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Evaluation of the Performance of Locally Developed Combine Equipment Used for Several Agricultural Operations at Once

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Abstract

A field experiment was conducted to evaluate the performance of locally developed combine equipment used for several agricultural operations at once in a silt clay loam soil texture. Three factors were used. The first is the forward speed of the machinery unit, with three speeds: of 2.98, 4.37, and 6.18 km h^{-1}, the second is plowing depths, with three plowing depths and subsurface irrigation pipes of 10/20, 15/25, 20/30 cm, the third is the distances between the subsurface irrigation pipes, with three distances of 50, 60 and 70 cm. The field efficiency of the combine equipment, soil moisture content, soil penetration resistance and soil bulk density were studied. Faltra tractor was used as a power source with a power of 88 kW (120 hp), with the combine equipment. The results showed that the speed of 6.18 km h^{-1} was significantly higher in obtaining the highest field efficiency. While the speed of 2.98 km.h^{-1} was outperformed in obtaining the highest value for soil moisture content, the lowest soil penetration resistance and the lowest soil bulk density compared to the other speeds. The depth of plowing and subsurface irrigation pipes 10/20 cm outperformed in obtaining the highest field efficiency, the highest moisture content, the least soil resistance to penetration, and the lowest soil bulk density compared to other depths. The distance of 70 cm was significantly outperformed in obtaining the highest field efficiency, the highest value of moisture content, the least soil resistance to penetration, and the lowest bulk density compared to other distances. The treatment of speed 2.98 km.h^{-1}, depth 10/20 cm, and distance 70 cm outperformed in obtaining the highest moisture content of 19.40%, the lowest soil penetration resistance of 2.42 kg.cm^{-2}, and the lowest soil bulk density of 0.93 µg.m^{-3} compared to other treatments.

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Introduction

The compound machine performs several agricultural operations at the same time, and the compound machines contain primary equipment as well as secondary equipment and crop service machines. The compound machine requires a high power that must be available in the agricultural tractor to complete the agricultural operations. Plowing and seeding machines are the basis for the productivity of the crop to be cultivated (Jasim, 2019). When using agricultural machinery and equipment in the process of soil preparation and other agricultural operations, it causes compaction of the soil, an increase in bulk density, a decrease in porosity, and an increase in soil resistance to root growth and seedling emergence. Where the compound machines work to reduce the compaction of the soil, reduce its compaction, reduce the energy expended, save the quantities of spent fuel, reduce the time, increase the susceptibility of leaching, reduce runoff, and reduce soil erosion to reach the best growth of the roots, and then we get an increase in the yield when performing any agricultural operation (Jasim *et al.*, 2018).

Speed is important in the processes that make the physical soil conditions suitable for plant growth. The optimal selection of equipment helps to maintain the specific characteristics of the soil, and if such equipment is not chosen correctly, this leads to negative effects on the physical characteristics of the soil and makes it inappropriate (Al-Banna, 1990), and the speed factor has a significant effect on field efficiency, as the increase in speed increases field efficiency, and the reason for this may be attributed to the fact that the higher the speed, the higher the practical productivity as a result of an increase in the working width of plowing, so the field efficiency increases (Al-Hashemi, 2012).

Field efficiency is affected by the increase in the depth of plowing, as the efficiency decreases with increasing depth (Al-Shujairi, 2008). Some soil characteristics are affected by the increase in the speed of the machine unit and the depth of plowing, such as an increase in the resistance of the soil to penetration and an increase in the bulk density of the soil, and it may lead to a decrease in moisture content at some times (Al-Azzawi, 2022; Abo-Habaga *et al.*, 2018). Increasing the distance between the subsurface irrigation pipes also leads to a decrease in the bulk density, as the distance of 20 cm outperformed by achieving the lowest bulk density of 1.20 $\mu g.m^{-3}$. While the distance of 10 cm recorded the highest bulk density of 1.23 $\mu g.m^{-3}$ (Jabbar, 2021) Considering the importance of developing, manufacturing and testing combine equipment that perform the most agricultural process at the same time by knowing the effect of forward speed, plowing depth, subsurface irrigation pipes, and the distance between subsurface irrigation pipes on the field efficiency of the machine and some physical properties of the soil is an imperative task Therefore, this study aims to develop, manufacture and test combine equipment that perform the most agricultural process at the same time by knowing the effect of forward speed, plowing depth, subsurface irrigation pipes and the distance between subsurface irrigation pipes on the field efficiency of the machine and some physical properties of the soil.

Materials and Methods

A field experiment was conducted at Al-Raed Research Station, 25 km west of Baghdad, to evaluate the performance of a locally developed combine equipment used for several agricultural operations at once in a sand, silt and clay soil texture, its physical and chemical properties are shown in Table (1) for the spring growing season 2022. Three factors were used in the experiment. The first is the forward speed of the machine unit, with three speeds of 2.98, 4.37, and 6.18 $km.\ h^{-1}$, The second is plowing depths, which included three plowing depths and subsurface irrigation pipes of 10/20, 15/25, 20/30 cm, the third is the distances between the subsurface irrigation pipes, with three distances of 50, 60 and 70 cm. The field efficiency of the combine equipment, soil moisture content, soil penetration resistance and soil bulk density were studied.

The experiment was designed according to the (Nest Design) system, under the randomized complete block system, with three replications, where the speed factor was allocated to the main plot, depth to sub-plot, and pipe distance to sub-sub plots. The least significant difference test was used with a probability of 0.05 (L.S.D = 0.05) to compare treatments means (Elsahooki and Wahib, 1990).

The experiment included 27 treatments (3 x 3 x 3), i.e. 81 experimental units. The length of the experimental unit is 10 m and the width is 3 m. That is, the area of the experimental unit is 30 m^2, leaving a distance of 10 m before each replicate for the purpose of the tractor gaining constant speed. The total area in which the experiment was carried out was 3 dunums (7500 m^2). A combine equipment consisting of a tillage system, subsurface drip irrigation pipe installation system, seeding system, fertilization system, first irrigation system, pesticide spraying system, and leveling system was developed, manufactured, and tested, as shown in Figure (1)

Table 1. Physical and chemical properties of soil texture

Soil depth cm	soil separates g. kg^{-1}			soil texture	Volumetric moisture content at field capacity %	Volumetric moisture content at wilting point %	pH	Soil Ec ds m^{-1}	bulk density $\mu g.m^{-3}$	soil penetration resistance kg cm^{-2}
	clay	silt	sand							
0-30	%12	%52	%35	silty clay loam	44.46	20.46	7.7	8.15	1.39	1.10
30-60	%11	%51	%36	silty clay loam	44.81	21.44	7.4	8.44	1.42	2.90

Figure 1. The compound equipment used in the experiment

The results of the experiment were measured as follows:

1- Field efficiency of the compound machine (%)

The field efficiency was calculated using the formula proposed by (Hunt, 1980):

$$\mathbf{Fe\ (\%) = Pp / Pt \times 100}$$

Whereas:
Fe: field efficiency of the machine (%)
Pp: practical productivity of the machine (ha/hour)
Pt: theoretical productivity of the machine (ha/hour)

2-Soil moisture content (%)

The moisture content of the soil was calculated according to the gravimetric method using the equation suggested by (Gardner, 1965):

$$P_w = \left(\frac{Msw - Ms}{Ms}\right) * 100\ \%$$

Whereas:
Pw: gravimetric moisture content
Msw: wet soil mass (g)
Ms: dry soil mass (g)

3- Soil Penetration Resistance (kg.cm^{-2})

Soil penetration resistance was measured using a pocket Penetrometer KM Mark (N715) made in Japan (Mousavi *et al.*, 2021), as shown in Figure 2.

Figure 2. The pocket penetrating soil resistivity meter

4- The bulk density of the soil (µg.m^{-3})

The bulk density was calculated using the equation proposed by Black (1965):

$$\rho_B = \frac{Ms}{V_{total}}$$

Whereas:
ρ_B : soil bulk density (µg.m^{-3})
Ms : mass of the oven-dried soil sample (µg)
V_{Total}: total soil volume (m^3)

Results and discussion

1- Field efficiency of the combine equipment (%)

The results indicate that there is a significant effect of the forward speed of the mechanical unit on the field efficiency of the compound machine, as the speed of 6.18 km.h^{-1} recorded the highest field efficiency value of 70.70% compared to other speeds (Table 2), due to the fact that the forward speed is one of the components of practical productivity, and when the speed increases, the productivity increases, and then the field efficiency increases, and these results are consistent with the results obtained (Muhammad and Jasim, 2021; Al-Azzawi *et al*., 2022).

The results also indicate that there are significant differences in the characteristic of field efficiency as a result of the depths of plowing, as the depth 20 cm. Significantly outperformed with the highest value for field efficiency (70.10%) compared to other depths, due to the decrease in practical productivity by increasing the depth, which leads to a decrease in field efficiency. These results are consistent with the results obtained by Al-Azzawi and Zain Al-Din (2022); Jebur (2018).

The results show the effect of the distance between the irrigation pipes on the field efficiency, as the distance between the irrigation pipes of 70 cm outperformed with the highest field efficiency of 69.58% compared to other distances (Table 2). This is due to the fact that the working width is one of the product components, and when the working width increases, the practical productivity increases, and thus the field efficiency increases and decreases when the distance decreases, due to the convergence of the arms of the chisel plow and the reduction of the working width.

The results indicate a significant two-way interaction between speeds and depths in the field efficiency, where the speed of 6.18 km. h^{-1}, and plowing depth of 10/20 cm, outperformed and achieved the highest field efficiency of 72.44%, while the speed of 4.37 km.h^{-1} and the plowing depth of 20/30 cm was the least field efficiency, (66.99%). These results agree with the results obtained by Taha (2011).

The two-way interaction between the speed of 6.18 km. h^{-1} and the distance between the irrigation pipes of 70 cm recorded the highest percentage of field efficiency (70.88%), while the speed of 2.98 km. h^{-1} and the distance between the pipes of 50 cm recorded the lowest field efficiency percentage of 66.56%.

The results of the analysis indicated a significant three-way interaction between the plowing depth and the distances between the pipes, as the depth of 10/20 cm and the distance of 70 cm gave the highest field efficiency value of 70.61% compared to other interactions.

The results indicate a significant three way interaction between speed, plowing depth, and distance between pipes, where the interaction treatment of speed 6.18 km.h^{-1}, depth 10/20 cm, and distance 70 cm outperformed with the highest field efficiency of 73.11%, while the interaction between speed 2.98 km h^{-1} and depth 20/30 cm and the distance 50 cm recorded lowest field efficiency of 65.23%.

Table 2. Effect of forward speed, plowing depth and distances between subsurface irrigation pipes on field efficiency (%)

forward speed (km. h^{-1})	plowing depth and irrigation pipes (cm)	Three-way interaction: Distance between sub-surface irrigation pipes 70 cm	60 cm	50 cm	speed x plowing depth
2.98	10/20	68.25	67.91	67.35	67.84
	15/25	67.50	67.67	67.11	67.43
	20/30	71.08	66.06	65.23	67.45
4.37	10/20	70.46	69.91	69.72	70.03
	15/25	69.74	69.76	69.46	69.65
	20/30	66.50	67.35	67.11	66.99
6.18	10/20	73.11	72.23	71.99	72.44
	15/25	70.24	70.60	70.15	70.33
	20/30	69.30	69.62	69.10	69.34
LSD=0.05		0.299			0.257
Pipe distance mean		69.58	69.01	68.58	
LS=0.05		**0.072**			
speed x distance					
Forward speed (km h^{-1})		**70 cm**	**60 cm**	**50 cm**	**speed mean**
2.98		68.94	67.21	66.56	67.57
4.37		68.90	69.01	68.76	68.89
6.18		70.88	70.82	70.41	70.70
LSD=0.05		**0.124**			**0.072**
Depth x Distance					
plowing depth and irrigation		**70 cm**	**60 cm**	**50 cm**	**Depth mean**
10/20		70.61	70.02	69.69	70.10
15/25		69.16	69.34	68.91	69.14
20/30		68.96	67.68	67.14	67.93
LSD=0.05		0.257			0.250

2 - Moisture content (%)

The results indicate that there are significant differences between the average speeds, as the speed of 2.98 km.h-1 recorded the highest soil moisture content of 18.24% compared to the other speeds (Table 3). These results agree with the results obtained by Al-Hashemi (2003).

The results also show that the depth of plowing and irrigation pipes have a significant effect on the moisture content of the soil (Table 3), as the depth 10/20 cm outperformed with the highest moisture content of (18.93 %). These results agree with the results obtained by AL-Halfi (2021).

The distance between the irrigation pipes had a significant effect on the moisture content, as the distance of 70 cm recorded the highest percentage of soil moisture content, amounting to 18.21% compared to other distances.

Table 3 shows the superiority of the two-way interaction between the forward speed of 2.98 km. h^{-1} and a depth of 10/20 cm. The highest value of the soil moisture content amounted to 19.23%, while the speed of 6.18 km.h^{-1} and a depth of 20/30 cm recorded the lowest value of 17.02%. The interaction between the speed of 2.98 km.h^{-1} and a distance of 70 cm recorded the highest value of 18.43%, while the speed of 6.18 km h^{-1} and a distance of 50 cm recorded the lowest value of 17.66%. A depth of 10/20 cm and a distance of 70 cm recorded the highest value in soil resistance to penetration of 19.04%, while a depth of 20/30 cm and a distance of 50 cm recorded the lowest value of 16.99%. A depth of 10/20 cm and a distance of 70 cm recorded the highest value in the soil moisture content of 19.04%, while a depth of 20/30 cm and a distance of 50 cm recorded the lowest value of 16.94%.

The results show that the three-way interaction between the forward speed, depth of plowing, and irrigation pipes, and the distance between the subsurface irrigation pipes had a significant effect on the moisture content of the soil, as the speed of 2.98 km.h^{-1}, and depth of 10/20 cm, and a distance of 70 cm, recording the highest value of 19.40%. While the three-way interaction between the speed of 6.18 km.h^{-1}, the depth of plowing and the irrigation pipes 20/30 cm and a distance of 50 cm recorded the lowest value of 16.78%.

Table 3. Effect of forward speed, plowing depth and distances between subsurface irrigation pipes on the moisture content of the soil (%)

forward speed (km h^{-1})	plowing depth and irrigation pipes (cm)	Three-way interaction: Distance between sub-surface irrigation pipes 70 cm	60 cm	50 cm	speed x plowing depth
2.98	10/20	19.40	19.23	19.05	19.23
	15/25	18.21	18.05	17.92	18.06
	20/30	17.68	17.37	17.21	17.42
4.37	10/20	18.94	19.04	18.99	18.99
	15/25	18.04	17.99	17.90	17.98
	20/30	17.70	17.40	16.81	17.30
6.18	10/20	18.79	18.50	18.42	18.57
	15/25	18.00	17.74	17.79	17.84
	20/30	17.08	17.19	16.78	17.02
LSD=0.05		0.084			0.058
Pipe distance mean		18.21	18.06	17.87	
LS=0.05		**0.026**			
speed x distance					
Forward speed (km h^{-1})		**70 cm**	**60 cm**	**50 cm**	**speed mean**
2.98		18.43	18.22	18.06	18.43
4.37		18.23	18.14	17.90	18.23
6.18		17.96	17.81	17.66	17.96
LSD=0.05		0.044			0.026
Depth x Distance					
plowing depth and irrigation		**70 cm**	**60 cm**	**50 cm**	**Depth mean**
10/20		19.04	18.92	18.82	18.93
15/25		18.08	17.93	17.87	17.96
20/30		17.49	17.32	16.94	17.25
LSD=0.05		0.058			0.051

3- Soil resistance to penetration (kg. cm^{-2})

The results showed that there was a significant effect of the forward speed on the soil resistance to penetration, as the speed of 2.98 km.h^{-1} outperformed with the lowest value of the soil resistance to penetration (2.65 kg. cm^{-2}) compared to the other speeds. The reason for this is that the increase in the speed works on the speed of extrusion of the soil masses, and then increases the fragmentation of the soil and thus increases the soil bulk density which leads to an increase in soil resistance to penetration, and this is consistent with the findings of Al-Rajabo and Hilal (2012).

The depth of plowing and irrigation pipes had a significant effect on the soil resistance to penetration, as the depth of 10/20 cm outperformed with the lowest value of 2.58 kg cm^{-2} compared to other depths. The reason for this is that the soil particles move to the surface area and settle in the large pores. This leads to an increase in the bulk density at that depth and a decrease in moisture content, which leads to an increase in the soil resistance to penetration, and this agreed with the results obtained by Menkhy and Jebur (2022); Talabani and Saad (2018).

The results indicate a significant effect of the distance between the irrigation pipes on soil resistance to penetration, as the distance of 70 cm outperformed with the lowest soil resistance to penetration value of 2.67 kg.cm-2 compared to other distances.

The results indicate that the two-way interaction between the speed, the depth of plowing and the irrigation pipes has a significant effect on the soil resistance to penetration, as the speed of 2.98 $km.h^{-1}$ and a depth of 10/20 cm outperformed with the lowest soil penetration resistance value of 2.53 $kg.cm^{-2}$. While the speed of 6.18 $km.h^{-1}$ and a depth of 20/30 cm, recorded the highest value of 2.90 $kg.cm^{-2}$. These results agree with the results obtained Al-Azzawi (2022). The results also indicate that the two-way interaction between speed and distance had a significant effect, as the speed of 2.98 km.h-1 and the distance between the irrigation pipes 70 cm, outperformed with the lowest value of soil penetration resistance of 2.61 $kg.cm^{-2}$, while the speed of 6.18 $km.h^{-1}$ and the distance between pipes. Irrigation of 50 cm, recorded the highest value of 2.77 kg. cm^{-2}.

The depth of 10/20 cm and the distance of 70 cm recorded the lowest value in the soil resistance to penetration amounted to 2.50 $kg.cm^{-2}$, while the interaction between the depth of 20/30 cm and a distance of 50 cm recorded the highest value in the soil resistance to penetration of 2.86 $kg.cm^{-2}$.

The three-way interaction between the speed of 2.98 $km.h^{-1}$ and a depth of 10/20 cm and a distance of 70 cm recorded the lowest value of 2.42 $kg.cm^{-2}$, while the interaction between the speed of 6.18 $km.h^{-1}$ and a depth of 20/30 cm with a distance of 50 cm recorded the highest value of 2.92 kg. cm^{-2}.

4- Bulk density (µg. m^{-3})

The effect of forward speed, plowing depth, irrigation pipes, and distances between subsurface irrigation pipes on the bulk density are presented in Table (5). The results indicate that the speed of 2.98 $km.h^{-1}$ outperformed with the lowest value in the bulk density of 1.24 $µg.m^{-3}$ compared to the other speeds. The reason for this is that the increase in speed leads to the extrusion of soil masses and their rapid fragmentation, which causes an increase in soil compact, and then a decrease in its porosity and an increase in the bulk density. These results agree with the results obtained by Al-Azzawi (2022). The results also indicate that the depth of plowing and irrigation pipes had a significant effect on the bulk density of the soil, as the depth of 10/20 cm, outperformed with the lowest value of the bulk density of 1.07 $µg.m^{-3}$ compared to other depths. The reason for this is that increasing the depth increases the compaction of the soil, which leads to the convergence of the soil particles and fills the voids in the soil, which results in an increase in the weight of the soil to a unit volume, so the bulk density increases. These results are consistent with the results of Al-Khalidi (2021); Mankhi and Jebur (2022). The results also indicate that there are no significant differences between the distances between the subsurface irrigation pipes in bulk density.

The results indicate a significant two-way between speed, depth of plowing and irrigation pipes in bulk density, where the speed of 2.98 $km.h^{-1}$ and a depth of 10/20 cm. outperformed with the lowest value of 0.98 $\mu g.m^{-3}$, while the speed of 4.37 $km.h^{-1}$ and a depth of 30/20 cm, recorded the highest value of 1.65 $\mu g.m^{-3}$, and these results agree with the results obtained (Al-Ardhi, 2011). The results also indicate that there are no significant two-way interaction between the speed and the distance between the subsurface irrigation pipes. The results also show a significant interaction between the depth of 10/20 cm and the distance between the subsurface irrigation pipes of 70 cm with the lowest value in bulk density amounting to 1.04 $\mu g.m^{-3}$, while the depth 20/30 cm and a distance of 70 cm recorded the highest value of 1.49 $\mu g.m^{-3}$.

The results show a significant three-way interaction between speed, plowing depth, irrigation pipes, and the distance between subsurface irrigation pipes. Where the speed of 2.98 $km.h^{-1}$, depth of 10/20 cm, and distance of 70 cm, outperformed with the lowest value of 0.93 $\mu g.m^{-3}$. While the interaction between the speed of 4.37 $km.h^{-1}$, depth of 20/30 cm,and distance of 70 cm, recorded the highest bulk density value of 1.65 $\mu g\ m^{-3}$, as well as the same result at the same speed and depth in the distance of 50 cm.

Table 4. Effect of forward speed, plowing depth and distances between subsurface irrigation pipes on soil resistance to penetration (kg. cm^{-2})

forward speed (km. h^{-1})	plowing depth and irrigation	Three-way interaction: Distance between sub-surface irrigation 70 cm	60 cm	50 cm	speed x plowing depth
2.98	10/20	2.42	2.54	2.64	2.53
	15/25	2.59	2.63	2.69	2.64
	20/30	2.81	2.73	2.79	2.78
4.37	10/20	2.52	2.56	2.66	2.58
	15/25	2.71	2.76	2.69	2.72
	20/30	2.80	2.82	2.86	2.82
6.18	10/20	2.55	2.60	2.68	2.61
	15/25	2.74	2.76	2.70	2.73
	20/30	2.87	2.91	2.92	2.90
LSD=0.05		0.048			0.028
Pipe distance mean		2.67	2.70	2.74	
LS=0.05		**0.026**			
speed x distance					
Forward speed (km h^{-1})		**70 cm**	**60 cm**	**50 cm**	**speed mean**
2.98		2.61	2.64	2.71	2.65
4.37		2.68	2.71	2.74	2.71
6.18		2.72	2.76	2.77	2.75
LSD=0.05		0.028			0.016
Depth x Distance					
plowing depth and		**70 cm**	**60 cm**	**50 cm**	**Depth mean**
10/20		2.50	2.57	2.66	2.58
15/25		2.68	2.72	2.70	2.70
20/30		2.83	2.82	2.86	2.83
LSD=0.05		0.028			0.020

Table 5. Effect of forward speed, plowing depth and distances between subsurface irrigation pipes on bulk density (μg. m^{-3})

forward speed (km. h^{-1})	plowing depth and irrigation pipes	Three-way interaction Distance between sub-surface irrigation			speed x plowing depth
		70 cm	60 cm	50 cm	
2.98	10/20	0.93	0.98	1.04	0.98
	15/25	1.14	1.15	1.52	1.27
	20/30	1.62	1.59	1.20	1.47
4.37	10/20	1.07	1.10	1.12	1.10
	15/25	1.38	1.31	1.17	1.29
	20/30	1.65	1.63	1.65	1.65
6.18	10/20	1.11	1.17	1.15	1.14
	15/25	1.15	1.53	1.60	1.43
	20/30	1.19	1.19	1.22	1.20
LSD=0.05		0.331			0.274
Pipe distance mean		1.25	1.29	1.30	
LS=0.05		**0.026**			
speed x distance					
Forward speed (km h^{-1})		**70 cm**	**60 cm**	**50 cm**	**speed mean**
2.98		1.23	1.24	1.25	1.24
4.37		1.37	1.34	1.31	1.34
6.18		1.15	1.30	1.32	1.26
LSD=0.05		N.S			0.016
Depth x Distance					
plowing depth and		**70 cm**	**60 cm**	**50 cm**	**Depth mean**
10/20		1.04	1.08	1.10	1.07
15/25		1.22	1.33	1.43	1.33
20/30		1.49	1.47	1.36	1.44
LSD=0.05		0.274			0.264

Conclusion

It can be concluded from the preceding the success of the use of the compound machine in conducting the plowing process and installing the irrigation pipes and the pipes of the planting seeds, the pesticide, the fertilization, the initial irrigation, the leveling and the mulching at the same time. We conclude that the speed of 2.98 km.h^{-1}, the depth of plowing, the subsurface pipes 10/20 cm, and the distance of 70 cm, outperformed because gave the best physical soil characteristics. We recommend using a compound machine manufactured and developed locally, and using a speed of 2.98 km.h^{-1}, a depth of 10/20 cm, and a distance of 70 cm. We also recommend conducting other experiments on using the other compound machine in other soils.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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References

Abo-Habaga, M., Imara, Z., and Okasha, M. (2018). Development of a Combine Hoeing Machine for Flat and Ridged Soil. *Journal of Soil Sciences and Agricultural Engineering*, *9*(12), 817-820. https://doi.org/10.21608/jssae.2018.36548

Al-Ardhi, J. K. Z., (2011). Effect Of Type of Tractor, Speed and Depth of Plowing on Some Technical Indicators of The Mechanical Unit and Physical Properties of The Soil. *Master thesis*, Department of Agricultural Machinery and Equipment, College of Agriculture, University of Baghdad.

Al-Azzawi, G. S., Al-Aani, F. S., and Dawood, M. A. (2021). The Effect of Practical Speed and Added Weights on the Efficiency Performance of tractors (NEW HOLLAND T1520), *Iraqi Journal of Soil Sciences, 22*(1), 116-123.

Al-Azzawi, R. A. R. and Zain Al-Din, L. A. A. (2022). Study of cloud efficiency and field efficiency and their impact on some physical soil characteristics, *Iraqi Journal of Soil Sciences*, *22* (2),18-25.

Al-Azzawi, R. A. R. S., (2022). Evaluating The Performance of a Compound Machine and Its Impact on Some Technical Indicators of The Mechanical Unit and Some Physical Soil Properties. *Master Thesis*, Department of Agricultural Machinery and Equipment, College of Agriculture, University of Baghdad.

Al-Banna, A. R. (1990). Soil Preparation Equipment, Directorate of Dar Al-Kutub for Printing and Publishing, Ministry of Higher Education and Scientific Research.

Al-Hashemi, L. A. A., (2012). The effect of the angle of inclination of the disc plow discs and the speed and depth of plowing on some technical indicators and the capacity requirements of the mechanical unit, *Iraqi Journal of Agricultural Sciences*, *43* (2), 143-132.

Al-Hashemi, L. A. Z. (2003). Studying Some Technical and Economic Indicators and Physical Soil Characteristics Under Tillage Systems. Master's thesis, Department of Agricultural Mechanization, College of Agriculture, University of Baghdad.

Al-Khalidi, W. F. S. (2021). Manufacture and Testing of a Hydraulic Device Used to Take Soil Samples at Different Depths. *Master Thesis*, Department of Agricultural Machinery and Machinery, College of Agricultural Engineering Sciences, University of Baghdad, Ministry of Higher Education and Scientific Research.

Al-Rajabo, S. A. and Hilal, Y. Y. (2012). The effect of the subsoil plow weapon with reciprocating wings on some physical and mechanical properties of the soil, *Iraqi Journal of Soil Sciences*, *12* (1), 18-28.

Al-Shujairi, T. A D. (2008). The Effect of The Added Weights of The Driving Tires on The Puller, The Type of Plow and The Depth of Plowing on Some Performance Indicators of The Mechanical Unit and Some Physical Properties of the Soil. *Master Thesis*, Department of Agricultural Mechanization, College of Agriculture, University of Baghdad.

AL-Halfi, K. M. M. (2021). Evaluation of deep tillage in cohesive soils of Queensland, Australia *(Doctoral dissertation, University of Southern Queensland)*.

Black, C. A. (1965). Methods of soil Analysis. AM. Soc. Agron. No. 9 Part 1.

Elsahooki, M. M., and Wahib K. M. (1990). Applications in Design and Analysis of Experiments, Ministry of Higher Education and Scientific Research, Dar

Al-Hikma for Printing and Publishing, University of Baghdad.

Gardner, W. H. (1965). Water content. Methods of Soil Analysis: Part 1 Physical and Mineralogical Properties, Including Statistics of Measurement and Sampling, *9*, 82–127.

Hunt, D. (1980). Farm Power and Machin Management .U.S.A.

Jabbar, F. A. (2021). The Effect of the Subsurface Drip Irrigation System on Some Soil Characteristics and the Growth and Production of Rice, *Master Thesis*, Department of Agricultural Machinery and Equipment, College of Agriculture, University of Baghdad.

Jasim, A. A., Ati, A. S., Dawood, S. S., and Hussein, O. (2018). The effect of speed and plowing depths on some performance indicators of the mechanical unit and the growth and production of maize using a five-purpose compound machine. *Iraqi Journal of Soil Sciences 18* (1) 28-35.

Jasim, A. A. (2019). The effect of the speed of the mechanized unit and irrigation systems on some technical indicators and the production of yellow corn. Proceedings of the Third International Agricultural Conference, University of Mosul, *Al-Rafidain Agriculture Journal*, *47* (1) 416-427.

Jebur, H. A. (2018). The effect of power losses for agricultural tractor on tractive efficiency. *Journal of Research in Ecology*, *6*(1), 1481-1489.

Mankhi, A. A., and Jebur, H. A. (2022). The effect of plowing and smoothing using a locally manufactured compound machine on some performance indicators of the machine. *Iraqi Journal of Soil Sciences*, *22* (1), 99-106.

Mousavi, F., Abdi, E., Ghalandarayeshi, S., and Page-Dumroese, D. S. (2021). Modeling unconfined compressive strength of fine-grained soils: Application of pocket penetrometer for predicting soil strength. *Catena*, *196*, 104890.

Muhammad, I. I., Jasim, A. A. (2021). The use of an agricultural robot in agriculture, fertilization and first irrigation in some performance characteristics, *Iraqi Journal of Soil Sciences*, *21* (1) 126-135.

Talabani, J. H. N., and Saad, T. M. (2018). The effect of soil moisture and plowing depths on some technical indicators using the triple disc plow, *Iraqi Journal of Soil Sciences*, *18* (1), 36-42.

Taha, F. J. (2011). Chisel plow performance under plowing depths and tractor speed, *Iraqi Journal of Agricultural Sciences, 42*(5) 67-72.