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THE EFFECTIVENESS OF MOLDBOARD PLOW IN SANDY SOIL TYPE OF THE NEWLY RECLAIMED LAND

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Abstract

This research work was carried out in Nobaria area to study the performance of moldboard plow in the new reclaimed soil to investigate proper tillage operations by using 3-bottoms moldboard plow with the 80 HP tractor (60 kW). The results show that the optimum working speed was 6.75 km/h (at no-load). At this speed the average slippage was 7.4%, 11.1% and 12.59% at tillage depths 20, 25 and 30cm respectively (less than 15%, allowable limit) and the power requirement 19.1, 22.5 and 26.0 kw respectively. The fuel consumptions were 7.98, 8.15 and 8.9 kg/h and the field capacities (or productivity) were 1.17, 1.13 and 1.11 fed/h at 20, 25 and 30cm tillage depths respectively. Also, the plow was working in stability case with the tractor, where both vertical and horizontal deviations were non-significant, and the loosening degree was 29, 30.8 and 33% of tillage depth, and the clods were in the acceptable range where the soil crumbling degree was 85.4, 86.07 and 87.01% at tillage depths 20, 25 and 33 cm in primary tillage. The vegetation burying degree was 97.24, 97.64 and 97.79% at tillage depths 20, 25 and 30cm respectively.

INTRODUCTION

The soil in new reclaimed areas of Nobaria is classified as sandy soil, where different weed types are growing. To control these weeds the moldboard plow could be used for this purpose besides lossening the soil. Bukhari S.B. and Jan M.B. (1982) concluded that the moldboard plow operating on soft soil turned up more soil and consumed less fuel as compared with this operation on hard soil at the same speed of operation. They also indicated that the moldboard plow proved to be more economical than the disk plow on soft soil at almost the same speed of operation. However, the disk plow, at reasonably higher speed of operation, gave better performance on hard soil than the moldboard plow. They also concluded that the work rate of disk harrow was much faster than the moldboard plow and disk plow on both soils but the depth of operation was less. Hence it would be better to operate the moldboard plow and disk harrow in combination on soft soil and disk plow and disk harrow in combination on hard soils. Rahmatullah J. M. *et al.* (1994) concluded that the actual field capacity of moldboard plow was less than theoratical field capacity, and the decrease in actual field capacity from the theoratical field capacity is between 45% to 48%. Also, they indicated that the moisture content of the soil influenced the tractor wheel slippage. For higher moisture content, wheel slippage increased which in turn affected the actual speeds of the plowing operation resulting in a decrease of the actual field capacity of the plow. The bulk density of the soil also influenced the actual plowing speed, for the higher value of bulk density less speed of plowing operation was recorded which in turn affected the actual field capacity. Tan L. *et al* (1994) designed some " Comet type passage-holes" in suitable position of moldboard and plow share. They concluded that the new type plow can produce an air-liquid medium layer on fricative surface between plow and soil in tilling, which changes fricative property, reducing plowing specific draft and saves energy.

The aim of this research is to investigate the tillage performance of a three bottom moldboard plow in the newly reclaimed soil at Nobaria area and its capability to control the weeds (by burying them in soil).

MATERIALS AND METHODS

Soil: The soil texture is sandy clay loam type, the moisture content was 18.2, 19.2 and 20.2% at 0-10 cm, 10-20 cm and 20-30 cm layers respectively. The bulk density was 920 kg/m3. The weeds were widely spread in soil and the weight of weeds per square meter was 635 gram. The previous crop was wheat.

Tractors: The Universal tractor (U-801) 80 HP (60 kW), and a test instrumentation tractor John Deere 4055-120 Hp or 90 kW) were used.

Implement: 3-bottoms mounted moldboard plow was used. The effective width of one bottom is 31 cm and the plow width is 93 cm. To control depth of plowing handle adjustment of depth wheel was used.

Experimental design: The complete block design was used to carry out this experiment. Three replicates were used with the following six treatments.

Three tillage depths 20, 25 and 30 cm each at two forwared speeds 4.20 and 6.75 km/h at no-load.

Measurements:

Tractive force: The tractive force was measured by using the strain gage dynamometer with dytronic and computer recording sets. The data were sent as signals from strain gage dynamometer to the dytronic which transforms it into digital readings and sent it to a computer unit to save it.

Fuel consumption: Fuel consumption was measured using the automatically actuated fuel consumption set. This set measures the fuel consumption as L/h as direct digital readings.

Forward speed: The forward speed was measured by measuring the traveling distance and it's time. The forward speed was measured at no-load and at load to calculate the slippage (or speed reduction).

Tillage depth: Ten replicates of tillage depth were measured by using 10 stikes as stations placed on each plot length, the average depth and its deviations were calculated.

Vegetation burying: To determine the vegetation burying degree, vegetation in a square meter (m2) as a sample was weighed before and after tillage operation. The vegetation burying degree was determined from the formula:

$$Ga = (Mva / Mt) *100.$$

where : Ga = The vegetation burying degree, %.
Mva = The weight of vegetation buried in soil, kg.
Mt = The weight of vegetation before tillage, kg.

The vegetation burying degree was used as an indication for weed control.

Soil crumbling: A tilled soil sample was taken from each treatment and separated the clods as sizes less than 10 cm and more than 10 cm and weighed the clods of each size. The formula used to determine soil crumbling degree is:

$$Gm = (Msc / Mst) *100.$$

where : Gm = The soil crumbling degree, %.
Mva = The weight of soil clods less than 10 cm, kg.
Mst = The total weight of soil sample, kg.

Soil loosening: Loosening degree was given the indication for the loss of soil and it's aeration. Loosening degree was determined by the formula:

$$Gaf = (h_m / a_m) *100.$$

where : G_{af} = Loosening degree, %.

h_m = The height of tilled soil above the untilled soil surface, cm.

a_m = The tillage depth, cm.

The plow stability: The plow stability was determined by estimating the vertical deviations (the variances of tillage depth from the average depth) and the horizontal deviations (the variances of tillage width from the plowing width). If vertical and horizontal deviations are non-significant stantistically, then the plow is working in a stable case (William R.G. and. Berg G.E.V. 1968).

RESULTS AND DISCUSSION

The results of moldboard plow performance in sandy soil at the new reclaimed land in Nobaria area are presented in table (3-1) at two tested speeds (4.20 and 6.75 km/h at no-load) and three tested plowing depths (20, 25 and 30 cm plowing depth). The discussions of results show that:

1. Tractive force and soil resistance:

The tractive force increase (the rate of increase tends to decrease) as tillage depth increase at the two tested levels of forward speed (4.20 and 6.75 km/h at no-load) (fig. 3-1), where it increased by 23.83% and 18.57% at 25 and 30 cm tillage depth respectively at 4.20 km/h speed, and 25.83% and 14.74% at 25 and 30 cm tillage depth respectively at 6.75 km/h speed. This could be explained as the dry layer at the soil surface need higher force to penetrate it and when the plow bottom going more deeper into soil it became easier to penetrate as the moisture content became higher. In the opposite way, the soil resistance (or specific tractive force) is decreasing (the rate of decrease tends to increase) as increasing tillage depth at the two levels of forward speed (fig. 3-2), where it decreased by-0.87% and -1.23% at 25 and 30 cm tillage depth respectively at 4.20 km/h (no-load) speed, and -1.86% and -1.90% at 25 and 30 cm tillage depth respectively at 6.75 km/h (no-load) speed. As mentioned before this may be due to the moisture content of soil, where it increased at deeper layers. The tractive force and soil resistance were increased as forward speed increased from 4.20 km/h to 6.75 km/h, i.e. from lower to higher forward speed.

2. Power and specific power requirements: The power requirement had the same behavior as tractive force, where it increased as tillage depth increased

Table 3.1. The performance of moldboard plow (3 bottoms) results in sandy soil.

tillage depth cm	Speed location	V km/h	Vo km/h	Ft kN	P kW	section of tilled soil area cm2	$S.P_b$ kW/ bottom	$S.P_{ts}$ W/cm2	$S.F_{ts}$ N/cm2	slip %	skid %	F.C. fed/h	Fc kg/h	$S.F_{cf}$ kg/fed	$S.F_{ca}$ g/m3
20	Ir	3.90	4.20	10.70	11.6	93.00x20=1860	3.87	6.24	5.75	7.14	7.00	0.73	6.38	8.74	10.4
	IIr	6.25	6.75	11.00	19.1	93.00x20=1860	6.37	10.27	5.91	7.41	7.40	1.17	7.98	6.82	8.12
25	Ir	3.82	4.20	13.25	14.1	93.00x25=2325	4.70	6.10	5.70	9.05	9.40	0.72	6.64	9.22	8.78
	IIr	6.00	6.75	13.48	22.5	93.00x25=2325	7.50	9.68	5.80	11.10	11.54	1.13	8.15	7.19	6.85
30	Ir	3.75	4.20	15.71	16.4	93.00x30=2790	5.47	5.88	5.63	10.71	10.70	0.70	6.94	9.91	7.87
	IIr	5.90	6.75	15.88	26.0	93.00x30=2790	8.68	9.33	5.69	12.59	12.30	1.11	8.90	8.02	6.37

where : V = actual speed, (km/h). Vo=No. load speed, (km/h).
Ft = tractive force, (kN). P = power requirement, (kW).
$S.P_b$ = specific power for one bottom, (kW/bottom).
$S.?_{ts}$ = specific power for tilled soil cross section area, (W/cm^2).
$S.F_{ts}$ = specific force for tilled soil cross section area, (N/cm^2).
F.C. = field capacity (or productivity), (fed/h).
F_c = fuel consumption, (kg/h).
$S.F_{cf}$ = specific fuel consumption per feddan, (kg/fed).
$S.F_{ca}$ = specific fuel consumption per volume unit of tilled soil, (kg/m3).

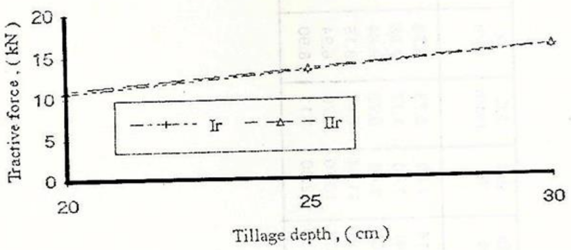

Fig. 3.1. The relationship between tillage depth and tractive force.

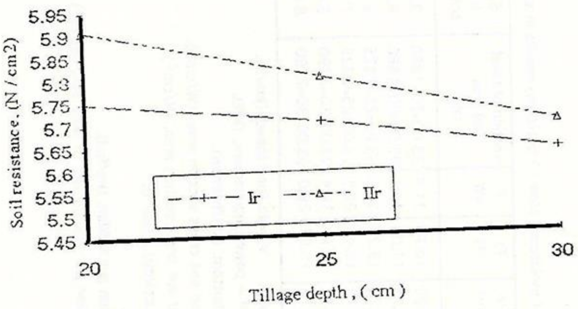

Fig. 3.2. The relationship between tillage depth and soil resistance (specific tractive force).

(the rate of increase tends to decrease) where it increased by 21.55% and 16.31% at 25 and 30 cm tillage depth respectively at forward speed 4.20 km/h, and 17.80% and 15.55% at 25 and 30 cm tillage depth respectively at forwared speed 6.75 km/h (Fig. 3-3). Also, it can be refereed to the moisture content of soil where it increased with the deeper layers. The specific power was determined for one bottom of the plow and for a unit of tilled soil cross section area, where the specific power for one bottom increased as tillage depth increased (the rate of increase tends to decrease), where it increased by 21.45% and 16.38% at 25 and 30 cm tillage depth respectively at forward speed 4.20 km/h, and 17.47% and 15.73% at 25 and 30 cm tillage depth respectively at forward speed 6.75 km/h. The specific power for unit tilled soil area decreased as tillage depth increased (the rate of increase tends to decrease) where it decreased by -2.25% and -3.25% at 25 and 30 cm tillage depth respectively at forward speed 4.20 km/h, and -5.74% and -3.62% at 25 and 30 cm tillage depth respectively at forward speed 6.75 km/h. It can also be refered to the moisture content of soil where it increased with the deeper layers. The power requirement and specific power increased as frorward speed increased from 4.20 km/h to 6.75 km/h, i.e. from lowest to highest forward speed.

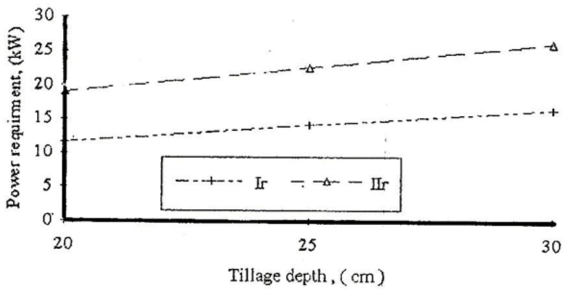

Fig. 3.3. The relationship between the tillage depth and power requirement.

3. The slippage and skiding:

The slip and skid percentages increased as tillage depth increased (the rate of increase tends to decrease), where the slippage increased by 26.75% and 18.34% at 25 and 30 cm tillage depth respectively at 4.20 km/h forward speed, and it increased by 49.80% and 13.42% at 25 and 30 cm tillage depth respectively at 6.75 km/h forward speed. The skidding increased by 34.29% and 10.83% at 25 and 30 cm tillage depth respectively at 4.20 km/h forward speed, and it increased by 55.95% and 6.59% at 25 and 330 cm tillage depth respectively at 6.75 km/h forward speed. This could be explained as soil surface and soil layer moisture content, increased at increasing depth with increasing load (the rate of increase tends to decrease). Also, they increased from 4.20 km/h to 6.75 km/h forward speed, i.e. from lowest to highest forward speed (Fig. 3-4).

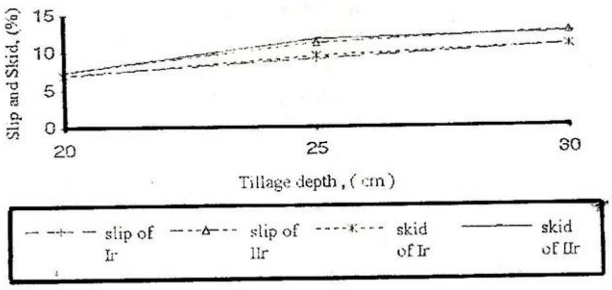

Fig. 3.4. The relationship between tillage depth and slip and skid percentage.

4. Fuel consumption and specific fuel consumption: The fuel consumption increased (the rate of increase tends to increase) as the tillage depth increased, where it increased by 4.08% and 4.52% at 25 and 30 cm tillage depth respectively at 4.20 km/h forward speed, and by 2.13% and 9.2% at 25 and 30 cm tillage depth respectively at 6.75 km/h forward speed (Fig. 3-5). The specific fuel consumption per feddan increased as tillage depth increased, where it increased by 5.49% and 7.48% at 25 and 30 cm tillage depth respectively at 4.20 km/h forward speed, and by 5.43% and 11.54% at 25 and 30 cm tillage depth respectively at 6.75 km/h forward speed. Also, the specific fuel consumption per unit volume of tilled soil (m^3) has the opposite way of fuel consumption, where it decreased as tillage depth increased by (-15.58%) and (-10.36%) at 25 and 30 cm tillage depth respectively at 4.20 km/h forward speed, and by (-15.64%) and (-7.01%) at 25 and 30 cm, tillage depth respectively at 6.75 km/h forward speed. The fuel and specific fuel consumptions increased as forward speed increased from 4.20 km/h to 6.75 km/h.

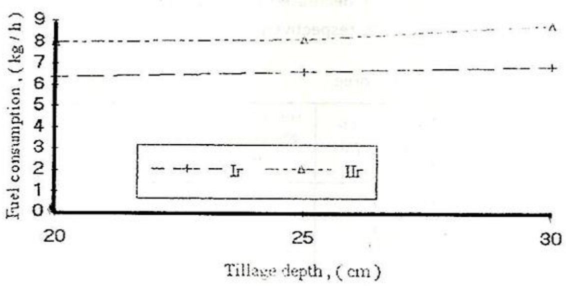

Fig. 3.5. The relationship between tillage depth and fuel consumption.

5. The vegetation burying degree : The results in table (3-2) showed that the relationship of vegetation burying with tillage depth and forward speed by moldboard plow, where it increased in all cases by more than 95%. It also increased as tillage depth increased by 0.50% and 0.332% at 25 and 30 cm tillage depth respectively at 4.20 km/h forward speed, and by 0.40% and 0.15% at 25 and 30 cm tillage depth respectively at 6.75 km/h forward speed). This means that the moldboard is useful as tillage technique to weed control in sandy soil.

Table 3.2. The vegetation burying degree.

tillage depth cm	Speed location	Speed km/h	Quantity of vegetation			Vegetation burying degree %
			before tillage	after tillage	burying vegetation	
20	Ir	3.90	635	25.0	609.0	95.90
	IIr	6.25	635	17.5	617.5	97.24
25	Ir	3.82	635	23	612.0	96.38
	IIr	6.00	635	15	620.0	97.64
30	Ir	3.75	635	19	614.0	96.69
	IIr	5.90	635	14	621.0	97.79

6. The loosening of soil degree : Table (3-3) indicated that the loosening of soil increased as tillage depth increased, and forward speed decreased, where it increased by 6.67% and 6.25% at 25 and 30 cm tillage depth respectively at 4.20 km/h forward speed, and by 6.21% and 7.14% at 25 and 30 cm tillage depth respectively at 6.75 km/h forward speed. Also, the loosening of soil decreased as forward speed increased, where it decreased by (-3.33)% (-3.75)% and (-2.94)% at 20, 25 and 30 cm tillage depth, respectively.

Table 3.3. The loosening of soil degree.

tillage depth cm	Speed location	Speed Km/h	Average tillage depth cm	Height of tilled soil above untilled soil surface cm	Loosening degree %
20	Ir	3.90	20	6.0	30.0
	IIr	6.25	20	5.8	29.0
25	Ir	3.82	25	8.0	32.0
	IIr	6.00	25	7.7	30.8
30	Ir	3.75	30	10.3	34.0
	IIr	5.90	30	9.9	33.0

7. The soil crumbling degree : The soil crumbling degree is used as the indicator of tillage quality or pullivraiziation degree. The results of analysis presented in table (3-4) showed that the crumbling degree was over 85% with all cases of tested tillage depths, where the crumbling degree increased as tillage depth increased, where it increased by 0.62% and 1.1% at 25 and 30 cm tillage depth respectively at the both forward speeds 4.20 and 6.75 km/h. This represents a good tilled soil, where more than 85% of soil clods was less than 10 cm in primary tillage.

Table 3.4. The soil crumbling degree.

tillage depth	Weight of soil sample	Weight of clods				Soil crumbling degree
		Size > 10 cm	Size 10-15cm	Size 15-25cm	Size <25 cm	
cm	kg	kg	kg	kg	kg	%
20	332	284	36	7	5	85.54
25	359	309	39	4	7	86.07
30	385	335	37	8	4	87.01

8. The plow stability : The plow stability was measured in two directions, vertically (as deviation of tillage depth) and horizontally (as deviation of tillage width), the results, are presented in table (3-5). The deviations of depth were between ± 1.1 up to ± 1.9 cm that's less than 10% of tillage depths. Also, the deviations of tillage width were between ± 2.4 up to 3.8 cm and that's less than 3%. The statistical analysis of diviations differences data indicatted that the deviations in two ways (depth and width of tillage) were nonsignificant. These results gave good indication for the plow stability in tillage operation to give good tilled soil.

Table 3.5. The stability of plow through plowing operation.

tillage depth	Average deviation of tillage depth	Maximum deviation of tillage depth		Tillage width	Average deviation of tillage width	Maximum deviation of tillage width	
cm	cm	cm+	cm-	cm	cm	cm+	cm-
20	1.26	1.8	1.7	93	2.44	3.2	3.8
25	1.11	1.8	1.9	93	1.96	3.2	3.8
30	0.72	1.1	1.4	93	1.90	2.4	3.7

9. The tractor power requirment : Assuming the power efficiency on drawbar is 60%, and the factor of safety is 40% power requirment for tilling soil at 30 cm depth and 6.0 km/h workable speed is 26 kW. The tractor power requirment = (26.0 x 100 x 1.4)/60 = 60.7 kW = 81 hp.

CONCLUSION

The 3-bottoms moldboard plow is useful to use for tilling sandy soil for weed control, where it controlled or buried over 95% of weed weight. Also, the soil has good condition tillage, the plow was working in stability case, where the deviations in two directions (depth and width of tillage) were non-significant statistically. The loosening degree decreased as forward speed increased, and it's values were between 29% and 33% of tillage depth. The soil crumbling degree increased as tillage depth increased, where over 85% were less than 10 cm diameter of clods. The results of trative force, tractive power and fuel consumption, which were obtained, showed that non-significant diferences from first forward speed (4.20 km/h at no load).

RECOMMENDATION

It is recommended to use 3-bottom mounted moldboard plow operated by 80 hp tractor at workable speed 6.00 km/h (6.75 km/h at no-load) in the sandy soil (reclaimed soil), as the weeds may be controlled successfully and upset the forage fertilizer, and give loose soil and to do tillage operation faster with same power requirement.

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تأثير أستخدام المحراث القلاب المطرحى المعلق ٣-بدن فى الأراضى الرملية كأراضى مستصلحة حديثاً

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نفذ هذا البحث فى أراضى النوبارية كأرض رملية مستصلحة حديثاً، وقد أستخدم المحراث القلاب المطرحى ثلاثة ابدان (عرض البدن الواحد ٣١ سم) معلق خلف جرار يونيفرسال ٨٠ حصان (٦٠ ك. وات) بأعماق حرث ٢٠ ، ٢٥، ٣٠ سم وبسرعتان أماميتان ٤,٢٠ و ٦,٧٥ كم/س عند اللاحمل على الترسين الأول والثانى على الترتيب. وقد كان قوام الأراض من النوع " رمليه طينيه طمييه"، والكثافة النوعية لها ٠,٩٢ جم / سم٣ ونسبة الرطوبة الأرضية هى ١٨,٢، ١٦,٦، ٢٠,٦٪ عند الطبقات صفر -١٠ ، ١٠ - ٢٠ و ٢٠ - ٣٠ سم على التوالى، وكانت النباتات الغير مرغوب فيها والنابته تلقائياً تزن ٦٣٥ جم /م٢. وكان المحصول السابق هو القمح.

وقد أظهرت النتائج أن المحراث القلاب المطرحى المعلق خلف الجرار ذو الثلاثة أبدان أعطى نتائج طيبة فى هذه الأراضى فلقد دفنت النباتات الغير مرغوب فيها بنسبة تزيد على ٩٥٪ فى جميع المعاملات، أما عن فوران التربة فقد حدث بنسبة ٢٩٪ إلى ٣٣٪، وكانت نسبة تفتيت التربة أكثر من ٨٥٪، والمحراث كان يعمل فى حالة متزنة حيث أعطت نتائج التحليل الأحصائى للأنحرافات عن المتوسطين أنحرافات غير معنوية ونسبة الأنحراف الرأسى (أتجاه عمق الحرث) ونسبة الأنحراف الأفقى (اتجاه عرض الحرث) أقل من الحدود المسموح بها. وكانت قوة شد المحراث هى ١٠,٧ ، ١٣,٢٥ و ١٥,٧١ ك. نيوتن عند أعماق حرث ٢٠ ، ٢٥و ٣٠ سم على التوالى عند السرعة ٤,٢٠ كم/س، و ١١,٠٠ ، ١٣,٤٨ و ١٥,٨٨ك. نيوتن عند أعماق حرث ٢٠ ، ٢٥ ، ٣٠ سم على التوالى عند السرعة ٦,٧٥ كم / س، وكانت السعة الحقلية (أنتاجية المحراث) هى ٠,٧٣ ، ٠,٧٢ و ٠,٧٠ فدان /س عند أعماق حرث ٢٠، ٢٥ ، ٣٠ سم على التوالى عند السرعة ٤,٢٠ كم/س ، ١,١٧، ١,١٣٤ و ١,١٠ فدان/س عند أعماق حرث ٢٠ ، ٢٥ ، ٣٠ سم على التوالى عند السرعة ٦,٧٥ كم/س أما عن الأستهلاك النوعى للوقود بالنسبة لوحدة الحجم من التربة المثارة (م٣) فقد كان يقل بزيادة عمق الحرث.