University of Thi-Qar Journal of agricultural research
ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 12, Issue 2 (2023) PP 59-69
https://jam.utq.edu.iq/index.php/main **https://doi.org/10.54174/utjagr.v12i2.263**

Study of the effect developed chisel plow on some energy requirements and some soil properties in a clayey mixture soil

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Abstract

The experiment was conducted at the fields of the College of Agriculture - University of Basra to study the effect height of sweeps shank equipped with the developed chisel plow (10 and 20 cm), with three depths (15, 25 and 35 cm) and three lateral distance (20, 25 and 30 m), on the field performance indicators of the draft force and the area of loosened soil. In a mixed alluvial soil with a density of (1.25) g-cm^3 and a moisture content of (15.17) %, the experiment was designed according to the randomized complete block design (RCBD).

The drafting force increased when the lateral distance and plowing depths increased, while it decreased when the arms of the sweeps shank increased by 20 cm. The loosened area increased when the plowing depths and the lateral distance increased when the arms of the duck hind legs were 10 cm high. The highest drafting force recorded at the height of the arms of the sweeps shank20 cm, the distance between them 30 cm, and the plowing depth 35 cm. The highest loosened area recorded at the height of the arms of the sweeps shank10 cm and the depth of plowing 35 cm.

Keywords: chisel plow, draft force, energy requirement, field performance, loosened soil area.

I. INTRODUCTION

The process of preparing the land for cultivation requires preparing a good place for the seeds and for the extension of the roots in this land to meet their needs of water, air and other nutrients [1]. [2] the total energy consumed in preparing the land for agricultural purposes reaches 60% of the total energy consumed in agricultural operations, as the chisel plow needs a pulling force of up to 60 kN in heavy soil [3], and the pulling force is affected by the depth of plowing [4], as the pulling force increased from 7.52 to 15.90 kN when the depth increased from 11.5 to 23 cm. [5] He also found a relationship and a significant effect between the pulling force and plowing depth, as the pulling force increased by 27% when the plowing depth increased from 15 to 20 cm, and the increase in plowing depth led to an increase in the pulling force, as it increased by 27% when the plowing depth increased from 15 to 20 cm, which led to an increase in the load on the tiller as a result of the increase in the pulling capacity of the tiller, and thus the pulling capacity increased

The loosened soil area is one of the most important factors for evaluating the field performance of a plow. It depends on several factors, including soil texture, moisture, depth of plowing, angle of inclination of the plow, and the additives provided by the plow. [7] He indicated that increasing the depth from 20 to 42 cm using the subsoil plow in the silty clay soil led to an increase in the loose area of 0.0184 to 0.0508 m 2 as a result of the critical depth moving away from the soil surface and increasing the cross-sectional width of the sectional area, as it was found [8] that increasing the plowing depth leads to an increase in the loosened soil area, and when increasing the depth from 30 to 60 cm, the loosened area increased by 114.29% in Clay soil. The reason is due to the critical depth moving away from the soil surface to the bottom. The results showed increase in the loosened area with the depth in the plowed soil is higher than in the unplowed soil for all the depths used in plowing due to the lower resistance of the plowed soil than the unploughed soil as a consequence of its lack of adhesion and low cohesion, which leads to an increase in the volume of the loosened soil and an increase in the width of the section of the loosened area. [9], in an experiment they conducted on the soil plow with different compositions and different soil moisture, found that the loosened area exceeded the humidity of 18.01% by 10.80% over the moisture treatment of 27.34%.

II. MATERIALS AND METHODS:

2.1 Chisel plow:

The developed chisel plow manufactured in the workshops at Department of Agricultural Machinery and Machinery used. The design is 200 cm wide and contains two rows of arms. The first row contains four shear tools of the type of sweeps shank with a width of 15 cm. The second row contains two types of shear tools. Three shear tools of the type of sweeps shank with a width 10 cm. Its height can be controlled to be 10 and 20 cm. below it are three shear tools, the type of narrow tine, with a width of 5 cm. The distance between the first and second rows is 70 cm, and the distance between the shear tools can be control to be 20, 25, and 30 cm.

2.2 Measuring the moisture content and bulk density of the soil:

Determine the soil moisture content as well as the bulk density by taking random samples from the field at depths of 0-15, 15-25 and 25-35 cm, with three replications for each sample to increase the accuracy of the experiment by means of the core, as the samples were dried in the oven, at a temperature of 105c for a period of 24 hours, then the percentage of moisture was calculated on the basis of dry weight, and calculated from equation (1)

$$MC = Wwet - Wdry / Wdry \times 100 \ldots\ldots\ldots\ldots (1)$$

So

M.C = soil moisture content (%). W_{dry} = dry mass of soil (g). W_{wet} = mass of wet soil (g).

The apparent density of the soil calculated from equation (2), and the results shown in Table No. (1).

$$\rho b = ms / vt \ldots\ldots\ldots\ldots (2)$$

so:

ms = soiled mass (g). **Vt** = total Volume (cm^3).

2.3 Agricultural tractors:

The agricultural tractor was used (Massy Ferguson 440 Xtra), manufactured in 2011, equipped with a four-cylinder diesel engine with a power 60 kW, the Revolutions per minute is 2200 rpm, and its liter volume is 4.4 litter. It was also used to load the developed chisel plow, the agricultural tractor type (CASE JX75T), manufactured in 2011, with a four-cylinder capacity of 55 kW that generates propulsion with its rear wheels, and the front wheels can also be used, and the weight of the tractor is 25.251 kN.

2.4 Draft force:

The draft force measured by a (load cell) device to calculate the required draft force of chisel plow. The device connected between the driving tractor (Massey-Ferguson 440 Xtra) and the driven tractor (CASE JX75T) and the developed chisel plow attached to it. Its arms barely touched the ground by means of a flexible metal wire and the tractor was in a neutral position. When working, the readings of the drafting force recorded through a laptop connected to the load cell device through a USB connection for each shear tools height. Lateral distance and plow depths.

2.5 Loosened area:

It calculated by digging a trench perpendicular to the path of the developed chisel plow and removing the soil to show the trace of the shear tools, and then the loosened area calculated from equation (3), appears as shown in Figure (1).

$$A = [0.5(b+(2S+3W2))*du] + 3(dc*w1) \ldots\ldots\ldots\ldots (3)$$

Since:

(A): The sectional area of the loosened soil (m2). **(b):** Width of loose soil from edge to edge (m).

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(du): depth of soil plowed with duck-leg arms for both rows (m). **(dc):** the depth of the groove from the end of the loose soil in the second row (m). **(S):** the distance between the two grooves (m).

(w1): the width of the groove from the top (m). **(w2):** groove bottom width (m).

(d): plowing depth (m).

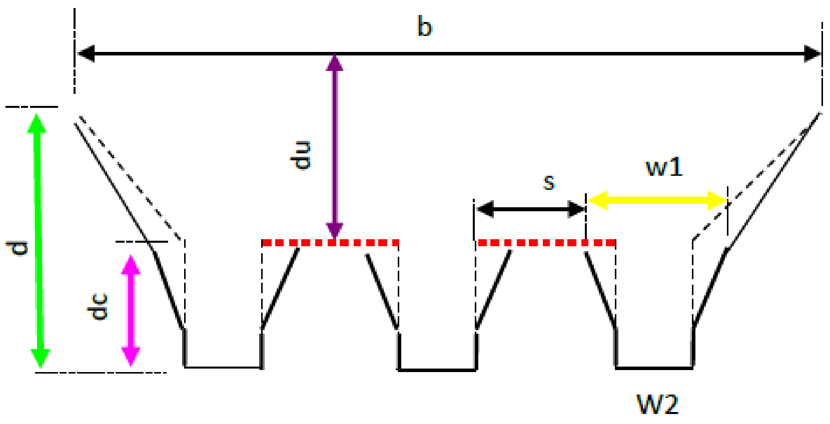


Figure (1) Geometric section of loose soil by the developed chisel plow

III. RESULTS AND DISCUSSION

3.1 Drafting force: Figure (2) shows an increase in drafting force by 19.40% at the first height of 10 cm. The reason for this may be due to the fact that the height of the shear tool is 10 cm away from the narrow tine shear tool, which leads to the deepening of the sweeps shank in the second row more in the soil, which made them work to cut the soil slice, and the presence of soil layers above them, which led to converting part of the available power into a force used to cut the soil in addition to stirring it.

The drafting force also affected by the lateral distance, as the lateral distance 30 cm recorded the highest drafting force, as it increased by 21.39% when the lateral distance increased from 20 to 30 cm. This may be because increasing the lateral distance to 30 cm increased the area of soil cut by the plow arms, which required consuming more power in order to overcome the strength of the soil and thus increased the drafting force. While, when increasing the lateral distance from 20 to 25 cm, the drafting force increased by 13.66%, because the lateral distance was small, which led to overlapping their work, as the front arms worked to dismantle the soil, and thus the role of the rear arms comes to work in a part of the soil that has been plowed to complete the rest of the un ploughed part.

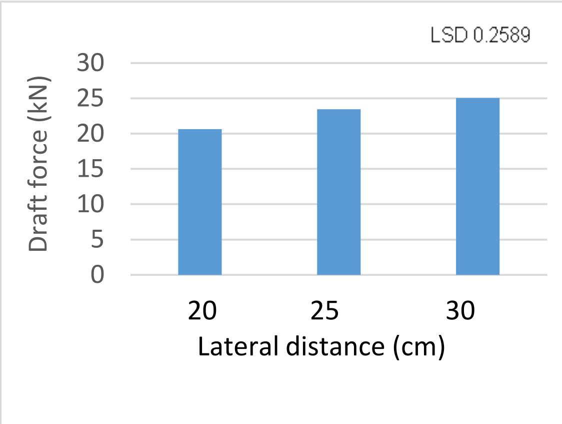


Figure (3) the effect of the lateral distance on the drafting force

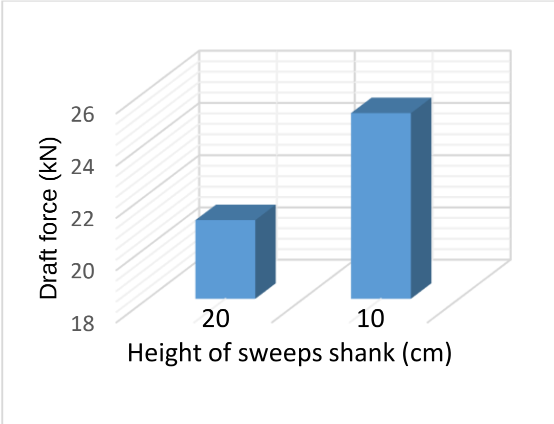


Figure (2) the effect of the height of the rear sweeps shank on the drafting force

Figure (10) also shows an increase in the drafting force when increasing the depth from 15 to 35 cm, by 24.73%, while the drafting force increased by 12.01% when increasing the plowing depth from 15 to 25 cm. The reason may be due to the increase in soil strength with depth because of increasing its cohesion and thus increasing its shear strength, as well as the weight of the soil affecting the plow arms, and this is consistent with what he found. . [10]

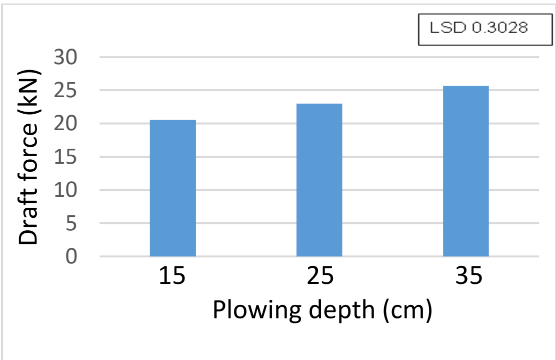
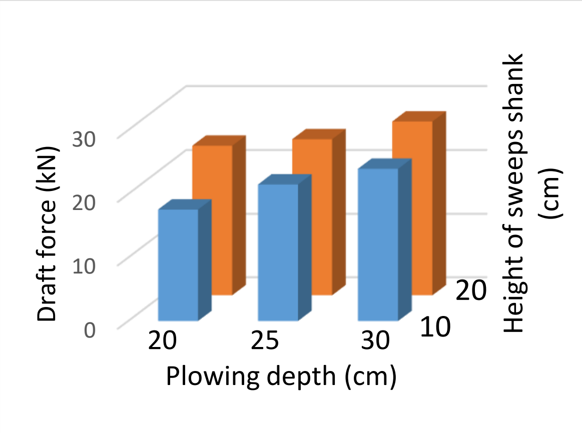


Figure (4) the effect of plow depth on the drafting force

Effect of Interferences on Draft Force:

The results of the statistical analysis, showed that there was a significant effect of the overlapping of the height sweeps shank and the lateral distance ($p < 0.05$), through Figure (5) we note the recording of the bilateral overlap between the height of sweeps shank 20 cm and the lateral distance of 30 cm for the arms. The higher the draft force was 27.63 kN, an increase of 37.79% compared to the required draft force when the bilateral overlap was 10 cm for the height of the sweeps shank and 20 cm for the lateral distance. The reason may be due to the increase in the area of the soil cut by the plow arms and the increase in the volume of soil on the sweeps shank in the second row, as well as the strength of the soil at great depths, which increases the required drafting force. And the drafting force increased by 5.95% at the plow distance of 20 cm and the height of 20 cm for the sweeps shank, compared with the height of 10 cm for the sweeps shank. While the drafting force increased by 29.14% when the lateral distance 25 cm and the height of the arms of the sweeps shank was 20 cm, compared with the height of the shear tool of the sweeps shank10 cm and the same lateral distance.

Figure (6) also shows the increase in the drafting force of the developed chisel plow with the overlapping of the height of sweeps shank and the depth of plowing. The increase in the drafting force is due to the increase in the depth of plowing, which in turn requires a greater drafting force to cut the soil and overcome the strength of the soil.



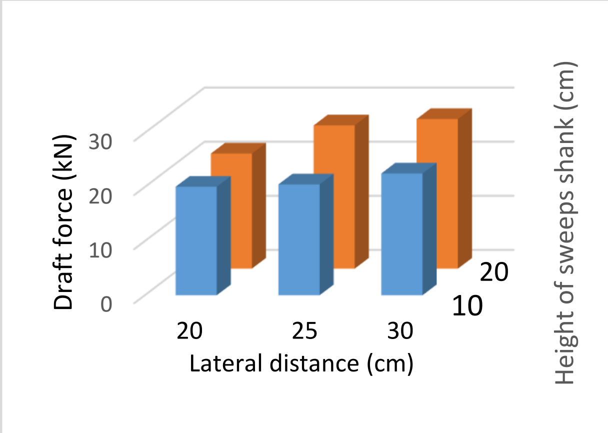


Figure (6) The effect of overlapping the height Of sweeps Shank and the depth of plowing On the drafting force

Figure (5) The effect of overlapping the height sweeps shank and the lateral distance on the drafting force

Figure (7) shows the increase in the plowing force developed by increasing lateral distance and depth of plowing, as the withdrawal force increased at the intermediary distance of shear tool 30 and depth The soil strength with increased depth.

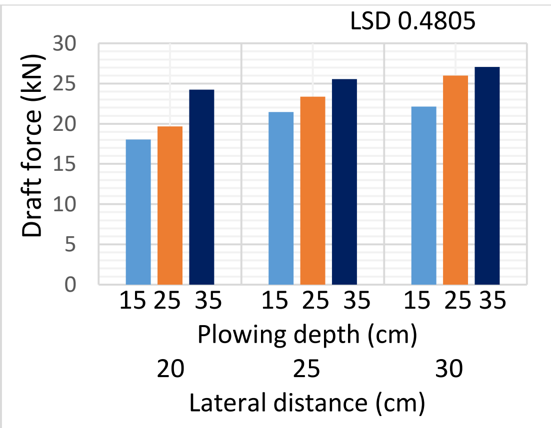


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Figure (7) The effect of overlapping the lateral distance and the depth of plowing on the drafting force

Table (1) shows the increase in the drafting force of the developed chisel plow when changing the height of sweeps shank, the lateral distance and the depth of plowing. Moreover, the reason for the increase in the drafting force is due to the increase in the area cut by the plow arms and the increase in the strength of the soil with the increase in depth, as well as the weight of the loose soil resulting from the increase in its size in front of the sweeps shank.

Table (1) shows the effect of the triple overlap of the height of sweeps shank, The lateral distance and plowing depth

Height of sweeps shank (cm)	Lateral distance (cm)	Plowing depth (cm)		
		15	25	35
10	20	17.850	19.590	22.710
	25	17.473	20.560	23.413
	30	17.413	24.360	25.733
20	20	18.227	19.737	25.763
	25	25.463	26.177	27.717
	30	26.823	27.643	28.413

3.2 Loosened area:

3.2.1 The effect of the height of the arms of the sweeps shank in the loosened area:

The loosened area increased Fig (8) by 11.82% compared to the loosened area when the sweeps shank were 20 cm high, and this may be due to the fact that the height of 10 cm led to the depth of the sweeps shank more in the soil and thus increased the area of contact of the arms with the soil, which increased the area of loosened soil.

3.2.2 Influence of the lateral distance in the loosened area:

The loosened area increased Fig (9) by 13.46% when increasing the lateral distance of the arms from 20 to 30 cm, while the loosened area decreased when reducing the lateral distance from 30 to 25 and from 25 to 20 cm by 3.80 and 8.38%, respectively, as shown in Figure (15). This may be due to the increase in the lateral distance, which increases the working width of the plow, as well as the increase in the contact area between the plow arms and the cut soil, thus increasing the area of loose soil.

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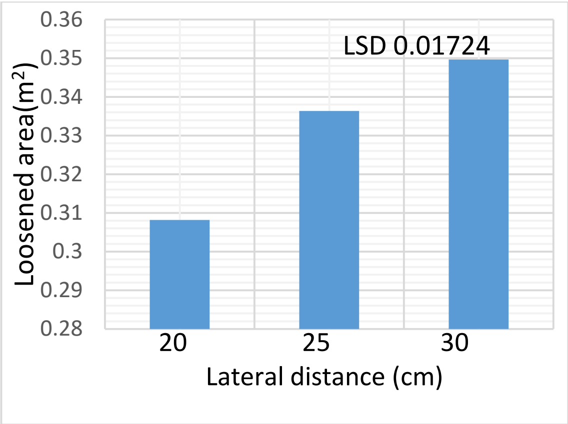

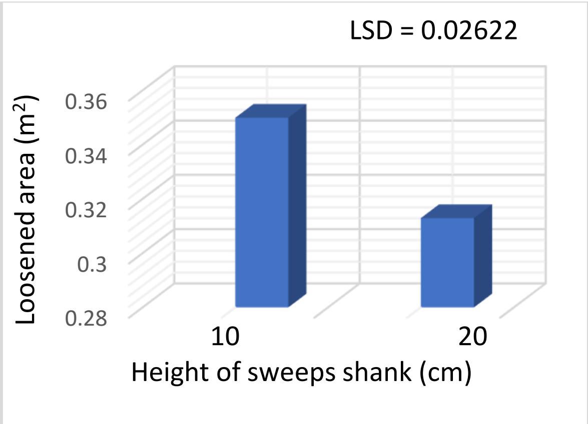

Figure (9) The effect of the lateral distance On the loosened area

Figure (8) The effect of the height of sweeps shank in the back row in the loosened area

3.2.3 Effect of tillage depth in the loosened area:

The loosened area increased Fig (10) by 179.34% when the depth increased from 15 to 35 cm. The reason is that the increase in depth led to an increase in the area plowed by the shear tool of the front row and increased cracks in the soil, which helped to increase the plowed area in the second row. In addition to increasing the depth of plowing, it works to increase the size of the loose soil blocks by the plow's shear tool with the increase in depth, which results in an increase in the loosened area, and this is consistent with [11] and [12].

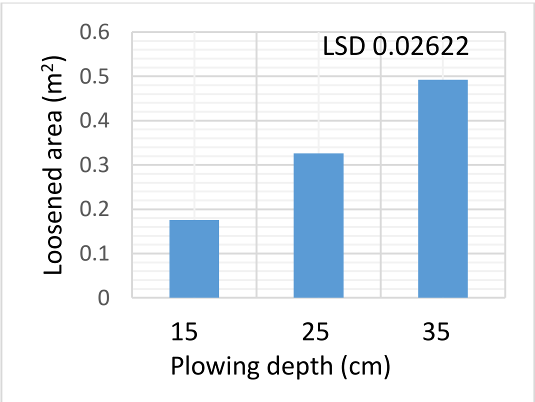

Figure (10) The effect of plowing depth on the loosened area

3.2.4 The effect of overlaps on the loosened area:

The results of the statistical analysis showed that there was no significant effect of the interference of the height sweeps shank and the lateral distance in the loosened area. With regard to the overlap between the height of sweeps shank and the plowing depth, loosened area increased by 202.75% when the sweeps shank were 10 cm high and the plowing depth was 35 cm when compared to sweeps shank height of 20 cm and the plowing depth of 15 cm.

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This may be due to the increase in the depth of plowing, as well as the deepening of the arms of the sweeps shank at a height of 10 cm, and thus an increase in the loosened area, Figure (11). The reason for the increase in the loosened area may be due to the height of the shear tool of the sweeps shank10 cm higher than the nose of the shear tool of the narrow tine, which led to a greater depth in the soil, thus increasing the area of contact with the soil, while the height of 20 cm for the shear tool of the sweeps shank is located near the surface of the soil, thus the area of contact of the arms with the soil decreases, and thus the loosened area decreases.

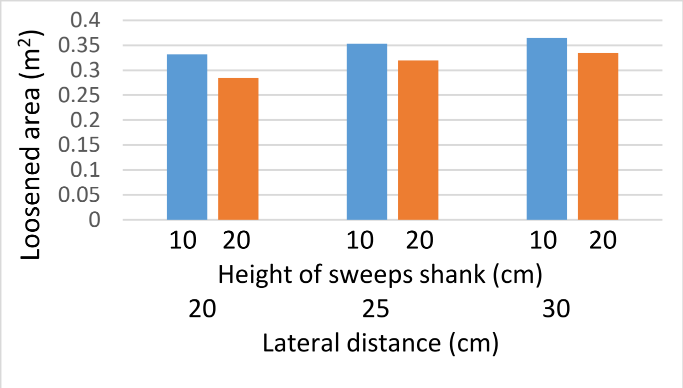

Figure (11) Overlapping the height sweeps shank and the depth of plowing in the loosened area

The results of the analysis did not show a significant effect of the overlap of the lateral distance and the depth of plowing in the loosened area ($p < 0.05$). The results of the statistical analysis also showed that there was no significant effect of the triple overlap between the height sweeps shank, the lateral distance and the depth of plowing in the loosened area ($p < 0.05$).table (3).

Table (2) Statistical analysis of draft force

Draft force					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
R stratum	2	3.9970	1.9985	3.22	
M	1	226.4433	226.4433	365.14	0.003
Residual	2	1.2403	0.6201	5.47	
A	2	180.1887	90.0944	794.36	<.001
M.A	2	58.5067	29.2534	257.93	<.001
Residual	8	0.9073	0.1134	0.59	
B	2	232.6251	116.3125	600.53	<.001
M.B	2	22.8501	11.4251	58.99	<.001
A.B	4	23.3232	5.8308	30.10	<.001
M.A.B	4	37.0540	9.2635	47.83	<.001
Residual	24	4.6484	0.1937		
Total	53	791.7842			

Table (3) Statistical analysis of the loosened area

loosened area					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
R stratum	2	0.0015899	0.0007949	1.59	
M	1	0.0184911	0.0184911	36.89	0.026
Residual	2	0.0010026	0.0005013	1.00	
A	2	0.0161756	0.0080878	16.07	0.002
M.A	2	0.0007108	0.0003554	0.71	0.522 N.S
Residual	8	0.0040252	0.0005031	1.32	
B	2	0.8994123	0.4497061	1183.46	<.001
M.B	2	0.0101786	0.0050893	13.39	<.001
A.B	4	0.0026224	0.0006556	1.73	0.177 N.S
M.A.B	4	0.0008507	0.0002127	0.56	0.694 N.S
Residual	24	0.0091198	0.0003800		
Total	53	0.9641789			

IV. CONCLUSIONS

1. The drafting force increased when the lateral distance and plowing depths increased, while it decreased when the arms of the sweeps shank increased by 20 cm.

2. The loosened area increased when the plowing depths and the lateral distance increased when the arms of the duck hind legs were 10 cm high.

3. The highest drafting force recorded at the height of the arms of the sweeps shank20 cm, the distance between them 30 cm, and the plowing depth 35 cm.

4. The highest loosened area recorded at the height of the arms of the sweeps shank10 cm and the depth of plowing 35 cm.

V. RECOMMENDATIONS

1- Using the developed chisel plow with the same experimental conditions to obtain the best results

2- Using the developed chisel plow at a height of 10 cm for the hind legs of the ducks, a spacing of 30 cm, and a plowing depth of 15 cm to obtain the lowest drafting force.

3- Using the developed chisel plow when the height of the arms of the sweeps shank is 10 cm, the distance between them is 30, and the plowing depth is 35, to obtain the highest loose soil area.

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