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Effect of rotary plow with different blades, plow cover height and different forward speed on some soil physical traits

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Abstract

This research was conducted to study the effect of different forms of rotary plow blades s on clay loam soils, through the use of three forms of blades (traditional blades (T1) and locally manufactured blades (T2 and T3)), and two forward plowing speeds (3.85 and 6.04) km.⁻¹ hour, two rotary tiller hood opening angles (35˚ and 70˚)and the study of its effect on the physical properties of clay soil: penetration resistance, average volume of stirred soil, percentage of earth masses with diameters less than 5 cm m², bulk density of soil, and total porosity. The research was carried out using the split split plank method according to the randomized complete block design (C.R.D) and with three replicates for each treatment. The results showed that the forward speed (3.85) kmh⁻¹ has achieved the best soil resistance to penetration. While the forward velocity (6.04) kmh⁻¹ achieved the best values for each soil volume rate, soil bulk density and total porosity. The angle (35˚) recorded the best values for each of the soil resistance to penetration and the proportion of soil masses, while the angle (70˚) excelled in recording the best values for each average of the volume of the soil stirred up, bulk density and porosity. The blades ((T3) was significantly excelled on the two blades (T1 and T2) in achieving the best values of penetration resistance, average volume of soil stirred up, mass ratio, bulk density, and porosity. As for the overlap between the two forward speeds and cover angles of the plow, the speed was (3.85) km per hour⁻¹ With angle ((35˚) best values for penetration resistance,As for the speed (6.04) km h⁻¹ with an angle ((70˚), the best values were recorded for the average volume of the stirred soil, bulk density and porosity. As for the interaction between the two speeds and the shape of the blades, the blades (T3) excelled at the forward speed (3.85) km/h⁻¹ in giving the best value for resistance to penetration. While the blades itself gave at the speed (6.04) kmh⁻¹ the best values for the average volume of soil stirred up. As for the overlap between the angles of cover for the plow and the shape of the blades, the blades (T3) excelled at the angle (70˚) in achieving the best values for the average volume of soil stirred up and density virtual and porous, At the angle (35˚), the blades achieved the best value of penetration resistance and the percentage of soil masses. As for the interaction between the two forward speeds of plowing, the angles of the opening of the rotary plow cover and the shape of blades, there were no significant differences in the physical traits of soil.

I. INTRODUCTION

The tillage process is one of the basic operations for preparing the soil, such as smoothing and breaking up the soil and preparing a good bed for the seed. In addition, choosing an inappropriate tillage method, especially in soils with a clay texture, negatively affects soil trait s, which leads to not preparing a suitable bed for the seed, as well as compacting the soil and increasing the spread of salts in the root zone, which negatively affects plant growth (Jasim et al., 2000).In spite of the great development that has occurred in recent years, the subject of tillage has remained far from a precise science, although the main purpose of tillage is to provide a suitable environment for plant germination and growth (Kepner et al. 1982).In general, the tillage process in general is one of the important operations that take place with the aim of preparing a good cradle for seeds, and increasing the degree of soil fragmentation or its cohesion, especially in clay soils, may sometimes be in excess of what is needed for good growth of roots, which negatively affects the trait s of the soil, and here comes the importance of choosing appropriate plow in determining the quality of the tillage process and improving soil properties, Despite the benefits of tillage, choosing the wrong type of plow may lead to results that negatively affect soil properties such as soil compaction, increase in bulk density, and increase soil penetration resistance. The rotary plow differs fundamentally from the rest of the plows in terms of its design, agitation, and soil fragmentation. The rotary plow is characterized by its ability to fully prepare the seed bed with the least passage in the field in one operation without the need to use several other machines in follow-up operations, such as plowing, leveling and smoothing.The rotary plow breaks up the soil and mixes it, where the soil leaves its mass dimensions less than 5 cm m^{-1}, and the plowing surface is flat, which makes it not in need of leveling and smoothing operations (Muhammad Ali and Ezzat, 1978) and (Shinde and Kajale, (2011). . The design of the rotary plow blades depends on three basic factors: the blades shape, soil conditions, and the method of moving the blades, which controls the method of moving the soil. Ju et al. (2004) The shape of the blades is the only factor that the designer can control. Likewise, the blades shape cannot be considered independent in its effect from the initial soil conditions or the nature of movement, as well as the angles of inclination of the blades and the blades shape in relation to the direction of travel. The method of moving the soil depends on the direction of the blades, the speed of movement during the plowing process, and the path of the blades's passage into the soil.The main purpose of the rotary plow blades is (to move the soil structure and return it) to the soil in order to obtain good conditions for plant growth. Mohsen (2017) found that the energy efficiency increases with the increase in the rate of the volume of loose soil and with a greater amount of increase in the energy required to break up and loosen the soil.Also, Al-Nassar (2015) indicated that the increase in the depth of plowing increases the average volume of loose soil, which leads to an increase in the porous voids of the soil, improves soil structure, and reduces the bulk density of the soil. This study aims to:

This study aims to:

Finding the best combination between the blades shape, the forward speed of the tractor, and the elevation angles of the rotary plow cover opening, in order to obtain the best physical traits of clay soil.

II. MATERIALS AND METHODS

The study was conducted to know the effect of using different designs of rotary plow blades, different heights of plow cover angles, and two forward plowing speeds on some of the studied indicators. This study included the use of three designs of rotary plow blades. The first blades is traditional in the form of the letter (C) and was named (T1) as in Figure ((1), and the second blades in the form of an axe was named (T2) as in Figure (2).As for the third blades in the form of an arrow or a triangle, it was named (T3), as shown in Figure (3).The second and third blades(T2 and T3) were manufactured locally by the researcher in one of the mechanical industries factories in Hamdan Industrial City in Basra Governorate. As shown in figures (8, 7, 6, 5, 4, the dimensions of the manufactured blades, The necessary tests and examinations were also conducted on the blades metal, which included examining the chemical composition and mechanical properties in the College of Engineering - Department of Mechanical Engineering, as shown in Table (1).The study also included the use of two plowing speeds (3.85 and 6.04) km per hour ($^{-1}$), and the use of two heights for the opening angles of the rotary plow cover (35° and 70°). 20 cm, In the research, an agricultural tractor of the type MF 285 G, with a design capacity of 56 kW, was used to pull and operate the rotary plow through the power take-off (P.T.O) shaft. the rotational speed of the power take-off shaft was measured by a tachometer, where the speed was 650 rpm^{-1} and the speed was fixed during the plowing process.The experiment was conducted in a split-split plot design with a complete random block design (RCBD) according to what was stated in (Dawood and Zaki, 1990).Where the field land was divided into three sectors that formed replicas of the experiment, the main boards were allocated for the forward speed of plowing, and each main board was divided into secondary boards that were allocated for the angles of the cover opening of the plow, Each sub plot was divided into sub-sub plot devoted to the blades shape, where the experiment was factorial and with three factors: The first factor is the forward speed of plowing in two levels (3.85 and 6.04) km per hour^{-1}, the second factor is the angles of the cover opening for the rotary plow in two levels (35° and 70°), and the third factor is the shapes of the rotary plow blades and in three levels, Duncan's multiple range test for averages was used to find a significant difference under (0.05) level for comparison between the treatments averages. The following indicators were studied

Soil physical traits were measured as follows:

1- Bulk density:

The bulk density of the soil was measured using the core sampler method, after the soil samples were dried in the oven at a temperature of 105 °C until the weight of the sample was fixed as in the method described by Black (1965), as in the following equation:

$$\rho_b = \frac{Ms}{Vt}$$

As:

ρ_b = bulk density of soil (g cm^{-3}).

M_s= mass of solid particles (g).

Vt = is the total volume of the soil and represents the volume of the cylinder (cm^3).

2- True Density:

The true density of the soil was measured using the pycnometer method mentioned in Black et al. (1965) as in the following equation:

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$$\rho_s = \frac{Ms}{Vs}$$

Since:

ρ_s = true density of soil (g cm^{-3})

Ms = dry soil mass (g)

Vs = dry soil volume (cm^3)

3-Total porosity:

Total porosity was measured according to the method of Black et al. (1965) and as in the following equation;

$$f = (1 - \rho_b/\rho_s) \times 100$$

Since:

f = total porosity %

ρ_b = bulk density of soil (g/cm^3).

ρ_s = true density of soil (g/cm^3).

4- Soil moisture content:

The moisture content of the soil was measured using the gravimetric method. This is done by taking soil samples by means of a cylinder (core sampler). The sample is weighed and then dried in an oven at a temperature of 105 ° C until the weight is stable. The percentage of moisture was measured by the method of dry weight of the sample, according to the method of Black et al. (1965).) as in the following equation:

$$PW = Mw / Ms \times 100$$

Whereas:

Pw = Percentage of soil moisture based on dry weight (%).

Mw = weight of moisture in soil (g).

Ms = weight of dry solid particles (g).

5- Soil particles distribution

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The particle volumes of soil were calculated using the pipette method, according to the method proposed by Black et al. (1965).

6- Soil resistance to penetration:

Soil penetration resistance (Cl) was measured by a cone penetrometer, as constant pressure is applied to the device in the vertical direction to push the column into the soil to depths (0-10), (10-20), and (20-30) cm, for three repetitions, and recording the device reading from index and then calculate the cone index (Cl) in kilonewton m^{-2} from the equation mentioned in (Gill and Vandenberg, 1968).

Cone Index (CI) = Penetration Force / Cone base area

(Cl)Cone Index = the index of the diameter of the cone (kNm^{-2}).

Penetration Force = Penetration Force (kN).

Cone Base Area= Area of the base of the cone (m^2).

7- Percentage of soil masses with diameters less than (5) cm m^2

The ratio of the soil masses with diameters less than (5) cm m^{-2} per square meter of plowed soil was calculated at the depth of the treatment, as the ratio between the weight of the soil masses with diameters less than (5) cm m^{-2} to the total weight of the sample was calculated according to Equation (14) taken from (Abbas, 2004).

$$M (\%) = ((W_1 - W_2) / W_1) \times 100 \ldots\ldots\ldots\ldots. (14)$$

M = Percentage of earthen blocks with diameters less than (5) cm m^{-2}.

W_1 = total sample weight (kg).

W_2 = weight of the sample that does not leak out of the sieve holes and whose diameter is greater than 5 cm.

Table (1) Soil physical traits and particle size distribution.

19.98	21.73	25.20	%	moisture content
3700	3550	3150	$kN\ m^{-2}$	Soil penetration resistance
soil depth (cm)			**Properties**	
20-10	10-5	0-5		

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275.2	284.7	300.3	gm kg^{-1}	Sand
333.5	325.9	315.8		Silt
398.9	392.5	388.2		Clay
clay	Clay loam	Clay loam		Texture
1.35	1.32	1.28	Mg m^{-3}	bulk density
2.63	2.67	2.70		true density
48.72	52.65	54.28	%	Porosity

Figure 1 shows the traditional blades (T1).

Figure (2) shows the locally manufactured axe blades (T2).

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Figure ((3) shows the locally manufactured triangular blades (T3)

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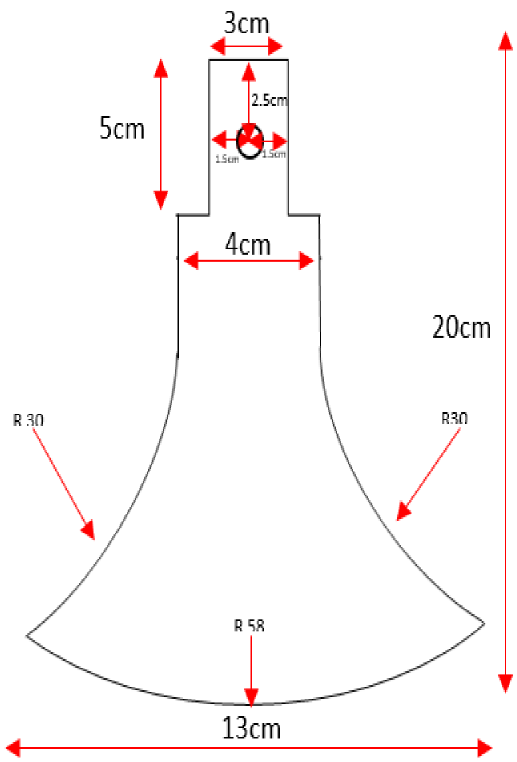

Figure (4) shows the frontal view of the locally manufactured axe blades (T2).

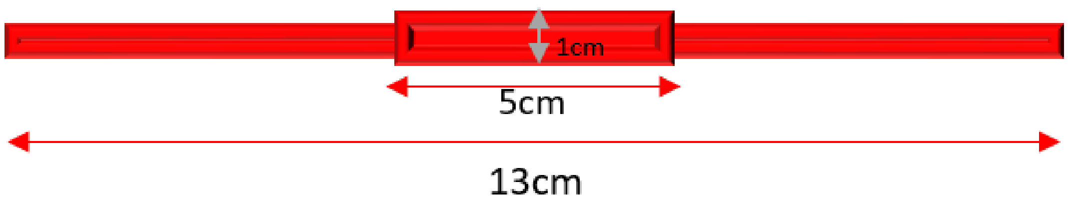

Figure (5) shows the upper location of the locally manufactured axe blades (T2).

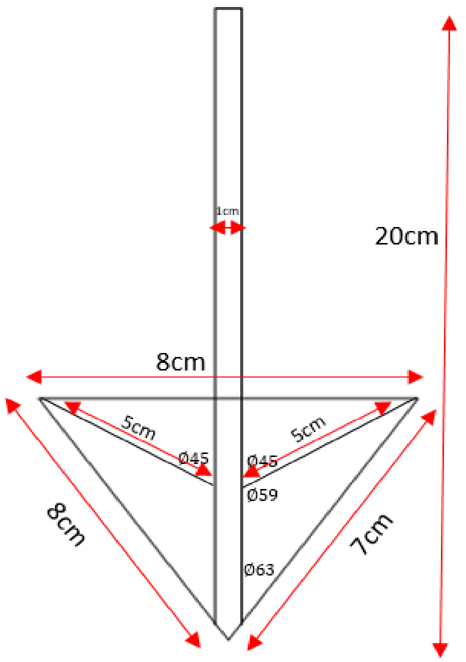

Figure (6) shows the front view of the locally manufactured triangular blades (T3).

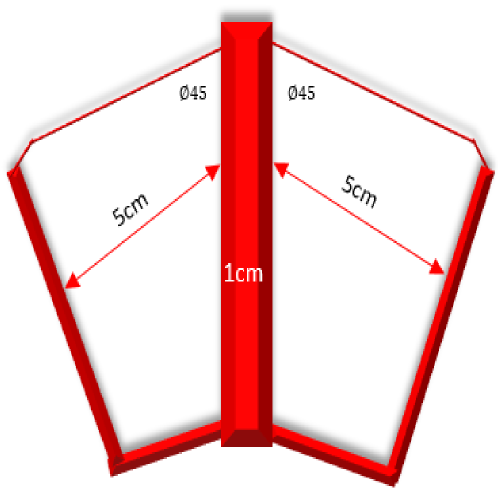

Figure (7) shows the top view of the locally manufactured triangular blades (T3).

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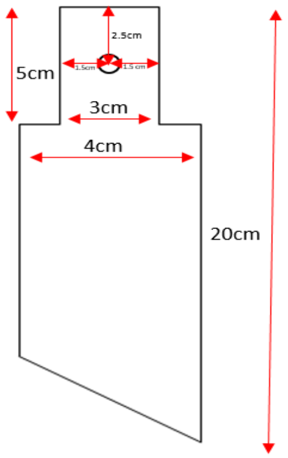

Figure (8) shows the side view of the locally manufactured triangular blades (T3).

Table (2) shows the chemical composition of traditional blades metal and locally manufactured blades

	chemical composition	**Mechanical properties**
Manufactured	**traditional**	**blades shape**
1338	**2317**	**Metal type according to AISI classification**
0.003	**0.003**	**Phosphorous (P%)**
0.005	**0.004**	**Molybdenum (mo%)**
0.3.5	**0.2**	**Carbon (C%)**
750	**850**	**tensile strength (MPa)**
0.04	**0.04**	**Sulfur (S%)**
0.1	**0.09**	**Chromium (Cr%)**
0.05	**3**	**Nickel (Ni%)**
0.4	**0.25**	**Silicon (Si%)**
135	**150**	**(J) Shock test**

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2	**0.5**	**Manganese (Mn%)**
35	**40**	**(HRC) Hardness**
14	**15**	**Elongation ratio (%)**
400	**600**	**yield stress(MPa)**

III. RESULTS AND DISCUSSION

1- The effect of the forward speed of plowing on the physical traits of the soil

Table (3) indicates that the increase in the forward speed from (3.85 to 6.04) km h^{-1} led to an increase in the volume of the excited soil from 627.42 to 818.52 $m^3 h^{-1}$, respectively, and this is due to the fact that the volume of the stirred soil is directly affected by the speed Forward plowing, when the forward speed of plowing increases, the actual productivity increases, which leads to an increase in the rates of volume of soil stirred up, due to the increase in the plowed area. This is consistent with what was indicated by Talabani (2008) and (2006). The forward plowing speed (6.04) km h^{-2} also gave the highest value of penetration resistance, which amounted to 1997.80 kN m^{-2}, while the forward plowing speed gave 3.85 km h^{-2} has the lowest soil penetration resistance, as it reached 1588.23 kN m^{-2}, This may be due to the fact that the velocity (6.04) km per $hour^{-2}$ worked to break the dirt blocks and increase and then increase the degree of fragmentation and smoothing, which by increasing it led to an increase in the resistance of the soil to penetration, and this is consistent with what was reached by Du Fine J (1999) and Khan et al. (1999). 2001) and Iqbal et al. (2005). It was also found that increasing the forward speed of plowing led to a decrease in the bulk density of the soil, where the forward speed (6.04) km h^{-1} achieved the lowest apparent density of 1.04 g cm^{-3}, while the forward speed (3.85) km h^{-1} achieved the highest a value of bulk density of 1.13 g cm^{-3}, The reason for this is that the increase in the forward speed with the stability of the speed of rotation of the column carrying the blades led to an increase in the distance between one stroke and another of the rotary plow blades , and as a result this will cause a decrease in the degree of fragmentation, because the degree of soil fragmentation has a clear effect in increasing its apparent density due to partial saturation. For large soil pores with smaller soil particles, which led to an increase in soil weight per unit volume, This is consistent with the findings of Al-Fahdawi (2001) and Abbas (2004). It is noted that the increase in the forward plowing speed from (3.85 to 6.04) km h^{-1} led to an increase in the porosity value from 58.09 to 61.58%, respectively. The reason for this is due to the decrease in the bulk density when increasing the forward speed of plowing, which led to an increase in the total porosity of the soil, as a result of the decrease in the degree of soil fragmentation, which causes the dirt masses to break down into small particles and settle in the inter-soil voids, which was confirmed by Jassem et al. (2006) and Jaber. et al (2009).

Table (3) shows the effect of the forward speed of plowing on the physical traits of the soil.

The total porosity of the soil %	soil bulk density g.cm⁻³ *	The proportion of earth masses with diameters less than	Penetration resistance kN m ² *	volume of soil stirred m ³ h⁻¹	forward speed km.hours⁻¹
58.09 b	1.13 a	91.36 a	1588.23 b	627.42 b	**3.85**
61.58 a	1.04 b	85.66 b	1997.80 a	818.52 a	**6.04**

2- The effect of the elevation angles of the cover hole of the rotary plow on the physical traits of soil

Table (4) that the increase in the cover opening angle of the rotary plow led to an increase in the volume of the soil stirred up.The cover hole angle of the rotary plow (70˚) recorded the highest value of the volume of soil stirred up to 743.50 $m^3 h^{-1}$, while the cover hole angle (35 ˚) achieved the lowest value of the volume of soil stirred up to 702.46 $m^3 h^{-1}$, The reason for this is that by increasing the angle of the cover opening of the rotary plow, the actual depth of plowing increases, which led to stirring up the largest amount of soil, and this means that a greater work is done, i.e. an increase in the rate of the volume of soil stirred up. It is also clear that the cover opening angle of the rotary plow (35˚) recorded the lowest value for this trait, which was 1596.45 kN m^{-2}. While the cover opening angle (70˚) recorded the highest value for this trait, which amounted to 2115.95 kN m^{-2}, and these results are consistent with the results reached by Dugrama J et al. ((1987) and Boydas and Turgut (2007). The cover opening angle also gave the plow The rotary plow (35˚) has the highest value for the ratio of earth lumps with diameters less than (5) cm m^2 compared to the opening angle of the rotary plow cover (70˚). It achieved 93.05% and 87.03%, respectively. The reason for this is due to the increase in the impact force of the dirt blocks on the plow cover when reducing the distance between the hole of the plow cover and the arms of the rotary plow, which caused an increase in the fragmentation of the dirt blocks. This is what Jabr et al. (2006) and Al-Jarrah (2006) reached. It is clear that increasing the cover opening angle of the rotary plow has led to a decrease in the bulk density of the soil.

As for the angle of the cover hole (35˚), the highest apparent density of soil was recorded, reaching 1.11 gm cm^{-3}, and the reason for this is due to the increase in the degree of fragmentation and smoothing when reducing the angle of the cover hole of the rotary plow, which leads to blockage of the large pores with small soil particles due to the softening of the soil This leads to an increase in the bulk density of the soil as a result of the increase in the weight of the soil per unit volume.This is what Al-Fahdawi (2001) concluded. It is noted that the porosity here has taken an opposite behavior to the behavior of the bulk density, where the bulk density increased at the angle of the lid opening (35˚), while the porosity decreased at the same angle of the lid opening, reaching 58.75%. As for the bulk density, it decreased at the angle of the cover opening of the rotary plow (70˚), accompanied by an increase in the porosity, reaching 60.92%. This is what Jabr et al. (2006) found

Table ((4) shows the effect of the angles of elevation of the cover hole of the rotary plow on the physical trait of soil

The total porosity of the soil %	soil bulk density $g.cm^{-3}$ *	The proportion of soil masses with diameters less than 5 cm m^2	Penetration resistance kN m^2 *	volume of soil stirred $m^3 h^{-1}$	Cover hole angles for the plow
58.75 b	1.11 a	93.05 a	1596.45 b	702.46 b	**35˚**
60.92 a	1.05 b	87.03 b	2115.95 a	743.50 a	**70˚**

3- Effect of the blades shape of the rotary plow on the physical traits of the soil

Table (5) the excelled of the blades (T3) in giving the highest value for the volume of soil stirred up, which amounted to 800.90 $m^3 h^{-1}$, while the blades (T1) gave the lowest value for this indicator, amounting to 641.70 $m^3 h^{-1}$, while the blades gave ((T2) value for this indicator amounted to 721.20 m^3 $hour^{-1}$, and the reason for this is due to the direct relationship between the actual productivity and the volume of the soil stirred up, as the increase in the actual productivity is accompanied by an increase in the volume of the soil stirred up, which is what happened with the blades (T3) unlike blades (T1) and (T2), which gave lower productivity.It is also noted that the blades (T3) achieved the lowest penetration resistance, which amounted to 1597.80 kN m^{-2}, while the blades (T1) achieved the highest value for soil penetration resistance, which was 2016.94 kN $m.^{-2}$, while the blades (T2) achieved a penetration resistance of

1999.78 kN m⁻², and the blades (T3) was excelled on blades (T1) in recording the highest percentage of dirt blocks with diameters less than (5) cm m ². It amounted to 93.42%, while the blades (T1) recorded the lowest value for this indicator, amounting to 87.23%, while the blades (T2) recorded a value of 89.66% for this indicator. The reason for this may be due to the different design of blades of length and dimensions that have a direct impact In the increase of this indicator as a result of the increase in the degree of cracking and fragmentation, and this was confirmed by Kouchakzadeh and Haghighi (2011), and on the other hand, the increase in this indicator is a measure of the surface roughness of the soil. ² It should not be less than 85% when using the rotary plow, and therefore the higher the percentage of dirt blocks with diameters less than 5 cm m⁻² the better, which is what happened when using the plow with arms (T3). It turns out that the blades (T3) gave the lowest apparent density of soil, which amounted to 1.07 g cm⁻³, while the blades (T1) recorded the highest apparent density of soil, which amounted to 1.09 g cm⁻³, while the blades (T2) recorded an apparent density of 1.09 g cm⁻³, and the reason for this is that the soil agitation and dismantling by means of the blades ((T3) was better because of the increase in the volume of the soil soil stirred up, which led to achieving a greater plowing depth, and this is what happened to the value of the bulk density when using the blades (T3) unlike The other blades , while the blades (T3) achieved the highest value of the soil porosity percentage, which amounted to 60.29%, while the blades (T1) achieved the highest porosity amounted to 59.38%, while the blades (T2) achieved a percentage of porosity amounted to 59.44%, and the reason for this is To the inverse relationship between porosity and the bulk density of the soil, and as a result, the increase in the proportion of porosity at the blades ((T3) resulted from the lack of bulk density of the soil, and the opposite happened when using plows with arms (T1) and (T2), where the porosity was higher and the bulk density was lower. In both cases, the increase or decrease in porosity depends on the degree of soil agitation and fragmentation.

Table (5) shows the effect of the blades shape of the rotary plow's on the physical traits of the soil

The total porosity of the soil %	soil bulk density *g.cm⁻	Percentage of soil mass lumps with diameters less than 5 cm m⁻²	The proportion of soil masses with diameters less than 5 cm m ²	volume of soil stirred m ³ h⁻	blades shape
59.38 c	1.09 a	87.23 c	2016.94 a	641.70 c	**T1**

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59.44 b	1.09 a	89.66 b	1999.78 b	721.20 b	**T2**
60.29 a	1.07 b	93.42 a	1597.80 c	800.90 a	**T3**

4- The effect of the interaction between the forward speed of plowing and the cover hole angles of the rotary plow on the physical traits of the soil.

Table (6) that the volume of the stirred soil increased with the increase of both the forward speed and the angle of cover opening of the rotary plow.) as it amounted to 837.13 m ^{3} h^{-1}, while the lowest value for the volume of soil stirred was given by the forward speed of plowing (3.85) km h^{-1} at the angle of the cover opening of the rotary plow (35°), which amounted to 604.97 m ^{3} h^{-1}, and the reason for this is due to The increase of both the forward speed of plowing and the angle of opening of the cover of the rotary plow led to an increase in the actual productivity, and as a result the average volume of soil stirred up increased at high speeds compared to low speeds, because speed is one of the factors determining the actual productivity and the actual productivity is one of the main components of the volume Soil stirred and directly proportional to it, and this is what was found by Yah (1998). It also turns out that the forward plowing speed (3.85) km h^{-1} and the cover opening angle of the rotary plow (35°) achieved the lowest value of soil penetration resistance, which amounted to 1597.67 kN m^{-2}, while the forward plowing speed achieved (6.04) km h^{-1} With the cover opening angle of the rotary plow (70°) the highest soil penetration resistance was 2205.18 kN m ^{2}. Also, the decrease in the forward speed with the decrease in the cover opening angle of the rotary plow led to an increase in the bulk density of the soil.$^{-3}$, while the cover opening angle of the rotary plow recorded (70°) at a speed of (3.85) km h^{-1} an apparent density of 1.10 g cm^{-3}, while the forward plowing speed was (6.04) km h^{-1} for the plow cover opening angle (35 ° and 70°), it recorded an apparent density of (1.06 and 1.01) g cm^{-3}, respectively, and the reason for this is due to the same reasons that were mentioned in the previous paragraphs, that the increase in the forward speed of plowing with the increase in the angle of the cover opening of the rotary plow led to a decrease in The bulk density of the soil, as a result of the low degree of fragmentation and softening of the soil, which has a clear effect in increasing the bulk density of the soil due to the molecular filling of the pores with smaller soil particles, which led to an increase in the weight of the soil per unit volume, and this is consistent with the findings of Al-Fahdawi (2001) and Abbas (2004).). While the percentage of total soil porosity increased by increasing the angle of the cover hole for the plow and for all the forward speeds of plowing, and it is also evident that the porosity percentage increased by increasing the forward speed of plowing and for all angles of the cover hole for the rotary plow, as the forward speed of plowing was (3.85) km h^{-1} and the angle of the hole opening The cover (35°) has the lowest soil porosity amounting to 56.87%, while the forward plowing speed (6.04) km h^{-1} and the angle of the cover opening (70°) achieved the highest porosity percentage of 62.52%, and this is due to the increase in the forward speed of plowing With the angle of the cover slot of the rotary plow, it leads to an increase in the volume of the soil stirred up and because of the decrease in the impact force of the dirt blocks when the angle of the cover slot of the plow and its arms is increased, which causes a decrease in the degree of fragmentation and softening of the dirt blocks, which leads to an increase in the large dirt blocks, and as a result a decrease in the bulk density soil and an increase in porosity.

Table (6) shows the effect of the interaction between the forward speed of plowing and the cover hole angles of the rotary plow on the physical traits of the soil.

The total porosity of the soil %	soil bulk density *g.cm⁻	Percentage of soil mass lumps with diameters less than 5 cm m⁻²	The proportion of soil masses with diameters less than 5 cm m ²	volume of soil stirred m ³ h⁻	Cover hole angles for the plow	forward speed km hours⁻¹
56.87 d	1.16 a	94.97	1597.67 d	604.97 d	**35°**	**3.85**
59.32 c	1.10 b	90.30	1842.71 c	634.11 c	**70°**	
60.64 b	1.06 C	89.61	2066.14 b	784.14 b	**35°**	**6.04**
62.52 a	1.01 d	84.23	2205.18 a	837.13 a	**70°**	

5- The effect of the interaction between the forward speed of plowing and the blades shape of the rotary plow on the physical traits of the soil

Table (7) that the blades (T3) achieved at the forward plowing speed (6.04) kmh⁻¹ the highest value for the average volume of soil stirred up was 916.59 m ³ h⁻¹ and at the forward speed (3.85) km h⁻¹ it was 672.60 m ³ h⁻¹, compared to the blades (T1), which achieved the lowest value for the average volume of soil stirred up at those two speeds, which amounted to 704.28 and 566.10 m ³ h⁻¹, respectively, while the blades (T2) achieved at these two speeds an average value of the volume of excited soil amounted to 724.40 and 580.18 m ³ hour⁻¹, respectively, and the reason for this is that the increase in the forward speed of plowing led to an increase in the actual productivity, and as a result, the average volume of soil stirred up increased at high speeds compared to low speeds, because the forward speed is one of

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the main factors in calculating productivity, and that the actual productivity is One of the factors of the volume of the soil stirred up, which is directly proportional to it, that is, the forward speed of plowing led to an increase in the actual productivity, which in turn works to increase the rate of the volume of soil stirred up due to the increase in the plowed area, and this is what happened with the blades (T3) compared to the blades (T2 and (T1).We also note that the blades (T3) recorded at both speeds (3.85 and 6.04) kmh^{-1} the lowest penetration resistance of 1568.22 and 1599.43 kN m^{-2} respectively, while the blades (T1) recorded at both speeds (3.85 and 6.04) How many hours^{-1} has the highest value for this traits, which amounted to 1997.60 and 2011.82 kN m^{-2}, respectively, while the blades (T2) recorded at both speeds a value for this traits that was 1744.64 and 1978.31 kN m^{-2}, respectively.

Table (7) shows the effect of the interaction between the forward speed of plowing and the blades shape of the rotary plow on the physical traits of the soil

The total porosity of the soil %	soil bulk density *g.cm^{-}	Percentage of soil mass lumps with diameters less than 5 cm m^{-2}	The proportion of soil masses with diameters less than 5 cm m^{2}	volume of soil stirred m^{3} h^{-}	blades shape	forward speed km hours^{-1}
57.62	1.14	89.69	1997.60 b	566.10 f	**T1**	**3.85**
58.10	1.13	92.64	1744.64 d	580.18 e	**T2**	
58.57	1.12	95.58	1568.22 e	672.60 d	**T3**	
61.14	1.05	83.67	2011.82 a	704.28 c	**T1**	**6.04**
61.58	1.03	86.92	1978.31 c	724.40 b	**T2**	
62.02	1.02	90.17	1599.43 f	916.59 a	**T3**	

6- The effect of the interaction between the angles of the cover hole elevation and the blades shape of the rotary plow on the physical traits of the soil

Table (8) that the blades (T3) has achieved the highest average value of the volume of soil stirred at the cover opening angles of the rotary plow (35˚ and 70˚) amounted to 766.70 and 801.69 $m^3 h^{-1}$, respectively, compared to the blades (T1), which achieved less The value of the average volume of soil excited at those angles was 601.19 and 648.33 $m^3 h^{-1}$, respectively. As for the blades (T2), it recorded at those angles of the lid opening an excited soil volume of 642.21 and 689.35 $m^3 h^{-1}$, respectively, that the reason for the decrease in the average soil volume Raised at the blades ((T1) is due to its instability well, especially at the angle of the cover opening ((35˚) as a result of a suffocation in the plow, which caused deviations in the path of its blades as a result of the high vibrations of the plow as well as the loading angle of its blades is small and its weight is small , which also led to a lack of depth in the soil and thus a decrease in the rate of volume of the soil stirred up, because their relationship is direct with the depth, compared to the blades (T3) whose high stability helped to go deep into the soil, and that this stability is a result of the working angles in it and its dimensions, and its large weight, Which helped him to agitate the soil and dismantle it, and as a result, the rate of the volume of the aroused soil increased significantly. We also note that the blades (T3) recorded at the cover opening angles of the rotary plow (35˚ and 70˚) the lowest penetration resistance of 1540.22 and 1670.43 kN m^{-2}, respectively, while the blades (T1) recorded at the cover opening angles of the rotary plow (35˚ and 70˚) the highest value for this trait , which amounted to 1896.87 and 1998.70 kN m^{-2}, respectively, while the blades (T2) recorded at both speeds a value for this trait that was 1722.34 and 1604.12 kN m^{-2}, respectively. Also, the blades ((T3) achieved at all angles of the cover opening of the rotary plow the highest percentage of dirt blocks with diameters less than (5) cm m^2 compared to the blades ((T1), which achieved at those angles the lowest value for the percentage of dirt blocks with diameters less than (5) cm m^2, the blades ((T3) at the angle of the cover opening of the rotary plow (35˚) achieved the highest percentage of dirt blocks with diameters less than (5) cm m^2 was 94.89%, and it achieved at the angle of the cover opening (70 ˚) the percentage of dirt blocks amounted to 91.96 %, while the blades (T1) achieved at those angles the proportion of dirt masses amounted to 90.79 and 83.67%, respectively, while the blades (T2) achieved at those angles the proportion of masses that were 92.84 and 87.81%, respectively, and the reason is due to the low percentage of dirt masses The blades (T1) increases the distance between one stroke and another for the plow blades in comparison with the blades ((T3), because increasing the distance between one stroke and another leads to a decrease in the degree of soil crushing, and thus the percentage of dirt blocks with diameters less than (5) cm m^2 decreases, and this What was found by Al-Basrawy ((1997). Also, the blades (T3) achieved the lowest apparent density at the angle of the lid opening (70˚), which amounted to 1.04 g cm^{-3}, and the blades (T1) achieved at the same angle an apparent density value that was 1.07 g cm^{-3}, while the blades (T2) achieved at that angle an apparent density value of 1.06 g cm^{-3}, while the blades (T1) achieved the highest bulk density value at the angle of the cover opening of the plow (35˚) was 1.12 g cm^{-3}, and achieved The blades (T3) at the angle of the cover opening (35˚) had an apparent density value of 1.10 g cm^{-3}, while the blades (T2) achieved at the same angle an apparent density of 1.11 g cm^{-3}, and it turns out that the lower the angle of the cover opening for the rotary plow The greater the value of the bulk density of the soil for all blades , the reason for this is that the bulk density of the soil is affected by the degree of fragmentation and softening of the soil, because there is a direct relationship between them, as the greater the degree of fragmentation and softening, the greater

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the value of the bulk density of the soil, because of the deterioration that occurs in the soil composition as a result of softening The large pores of the soil are clogged with small soil particles, and this leads to an increase in the weight of the soil per unit volume, and this is what Abbas (2004) found. Here, the porosity behaved in reverse, as the percentage of porosity increased with the increase in the angle of the rotary plow cover opening for all blades , especially the blades (T3), which recorded at the angle of the cover opening (70˚) a porosity percentage of 63.56%, compared to the blades (T1), which was recorded at the corner. The same percentage of porosity was 62.49%, while the blades ((T2) recorded at the same angle a percentage of porosity amounted to 63.02%, while the percentage of porosity decreased at the angle of the plow cover opening (35˚) for all blades , especially the blades ((T1), which recorded a percentage of porosity amounted to 60.47%, while the blades ((T3) recorded at that angle a porosity rate of 61.23%, and the blades ((T2) recorded at the same angle a porosity of 60.85%, that the increase in porosity when increasing the angle of the cover opening of the rotary plow due to the decrease in the degree of fragmentation and softness of the soil, This is consistent with what Abdel Karim and Hammoud (2011) confirmed.

Table (8) shows the effect of the interaction between the elevation angles of the cover hole and the blades shape of the rotary plow on the physical traits of the soil

The total porosity of the soil %	**soil bulk density *g.cm^{-}**	**Percentage of soil mass lumps with diameters less than 5 cm m^{-2}**	**The proportion of soil masses with diameters less than 5 cm m^{2}**	**volume of soil stirred m^{3} h^{-}**	blades shape	**forward speed km hours^{-1}**
60.47 f	1.12 a	90.79 a	1896.87 b	601.19 f	**T1**	**35˚**
60.85 e	1.11 b	92.84 a	1722.34 c	642.21 e	**T2**	
61.23 d	1.10 c	94.89 a	1540.22 f	766.70 b	**T3**	
62.49	1.07	83.67	1998.70	648.33		

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c	d	c	a	d	**T1**	
63.02 b	1.06 e	87.81 b	1604.12 e	689.35 c	**T2**	**70°**
63.56 a	1.04 f	91.96 a	1670.43 d	801.69 a	**T3**	

7- The effect of the interaction between the forward speed of plowing, the angles of the cover hole and the shape of the arms of the rotary plow on the physical properties of the soil

It can be seen from Table (9) that there are no clear significant differences for this overlap in the physical properties of the soil.

Table (9) shows the effect of the interaction between the forward speed of plowing and the angles of the cover opening and the shape of the arms of the rotary plow on the physical traits of the soil

The total porosity of the soil %	**soil bulk density *g.cm^{-}**	**Percentage of soil mass with diameters less than 5 cm m^{-2}**	**The proportion of soil masses with diameters less than 5 cm m^{2}**	**volume of soil stirred m^{3} h^{-}**	**blades shape**	**Cover hole angles of the rotary plow**	**forward speed km hours^{-1}**
56.55	1.17	92.69	1800.62	560.05	**T1**		
56.80	1.15	93.70	1623.16	609.44	**T2**	**35°**	
57.18	1.14	97.75	1511.54	658.90	**T3**		**3.85**
58.69	1.11	86.69	1931.70	581.47	**T1**		

59.54	1.10	88.91	1771.85	634.11	**T2**	**70°**	
60.00	1.08	93.41	1570.42	686.75	**T3**		
60.20	1.07	87.80	2020.89	673.55	**T1**	**35°**	**6.04**
60.72	1.05	88.60	1999.87	784.14	**T2**		
61.08	1.03	90.42	1797.65	894.73	**T3**		
62.09	1.00	79.55	2158.31	735.42	**T1**	**70°**	
62.23	0.99	80.44	2110.13	837.14	**T2**		
63.00	0.97	88.92	2000.94	938.85	**T3**		

Based on the results of the study, it can be concluded that the good design of the rotary plow blades in the form of (T3) has been superior to the traditional blades in all the studied characteristics. And that the study recommends the use of locally manufactured arms for the rotary plow under different soil conditions in the upcoming studies and using them with higher forward speeds to achieve high field productivity.

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