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Research article

Effect of Soil Moisture and Distance of Scraper in Field Performance of Disk Plow

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Abstract

Keywords

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forward speed;

soil overturn;

disk scraper

Soil tillage is a critical process in agricultural production. Furthermore, the process consumes a lot of energy and time to complete the soil tillage practices. A disk plow with triple disks was tested in one of the Agriculture and Forestry college plantations at the University of Mosul during season 2013. The research included two soil moisture contents (10.7 and 16.2%), and three distances between the inner disk face and the scraper (2, 4, and 6 cm). Besides, two forward speeds for the tractor (2.29 and 5.85 km/h) were used. The disk plow test was adopted to evaluate the energy consumed, the specific energy, the volume of soil pulverized, and the soil adhesion on the disks. The test also evaluated the ratio of soil overturn, the lateral soil transfer, and the number of soil clods bigger than 10 cm/m^2. The data were analyzed with the statistic randomized complete block design (RCBD) using the split-split plots system. The results indicated significant differences with the factor level of soil moisture 10.7% with the first scraper position of 2 cm, and forward speed of 5.85 km/h, and for the traits of soil adhesion and lateral soil transfer, which were 0.11 N/m^2 and 170.33 cm, respectively. On the other hand, there were no statistical significant differences in the traits of energy consumed, specific energy, volume of soil pulverized, soil overturn, and number of soil clods bigger than 10 cm/m^2. The consumed energy, specific energy, and number of soil clods decreased, while the volume of pulverized soils and soil overturn ratio increased, at soil moisture 16.2% with the same levels of treatment.

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1. Introduction

Agricultural mechanization involves advanced innovations that are aimed at enhancing the productivity of food crops whilst decreasing the numbers of workers [1]. Tillage processes are the most critical soil preparation practices in crop production processes. Moreover, it takes a lot of energy and time to complete tillage-related processes compared to other agricultural practices. Furthermore, the cost of production depends on soil fertility, physical and chemical characteristics, as well as power sources and the type of equipment used during the plowing process [2, 3].

The disk plow is considered as one of the soil tillage equipment that prepares the soil for primary processes through the movement of its working parts in the soil, which are the disks. The plow disks can reach the depth of soil required for the soil tillage process under good soil conditions [4]. The disks can cut and roll on roots and crop residues. In addition, the disks can work in non-reclaimed soil with the scraper but this does not provide complete coverage of plant residues [5]. The scraper is an auxiliary part of the plow that is vital to the improvement of the pulverization coefficient, the cleaning of soil from the disk surface (especially in the cases of wet clay soils), and the improvement of soil section inversion [6]. Soil cultivation must proceed at suitable soil moisture conditions and the main task of tillage is to prepare the soil for cultivation. The soil moisture is the most critical factor affecting the physical soil properties.

Moreover, soil moisture directly affects soil hardness, which is inversely proportional to the soil moisture under the soil moisture limits of 14-20%, and the quality of tillage when the soil is treated with optimum moisture content. When the soil moisture content increases, the strength of the soil adhesion increases on the surface of the working parts of the locally produced chisel plow. The moisture content of 6.5% achieved a soil adhesion force of 1 kPa. At the same time, when the soil moisture content was 13.1%, a soil adhesion force of 3 kPa was recorded [7]. The effect of soil moisture content and the forward speed of the disk plow on the draft force requirements indicate that the draft force decreases with increase of soil moisture [8]. The research examined the effects of five types of soil cultivating equipment on traction force and fuel consumption requirements. The investigation included disc plowing at two soil moisture levels (4.20-14.80%), and three forward speeds (3.5, 4.0, and 4.5 km/h). Increased soil moisture reduced the draft force and fuel consumption. As forward speed increased, draft force increased, but fuel consumption per unit area decreased [9].

Nassir *et al*. [10] studied the effects of soil moisture content (29.24, 16.62, and 8.92%) and forward speed (1.05, 0.70, and 0.45 m/s) on the specific energy requirements for the moldboard plow. The results showed that at the soil moisture content of 16.62%, the lowest value of specific energy, 46.80 kJ/m^3 was recorded, followed by the soil moisture content of 8.92% with a specific energy of 59.32 kJ/m^3, and the soil moisture content of 29.24% with specific energy 69.23 kJ/m^3. Khadr [11] examined the impact of three soil tillage equipment (chisel, moldboard plow, and disk harrow) and five forward speeds ranging from 0.89 to 2.06 m/s. The results showed increased energy consumption and specific energy with increase in the forward speed for all types of equipment used. This increase in energy consumption was due to the increased degree of soil pulverization, which required greater draft forces. A field study was conducted on the impact of the tractor forward speed on disk plow draft force requirements. The results indicated a 100% increase in draft force and a 71.35% increase in specific draft resistance when forward speed was increased from 3 to 9 km/h [12].

Moreover, the draft force increases when a tractor's forward speed is increased [13]. Another field experiment studied the effects of varying forward speed (0.56, 0.87, and 1.36 m/s) and tillage depth (10, 20, and 30 cm) on the specific energy and soil volume raised when using the chisel plow. The results showed an increase of 139.43% in the specific energy and 85.10% in the soil volume raised when the forward speed was increased from 0.56 to 1.36 m/s. At the same time, the specific energy decreased by 19.86%, and the soil volume increased by 87.38% when the tillage depth was increased from 10 to 30 cm [14].

This research was aimed to determine the disk plow's energy requirements and field performance under the impact of three factors. The studied factors were two levels of soil moisture content, which were 16.2 and 10.7%, three distances of 2, 4, and 6 cm between the inner disk face and the scraper, and two forward speeds for the tractor of 2.29 and 5.85 km/h. Besides, the study was attempted to assess the effects of three factors on the variables of soil adhesion on the disks, percent of soil overturn, and lateral soil transport.

2. Materials and Methods

2.1 Materials used in the research

The research was conducted during the season 2013, in the fields of Agriculture and Forestry College at the University of Mosul, Mosul 41002, Nineveh, Iraq. Furthermore, the soil structure was clay (clay 60%, silt 35%, and sand 5%, respectively).

2.1.1 Disk plow

The specification for the disk plow used in the experiment was clarified in Table 1. The disk plow was connected to a tractor to carry out the experiment (see Figure 1).

Table 1. The specification for the disk plow used in the experiment

Disk plow	Items	References
Type of plow	Disk plow	[15]
No. of disks	3	
Diameter for every disk	63 cm	
Total working width	90 cm	
Type of join with tractor	Mounted	
Disk angle	42^o	
Disk tilt angle	15^o	

Figure 1. The MF tractor connects with the disk plow with scrapers for disks

2.1.2 Tractor

The tractor used in the experiment was a Massey Ferguson (MF) model (285 S), and its horsepower was 75 HP.

Two tractors were used to connect the dynamometer model (Dillon), which was placed between them. The disk plow was connected to the second tractor. The dynamometer gauge, which was able to read force between 0-3500 kg.force, was used to measure the plow draft force during the field test, as can be seen Figure 2.

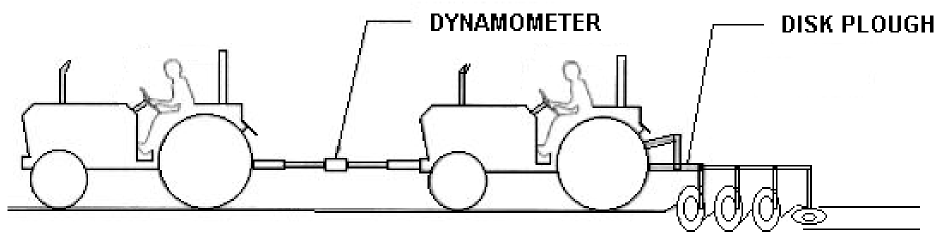

Figure 2. The connection of two tractors with dynamometer and disk plow in an operating position

2.2 Experiment setup

The width of each treatment was 1 m, and a length of 30 m was adopted. The first 5 m at the beginning and 5 m at the end were left to set the tractor speed and the tillage depth during work. Thereby, the length of the actual plowing was 20 m. A wooden frame with an area of 0.25 m^2 was used to determine the number of soil clods larger than 10 cm for 1 m^2. After that, the values taken were multiplied by four to adjust them for a one-meter square. The wooden frame was also used to determine the plants within the plowed area before tillage and after. The plants were placed in plastic bags, and then these samples were used to calculate the soil's overturn ratio.

2.3 Experimental design and data analysis

The data was analyzed by randomized complete block design (RCBD) using the split-split plots system. The study included three factors: soil moisture content (10.7 and 16.2%), the position of the scraper (distance between the scraper and inner face of the disk plow) at three levels (2, 4, and 6 cm), and the forward speed at two levels (2.29 and 5.85 km/h).

The experiment field was divided into two main plots for soil moisture, and each main plot was split into three subplots dedicated to scraper positions. While each subplot was furhter divided into two sub-sub plots assigned to the forward speed. The means of the treatments were tested using the Duncan multi-range test at the 5% probability level [16]. The effect of the factors mentioned previously was studied in terms of some energy and field performance indicators that were calculated as follows.

2.3.1 Energy

The energy consumed was calculated from the following equation:

$$E_c = \frac{Dp * 3.6}{Pp} \tag{1}$$

Where (Ec) is energy consumed (MJ/ha), (Dp) is draft power (kW), and (Pp) is practical productivity (ha/h) [17].

2.3.2 Draft power

The draft power was determined from the following formula:

$$Dp = Df * Va \tag{2}$$

Where (Dp) is draft power (kW), (Df) is draft force measured by the dynamometer (kN), and (Va) is the actual forward speed of the tractor (m/s) [18].

2.3.3 Practical productivity

The practical productivity was determined from the following formula:

$$Pp = 0.1 * Bp * Va * Ft \tag{3}$$

Where (Pp) is the practical productivity (ha/h), (Bp) is the actual width of the disk plow (m), (Va) is the actual forward speed of the tractor (km/h), and (Ft) is the time utilization coefficient which is considered as an average of 0.7 for the plows [13].

2.3.4 Specific energy

The specific energy was calculated from the following equation:

$$S_e = \frac{Dp * 3600}{Vps} \tag{4}$$

Where (Se) is the specific energy (kJ/m^3), and (Vps) is the volume of pulverized soil (m^3/h) [11].

2.3.5 Volume of pulverized soil

The volume of pulverized soil (Vps) was calculated from the following formula:

$$V_{ps} = Pp * Td * 10000 \tag{5}$$

Where (Vps) is the volume of the pulverized soil (m^3/h), (Pp) is the practical productivity (ha/h), and (Td) is the tillage depth (m) [19, 20].

2.3.6 Soil adhesion

The soil adhesion to disks was calculated from the following formula:

$$S_{ad} = \frac{Swad}{Tacd} \tag{6}$$

Where (Sad) is the soil adhesion to disks (N/m^2), (Swad) is the soil weight adherence to the disk (N), and (Tacd) is the total area of the concave disk surface (m^2) [21].

2.3.7 Soil overturn ratio

Soil overturn ratio was calculated from the following formula:

$$S_{or} = \frac{\mathrm{Wwb} - \mathrm{Wwa}}{\mathrm{Wwb}} \times 100 \tag{7}$$

Where (Sor) is the soil overturn ratio (%), (Wwb) is the weight of the weeds before tillage (g/m^2), and (Wwa) is the weight of the weeds after tillage (g/m^2) [22].

2.3.8 Number of soil clods

The numbers of soil clods larger than 10 cm for 1 m^2 were determined in the field using a wooden frame with an area of 0.25 m^2.

3. Results and Discussion

3.1 Effect of soil moisture on studied variables

Table 2 indicates that there was a significant effect of soil moisture with all studied variables, except for soil overturn ratio. The soil moisture of 16.2% had a significant difference and coincided with the lowest energy consumed of 119.41 MJ/ha, and specific energy of 50.85 kJ/m^3. The number of soil clods was 12.94 clods/m^2, the highest volume of soil pulverized was 792.18 m^3/h and lateral transfer of soil was 158.28 cm, while the soil moisture of 10.7% achieved a significantly lower value of adhesion to the soil at 0.524 N/m^2. The decrease in energy consumption and specific energy at soil moisture of 16.2% was due to the low soil resistance to tillage, a result that was consistent with Nassir *et al*. [10]. Moreover, lateral soil transport increased at the soil moisture by 16.2% due to increased soil ability of fragmentation, which led to it being thrust and thrown further. Also, this was reflected in the decrease in clods larger than 10 cm/m^2 at the mentioned soil moisture. Furthermore, the strength of soil adhesion on plow disks increases when soil moisture increases because soil moisture is an effective factor for soil adhesion on the equipment's working parts [7].

Table 2. Effect of soil moisture content on studied properties

Soil moisture content	Energy consumed* (MJ/ha)	Specific energy* (kJ/m^3)	Volume of soil pulverized* (m^3/h)	Soil adhesion on disks* (N/m^2)	Soil overturn (%)	Lateral soil transfer * (cm)	Number of soil clods* (10 cm/m^2)**
10.7	125.00^a	70.73^a	566.78^b	0.524^b	86.94	155.39^b	24.89^a
16.2	119.41^b	50.85^b	792.18^a	39.101^a	87.49	158.28^a	12.94^b

* The values with the same letter do not differ significantly at the 0.05 probability level.
** Soil clods which have a diameter larger than 10 cm.

3.2 Effect of the scraper position on the studied variables

There was a significant effect of the scraper position on the soil adhesion force, lateral soil transport, and the number of soil clods larger than 10 cm/m^2, while the other variables were not significantly affected (Table 3). However, the first position of the scraper was significantly higher and achieved less adhesion of the soil at 15.21 N/m^2, the number of soil clods was 15.67 clods/m^2, and the top side of the soil was 164.33 cm. Low adhesion of the soil to the disks is generally observed when the scraper approaches the inner surface of the disk, scrubbing and cleaning the disk from the soil attached to it. Moreover, the number of soil clods larger than 10 cm/m^2 at the closest scraper position to the inner surface of the disk was reduced due to the contribution of the scraper at this position to increasing soil fragmentation. It was also observed that there was an inverse relationship between the distance of the scraper position from the inner disk surface and the lateral soil transport. This was because the closer scraper position from the inner surface of the disk caused more soil lateral transport. This was due to the increases in fragmentation percentage of the soil causing it to be thrown further.

Table 3. Effect of scraper position on studied properties

Scraper position (cm)	Energy consumed (MJ/ha)	Specific energy (kJ/m^3)	Volume of soil pulverized (m^3/h)	Soil adhesion on disks* (N/m^2)	Soil overturn (%)	Lateral soil transfer* (cm)	Number of soil clods* (10 cm/m^2)**
2	123.49	62.75	665.44	15.21^c	86.92	164.33^a	15.67^c
4	123.24	61.95	674.58	17.99^b	87.96	154.58^b	19.00^b
6	119.87	57.67	698.42	26.23^a	86.77	151.58^c	22.08^a

* The values with the same letter did not differ significantly at the 0.05 probability level.
** Soil clods which have diameter bigger than 10 cm/m^2.

3.3 Effect of forwarding speed on studied variables

Table 4 indicates the significant effects of the tractor forward speed on all studied variables. The speed of 2.29 km/h had a statistically significant effect, and the lowest energy consumed was 118.21 MJ/ha. Besides, a specific energy of 56.09 kJ/m^3 and a soil adhesion strength of 19.09 N/m^2 were recorded. However, the higher volume of soil pulverized of 952.57 m^3/h was observed at the forward speed of 5.85 km/h, which was significantly different when compared to the volume of soil pulverized (406.39 m^3/h) at the forward speed of 2.29 km/h.

Furthermore, the soil overturn ratio was 88.94%, the lateral transfer of soil was 160.44 cm, and the lowest number of soil clods was 18.00 clods/m^2. The reason for the increase in energy consumption and specific energy was the increase in draft force resulting from increase in forward speed. The draft force was one of the main factors affecting on the two energies, a conclusion that was consistent with Khadr [11].

Furthermore, the soil adhesion increases when forward speed increased, and this was consistent with Al-Taie [23]. The volume of soil pulverized increased when the forward speed increased. This was due to the increase in the forward speed increasing the area of the plowed soil, which was one of the factors determining the volume of soil pulverized, a result in agreement with Muhsin [14]. In addition, the soil overturn ratio increased when the forward speed increased. This was due their being more opportunity for soil to rush to the inner surface of the disk, which then rotated the soil and overturned it, an observation in common with Al-Tahan *et al*. [22]. Besides, the increase in lateral soil transport was due to increasing the forward speed. That was because the increased momentum of the plow disks on the soil threw it further, which was consistent with Bukhari *et al*. [24].

Moreover, the number of soil clods with a diameter greater than 10 cm/m^2 was decreased when forward speed increased. This was because the increase in forwarding speed caused an increase in the speed of the impact of plough disks with soil clods.

Table 4. Effect of forwarding speed on studied properties

Forward speed (Km/h)	Energy consumed (MJ/ha)	Specific energy (kJ/m^3)	Volume of soil pulverized (m^3/h)	Soil adhesion on disks* (N/m^2)	Soil overturn (%)	Lateral soil transfer* (cm)	Number of soil clods* (10 cm/m^2)**
2.29	118.21^b	56.09^b	406.39^b	19.09^b	85.49^b	153.22^b	19.8^a
5.85	126.19^a	65.50^a	952.57^a	20.54^a	88.94^a	160.44^a	18.00^b

* The values with the same letter did not differ significantly at the 0.05 probability level.
** Soil clods which have diameter bigger than 10 cm/m^2.

3.4 Effect of the interaction between soil moisture and scraper position on studied variables

There was a significant effect due to the interaction of soil moisture and scraper position on the soil adhesion and lateral soil transfer, as can be seen in Table 5, while the other variables were not significantly affected. Also, the soil moisture treatment of 10.7 % with the first scraper position of 2 cm produced a lower soil adhesion value of 0.16 N/m^2. Moreover, no significant differences were recorded for the soil moisture of 10.7% with the second and third positions of the scraper. The same treatment significantly exceeded the rest of the transactions, and produced the highest lateral transfer of soil, which was 165.50 cm, a result which was consistent with Al-Hashimy [25].

Table 5. Effect of soil moisture content and scraper position on studied properties

Soil moisture content (%)*	Scraper position (cm)	Energy consume d (MJ/ha)	Specific energy (kJ/m^3)	Volume of soil pulverized (m^3/h)	Soil adhesion on disks* (N/m^2)	Soil overturn (%)	Lateral soil transfer* (cm)	Number of soil clods* (10 cm/m^2)*
10.7	2	125.61	73.85	541.20	0.16^d	86.79	165.50^a	21.50
	4	126.56	71.93	568.00	0.39^d	87.71	151.00^e	24.50
	6	122.81	66.42	591.13	1.02^d	86.30	149.67^e	28.67
16.2	2	121.38	51.66	789.68	30.26^c	87.05	163.17^b	9.83
	4	119.92	51.98	781.17	35.60^b	88.20	158.17^c	13.50
	6	116.92	48.92	805.70	51.44^a	87.24	153.50^d	15.50

* The values with the same letter did not differ significantly at the 0.05 probability level.
** Soil clods which have diameter bigger than 10 cm/m^2.

3.5 Effect of the interaction between soil moisture and forward speed on studied variables

Table 6 indicates that there was a significant effect of the interaction between soil moisture and tractor forward speed on the soil volume pulverized, the impact of soil adhesion, and lateral soil transfer, while the other variables were not significantly affected. The soil moisture of 16.2% at a speed of 5.85 km/h produced a significant difference from the rest of the transactions and gave the highest volume of soil pulverized at 1122.12 m^3/h. The lowest soil adhesion forces were 0.50, 0.55 N/m^2, at soil moisture of 10.7% with forward speeds of 5.85, 2.29 km/h, respectively, and these were significantly different from the soil moisture treatment of 16.2% at the first and second forward speeds. The results showed a statistically significant value for the highest lateral transfer of soil values of 160.33, and 160.56 cm, both at a forward speed of 5.85 km/h with soil moistures of 10.7, 16.2%, respectively, compared with the forward speed of 2.29 km/h at the soil moisture levels of 10.7 and 16.2%.

Table 6. Effect of soil moisture content and forward speed on studied properties

Soil moisture content (%)*	Forward speed (Km/h)	Energy consumed (MJ/ha)	Specific energy (kJ/m^3)	Volume of soil pulverized (m^3/h)	Soil adhesion on disks* (N/m^2)	Soil overturn (%)	Lateral soil transfer* (cm)	Number of soil clods* (10cm/m^2)**
10.7	2.29	121.32	64.46	350.53^d	0.55^c	85.56	150.44^c	25.89
	5.85	128.67	77	783.02^b	0.50^c	88.31	160.33^a	23.89
16.2	2.29	115.11	47.71	462.24^c	37.62^b	85.41	156.00^b	13.78
	5.85	123.71	54	1122.12^a	40.58^a	89.58	160.56^a	12.11

* The values with the same letter did not differ significantly at the 0.05 probability level.
** Soil clods which have diameter bigger than 10 cm/m^2.

3.6 Effect of the interaction between the scraper position and the forward speed on the studied variables

The effect of both soil adhesion and lateral soil transfer due to the interaction between the scraper position and forward speed was present in Table 7. The treatment with the first scraper position at the rate of 2.29 km/h was significantly different from the rest of the treatments and produced the lowest soil adhesion force of 14.53 N/m^2. The first scraper position of 2 cm at a speed of 5.85 km/h differed statistically from the other treatments, and produced the highest lateral soil transfer of 167.50 cm.

Table 7. Effect of scraper position and forward speed on studied properties

Scraper position (cm)	Forward speed (Km/h)	Energy consumed (MJ/ha)	Specific energy (kJ/m^3)	Volume of soil pulverized (m^3/h)	Soil adhesion on disks* (N/m^2)	Soil overturn (%)	Lateral soil transfer* (cm)	Number of soil clods* (10cm/m^2)**
2	2.29	118.89	56.88	408.8	14.53^d	85	161.17^b	16.17
	5.85	128.1	68.63	922.08	15.90^c	88.84	167.50^a	15.17
4	2.29	121.33	58.39	402.45	16.52^c	86.15	152.17^d	20
	5.85	125.15	65.52	946.72	19.47^b	89.76	157.00^c	8
6	2.29	114.42	52.99	407.92	26.21^a	85.3	146.33^e	23.33
	5.85	125.32	62.35	988.92	26.25^a	88.23	156.83^c	20.83

* The values with the same letter did not differ significantly at the 0.05 probability level.
** Soil clods which have diameter bigger than 10 cm/m^2.

3.7 Effect of the interaction among soil moisture, scraper position, and forward speed on studied variables

Table 8 shows that the soil adhesion and lateral soil transfer were significantly affected by the interaction between the three studied factors. The soil moisture treatment of 10.7% with scraper position of 2 cm and with speed of 5.85 km/h produced significantly higher values for soil adhesion and lateral soil transfer, which were 0.11 N/m^2, 170.33 cm, respectively. Moreover, soil moisture of 10.7% produced significant differences compared to the soil moisture treatment of 16.2% at the three scraper positions and the two forward speeds.

Although there were no significant differences in the traits of energy consumed, specific energy, volume of soil pulverized, soil overturn and number of soil clod bigger than 10 cm/m^2, the soil moisture of 16.2% produced the best values for those studied traits at the same levels of the scraper location and forward speeds of the tractor. The consumed energy, specific energy, and number of soil clods decreased, while the volume of pulverized soils and soil overturn ratio increased. The reason for this was that an increase in soil moisture content from 10.7% to 16.2% had a positive effect on the above-mentioned traits.

Table 8. Effect of soil moisture content, scraper position, and forward speed on studied properties

Soil moisture content (%)	Scraper position (cm)	Forward speed (Km/h)	Energy consumed (MJ/ha)	Specific energy (kJ/m^3)	Volume of soil pulverized (m^3/h)	Soil adhesion on disks* (N/m^2)	Soil overturn (%)	Lateral soil transfer* (cm)	Number of soil clods* (10cm/m^2)**
10.7	2	2.29	121.02	66.30	336.93	0.22^{e}	84.87	160.67^{c}	22.00
		5.85	130.19	81.39	745.47	0.11^{e}	88.71	170.33^{a}	21.00
	4	**2.29**	**124.49**	**66.69**	**349.57**	**0.33^{e}**	**86.39**	**148.67^{f}**	25.67
		5.85	128.64	77.17	786.43	0.45^{e}	89.04	153.33^{e}	23.33
	6	2.29	118.44	60.38	365.10	1.08^{e}	85.43	142.00^{g}	30.00
		5.85	127.19	72.45	817.17	0.95^{e}	87.17	157.33^{d}	27.33
16.2	2	2.29	116.75	47.45	480.67	28.83^{d}	85.13	161.67^{c}	10.33
		5.85	126.00	55.88	1098.70	31.69^{c}	88.96	164.67^{b}	9.33
	4	2.29	118.18	50.10	455.33	32.71^{c}	85.91	155.67^{d}	14.33
		5.85	121.67	53.86	1107.00	38.49^{b}	90.48	160.67^{c}	12.67
	6	2.29	110.39	45.59	450.73	51.33^{a}	85.17	150.67^{f}	16.67
		5.85	123.46	52.25	1160.67	51.55^{a}	89.30	156.33^{d}	14.33

* The values with the same letter did not differ significantly at the 0.05 probability level.
** Soil clods which have diameter bigger than 10 cm/m^2.

4. Conclusions

The effects of the three factors, soil moisture, scraper position, and forward speed of tractor on the studied variables were evident in the present study. Although there were no significant differences in the studied variables, except for soil adhesion strength and lateral soil transfer, there was an interaction effect of the factors on variables, to varying degrees. The strength of adhesion was negatively affected when soil moisture increased.

According to the results, further investigations are necessary to figure out the effect of the scraper on the soil overturn for the disk plow. However, lateral soil transmission increased due to the presence of a scraper, which pushes, flips, and scrapes the soil from the inner surface of the disk plow. Thus, it is necessary to conduct more research on the impact of scraper design and especially on the shape and concavity of the scraper, and its performance effect with the disk plow on the soil physical properties, and on vegetation on the top of soil, and under different field operating conditions.

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References

[1] Yamin, M., Hamid. S., Ali, M.A., Bashir, S., Iqbal, M. and Ashraf, M., 2022. Performance optimization and knife dynamics of power tiller operated reaper during wheat harvesting. *Pakistan Journal of Agricultural Sciences*, 59(2), 261-268, DOI: 10.21162/PAKJAS/22.1406.

[2] Ebrahimi, M., Souri, M.K., Mousavi, A. and Sahebani, N., 2021. Biochar and vermicompost improve growth and physiological traits of eggplant (*Solanum melongena* L.) under deficit irrigation. *Chemical and Biological Technologies in Agriculture*, 8, DOI: 10.1186/s40538-021-00216-9.

[3] Prem, M., Ranjan, P., Dabhi, K.L., Baria, A.V., and Lepcha, P.T., 2017. Use of different tillage tools for minimizing number of passes in secondary tillage operations, *International Journal of Current Microbiology and Applied Sciences,* 6(12), 3109-3116, DOI: 10.20546/ijcmas.2017.612.363.

[4] Hamid, A.A.A., 2012. Evaluatıon and performance comparıson of moldboard. *Iraqi Journal of Agricultural Science,* 43(5), 110-121.

[5] Jahun, B.G., Yamin, M., Ahmad, D.B., Mahdi, M.R., Suleiman, S. and Abdulkadir S.A., 2020. Parametric analysis of the mulching depth of oil palm fronds achieved by tractor operated mulcher. *Sarhad Journal of Agriculture,* 36(2), 632-638, DOI: 10.17582/journal.sja/2020/36.2.632.638.

[6] Al-Banna, A.R., 1990. *Soil Tillage Equipment.* Mosul: Dar Ibn Al-Atheer Press.

[7] Rajab, A.A.A., 2005. *Development of the Chisel Plough Locally*. Ph.D. University of Mosul, Iraq.

[8] Nkakin, S.O. and Fubara-Manuel, I., 2014. Effects of soil moisture and tillage speeds on tractive force of disc ploughing in loamy sand soil. *European International Journal of Science and Technology,* 3(4), 157-164.

[9] Ali, A.D. and Muhieldeen, O.A., 2015. Determination of draft power requirements for tillage implements under central gezira clay soil conditions. *Scholars Journal of Agricultural and Veterinary Sciences*, 16(2), 20-26.

[10] Nassir, A.J., Meshaal, A.A. and Ramadan, M.N., 2016. Effect of soil moisture content on pulverization energy of moldboard plow in silty loam soil. *Basrah Journal of Agricultural Sciences,* 29(2), 206-221, DOI: 10.33762/bagrs.2016.120235.

[11] Khadr, K.A.A., 2008. Effect of some prımary tıllage ımplement on soıl pulverızatıon and specıfic energy. *Misr Journal of Agricultural Engineering,* 25(3), 731-745.

[12] Omofunmi, O.E., Tanimola, O.A. and Oyekunle, O.O., 2016. To assess the ımpact of disc plough weight and draught on physical properties of sandy loamy soil. *IOSR Journal of Agriculture and Veterinary* Science, 9(2), 45-50.

[13] Tahir, H.T. and Jarad, A.H., 2017. Study the effect of front speed and workıng wıdth on some performance ındıcators, power requırement and economıc costs for dıfferent sızes of agrıcultural tractors. *Iraqi Journal of Agricultural Sciences,* 48(6), 1782-1795.

[14] Muhsin, S.J., 2017. Determination of energy requirements, plowed soil volume rate and soil pulverization ratio of chisel plow under various operating conditions. *Basrah Journal of Agricultural Sciences,* 30(1), 73-84, DOI: 10.37077/25200860.2017.24.

[15] Al-Nuaimy, W.N.H., 2008. *Effect of Tilt Angle for the Disk Plow in Some of the Power Requirments and Some of Soil Physical Properties*. M.Sc. University of Mosul, Iraq.

[16] Dawod, K.M. and Abdulyas, Z., 1990. *Statistical Procedures for Agricultural Researches.* Mosul: Higher Education Press.

[17] Abo-Habaga, M.M.E., Khadr, K.A.A. and Naeem, O.E.M.M., 2010. Energy requırements for operatıng the rotary plow under egyptıon condıtıons. *Journal of Soil Sciences and Agricultural Engineering,* 1(5), 463-473, DOI: 10.21608/jssae.2010.74865.

[18] Ranjbarian, S., Askari, M. and Jannatkhah, J., 2017. Performance of tractor and tillage implements in clay soil. *Journal of the Saudi Society of Agricultural Sciences,* 16(2), 154-162, DOI: 10.1016/j.jssas.2015.05.003.

[19] Amer, K.Z., 2017. Effect of dıfferent speed of two plows types on some maghınary unıt performance ındıcators. *Iraqi Journal of Agricultural Scıences,* 48(4), 1141-1147, DOI: 10.36103/ijas.v48i4.375.

[20] Al-Hashimy, L.A., 2014. Performance of some specıal tıllage equıpments under plowıng and harrowıng system's. *Iraqi Journal of Agricultural Sciences,* 46(1), 36-45.

[21] Al-Suhaibani, A.M. and Wahbi, A.N., 1985. *Principles of Agricultural Machinery*. Riyadh: King Saud University Publishing House.

[22] Al-Tahan, Y.H., Amin, S.M. and Al-Abdullah, H.H., 1995. The effect of plowing forward speeds on the field performance of the mouldboard and disk plows. *Mesopotamia Journal of Agriculture,* 27(2), 77-80.

[23] Al-Taie, Y.F.M.M., 2013. *Comparison of the Performance of Some Types of Ploughs in the Mechanical and Physical Properties of the Soil*. M.Sc. University of Mosul, Iraq.

[24] Bukhari, S., Baloch, J.M., Mari, G.R., Mirani, A.N., Bhutto, A.B. and Bhutto, M.A., 1990. Effect of different speeds on the performance of moldboard plow. *Agricultural Mechanization in Asia, Africa, And Latin America,* 21(1), 27-31.

[25] Al-Hashimy, L.A.Z., 2012. The effect of disc tilt angle, tillage speed and depth on some of machinery unit technical and energy requirements parameters. *Iraqi Journal of Agricultural Science,* 43(2), 132-143.