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Article

Field Performance Evaluation of a New Tillage System

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Abstract: This study was conducted to evaluate the field performance of the new tillage machine in silty clay soil, which consists of two subsoiler plows, a rotary plow, and two opener furrows, and their effect on some mechanical and field indicators, which included: draft force, mean weight diameter and field efficiency. Three depths of plowing were used(30, 40, and 50 cm), two rotational speeds for the rotary plow blades are(250 and 300 rpm), and three distances between two plates of the two opener furrows are(35, 40 and 45 cm). The results showed an increase in the draft force with an increase in the plowing depth from 30 to 50 cm, a decrease in the rotational speed of the rotary plow from 300 to 250 rpm, and an increase in the distance between two plates of the two opener furrows from 30 to 40 cm. The mean weight diameter was decreased when using shallow plowing with a depth of 30 cm compared to deeper plowing with a depth of 50 cm and with an increase in the rotational speed of the rotary plow blades from 250 to 300 rpm. As for field efficiency, the highest average was recorded for shallow plowing at a depth of 30 cm, a high rotational speed of 300 rpm, and the small distance between two plates of the two opener furrows of 35 cm was 73.28, 69.12, and 68.39%, respectively.

Keywords: Plowing depth, Rotational speed, Mean weight diameter, Draft force, Field efficiency

Introduction

The soils of the southern region suffer from a hard pan under the soil surface because of the repetition of the plowing process at constant depths using traditional plowing machines, especially in the depths these plows do not reach. These layers negatively affect the properties of the soil as the bulk density, total porosity and the efficiency of the washing process, which leads to the accumulation of salts in the root area [1]. in addition to a decrease in the activity of microorganisms in the soil as a result of the supremacy of anaerobic conditions. The method of using the mechanical assembly of machines has a high ability to rebuild the soil and obtain a low density and porosity suitable for plant growth. This type of combined machine is fundamentally different from the rest of the traditional machines that work independently to prepare the seedbed in several passes. A group of researchers in the Russian Federation[2] manufactured a combined plowing machine consisting of a plow, a rotary harrow, and a roller, as it was registered in China a patent by a group of researchers [3] on the design of a ditcher opener equipped with a rotary plow, and it was with one pass in the field. It leads to an increase in the number of passages in the field, and it cannot be used in soils that contain hard pans or soils with a high salt content. Large soil bulks produced by a sub-soiler plow in heavy soil should be broken up and flattened to diminish their size and prepare them to be an appropriate seedbed for germination and plant growth. This will result in the maximum potential production. As a result, the rotary plow was applied, which varies significantly from other types of plows in design and soil handling, as it is characterized by the ability to prepare a proper seedbed, reducing the need for additional machines in subsequent processing [4]. The rotary plow may control the degree of soil dissociation by modifying the tractor's forward speed, changing the rotating speed through the gearbox, increasing the number of blades placed on the rotary shaft, or adjusting the height of the plow's rear cover. In the field, farrow ridges create shallow channels. The dimensions and shapes of these farrows vary depending on the type of crop, variety, plant size, water requirements, soil type, and slope. Smaller plants necessitate smaller farrows, and vice versa. Farrows are classified into two sorts based on their shape: total triangles and truncated triangles at the farrow's bottom [5].

To treat the salinity-affected soils of the southern region, as well as the need for cultivation under the salt collection line in furrows, and to reduce time, effort, and costs, a multi-purpose machine has been manufactured that breaks the soil ban and dismantles the soil beneath the surface, then breaks it down, loosens it, and mixes it with the plant residues with leveling, as well as creating furrows for preparing them with different operation widths to obtain various profile size to achieve all soil preparation processes in the same time within single pass for planting. The study aims to evaluate the field performance of the new plowing machine by studying the effect of different plowing depths, the speed of the rotary plow blades and the changing distance between two plates of the two opener furrows.

Material and Methods

The combined tillage machine and two opener furrows in Figure 1 comprise two subsoiler plows to break the hardpan layer. The length of their legs is 90 cm, the distance between them is 75 cm, and they declined from the horizon at an angle of 70◦, at the end of which a foot with wings is 35 cm long, and its front is cut at an angle of 30^{o} to enable it to penetrate the soil.

The distance between the two plows can be changed by moving their hitch points on the frame. Followed by the two plows at a distance of 50 cm is a rotary plow that pulverizes the soil blocks that resulted from the subsoiler plows, mixing with the soil particles and the rest of the previous crop. In addition to leveling the soil. Working width of 150 cm, equipped with feathered blades mutually fixed on the axis of rotation. The length of each blade is 20 cm. It drives its rotational motion by connecting the plow shaft to the power take of a tractor by flexible couplings. The plow was fixed to the frame with two hitch points; they are 140 cm away. The height and decrease of the rotary plow relative to the level of the tines of the subsoiler can be controlled through a screw lever, and its rotational speed can be reduced by means of gears placed inside an oil-immersed, and there is a sliding clutch to protect gears and blades when the load is increased or there is an obstacle in front of it. It also attached two opener furrows after the rotary plow with a distance of (50 cm), which are connected to two body holders. The distance between them is 75 cm, and it can be changed by moving the two hitch points for the two body legs on the frame to suit the distances of the crops grown on the furrows. One hull consists of two wings that can regulate the distance between them using two sliding steel rulers to form varying furrows in a cross-sectional area.

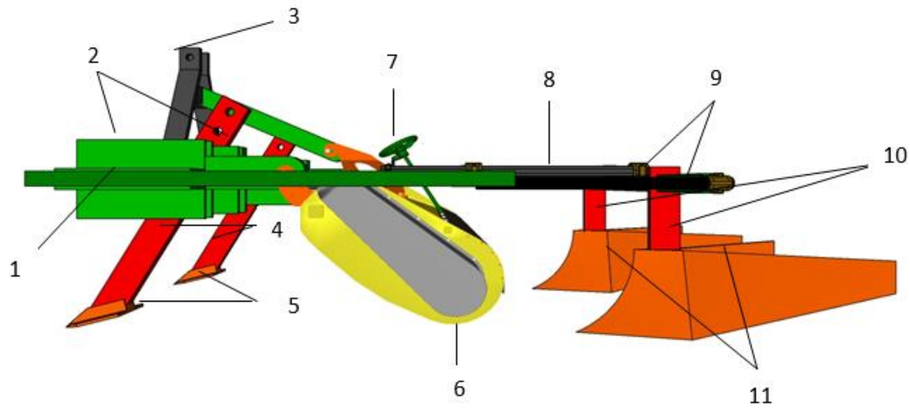

Figure 1. Combined tillage machine and two opener furrow: 1. Frame 2. Two lower linkage points 3. upper linkage point 4. Leg of subsoiler 5. Feet of subsoiler *6.* Rotary plow 7. Rotary plow lifting and lowering lever 8. Telescopic shafts control the distance between the opener furrows and the rotary plow 9. Installation point of opener furrows in frame 1*0.* Holder of opener furrows 11. Plates of the opener furrows.

Experiment of design:

The study was conducted by factorial experiments(factorial within the split block) according to the randomized complete block design(RCBD) with three replicates [20]. Tilling depths(30, 40 and 50 cm) occupy the longitudinal strips while the two rotational speeds are(250 and 300 rpm) and the distance between two plates of the opener furrows(25, 30 and 35 cm) randomly distributed within each strip where each block contain 36 treatments .thus, the number of experimental units is 108 units

Measuring soil characteristics:

Samples were randomly taken from the field soil and analyzed in the laboratory to know the general soil characteristics Table 1. The following characteristics were measured for three depths (0-20, 20-40 and 40-60 cm).

Soil texture:

Soil separations were estimated by pipetting method to determine soil texture, and the results are shown in Table 1, [6].

Moisture Content:

Soil moisture was estimated by the gravimetric method, and the moisture percentage was calculated depending on the dry weight. The results are shown in Table 1.

Soil Bulk Density:

The bulk soil density was measured by using the Core sample method, and it was calculated from the following relationship after drying the samples for 24 hours in an electric oven at a temperature of 105 °C; the results are shown in Table 1. [6]

$$\rho_p = \frac{ms}{V}$$

where:

ρ_p: Bulk density(Mg m^{-3})

ms: mass of solid particles(Mg)

V : The total volume of the soil represents the volume of the cylinder (m^3)

Total porosity

The total porosity was calculated from the relationship between the bulk density and the particle density, according to the method described by [7], and the results are shown in Table 1.

Electrical conductivity:

It was measured in a filtrate-saturated dough using the meter-EC according to the method described in [8]. As shown in Table 1.

Penetration of the soil resistance**:** Measured using a digital penetrometer (HUMBOLDT). The device was used by applying a constant force to its handle, which is 0.10 m long and connected to a stem of 0.80 m that ends from the bottom with a cone with a base diameter of 0.015 m and a summit angle of 30º. The device was used by placing it perpendicular to the surface of the soil and pushing the cone into the soil. The penetration resistance was measured directly through a screen at the top of the device for depths from 0 to 60 cm, which gives the reading in kilograms, which was converted to kN by multiplying it by the conversion factor 9.81, and the results are shown in Table 1.

A 100 g sample was ground in a ceramic mortar with 20 ml of acetone to a concentration of 80% and put into a centrifuge at a speed of 3000 revolutions per minute for 15 minutes. The filtrate was removed and reextracted by adding 5 ml of acetone each time until the filtrate was lost in color. Then, the filtrate was collected and used to estimate the carotene concentration; the absorbance was measured at wavelengths 480, 645 and 663 nm using a spectrophotometer. The following equation estimated the carotene content:

Carotene (mg.gm-1)= ((A480 + A663 0.114) – (A645 0.638))/ W $\times$1000 $\times$a)

a. The wavelength within the spectrophotometer cell.

v= The volume of the sample.

w= The fresh weight of the sample.

Plowing depth (cm)	Moisture content (%)	Bulk density (Mg m^{-3})	Porosity(%)	Ec (Specimens m^{-1}	Soil resistance penetration (kN m^{-2})
0-20	.49116	2.55	51.313	10.629	3824.85
20-40	19. 515	2.58	49. 527	9.503	4573.02
40-60	21.732	2.61	47.264	7.28	5290.71
Average	19.246	2.58	49.368	9.137	4562.86
Soil texture: Silty clay	**Clay (g kg^{-1})**	**Silt (g kg^{-1})**	**Sand (g kg^{-1})**	**Irrigation water salinity Decimens m^{-1})(**	2.731

Table 1. Physical characteristics of the soil.

Measuring field performance indicators:
The study was conducted at Agricultural College- University of Basrah, Karmatt-Ali site northwest of Basrah Governorate, in Silty clay soil. Table 1 evaluates the

field performance of the combined tillage and opener furrows machine and its effect on some mechanical and field indicators that included

Draft force:

A load cell was used to measure the draft force of the combined tiller cultivator for all study parameters. Using a flexible wire, the load cell was connected between the Massey-Ferguson 440 extra tractor (MF1) and the Massey-Ferguson 285 driven tractor. The two tractors and the machine almost touched the ground to measure the rolling resistance, and the tractor was driven in a neutral position. When working, the readings of the draft force are recorded through a laptop connected to the load cell, where the draft force is calculated according to the following equation: [9].

$$F = Ft - Rr$$

where:

F: the draft force of combined machine(kN).

Ft: Total draft force(kN).

R: eTractor rolling resistance(MF1) (kN

Mean weight diameter:

The mean weighted diameter was estimated as evidence of the stability of soil aggregates for all study factors after using the combined tiller using the Sieving Dry method according to the following equation: [10].

$$MWD = \sum_{i=1}^{n} \bar{X} iWi$$

Whereas:

MWD refers to Mean weight diameter(mm).

Wi:: refers to the mean diameter for any volumetric range of separated assemblies.

$\bar{X}$: The weight of the remaining aggregates within one volumetric range as a proportion to the total dry weight of the soil model.

Field efficiency**:**

It represents the ratio between the actual field productivity and the theoretical productivity of the combined tillage machine, and it is calculated from the following equation: [11].

$$Fe = \frac{Pp}{Pt} \times 100$$

Fe: The field efficiency of the plow (%).

Pp: Practical productivity of the combined tiller (he h^{-1}).

Pt: Theoretical productivity of the combined tiller (he h^{-1})

Whereas practical productivity is the actual performance of the combined tillage machine during a specified time, and it is calculated according to the following equation:

$$Pp = 0.1 \times Bp \times Vp \times Ft$$

As for the theoretical productivity, it is calculated from the following equation:

$$Pt = 0.1 \times Bp \times Vt$$

Results

Draft force(F):

Effect of the depth of tillage on the draft force

Table 2 shows the relationship between the depth of plowing by the combined machine and the force required to pull it, as the pulling force increases with the increase in the depth of plowing, and the reason for this is due to the increase in the bulk density of the soil as a result to the increase in its disassembled size in addition to the increase in its cohesion force. The increase in the depth of the soil leads to a decrease in The movement of the soil towards the surface and transmission of its movement forward because of the increase in the pressure of its weight, which increases the resistance of the soil on the machine, to collide the plowed soil with the non-plowed soil, as this requires a force to cut it, which increases the force required to pull the machine. The results showed an increase in the pulling force from 20.90 kN to 31.13 kN when the plowing depth was increased from 30 cm to 50 cm.

Effect of the rotational speed of rotary plow blades on the draft force

The results of Table 2 show the effect of the speed of rotation of the rotary plow blades on the pull force. The pulling force decreased significantly($P < 0.05$) with the increase in the rotational speed, as the increase in the speed of the rotary plow blades reduced the force required to pull the machine because the direction of rotation of the blades is the same as the direction of the rotation of the tractor wheels, and this increases the cohesion force between the mechanical group with the soil, This helps to overcome the resistance that the soil shows on the plow blades, which reduces the force required to pull the machine. At 300 rpm, the lowest pulling force reached 24.15 kN, while the rotation speed recorded at 250 rpm, the highest pulling force reached 28.12 kN.

Effect of The distance between two opener furrow plates on the draft force

Increasing the distance between the two plates of the two opener furrows led to a significant increase in the pulling force of the combined machine, as we note through the results shown in Table 2 that the highest average of pulling force was reached at 30.78 kN at the distance of 45 cm. In contrast, the distance of 35 cm recorded the lowest average, reaching 21.88 kN. The reason is due to the resistance of the cross-sectional area due to the increase in the width of the furrow.

Effect of the interaction between the depth of tillage and the rotational speed of the rotary plow blades on the draft force

Table 3 shows the effect of the interaction between the depth of plowing and the speed of the rotary plow blades on the draft force. The draft force decreased with increased rotational speed for all plowing depths, but the 50 cm depth recorded the highest draft force at the slow rotational speed of 250 rpm^{-1}, amounting to 33.22 kN. While the depth of 30 cm and the high rotational speed of 300 rpm^{-1} recorded, the lowest pulling force reached 19.72 Kn.

Effect of the interaction between the depth of tillage and the distance between two opener furrow plates on the draft force

The results shown in Table 3 refer to no significant differences between the average pulling force by the effect of the interaction between the depth of plowing and the distance between the two plates of the two opener furrows.

The effect of interaction between the speed of the rotary plow blades and the distance between the two opener furrow plates on the draft force:

The results shown in Table 3 show significant differences(P< 0.05) in the pulling force due to the interaction effect of the rotational speed of the rotary plow blades and the distance between the two plates. The rotational speed of 250 rpm and the distance between the two plates of 45 cm achieved the highest pulling force of 33.00 kN, while the rotational speed was recorded at 300 rpm and the distance between the two plates, 35 cm, recorded the lowest pulling force of 20.40 kN.

Effect of the interaction between depth of tillage, the rotational speed of the rotary plow blades, and the distance between two opener furrow plates on the draft force

The results shown in Table 3 show the insignificance(P< 0.05) of the effect of interaction between the depth of. Plowing, the speed of the rotary plow blades, and the distance between the plates of two opener furrows on the draft force.

depth of tillage(cm)			The rotational speed of the rotary plow(rpm)		The distance between two opener furrow plates(cm)		
D1	**D2**	**D3**	**S1**	**S2**	**W1**	**W2**	**W3**
20.90 ± 0.39	**31.13 ± 0.58**	**26.50±0.49**	**28.21 ± 0.52**	**24.15 ± 0.45**	**21.88 ± 0.41**	**25.88 ± 0.48**	**30.78 ± 0.57**
LSD(D) 2.079			**LSD(S) 1.057**		**LSD(W) 1.295**		

D: Depth of plow(cm), S: rotational speed of the rotary plow blades(rpm), W: the distance between the two plates of the two opener furrows(cm). The means show a significant difference at 5%; N.S.: This means no significant difference.

Table 2. Effect of the depth of tillage, the rotational speed of the rotary plow, and the distance between two opener furrow plates on the draft force.

depth of tillage, the rotational speed, the distance between two opener furrow plates						
D & S & W	**S1**			**S2**		
D	**W1**	**W2**	**W3**	**W1**	**W2**	**W3**
D1	17.56 ± 0.33	21.47 ± 0.40	27.24 ± 0.50	16.41 ± 0.30	18.43 ± 0.34	24.23 ± 0.45
D2	24.46 ± 0.45	29.38 ± 0.54	34.11 ± 0.63	19.45 ± 0.36	23.25 ± 0.43	28.38 ± 0.52
D3	28.09 ± 0.52	33.91 ± 0.63	37.66 ± 0.70	25.33 ± 0.47	28.83 ± 0.53	32.95 ± 0.61
	N.S.					
depth of tillage and the rotational speed						
D & W	**W1**	**W2**	**W3**	**D & S**	**S1**	**S2**
D1	16.98 ± 0.31	19.95± 0.37	25.78 ± 0.48	**D1**	22.09 ± 0.41	19.72 ± 0.37
D2	21.96 ± 0.41	26.31± 0.49	31.24 ± 0.58	**D2**	29.31 ± 0.54	23.69 ± 0.44
D3	26.71 ± 0.49	31.37± 0.58	35.31 ± 0.65	**D3**	33.22 ± 0.62	29.04 ± 0.54
N.S.				**LSD(D & S) 1.832**		
the rotational speed and the distance between two opener furrow plates						
S & W	**W1**		**W2**		**W3**	
S1	23.37± 0.43		28.25 ± 0.52		33.00 ± 0.61	

S2	20.40 ± 0.38	23.51 ± 0.44	28.55 ± 0.53
LSD(S & W) 1.832			

D: Depth of plow(cm), S: rotational speed of the rotary plow blades(rpm), W: the distance between the two plates of the two opener furrows(cm).

The means show a significant difference at 5%; N.S.: This means no significant difference.

Table 3. Effect of the interaction between the depth of tillage, the rotational speed of the rotary plow, and the distance between two opener furrow plates on the draft force.

Mean weight diameter(MWD):

Effect Depth of tillage on mean weight diameter:

The results presented in Table 4 show significant differences($P < 0.05$) in the mean weight diameter; the mean weight diameter increased from 13. 56 to 18..29 and then 25.07 mm by increasing the plowing depth from 30 to 40 to 50 cm, respectively. The reason for the decrease in the mean weight of the diameter at a depth of 30 cm is due to the decrease in the bulk density and the increase in the moisture content, which led to the penetrating easily of subsoiler shanks because the soil had weaker cohesive within this depth, As this led to an increase in the percentage of soil pulverization compared to the depth of 50 cm,

Effect of the rotational speed of the rotary plow blades on the mean weight diameter

Table 4 shows the effect of the rotational speed of the rotary plow blades on the mean weight diameter. There was a significant decrease($P < 0.05$) in the mean weight diameter from 26.13 to 11.82 mm with increasing rotational speed from 250 to 300 rpm, respectively.

Effect of the distance between two opener furrow plates on the mean weight diameter:

The results shown in Table 4 illustrated no significant differences($P < 0.05$) in the mean weight diameter due to the effect of the distance between two opener furrow plates.

Effect of the interaction between depth of tillage and the rotational speed of rotary plow blades on the mean weight diameter: From the results shown in Table 5, noticing a significant increase($P < 0.05$) in the mean weight diameter with the increase in the plowing depth and the minimum rotational speed of the rotational speed of rotary plow blades. The agreement between the most significant depth of 50 cm and the slow rotational speed of 250 rpm was achieved, and the highest mean weight diameter reached 36.47 mm, compared with the depths of 30 and 40 cm and a high rotational speed of 300 rpm, which recorded the lowest mean weight diameter 10.35 and 11.45 mm respectively.

Effect of the interaction between the rotational speed of the rotary plow blades and the distance between the two opener furrow plates on the mean weight diameter:

Table 5 shows no significant differences ($P < 0.05$) between the average values of the mean weight diameter due to the interaction between the plowing depth and the distance between the plates of the two opener furrows.

Effect of the interaction between depth of tillage, the rotational speed of rotary plow blades and the distance between the two opener furrow plates on the mean weight diameter:

The results shown in Table 5 did not show significant differences between the average values of the mean weight diameter by the effect of the interaction between the rotational speed of the rotary plow blades and the distance between the plates of the two opener furrows.

depth of tillage(cm)			The rotational speed of the rotary plow(rpm)		The distance between two opener furrow plates(cm)		
D1	**D2**	**D3**	**S1**	**S2**	**W1**	**W2**	**W3**
13.56 ± 0.25	**18.29 ± 0.34**	**25.07± 0.46**	**26.13 ± 0.48**	**11.82 ± 0.22**	**19.32 ± 0.36**	18.93 ± 0. 53	18.69± 0.35
LSD(D) 0.472			**LSD(S) 0.482**		**NS**		

D: Depth of plow(cm), S: rotational speed of the rotary plow blades(rpm), W: the distance between the two plates of the two opener furrows(cm). The means show a significant difference at 5%; N.S.: This means no significant difference.

Table 4. Effect of the depth of tillage, the rotational speed of the rotary plow, and the distance between two opener furrow plates on the mean weight diameter.

depth of tillage, the rotational speed, the distance between two opener furrow plates						
D & S & W	**S1**			**S2**		
D	**W1**	**W2**	**W3**	**W1**	**W2**	**W3**
D1	17.81 ± 0.33	16.22 ± 0.30	16.30 ± 0.30	10.77± 0.20	10.24 ± 0.19	10.04 ± 0.19
D2	25.30 ± 0.47	24.95 ± 0.46	25.17 ± 0. 65	11.53 ± 0.21	11.44 ± 0.21	11.37 ± 0.21
D3	36.84 ± 0.68	36.82 ± 0. 68	35.75 ± 0.66	13.65 ± 0.25	13.88 ± 0.26	13.50 ± 0.25
N.S.						
depth of tillage and the rotational speed						
D & W	**W1**	**W2**	**W3**	**D & S**	**S1**	**S2**
D1	14.29 ± 0.26	13.23 ± 0.25	13.17 ± 0.24	**D1**	16.78 ± 0.31	10.35 ± 0.19
D2	18.42 ± 0.34	18.20 ± 0.34	18.27 ± 0.34	**D2**	25.14 ± 0.47	11.45 ± 0.21
D3	25.25 ± 0.47	25.35 ± 0.47	24.36 ± 0.45	**D3**	36.47 ± 0. 68	13.68 ± 0.25
N.S.				**LSD(D & S) 0.835**		
the rotational speed and the distance between two opener furrow plates						
S & W	**W1**		**W2**		**W3**	
S1	26.65 ± 0.49		26.00 ± 0.48		25.74 ± 0.47	
S2	11.98 ± 0.22		11.85 ± 0.22		11.64 ± 0.22	
N.S.						

D: Depth of plow(cm), S: rotational speed of the rotary plow blades(rpm), W: the distance between the two plates of the two opener furrows(cm). The means show a significant difference at 5%, N.S.: Means no significant difference

Table 5. effect of the interaction between the depth of tillage, the rotational speed of the rotary plow, and the distance between two opener furrow plates on the mean weight diameter.

Field Efficiency(Fe):

Effect depth of the tillage on field efficiency:

The results in Table 6 showed a significant decrease($P < 0.05$) in the field efficiency of the combined plowing machine by increasing the plowing depth. The field efficiency decreased from 73.28 to 58.21% when the plowing depth was increased from 30 to 50 cm. This is due to the increasing difference between practical and theoretical productivity, which resulted from the high slip, which increased the time required to complete the work.

Effect of the rotational speed of the rotary plow blades on field efficiency: The results of Table 6 show that the field efficiency increased significantly($P < 0.05$) with increasing rotational speed. The high rotational speed of 300 rpm recorded the highest field efficiency, reaching 69.12%, while the lowest rotation speed at 250 rpm recorded the lowest field efficiency, reaching 63.81%.

Effect of the distance between two opener furrow plates on field efficiency: Table 6 shows the relationship between the distance between two opener furrow plates and the field efficiency, as the field efficiency decreased significantly ($P < 0.05$) from 68.39% to 66.63 and 64.38% when increasing the distance between two opener furrows plates from 35 to 40 and 45 cm, respectively. To develop the feet opener furrows to the no-till sowing by adding a plate on the shallows of the opener with a width of 7 and 9 cm, where the practical productivity of the wide opener furrow (9 cm) was significantly reduced, as it reached 1.372 he hour-1 compared to the traditional merow opener And the narrow-lamellar (7 cm) marrow opener, which recorded the highest practical productivity, which did not differ significantly, was 1.402 and 1.406 ha hr-1, respectively, Since the relationship between the field efficiency and the practical productivity is a positive relationship.

Effect of the interaction between the depth of tillage and the rotational speed of rotary plow blades on the field efficiency: Table 7 shows the interaction effect between the plowing depth of the combined machine and the rotary plow blades' rotation speed. The results showed the best significant agreement($P < 0.05$) between the shallow plowing depth of 30 cm and the second rotation speed of 300 rpm, where the highest field efficiency reached 75.49 %. In comparison, the shallow depth of 30 cm, the rotation speed of 250 rpm, the medium depth of 40 cm and the rotation speed of 300 rpm recorded a good field efficiency, reaching 71.07 and 70.05%, respectively. While the depth of 50 cm and the slow speed of 250 rpm were recorded, the lowest field efficiency reached 54.60 %.

Effect of the interaction between the depth of tillage and the distance between two opener furrow plates on the field efficiency: The results of Table 7 show that there are no significant differences between the average field efficiency of the combined tillage machine and the two opener furrows by the effect of the interaction between the depth of plowing and the distance between the wings of the two opener furrows.

depth of tillage(cm)			The rotational speed of the rotary plow(rpm)		The distance between two opener furrow plates(cm)		
D1	**D2**	**D3**	**S1**	**S2**	**W1**	**W2**	W3
73.28 ± 1.36	**67.90 ± 1.26**	**58.21 ± 1.08**	**63.81 ± 1.18**	**69.12 ± 1.28**	**68.39 ± 1.27**	**66.63 ± 1.23**	64.38 ± 1.19
LSD(D) 1.509			**LSD(S) 0.763**		**LSD(W) 0.934**		

D: Depth of plow(cm), S: rotational speed of the rotary plow blades(rpm), W: the distance between the two plates of the two opener furrows(cm).

The means show a significant difference at 5%; N.S.: This means no significant difference.

Table 6. Effect of the depth of tillage, the rotational speed of the rotary plow, and the distance between two opener furrow plates on the field efficiency.

depth of tillage, the rotational speed, the distance between two opener furrow plates						
D & S & W	**S1**			**S2**		
D	**W1**	**W2**	**W3**	**W1**	**W2**	**W3**
D1	72.96 ± 1.35	71.11 ± 1.32	69.15 ± 1.28	76.89 ± 1.42	75.56 ± 1.40	74.01 ± 1.37
D2	66.97± 1.24	65.94 ± 1.22	64.32 ± 1.19	72.21 ± 1.34	70.12 ± 1.30	67.83 ± 1.26
D3	56.66 ± 1.05	55.05 ± 1.02	52.10 ± 0.96	64.62 ± 1.20	62.01±1.150	58.84 ± 1.90
N.S.						
depth of tillage and the rotational speed						
D & W	**W1**	**W2**	**W3**	**D & S**	**S1**	**S2**
D1	74.93± 1.39	73.33 ± 1.36	71.58 ± 1.33	**D1**	71.07 ± 1.32	75.49 ± 1.40
D2	69.59± 1.29	68.03± 1.26	66.07± 1.22	**D2**	65.74 ± 1.22	70.05 ± 1.30
D3	60.64± 1.12	58.53±1.08	55.47± 1.03	**D3**	54.60 ± 1.01	61.83 ± 1.15
NS				**LSD(D & S) 1.321**		
the rotational speed and the distance between two opener furrow plates						
S & W	**W1**		**W3**		**W3**	
S1	65.53 ± 1.21		64.03 ± 1.19		61.86 ± 1.15	
S2	71.24 ± 1.32		69.23 ± 1.28		66.90 ± 1.24	
N.S.						

D: Depth of plow(cm), S: rotational speed of the rotary plow blades(rpm), W: the distance between the two plates of the two opener furrows(cm).

The means show a significant difference at 5%; N.S.: This means no significant difference.

Table 7. Effect of the interaction between the depth of tillage, the rotational speed of the rotary plow, and the distance between two opener furrow plates on the field efficiency.

Effect of the interaction between the rotational speed of rotary plow blades and the distance between the two opener furrow plates on the field efficiency: The results in Table 7 show that there are no significant differences in field efficiency as a result of the interaction effect between rotational speed and the distance between the plates of the two opener furrows.

Effect of the interaction between depth of tillage, the rotational speed of rotary plow blades, and the distance between two opener furrow plates on the field efficiency: The results shown in Table 7 show that there are no significant differences in field efficiency as a result of the interaction between the depth of plowing and the rotational speed of the axis of the rotary plow blades and the distance between the plates of the two opener furrows.

Discussion

The results of the effect of the depth of tillage on the draft force were confirmed by [12]. This also agrees with [13], who mentioned an increase in the drag force required for the two-armed plow under the soil surface by 11.45 kN when the plowing depth was increased from 25 to 45 cm. Similarly, [14] is reached in his study to perform the performance analysis of a tractor-power harrow system under different working conditions and increase the pulling force by increasing the rotational speed of the power harrow at both depths 6 and 10 cm in both locations A and B. The Effect of The distance between two opener furrow plates on the draft force finding was also reached by [15], who mentioned the existence of significant differences in the draft force as a result of the effect of changing the angle between the wings of the movable-winged ditcher opener with a time of subsoiler compared to the ditcher opener with a fixed width(35) cm, where the draft force increased from 17.39 to 18.40 and then to 21.01 kN when increasing the angle between of a movable-wing of opener ditcher from 45◦ to 60º and then to 75◦ respectively. Interaction between the depth of tillage and the rotational speed of the rotary plow blade*:* causes the increase in the draft force with an increase in the depth of plowing, and a decrease in the rotational speed is the increase in the bulk density of the soil by increasing its loose volume and increasing its cohesion and resistance to Penetration by increasing the depth of plowing. It increases the resistance of the soil on the machine as a result of the collision of the plowed and non-plowed soils, and therefore, the machine's blades need more force to cut the soil; in addition, the decrease in the rotational speed has led to the convergence of the slow rotational speed rotary plow with the forward speed of the tractor, which increases the requirements for its pull. Also, the high rotational speed reduces the draft force necessary for the direction of rotation of the plow blades in the same direction as the tractor wheels, which increases the cohesion of the wheels with the soil and overcomes the resistance shown by the soil. As a result, the increased acceleration of soil particles and their kinetic energy. The variatiom in the result of interaction between the speed of the rotary plow blades and the distance between the two opener furrows plates on the draft force is due to the convergence of the slow rotational speed of the rotary plow blades with the forward speed of the tractor, which increased the requirements for pulling it, In contrast to the high rotational speed of the rotary plow blades that rotate in the same direction as the tractor wheels, which increases the force of soil cohesion with the mechanical group, generating a higher thrust than the resistance that the soil exerts on the operating machine units, which reduces the requirements for its pulling, In addition to the increase in the area of contact of the side plates of the bodies of the two opener furrows, although from the increase in the distance between its plates, which increased the lateral pressure of the soil on its plates, as well as the increase in the width of the loose section of soil, which increased the force required to pull the machine.

The Effect depth of the tillage on field efficiency presents a good agreement with [16]. They reported an increase in the mean weight diameter of the conventional digger and modified plow(with the addition of one pulverizer and two pulverizers with an increase in depth from 15 to 20 and then to 25 cm, respectively. The reason for the effect of the rotational speed of the rotary plow blades is that the speed of rotation reduces the distance from one stock to another since the volume of soil blocks decreases with the shortening of the length of the stroke, In addition, when the speed of rotation of the shaft increases, as the size of the soil masses decreases with the shortening of the length of the stroke, as well as, when the rotation speed of the shaft increases, the soil masses resulting from plowing will break more due to the increased collision with the cover or with the soil after soil expulsion by a shaft of plow blades. This is in agreement with [17]. Who showed a decrease in the mean weight diameter with an increase in the rotational speed of the rotary plow. The increase in the mean weight diameter for interaction between the depth of tillage and the rotational speed of rotary plow blades is due to the increase in the volume of the soil masses and their bulk density with the increase in the plowing depth. In addition, due to its high rotational speed, the blades of the rotary plow led to a shorter stroke length and an increase in the number of blade strokes per unit area. The collision of soil particles with the plow cover and each other led to the soil pulverizing more than a slow rotation speed on the surface.

The effect depth of the tillage on field efficiency results was confirmed by [18]. In his study, which he conducted to measure the field efficiency of some agricultural machines, the results showed a decrease in the field efficiency of all agricultural machines used in the study with an increase in depth from 20 to 80 cm. Furthermore, the rotational speed of the rotary plow blades on the field efficiency resulted from the direction of rotation of the shaft of the bearing blades being in the same direction as the tractor wheels, and this increases the force of cohesion between the soil and the mechanical group, so slipping is reduced, and that reducing slip is an indication of increased field efficiency. This is what Abbas (2004) has achieved about the effect of the rotary plow in breaking up the soil at different depths and speeds. Increasing the rotational speed of the shaft carrying blades from 182 to 285 pm-1 led to a significant increase in the field efficiency value from 70.09 to 70.48% (with an increase amount of 0.55%)

The reason for the distance between two opener furrow plates on field efficiency results in variation is due to the increase in the load and specific resistance, the increase in the percentage of slip and the slowing down of the forward speed of the mechanical assembly as a result of the increase in the distance between the opener furrows plates, This is the conclusion of [19].

Effect of the interaction between depth of tillage and the rotational speed of rotary plow blades on the field efficiency The reason is due to the decrease in the specific resistance and the bulk density of the soil at shallow and medium depth compared to the immense depth of 50 cm. The increase in the speed of the shaft of the rotary plow blades increased the cohesion of the tractor wheels. It reduced the slip, which led to an increase in the coefficient of exploitation of time and speed, and this led to an increase in productivity. This is one of the essential elements in estimating field efficiency, which is directly proportional to it.

Conclusion

Through the results, we conclude that the depth of 30 achieved the lowest draft force for the combined tillage machine, the lower mean weight diameter, and the highest field efficiency compared to the depths of 40 and 50 cm and the rotational speed of 300 rpm for the axis of the rotary plow blades recorded the lowest draft force, the mean weight diameter and the highest efficiency field compared to the rotational speed of 250 rpm. The distance between the wings of the two opener furrows of 35 cm achieved the lowest draft force and the lowest field efficiency compared to the distances of 40 and 45 cm. Accordingly, we recommend using the combined tiller machine with a depth of 30 cm, a rotational speed of 300 rpm, and a distance of 35 cm between the plates of the two cultivars to give them the lowest pulling force and a suitable mean weight diameter and the highest field efficiency.

References

1. Kuht , J. and Reintam E. (). Soil compaction effects on the content of nutrients in spring (HordeumVulgare L.) and spring wheat (Triticum Aestivum L.), Agronmy Research 2 (2), 187.
2. Bychkov V.V., O. A., Sizov, A.Y., Izmailov, O. S., Marchenko V. G., Yakunin T. V., Tsarkova, R.J &., Tekushev J. a. Method of accelerated meadow formation of turf-covered soils in meadowlands and device for its realization. (patent).RU2423034C1.Russia. **2009**.
3. Guangxin, P., Ruili, W., & Yu, Y. Burying Straw at Greater Depths into Soil Using Machinery. **2015**.
4. Formato, A.; Faungo. S and Paolillo G. Numerical simulation of soil-plough moldboard interaction, *Bios Systems Engineering*, **2005**; *92 (3)*, 309-316.
5. Grisso, R. D., Holshouser, D. L., & Pitman, R. M. Planter/drill considerations for conservation tillage systems. Virginia Cooperative Extension. **2014**; P(442-457).
6. Black, C. A.; Evans; J. L. White; L.E. Ensminger & Clark. F.E. Methods of Soil analysis 6th ed. I.Soil physics Am. Soc. Agron. Madison, Wisconsin. The USA. **1983**.
7. Black, C. A .; D.D.Evans ; L.L.White ; L.E.Ensminger and F.E.Clark. Method of soil analysis, Am. Soc . of Agronomy No. 9 part I and II. **1965**.
8. Page, A. L., Miller, R. H., & Keeney, D. R. Methods of soil analysis, part (2) Agronomy g–Wisconsin, Madison. Amer. Soc. Agron. Inc. Publisher. **1982**.
9. McKyes, E. (Ed.). Soil cutting and tillage. Elsevier https://books.google.iq/books?hl=ar&lr=&id=Ho1SW55M13cC&oi. **1985**.
10. Zhang, B., & Horn, R. Mechanisms of aggregate stabilization in Ultisols from subtropical China. Geoderma, 99(1-2), 123-145.https://doi.org/10.1016/S0016-7061(00)00069-0. **2001**.
11. Hancock, J. N., Swetnam, L. D., & Benson, F. J. Calculating farm machinery field capacities. https://uknowledge.uky.edu/aen_reports/20. **1991**.
12. Aday, S. H., Muhsin, S. J., & Hameed, F. M. Design and manufacture subsoil manure laying implement and studying its field performance. *Basrah J. Agric. Sci*, **2008**; *21*, 443-459. https://www.iasj.net/iasj/issue/3419
13. Bander, S. A. Effect of the tractor forward speed and plowing depths on the draft force and the specific resistance of the double tines subsoiler. *Basrah J. Agric. Sci*, **2007**. *20 (2)*, p207-207. 2/3p. https://www.iasj.net/iasj/download/d7ce3091d233287f
14. Balsari, P., Biglia, A., Comba, L., Sacco, D., Alcatraz, L. E., Varani, M., & Aimonino, D. R. Performance analysis of a tractor-power harrow system under different working conditions. Biosystems Engineering, V(202): 28-41. https://doi.org/10.1016/j.biosystemseng.2020.11.009. **2021**.
15. Aday, S.H., & Al-Muthafar, Y.M. Comparison between the performance of movable boards ditch opener and conventional ditch opener in cultivated and uncultivated soils Part 1: The draft force. *Basrah J. Agric. Sci.*, **2018**; *31(1):* 85-92. https://doi.org/10.37077/25200860.2018.81
16. Aday, S. H., & Nassir, A. J. Field study of a modified chisel plow performance: (A): the draft force requirement and the soil pulverization ability. *Basrah J. Agric. Sci,* **2009**; *22(1),* 95-108. https://www.researchgate.net/publication/330384414
17. Hashemi, A., Ahmad, D., Othman, J., & Sulaiman, S. Design, development and performance of a disk plow combined with rotary blades. In IOP Conference Series: *Materials Science and Engineering.* **2012**; *36 (1)* p. 012003). IOP Publishing. http://dx.doi.org/10.1088/1757-899X/36/1/012003
18. Abdelhfeez, A. M. Effect of Some Tillage Operations on Physical Properties of the Soil and Tractor Performance and Sorghum Crop Yield in Sondos Scheme. Thesis degree of the Doctor of Philosophy. Al Neelain University. http://repository.neelain.edu.sd:8080/xmlui/handle/123456789/14536. **2018**.
19. Younis¹, A. F., Tahir, H. T., & Kareem, T. H. Development of a device to cover the shank of furrow openers of zero-tillage planters. *Plant Archives,* **2020**; *20(1),* 576-581. https://www.academia.edu/42952612/
20. Federer, W. T., & King, F. Variations on split plot and split block experiment designs (Vol. 654). John Wiley & Sons. https://doi.org/10.1016/j.biosystemseng.2005.07.005 . **2007**.
21. Aday, S. H., & Al-maliky, H. J. C. (). Further development of a modified chisel plow and studying: (B) Its specific and equivalent energies and energy utilization efficiency (part 2). *BasraJ. Agric. Sci., (23 (2)* : 1-17. https://www.researchgate.net/publication/330305413

22. Kerketta, A. K., Mishra, B. P., Choudhary, S., & Mahilang, K. K. S. Development of Subsoiler Suitable for Chhattisgarh Plain. *Int. J. Pure App. Biosci*, **2018**; *6(1),* 1478-1485. http://dx.doi.org/10.18782/2320-7051.6373
23. McKyes, E., & Maswaure, J. Effect of design parameters of flat tillage tools on loosening clay soil. Soil and Tillage Research, 43(3-4), 195-204 https://doi.org/10.1016/S0167-1987(97)00014-7. **1997**.

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