disc harrow offset with tractor engine 120 horse power under different moisture soil (14 % and 8 %), depth of pulverization (8 and15 cm) speed of tractor (4.7 and 8.2 km.h^{-1}) in medium texture soil which was silty clay loam, after soil tilted at 20 cm by used moldboard plow width 1.05 cm as a primary tillage. Pulverization the soil under moisture 8 % gave higher (best) soil pulverization rate was 70.49 %, productivity 1.5824 ha.h^{-1}, specific productivity 5273 m.h^{-1}, least number of clods < 0.05 was 7.83 clods.m^{-2} and fuel consumption 12.40 L. ha^{-1}. Depth pulverization 8 cm gave on the best pulverization soil rate 71.51 %, number of clods < 0.05 was 5.08 clods.m^{-2}, productivity 1.5992 ha.h^{-1} and least fuel consumption 12.04 L. ha^{-1}. Speed of the tractor8.2 km.h^{-1} gave better soil pulverization rate 70.57 %, productivity 2.0151 ha.h^{-1}, specific productivity 6715 m.h^{-1}, least number of clods< 0.05 was 7 clods.m^{-2} and fuel consumption 11.81 L. ha^{-1}. All interaction among the treatments was significant difference. Correlation were direct and inverse, significantly and non-significant. Concluded the most effected factors in the study was tractor speed then depth of tillage and both of them more than influent from moisture of soil, pulverization soil at low moisture level 8 % and used higher speed tractor 8.2 km.h^{-1} and pulverize depth 8 cm gave a better results comparing with the rest of the factors in this field experiment.

***Keywords*:** Disc, Tractor, soil, fuel, pulverization rate.

INTRODUCTION

The agricultural tractor is a source of power in the field or farm and pulls various agricultural equipment or provide energy to the machine, in addition, decrease effort on the farmers. Secondary tillage is operation perform after primary tillage to prepare soil for planting or seeding. The disc harrow offset was done by a set rotating disc rotating in the ground when the harrow pulled a head. The disc harrow can have worked in the offset behind the tractor as an offset position; therefore, it was given this name. Offset disc harrow can have operated after primary tillage plows for pulverization soil and break up the clods, and addition, work in orchards near trees, also under limbs. Disc harrow offset is a double action disc, right gang pulverize the soil to the right, and the other left gang pulverize the soil to the left. In Iraqi agricultural soils, Researchers use one of the commonly used plows, which are the moldboard, disc and chisel, after that they use secondary tillage equipment such as disc harrow or others, finally, they planting or seeding [1] [2] [3] [4] [5], an addition, most of the farmers also use the same method in their fields.

The optimal operation of disc harrow depends on the shape, size and weight of the disc, operation speed, set depth, type of soil, moisture, density and amount of residue [6] [7]. [8] funded the number of colds < 5 cm was 6.66 clods.m^{-2} when used disc harrow under moisture soil 15-17% and speed of tractor 6.52 km.h^{-1}. [9] founded when used the disc harrow at depth 15 cm and New Holland tractor with horsepower 75 hp, that the fuel consumption was 31.98 L.h^{-1}. [10] founded in experiment for study disc harrowing and Massy Ferguson tractor with 111 horsepower engine, founded decreasing the fuel consumption and increasing the productivity when the speed increasing. [11] conclude that productivity of disc harrow increases to 25.41 % when tractor speed increase from 6.58 to 6.71 km.h^{-1}. [12] founded when used disc harrow at depth 10 cm that the soil pulverization rate was increased from 67.60 % to 71.18 % when speed of the tractor increase from 1.11 m. s^{-1} to 2.06 m. s^{-1}. [13] founded decreasing the fuel consumption when speed of the tractor increase, also concluded that the pulverization depth depends on the machine harrow setting, speed and machine load. [14] funded in two types of soil the productivity of disc harrow offset increased in silty loam soil 0.48 - 0.76 - 1.35 ha.h^{-1}, and 0.46 - 0.74 -1.15 in clay soil when speed tractor increase from 2.54 - 3.84 - 5.77 km.h^{-1}, respectively, also founded soil pulverization increasing with tractor speed increased. [15] noticed when used disc harrow offset that the number of clods < 0.05 in one-meter square was increased when depth increased, and clods were 13.41 and 12.09 clods.m^{-1} when operation done in winter and spring, respectively. Found many researchers [16] [17] [18] [19] [20] [21] that were some factors effected in fuel consumption, productivity, number of clod after operation and soil pulverization such as moisture of soil, depth, speed of the tractor, machine width and shape the parts which deal with the soil, soil texture and amount of residue in soil surface.

The aim of the research is to evaluate the performance of the machinery unit as a tractor and disc harrow offset under different moisture of soil, depth of pulverization and speed of the tractor by studying soil pulverization rate, number of clods > 5 cm, fuel consumption, productivity and specific productivity.

Material and Methods

Experiment sit

The field experiment was carried out in 2024 in southern Baghdad, 25 km far from the central of Baghdad, Iraq, with in coordinates Latitude 33.07908° N, Longitude 44.251662° E. According to climate classification by KÖPPEN, Iraq with in arid climate. The field area was 24000 m^2 (160 m long and 150 m wide) and 31.8 m above sea level. Factorial experimental design (RCBD) was used in this study. Eight random core samples were selected and analyzed from upper soil layer (depth 20 cm). The samples heated by using electric oven at 105° C for 24 hr (According to Black' method 1965), samples were dried and measured moisture content of the soil which was 17-19 % when tilled by moldboard plow on depth 20 cm, and bulk density was 1.43 $g.cm^{-3}$, soil texture was silt clay loam.

Tractor and equipment used in the experiment

Tractor: Massy Ferguson 4WD (driving type), water cooling system, four cylinder direct injection diesel engine with 120 hp (89.5 kW), displacement 4.4 L, bore/stroke (108×120 mm), rated speed 2200 rpm, torque 470.1 N.m, firing order 1-2-4-3, and oil engine capacity 15 L with dry air filter, fuel tank capacity 145 L, synchromesh type transmission with 12 forward and 4 reverse gear with oil gear capacity 45 L, hydraulic wet disc brake, hydrostatic power steering, tractor weight 4150 kg, standard tires 14.9-24 front and 18.4-34 rear, power take off (P.T.O) shaft speed 540 / 1000 rpm, tractor rear lift 3800 kg.

Moldboard plow: Three bottoms each one 350 mm wide, with a total width of 1050 mm, weight 305 kg, and made by General Company for Mechanical Industries- Ministry of Industry and Minerals- Republic of Iraq. The experiment field was tilted by the moldboard plow at a regulated depth of 200 mm and a tractor speed of 4 $km.h^{-1}$, then used disc harrow according to experiment design.

Disc harrow offset: NARDEEN heavy disc harrow offset with two gang and adjustable rigid scrapers made in Italy, 3 m width, two wheel-mounted with folding system for road transport, 12 front serrated edge discs with diameter 680 mm and 12 rear smooth edge discs with diameter 600 mm, distance between the discs 250 mm, disk thickness 6 mm, maximum depth 200 mm, gang angle (front 15˚ rear 25˚ and gang open out angle 50˚), power requirement 40 – 65 hp, height of the chassis from the ground 940 mm, frame dimensions 3600 × 2760× 2600 mm right, left and width respectively, weight 1780 kg (fig. 1).

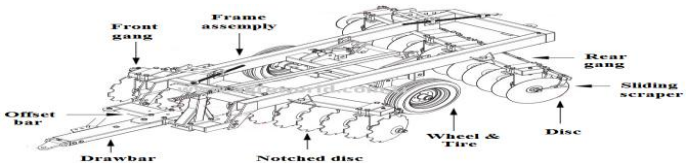

Fig. (1) Schematic heavy disc harrow offset.

Experiment design

Factorial experiment under Randomized Complete Block Design (RCBD) with three replications. Statistical Analysis System (SAS) software 9.2 was used. Means were compared at significant of 0.05 and 0.01 by used Least Significant Difference (L.S.D) method. Three factors sit in this experiment: Soil moisture (14 and 8 %), Depth of pulverization (8 and 15 cm) and speed of the tractor (4.7 and 8.2 $km.h^{-1}$). Eight treatment with 3 replication for each one, the treatments total was 24 treatments (2×2×2×3 replications = 24 treatments). Long treatment was 30 m, width 3 m and left a distance between treatment and another

Performance Indicators

1- Soil pulverization rate

The percentage of the weight of soil and clods smaller or equal to 22 mm which passes through a sieve of 25 mm openings to the total weight of the soil sample [12], it calculated from the following equation:

$$P_r = (C_c \ / \ T_w) \ \times \ 100 \qquad (1)$$

Where P_r is the soil pulverization rate %, C_c weight of clods of the soil ≤ 22 mm that pass through the sieve openings of 25 mm, T_w is the total weight of all clods produced by pulverization.

2- Number of clods < 5 cm

Number of clods a greater than 5 cm per square meter in soil tilt which appear on the soil surface after used any equipment classified to the secondary tillage equipment such as disc harrow, spring tooth ,rotary tiller, spike tooth, roller ..act. Measured by calculated the size clods number bigger than 5 cm, which remains on a sieve with openings of 5 cm and dimensions of 0.5 m × 0.5 m, after that, the number of clods is multiplied by 4 to convert to square meter unit [22] [23].

3- Fuel consumption:

Fuel consumption was measured using the method of refilling the tractor fuel tank, this method fills the fuel tank tractor to the brim before began pulverization treatment and after, by a graduated cylinder with a capacity of 1000 ml. The fuel

amount used at the time of operation measured by following equation [24] [25].

$Q_F = q_l \times 10000 / W \times L \times 1000$ (2)

Where Q_F is the fuel quantity consumption (L.ha^{-1}), q_L is measured quantity of fuel for one treatment (ml), W is width of the disc harrow (m), L is length of treatment (m), 10000 and 1000 are the factor conversation.

4- Productivity:

The practical productivity of disc harrow offset was calculated from the following equation [26] [27]:

$P = 0.1 \times W_d \times S_d \times f_t$ (3)

Where P is the practical productivity of disc harrow offset (ha.h^{-1}), 0.1 is the conversion factor, W_d is actual width of disc harrow offset, Sd is the practical speed tractor during secondary tillage operation and f_t is utilization time factor is equal to 0.80 – 0.90, and typical 0.85 is taken as the average in this field experiment [28].

5- Specific productivity

The number of meters that are pulverization by the heavy disc harrow offset per one hour, it is calculated by dividing the practical productivity by the working width of the disc harrow offset, and calculated from the following equation [29[[30]:

$S_p = (10000 \times P) / W_d$ (4)

Where S_p is the specific productivity of pulverization m.h^{-1}, 10000 is conversation factor.

Result and Discussion

Table 1. showed the soil moisture 8 % recorded the highest rate of the clods smaller than or equal to ≤ 22 mm 70.49 %, which passed through a sieve 25 mm, also recorded least number of clods < 5 cm in m^2 7.83 clods.m^2 , compared to a soil moisture of 14 %, the reason is due to the weak cohesion of soil particles with each other when soil moisture is low, therefore, breaking and pulverization of the soil by used a disc harrow offset is easier and pulverization rate increase. soil pulverized at moisture 8 % helped reduce fuel consumption to 12.40 L.ha^{-1} and increase productivity to 1.5824 ha.h^{1-} and specific productivity 5273.4 m.h^{-1}, due to reducing the slippage of the tractor wheels and increasing the time utilization factor compared to 15 % soil moisture.

Pulverization depth 8 cm recorded the better values in all attributes of the experiment comparing with depth 15 cm, and that belong to the number of clods decreases as the depth of the pulverization layer decreases, and the accomplishment treatment at a short time, which mean better utilizer time. Same result noticed by [15], when depth decrease the clods < 0.05 decrease too.

Tractor speed 8.2 km.h^{-1} were recorded higher pulverization 70.57 %, number of clods 7.00 clods.m^2, and due to the increase in the tractor speed, the impact force and friction of the soil with the discs of harrow offset machine increase. Increasing the tractor speed to 8.2 km.h^{-1} leads to decrease the fuel consumption 11.81 L. ha^{-1}, this result agrees with [10] [6], and that because of utilization of tractor engine power and reduce time of the operation, in addition, the tractor speed is represented one of the equation factors in calculated the productivity, therefore, the higher speed 8.2 km.h^{-1} was recorded a higher productivity 2.0151 ha.h^{-1} and a specific productivity 6715.5 m.h^{-1}, this result with same line [31] [14].

Table (1) The values of the studied attributes of the experiment factors (X1 Soil pulverization rate %, X2 Numbers of clods < 5 cm, X3 Fuel Consumption L. ha^{-1}, X4 Productivity ha.h^{-1}, X5 Specific productivity m.h^{-1})

Experiment factors	X1 *	X2 *	X3 *	X4 **	X5 **
Soil moisture 14 %	67.37 a	10.08 a	13.66 a	1.5559 b	5189.7 a
Soil moisture 8 %	70.49 b	7.83 b	12.40 b	1.5824 a	5273.4 b
Depth of pulverization 8 cm	71.51 a	5.08 b	12.04 a	1.5992 a	5329.3 a
Depth of pulverization 15 cm	66.35 b	12.83 a	14.02 b	1.5391 b	5133.8 b
Tractor speed 4.7 km.h^{-1}	67.97 a	10.91 a	14.25 a	1.1232 b	3747.6 b
Tractor speed 8.2 km.h^{-1}	70.57 b	7.00 b	11.81 b	2.0151 a	6715.5 a

***** Lower value is the better. ** Higher value is the better.

The same letter for the same factors are not significantly different.

Table 2 showed the simple statistic of the characteristics of field, standard deviation (Std. Dev) was good and not higher for soil pulverization rate, numbers of clods < 5 cm, fuel consumption, productivity 3.638, 4.958, 1.818 and 0.456 respectively, which means the data which obtained in 24 treatments in the field experiment was not far away from the mean. While the standard deviation of specific productivity was 1532, a higher deference among 24 treatments in experiment, so there was far from the mean 5232. The varying difference in the maximum and minimum values of the characteristics studied in the field experiment indicate, explain the presence of a clear effect of the field experiment factors: soil moisture, depth of pulverization and speed of the tractor.

Table (2) statistical analysis of the characteristics studied in the field experiment

Treats	N	Mean	Std. Dev	Sum	Min *	Max *
Soil pulverization rate	24	68.933	3.638	1654	62.180	75.120
Numbers of clods < 5 cm	24	8.958	4.958	215	3	19
Fuel consumption	24	13.032	1.818	312.79	10.110	16.550
Productivity	24	1.569	0.456	37.660	1.076	2.0655

Specific productivity	24	5232	1520	125558	35887	6868

N are the treatments (2 × 2 × 2 × 3 replication = 24).

Minimum and Maximum values obtained in the field experiment.

Interaction moisture of soil, depth of pulverization and speed of tractor on soil pulverization rate and number of clods < 0.05 in m^2 were significant difference (fig.2 and 3), interaction moisture of soil 8 % with depth 8 cm and tractor speed 8.2 $km.h^{-1}$ got a higher soil pulverization rate 74.54 % and least (better) number of clods < 0.05 in m^2 , while interaction moisture 14 % with pulverize depth 15 cm and tractor speed 4.7 $km.h^{-1}$ got least soil pulverization rate 62.59 %, and number of clods was 3.33 clods . m^{-2} , and that because of the reduced the moisture make the cohesion between particles soil weak, also small depth of layer 8 cm comparing with 15 cm, addition to the higher speed help and increased the break up the clods and smashed by discs. Interaction moisture of soil 8 % with depth of pulverization 8 cm and tractor speed 8.2 $km.h^{-1}$ (fig.4) got least fuel consumption 10.48 $L.ha^{-1}$, while the higher value 16.10 $L.ha^{-1}$ was when interaction moisture 14 % with pulverize depth 15 cm and tractor speed 4.7 $km.h^{-1}$. That because when increasing depth increased the resistance against the discs and increased the quantity of soil which must deal with it, addition to increase slippage when moisture of soil increase (that in case 14 % moisture of soil), in addition too, the higher speed of the tractor 8.2 $km.h^{-1}$ make the operation fast and good utilization power tractor and reduce the time of operation. Interaction moisture of soil 8 % with depth of pulverization 8 cm and tractor speed 8.2 $km.h^{-1}$ (fig. 5 and 6) recorded higher productivity 2.0595 $ha.h^{-1}$ and specific productivity 6859 $m.h^{-1}$. In contrast, the least productivity was 1.0811 $ha.h^{-1}$ and specific productivity was 3618 $m.h^{-1}$, when interaction moisture 14 % with pulverize depth 15 cm and tractor speed 4.7 $km.h^{-1}$. That belong to a depth and a speed are the factors in calculated the productivity, so, when speed increase and depth decrease productivity increase too.

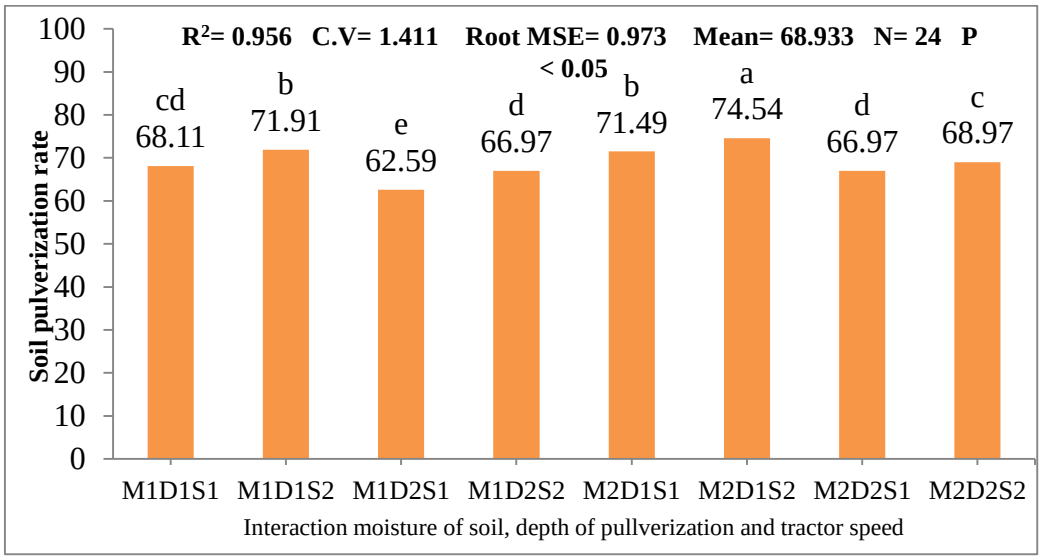

Fig. (2) Interaction moisture of soil, depth of pulverization and tractor speed on soil pulverization rate (the same letter are not significantly different), (M1 moisture of soil 14%, M2 moisture of soil 8%, D1 depth of pulverization 15 cm, D2 depth of pulverization 8 cm, S1 speed of tractor 4.7 $km.h^{-1}$, S2 speed of tractor 8.2 $km.h^{-1}$).

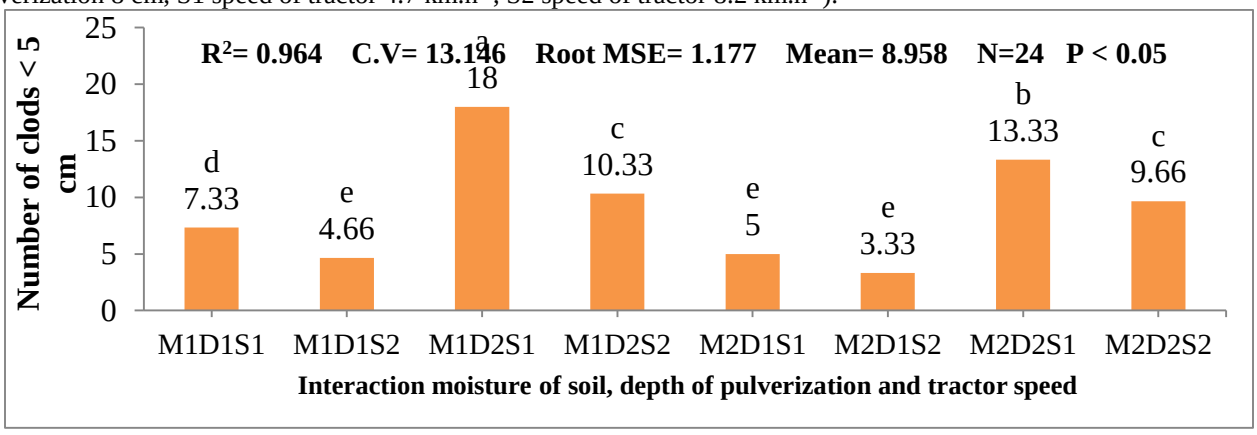

Fig.(3) Interaction moisture of soil, depth of pulverization and tractor speed on number of clod < 0.05.

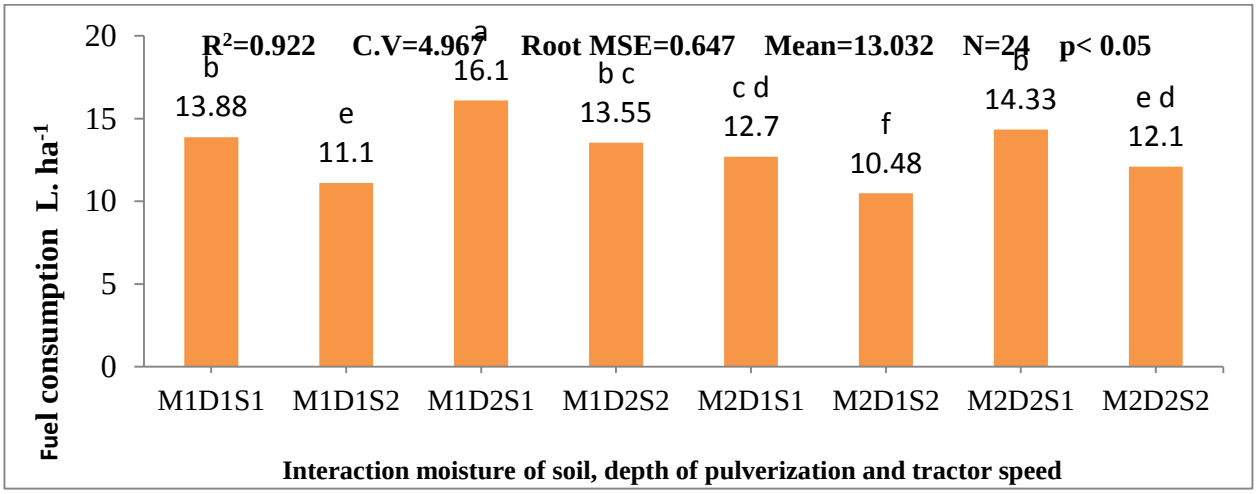

Fig. (4) Interaction moisture of soil, depth of pulverization and tractor speed on fuel consumption.

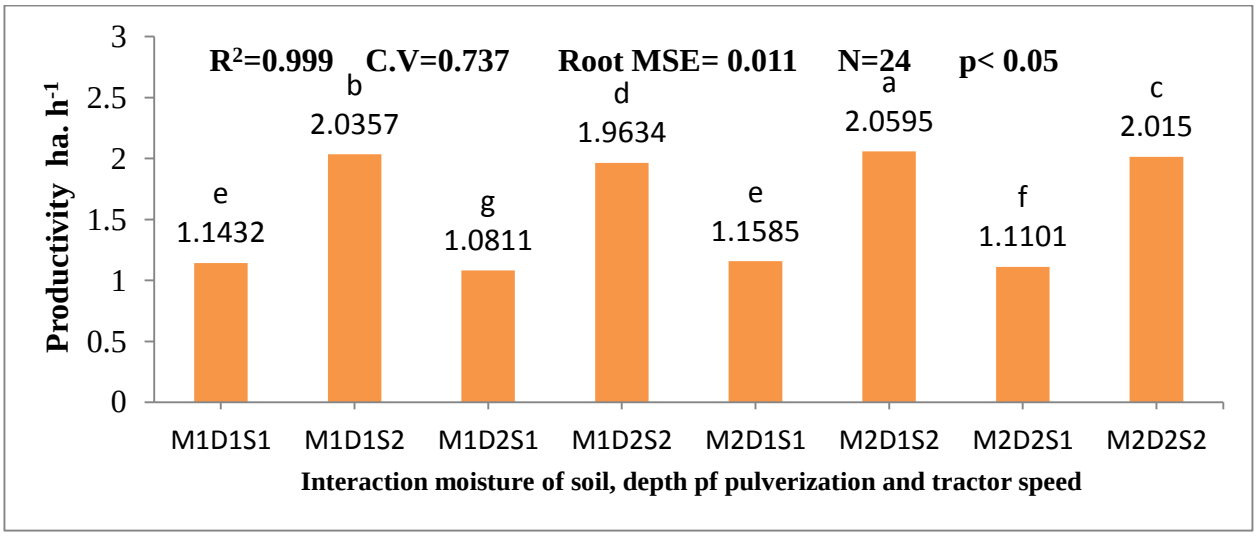

Fig.(5) Interaction moisture of soil, depth of pulverization and tractor speed on productivity.

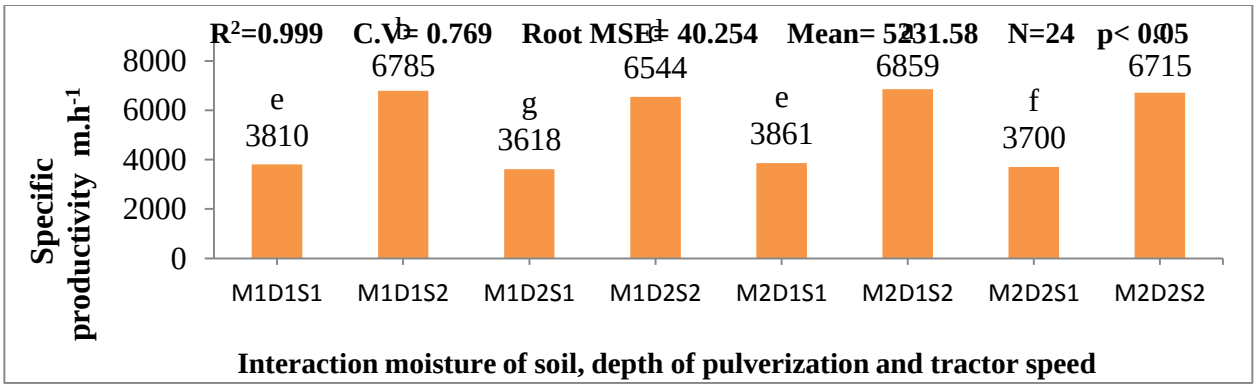

Fig.(6) Interaction moisture of soil, depth of pulverization and tractor speed on specific productivity.

Correlation between the attributes of the study

Statistical analysis system SAS funded the correlation among the characteristics of the field experiment was a direct (positive) and inverse (negative) and significant and non-significant, as show in (table 3). Highest significant direct correlation was between the productivity and specific productivity, which was 0.99998 and this explain the strong correlation which mean if the productivity increasing then the specific productivity will increase, because the value of productivity used in equation specific productivity. Least significant was between soil pulverization rate and productivity was 0.52008 at L.S.D 0.05. addition, least significant inverse correlation between the number of clods < 0.05 and specific productivity was – 0.46956 at L.S.D 0.05.

Table (3) Correlation characteristics of the studied.

	X1	X2	X3	X4	X5
X1	1.000				
X2	- 0.92537 **	1.000			
X3	- 0.87937 **	0.83882 **	1.000		
X4	0.52008 *	- 0.47107	- 0.73625	1.000	
X5	0.51836 *	- 0.46956 *	- 0.73513	0.99998	1.000

* Significant in L.S.D 0.05** Significant in L.S.D 0.01

X1 Soil pulverization rate %, X2 Numbers of clods < 5 cm, X3 Fuel Consumption L. ha^{-1},
X4 Productivity $ha.h^{-1}$, X5 Specific productivity $m.h^{-1}$.

Conclusion

In light of this findings, concluded when conducted the secondary tillage by used heavy disc harrow offset at moisture of soil to 8 % got best results such as soil pulverization rate, number of clods < 0.05, fuel consumption, productivity and specific productivity comparing with moisture of soil 14 %. Reducing the depth of pulverization reduced the number of clods < 0.05, fuel consumption, addition to increase the soil pulverization rate, productivity and specific productivity. Higher speed tractor 8.2 $km.h^{-1}$ increase productivity, specific productivity, soil pulverization rate, while reduced number of clods < 0.05 and fuel consumption. The tractor speed and pulverization depth, had more influence on all characteristics of the study, than moisture of soil. Finally, the correlation was significant and non-significant

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أداء المنعمة القرصية الثقيلة المنحرفة في تربة متوسطة النسجة.

أحمد عبد علي حامد

قسم شؤون الأقسام الداخلية ، جامعة بغداد ، بغداد ، العراق.

الخلاصة

تجربة عاملية نفُذت في عام 2024 في جنوب بغداد بهدف تقييم اداء المنعمة القرصية الثقيلة المنحرفة مع جرار ذي قدرة 120 حصان ميكانيكي تحت مستويين مختلفين لرطوبة التربة 14 و 8 % وعمقان للتنعيم 8 و 15 سم وسرعتين للجرار الزراعي 4.7 و 8.2 كم/ ساعة في تربة مزيجية طينية غرينية ذات نسجة متوسطة، بعد أجراء عملية حراثة رئيسية على عمق 20 سم باستخدام محراث مطرحي قلاب عرضه الشال 1.05 متر. تنعيم التربة تحت مستوى رطوبة 8 % أعطى أعلى (أفضل) نسبة تنعيم للتربة كانت 70.49 %، وإنتاجية 1.5824 هكتار/ ساعة وإنتاجية نوعية 5273 متر/ ساعة وأقل عدد كتل ترابية اصغر من 5 سم 7.83 كتلة / متر^2 واستهلاك وقود 12.04 لتر/ هكتار. عمق التنعيم 8 سم أعطى أفضل نسبة تنعيم للتربة 71.51 % وعدد كتل ترابية أصغر من 5 سم بلغت 5.08 كتلة / متر^2 وإنتاجية 1.5992 هكتار/ ساعة وأقل استهلاك وقود 12.04 لتر/ هكتار. سرعة الجرار 8.2 كم / ساعة حققت أفضل نسبة تنعيم للتربة بلغت 70.57 % وإنتاجية 2.0151 هكتار/ ساعة وإنتاجية نوعية 6715 متر/ ساعة وأقل عدد كتل ترابية أصغر من 5 سم بلغت 7 كتلة / متر^2 واستهلاك وقود 11.81 لتر/ هكتار . جميع التداخلات بين المعاملات كانت معنوية. الارتباط بين الصفات المدروسة في التجربة الحقلية كان معنوي وغير معنوي. نستنتج أن أكثر عامل مؤثر على الصفات المدروسة في التجربة الحقلية هو سرعة الجرار ثم عمق التنعيم، وكلاهما أكثر تأثيراً من رطوبة التربة، تنعيم التربة عند مستوى رطوبي منخفض 8 % وسرعة عالية للجرار 8.2 كم/ ساعة أعطى نتائج جيدة مقارنة مع بقية عوامل التجربة الحقلية.

الكلمات المفتاحية: قرص ، جرار ، تربة ، وقود ، نسبة التنعيم.