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A STUDY OF SOME MECHANICAL CHARACTERISTICS TO EVALUATE THE FIELD PERFORMANCE OF THE FURROWS OPENER DEVELOPED UNDER DIFFERENT PLOWING SYSTEMS

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Abstract:

The research was conducted in clayey loamy soil using two plowing systems (T1 chisel) and (T2 moldboard) and three depths of plowing D (10, 20, 30 cm) and three between the two plates of each of the furrows opener (40, 50, 60 cm). to study the effect of the developed sensor on the mechanical properties (draft force, , energy efficiency, and slip ratio).

The results showed the superiority of the machine when used after the chisel (T1) by giving it the least draft force, the lowest slip percentage and the highest rate of energy efficiency. It also showed the superiority of the D3 depth (30 cm) by recording the highest draft force, the lowest energy efficiency and the highest slip rate compared with the two depths (20 and 10 cm). It showed the superiority of the W3 distance (60 cm) over the two distances (40 and 50 cm) by giving it the highest draft force, the lowest energy efficiency, and the highest slip percentage.

The effect of the bilateral interactions between each of (tillage systems and the depth of the furrow opener and between the tillage systems and the spacing between furrow opener boards) had a significant effect on the mechanized traits. While the double and triple interactions recorded a significant effect on the slip percentage.

Keywords: Plowing systems, the depth of the machine (the depth of plowing), the distance between the two extremities of each weapon.

INTRODUCTION:

Agricultural and industrial production methods multiplied and increased rapidly, and this increase is still accelerating as a result of technical and scientific development. Raw materials, products, machines, equipment, and methods created an unprecedented diversity in production methods. The development of mechanization of agricultural processes remained within the framework of the development of the technological process, and this was related to the goal. At the beginning of the industrial revolution, the goal was to produce the machine. Nowadays, the goal has become to improve the design of the machine in order to achieve the required reduction in energy and material consumption. On this basis, new agricultural machines were produced in order to suit modern methods of agricultural production. [1]. The dimensions and shapes of the cultivators, which are made by the machine for opening the cultivators, vary according to the type of crop, its variety, its size, and water needs, as well as the type of soil and the amount of slope. Young plants need small cultivars, and vice versa [2]. furrows are divided according to their shapes into two common types: the full triangle shape and the flat triangle at the base of the furrows. He referred to the standard dimensions of the furrows that meet the needs of most of the crops grown in Iraq [3].

The aim of this research is to study the effect of the interaction between opener furrows treatments (machine depth and angles of boards) and plowing systems in improving some mechanized characteristics.

MATERIALS AND WORK METHODS:

The agricultural and mechanical experiment was conducted on mixed soil for the agricultural season 2022-2023. In one of the agricultural fields affiliated to the Agricultural Research Station - College of Agriculture - Karmat Ali complex, between latitude 30.47 north and longitude 47.80 east, near the teachers' homes, with an area of 1000 square meters, in soil with a mixed, alluvial texture, as shown in Table (1).

Table (1): Primary physical, chemical and mechanical properties of the soil used in the experiments

NO	Properties	Units	Depth (cm)		
			0-10	10 – 20	20 – 30
1	Sand	gm kg-1	208.81	197.22	183.68
	Silt		576.37	586.65	609.83
	Clay		214.82	216.13	206.49
	soil texture		Silt Loam	Silt Loam	Silt Loam
2	bulk density	Mg /m^3	1.44	1.46	1.47
	true density	Mg /m^3	2.62	2.64	2.64
3	Porosity	%	45.04	44.65	44.32
4	moisture content	%	12.46	15.63	19.09
5	penetration resistance	kn / m^2	2479	2648	2872
6	ECe	ds / m	12.41	13.08	13.63

The system of factor experiments according to the method of split plots according to the randomized complete block design (RCBD) with three replicates for each treatment that included dividing the land into two parts, during which two systems were used for plowing (chisel T1) and (moldboard T2) with a depth of 25 cm for both systems, after which the developed furrow opener was introduced With three depths of the furrow opener (10, 20, and 30 cm) and with three distances between the two extremities of each of the three furrows opener (40, 50, and 60 cm), so that the total is 54 treatments with a length of 5 m, with three razors for each treatment to study the effect of the developed razor on some mechanical properties. (Draft force and, energy efficiency, Slipping percentage . The studied characteristics were measured as follows:

Manufacturing Of The Implement

furrows opener developed designed and manufactured the angles between the two beds in the workshop of the Department of Agricultural Machinery and Machinery, College of Agriculture / University of Basra, to perform several functions of the appendices.

First: Opening three passages with one pass.

Second: The possibility of changing the distances between the two balls to control the width of the slide.

Third: The possibility of using it as a digger plow at zero angle.

Fourth: The possibility of using it as a compound machine by adding other mechanical units.

Fifth: Reducing the time, effort and cost required to conduct agricultural operations.

Draw force (F)

The total draft force of the tillage machine was measured using the load cell device. The device was fixed on the rear of the tractor (MF1) and the front of the tractor (MF2) and the anchors were attached to the other end of the load cell by a thick wire. The speed of the tractor engine (MF1) was fixed at 1500 revolutions. / min and its forward speed is 0.37 m/s, it pulled the tractor (MF2) with the anchor attached to it by the first tractor (MF1). The total draft force was measured during the draft process, and according to the design used to measure the draft requirements, for the anchorage at three depths and at three angles for the two systems, by taking a distance of 15 meters from each system. The values of the draft force were recorded by a laptop connected to the weight cell device, the measurement process was repeated three times for all depths and angles used in the experiment, and the draft force was calculated from equation (1) taken from [4].

$$F = Ft - R \quad \text{..... (1)}$$

So that:

F = draft force of the tiller (kn)

FT = total draft force (kn)

R = rolling resistance of the MF2 tractor (kn), measured using the same method as above but with the tiller raised from the tractor.

Energy utilization efficiency (η)

Energy efficiency was calculated from equation (3) taken from [4].

$$\eta = 1000 / SR \text{.....(3)}$$

whereas :

η = energy efficiency (m3/ MJ)

SR = specific resistance (kN^{-2})

Slipping percentage (S)

The percentage of tractor wheels slip (MF1) was calculated during the process of opening the corridor for a distance of 10 m for each system and for each depth and angle from Equation (4) mentioned (5), by measuring the

practical speed of the tractor (the time it takes for the tractor to cover a distance of 10 m during opening process). The theoretical speed of the tractor (the time taken for the tractor to travel a distance of 55 m on paved land and the tillage machine raised from the surface), the measurement process was repeated three times for all the tillage machines used in the experiment.

S= 1-$\boldsymbol{Va}$ / $\boldsymbol{Vt}$ X 100 ……..[4]

Since:

S = Slip %

Va = Practical speed (in km/h)

vt = theoretical speed (in km/h)

RESULTS AND DISCUSSION:

Table(2) Analysis of variance table represented by the effect of individual study factors and their interactions to evaluate the field performance (mechanical characteristics) of the furrows opener developed

Sources of Variation S.O.V	df	**Draw force (F)** (kn)	Energy utilization efficiency (ŋ) (m3/ MJ)	**Slipping percentage (S)** (%)
r stratum	2	0.20	0.12	0.62
T	1	38.45*	27.86*	462.98*
Residual	2	3.88	5.48	1.14
D	2	153.82**	2200.45**	349.66**
T +D	2	0.83*	6.50*	40.45**
Residual	8	0.69	0.69	1.26
W	2	78.65**	60.91**	74.55**
T +W	2	0.83*	1.08*	0.88*
D+W	4	4.96*	6.59*	5.62*
T+D+W	4	0.63ns	0.11ns	3.95*
Residua	24			
Total	53			

1-DRAFT FORCE:

The results of the variance analysis table shown in Table (2) showed a significant effect when using the opener furrows after different plowing systems in the draft force ,as Table (3) showed that the lowest average draft force when used after the chisel plow amounted to 14.564 KN, compared to its use after the moldboard plow recorded the highest average of 16.397 KN, and this may be due to the nature of the work of The compared with the moldboard plow, the chisel the soil with cutting it without turning it over, which produces less draft force as well as the surface area of the plow mills in contact with the soil surface The chisel plow, due to the small surface area of the weapons in contact with the soil, which results in less resistance than the resistance shown by the soil against the moldboard plow, which led to the recording of a lower draft force, which is consistent with [5] and the findings of [6] as they confirmed the superiority of the chisel plow over the moldboard Plow by recording a lower draft force.

The results of the variance analysis table shown in Table (2) showed that there were significant differences in the value of the draft force with increasing the distance between the two dumpers of opener furrows. as Table (3)shows that the draft force increased from 14.132 to 15.413 and then 16.896 KN , when the distance between the two dumpers of opener furrows increased from 40. To 50 and then to 60 cm, meaning that the draft force increased by 1.281 and 1.483 KN, by 9.1 and 10.5%, respectively. The reason for the difference may be due to the increase in the width of the auger, which in turn increased the specific soil resistance as the soil's reaction to the auger mills increased, and this What was found by [8] where there was a significant increase in the draft force with the increase of the distance between the two dumpers of opener furrows, as the draft force increased from 21.88 and 25.88 and then to 30.78 KN when the distance between the two panels increased from 35 and 40 and then to 45 cm in succession, and it agrees with .[9]

The results of the variance analysis table shown in Table (2) show that there is a significant difference in the bilateral interaction between plowing systems and plowing depths in the draft force. as Table (3) showed an increase in the draft force, as the milling moldboard plow at the depth of 30 cm by recording the largest draft force of 17.690. kn, while the chisel plow recorded the lowest draft force, amounting to 16,004 kn, while the moldboard plow at a depth of 10 cm recorded the lowest value of draft force, amounting to 14,557 kn, while the chisel plow recorded 12,849 kn, meaning that the draft force of the moldboard plow increased by 3,133 kn, i.e. by 21.6% when the depth increased

from 10 to 30 cm, while the percentage increase in the value of the draft force of the chisel plow by 3.155 kn was 24.55%.

The results of the variance analysis table shown in Table (2)showed that there was a significant difference in the bilateral interaction between the plowing system and the distance between the two dumpers of opener furrows, as Table (3) indicated that the distance of 60 cm between the two cultivators of the god's weapons when plowing with the moldboard plow was greater than the distances of 40 cm and 50 cm. It recorded 14,914, 16,479, and then 17,798 kn, respectively, meaning that the draft force increased by increasing the distance by 1.6 and 1.31 kn, by 10.7 and 8.78%, superior to the use of a chisel plow, in which the distance of 60 cm gave the highest pulling force compared to the distances of 40 and 50. cm, where the results were recorded at 13.350, 14.348, and then 15.993 kn, meaning the increase was from 1 to 1.645 kn, i.e. a rate of 7.48 and 12.33%.

The results of the variance analysis table shown in Table (2)indicated that there were significant differences for the second interaction between the depth of the machine and the distance between the two dumpers of opener furrows. as Table (3) shows the depth of 30 cm with the distance of 60 cm. The highest draft force amounted to 18.567 kn, while the distance gave 40 cm with The depth is 10 cm. The lowest value of the draft force was recorded as 12.272 kn.

The results of the statistical analysis shown in Table (2) showed that there were no significant differences for the three-way interaction between the tillage systems, the depth of the machine, and the distance between the furrow opener boards, as shown in Table (3)

Table (3) the effect of the individual study factors and their interactions on the draft force

Tillage systems (T)	Depth (D) cm	The distance between furrow opener boards W (cm)			Between(T& D)
		W1	W2	W3	
T1	D1	11.333	12.547	14.667	12.849
	D2	14.233	14.580	15.700	14.838
	D3	14.483	15.917	17.613	16.004
T2	D1	13.210	14.287	16.173	14.557
	D2	16.170	16.963	17.700	416.94
	D3	15.363	18.187	19.520	17.690
LSD 0.05				NS	0.9827
					Medium D (cm)
Overlap between (D&W)	D1	12.272	13.417	15.420	13.703
	D2	15.202	15.772	16.700	15.891
	D3	14.923	17.052	18.567	16.847
LSD 0.05				0.7374	0.4239
					Medium (T)
Overlap between (T&W)	T1	13.350	14.348	15.993	14.564
	T2	14.914	16.479	17.798	16.397
LSD 0.05		0.9627			1.2721
(cm) Medium W		14.132	15.413	16.896	
LSD 0.05		0.4551			

ENERGY UTILIZATION EFFICIENCY (H):

The results of the graphical analysis shown in Table (2) showed a significant difference when using furrow opener in two different tillage systems. Table (4) shows that the highest energy use efficiency was recorded when using furrow opener in two different tillage systems, which amounted to 40.33 m^3 / MJ, while it reached 40.33 and 35.57 m^3 / MJ, when used after a moldboard plow. The reason for this superiority may be due to the large working width of the chisel plow, which reduced the specific resistance of the soil and increased the volume of loose soil. Thus, when using the agitator in the part plowed by the chisel plow, it gave the lowest average efficiency of energy, superior to the part plowed by the moldboard plow, and this is what was confirmed [9]

The results of the analysis of variance shown in Table (2) indicate the presence of a highly significant effect between the averages of energy use efficiency, as it increased with an increase in depth from 10 to 20 and then 30 cm. The depth of the machine exceeded 30 cm, giving the highest value of 53.52 m^3 / MJ , at the depth of 20 cm recorded 38.11 m^3 / MJ, and the lowest value at a depth of 10 cm was 22.21 m^3 / MJ, as the amount of increase reached 15.41 and 15.9 m^3 / MJ, with an increase rate of 69 and 71.5%, respectively. The reason for this may be attributed to the forward movement of the soil. The aspects that are accompanied by an increase in the volume of loose soil with increasing depth, which leads to an increase in the efficiency of energy use, and this agrees with [10], [11] and [7].

The results of the analysis of variance in Table (2) show that the efficiency of energy use was significantly affected by the distance between the two the furrow opener boards, as the relationship was inverse in the direction of increase. Table (4) shows that the efficiency of energy use decreased from 41.07 to 37.97 and then to 34.79 m^3 / MJ When the distance increased from 40 to 50 and then to 60 cm, that is, the amount of decrease reached 3.1 and 6.28 m^3 / MJ, and the reason for this may be due to the increase in specific resistance and thus a decrease in the disassembled area and an increase in the pulling force, which leads to a decrease in the amount of energy use efficiency. This does not agree With [7] and [8]. The results shown in the cross-sectional analysis table (2) indicate that there is a significant effect of the bilateral interaction between tillage systems and machine depth on energy efficiency. We note from Table (4) the superiority of the first plowing system (using the chisel) and a depth of 30 cm over depths of 10 and 20. cm for the same system, where the highest value was recorded at 56.64 m^3 / MJ for the depth of 30 cm, and 23.66 and 40.68 m^3 / MJ for the depths of 10 and 20 cm, respectively, while the second system (using the moldboard) at the depth of 10 cm recorded the least energy efficiency, recording 20.76 m^3 / MJ, while the depths of 30 and 20 cm for the same system recorded 50.40 and 35.54 m^3 / MJ.

The results of the analysis of variance shown in Table (2) show that there is a significant effect of the bilateral interaction between the tillage systems and the distance between the furrow opener boards in terms of energy efficiency. We note that the furrow opener when used in the chisel part plowed recorded a remarkable superiority over the moldboard plowed part with its decrease in both systems by increasing the distance between the furrow opener boards, as we notice a decrease in its value when the distance between the furrow opener boards in the first system from 43.69 to 40.60, then to 36.69 m^3 / MJ, when the distance is increased from 40 to 50 and then 60 cm, i.e. by 3.1 and 3.64 m^3 / MJ, with a ratio of 8.4 and 10.6%, while the sedimentation in the part used in the plowing of the second system (the moldboard) recorded lower values than in the first system if it gave lower values by increasing the distance between the tillers, which reached from 38.45 to 35.35 and then to 32.89 m^3 / MJ ، when increasing the distance from 40 to 50 and then to 60 cm,, i.e. 3.1 and 7 m^3 / MJ, while the plow was recorded in the part used in plowing the second system (the moldboard plow).

It is noted from the results of the analysis of variance table shown in (2) that the efficiency of energy use was significantly affected by the bilateral interaction between the depth of the machine and the distance between the opener furrows waterways,. We note from table (4) that the maximum value of energy use efficiency was recorded at the depth of 30 cm and the distance of 40 cm. 58.85 m^3 / MJ, while the depth of 10 cm and the distance of 60 cm recorded the lowest value of 19.51 m^3 / MJ.

The results of the analysis of variance table shown in Table (2) indicated that there was no significant effect of the three-way interaction on the averages of each of the tillage systems, the depth of the machine, and the distance between the opener furrow, as shown in Table (4).

Table (4) The effect of individual study factors and their interactions on energy efficiency

Tillage systems(T)	Depth (D) cm	The distance between furrow opener boards W (cm)			Between(T& D)
		W1	W2	W3	
T1	D1	26.54	23.98	20.47	23.66
	D2	42.33	41.24	38.48	40.68
	D3	62.21	56.58	51.13	56.64
T2	D1	22.72	21.00	18.56	20.76
	D2	37.15	35.47	33.99	35.54
	D3	55.49	49.57	46.14	50.40
LSD 0.05		NS			3.058
					Medium D (cm)
Overlap between (D&W)	D1	24.63	22.49	19.51	22.21
	D2	39.74	38.36	36.24	38.11
	D3	58.85	53.08	48.63	53.52
LSD 0.05		1.900			1.088

					Medium (T)
Overlap between (T&W)	T1	43.69	40.60	36.69	35.57
	T2	38.45	35.35	32.89	40.33
LSD 0.05		2.952			3.883
(cm) Medium W		41.07	37.97	34.79	
LSD 0.05		1.174			

SLIP PERCENTAGE:

The results of the analysis of variance table shown in Table (2) showed that there is a significant effect of the plowing systems on the slip rate. Table (5) shows that there as there were significant differences for the tillage systems on the slippage characteristic of the opener of the plow, where the part plowed by the chisel excelled by recording the lowest slip rate of 8.043%, while the plow was recorded in the part plowed by moldboard has a value that exceeds 10.816%, and the reason for this is attributed to the nature of the work of the two plows, where the moldboard works when used in plowing the land on the processes of overturning and pulverization, which leads to the appearance of blocks. Soil and plant remains, as using the compactor with this system increased the draft force and soil resistance, which showed superiority in the value of the slip rate. While the chisel plow works on the process of breaking up the soil without it, and therefore when using the opener furrow with this system, it led to this noticeable superiority, and these results do not agree with [5] , [12]and[13]

The results of the analysis of variance shown in Table (2) showed a highly significant difference between the depth of the machine in the slip ratio. Table (5) showed that the slip rate was directly affected by the depth of the machine, as it recorded an increase from 7.434 to 9.522 and then to 11.333% when the depth increased from 10. To 20 and then to 30 cm, where the amount of increase reached 2.088 and 1.811%, respectively. The reason for this increase may be attributed to the increase in the volume of soil that the machine disintegrates with depth, which leads to the accumulation of soil on the shaft of the weapon, and here in turn increases the draft force, which leads to an increase The load on the tug. These results agree with [5]، [14]and[15]

The results of the analysis of variance in Table (2) also indicate that there is a highly significant difference in the effect of the distance between the furrow opener boards on the slip rate, as the increase was direct with increasing distance. Table (5) shows that at the maximum distance (60 cm), the highest slip rate was recorded, amounting to 10.308%. This is superior to the distances of 50 and 40 cm, if they recorded a percentage of 9.245 and 8.736%, respectively. The reason for this increase in the slip rate with the increase in the distance between the two rakes is due to the increase in the width of the furrow, which leads to an increase in the resistance of the soil on the rakes that work to sweep away the soil, which is accompanied by an increase In the load on the used with an increase in the draft force, which leads to this increase in the slip rate.

The results of the analysis of variance shown in Table (2) showed a highly significant difference in the bilateral interaction between the tillage systems and the depth of the machine in the slip ratio. Table (5) showed that the relationship between the interaction and the value of the slip ratio is a direct relationship, as the part that was plowed by the chisel plow was recorded. At a depth of 10 cm, the lowest slippage rate was 6.379%, while the part that was plowed by a milling plow at the same depth recorded 8.490%. While the part used in the plowing of the moldboard plow with the maximum depth of the machine (30 cm) recorded the highest slip rate of 12.287%, superior to the 20 cm depth for the same system, in which the slip rate reached 11.672%.

The results of the analysis of variance table shown in Table (2) showed that the bilateral interaction between the distance between the two harrows and the tillage systems had a highly significant effect on the slippage rate, as Table (5) showed that the distance (40 cm) exceeded the distance in the part that was plowed by the chisel plow, recording the lowest percentage. A slippage of 7.296% was recorded, while the same distance when using the plow in the part that was plowed by the moldboard plow recorded 10.176%, while the distance (60) with the moldboard plow recorded the maximum slip rate of 11.594%, and with the chisel plow the slip rate was 9.022%.

The results of the analysis of variance table shown in Table (2) indicate that there is a significant effect of the bilateral overlap between the depth of the machine and the distance between the furrow opener boards in the slip rate, as Table (5) shows the presence of a direct relationship in the slip ratio with the bilateral interaction between the two factors, where the depth was recorded (10 cm) with a distance of (40 cm), a slip rate of 6.857%, surpassing the maximum distance of (60 cm) with a maximum depth of (30 cm), which recorded the highest slip rate of 12.705%.

The results of the analysis of variance shown in Table (2) showed that the triple interaction between the tillage systems, the depth of the machine, and the distance between the two furrow opener of the furrow opener has a significant effect on the slip rate, as Table (5) showed that the triple overlap between plowing systems, the depth of the plow and the distance between the two plows of the plow had a significant effect on the slip percentage, as the part that was plowed by the plow and the maximum depth of the plow was (30 cm) with the maximum distance between the two plows of the plow (60 cm). The highest slip rate was recorded at 13.170%, while the first system

(the land plowed by the chisel) with the lowest depth (10 cm) and the lowest distance (40 cm) recorded the lowest slip rate at 6.000%

Table (5) The effect of individual study factors and their interactions on the slip rate.

Tillage systems (T)	Depth (D) cm	The distance between furrow opener boards W (cm)			Between(T& D)
		W1	W2	W3	
T1	D1	6.000	6.367	6.770	6.379
	D2	6.627	7.430	8.057	7.371
	D3	9.260	9.637	12.240	10.379
T2	D1	7.713	8.457	9.300	8.490
	D2	11.093	11.610	12.313	11.672
	D3	11.720	11.970	13.170	0.3387
LSD 0.05				0.6920	0.4871
					Medium D (cm)
Overlap between (D&W)	D1	6.857	7.412	8.035	7.434
	D2	8.860	9.520	10.185	9.522
	D3	10.490	10.803	12.705	11.333
LSD 0.05		0.4853			0.3402
					Medium (T)
Overlap between (T&W)	T1	7.296	7.811	9.022	8.043
	T2	10.176	10.679	11.594	10.816
LSD 0.05		0.4448			0.5546
(cm) Medium W		8.736	9.245	10.308	
LSD 0.05		0.2713			

CONCLUSIONS:

From the experiments conducted, we conclude the following:

1- The developed plow recorded superiority when used after the chisel (the first plowing system) in all mechanical performance indicators (draft force, energy efficiency, percentage of slip) compared to when used after the excavated plow (the second tillage system), which is due to Economic benefit and reduce expenses resulting from fuel and energy and improve arable soil.

2- The use of the developed anchor when increasing the depth from (10 to 30 cm) led to an increase in (draft force, and slip percentage) with a decrease in (energy efficiency).

3- When the distance between the two plates of each of the upgraded furrows opener was increased from (40 to 60 cm), this led to an increase in (draft force, slip percentage) and a decrease in (energy efficiency).

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