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THE EFFECT OF LANDSIDE LENGTH ON TRACTOR FUEL CONSUMPTION AND DEPTH STABILITY OF MOLDBOARD PLOW

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ABSTRACT

The moldboard plow is considered one of the most important implements used for plowing in Jordan, and the landside is considered one of the important plow parts which counteract the side pressure exerted by the furrow slice on the moldboard. For this reason, the experiments were conducted to study the effect of three speeds (5, 7 and 9 km/hr), three lengths of the front bottom landsides (20, 25 and 30 cm), and three lengths of the rear bottom landsides (20, 25 and 30 cm) on fuel consumption and depth stability of 2-bottom moldboard plow attached to 60 kW tractor working in sandy clay loam soil. The soil moisture content was approximately 10%. The plowing depth was adjusted at about 30 cm. Results showed that the fuel consumption was significantly ($p<0.05$)affected by the length of landsides and plowing speed. Minimum fuel consumption (12.60 l/ha) can be in conclusion obtained by using a 20 cm length for front bottom, and 25 cm length for rear bottom landsides, with 7 km/hr plowing speed, while the highest depth stability can be obtained by using 30 cm length of front and rear bottoms landside. In addition, the moldboard plow should not be used at a high speed, because that would increase fuel consumption, and negatively affect the depth stability.

Key words: *depth stability, fuel consumption, landside , moldboard plow.*

1. INTRODUCTION

The cultivated areas (rainfed and irrigated) in the Arab Countries reach 51037.06 thousand hectares (AOAD, 2004). This area needs primary tillage operations yearly, which means consuming great quantity of fuel. At present, the moldboard plow is considered to be one of the most important implements for tillage operations in Arab Countries.

The agricultural sector plays an important role in Jordan's economy, and the mechanization of agricultural operations would solve many of the problems facing Jordan's farmers. It will lead to increasing the yield, reducing cost and solving the hand labor shortage problem. At present, farm mechanization in the rainfed areas of Jordan is limited to plowing, seed planting and grain harvesting (Khdair and Abu-Hamdeh 2002).

Tillage is the practice of modifying the state of the soil in order to provide conditions favorable to crop growth (Bukhari *et al.,* 1992). Also, it is the most important operation in crop production system and one of the most influential technical factors on the outcome of a crop (Thompson and Taylor, 1982; Varco *et al.*, 1989; Pilbeam *et al.,* 1991; De Costa *et al.,* 1997). This is particularly important in hot arid climates .The major objectives of primary tillage are to prepare a suitable seedbed, conserve soil moisture, control weed growth, to manage plant residues and incorporate applied fertilizers (Kadir *et al.*, 1999).

The moldboard plow embeds the residues, weeds, minerals and organic fertilizers, and improves the soil's physical condition (Sakine and Çay, 2005), by increasing soil infiltration rate (Faizan-Ul-Haqkhan *et al.,* 2001).

The moldboard plow is considered one of the most important tools used for plowing in Jordan, mainly for plowing those agricultural districts where they depend on rain strictly. It has historically been the most important primary tillage implement in agriculture. As draft animals were replaced by tractors in the twentieth century, tillage operations grew in scale, speed, and efficiency (Plouffe *et al.,* 1995). The moldboard plowing ranks among the highest energy consuming primary tillage operations (ASAE, 1992).

The landside is considered one of the important moldboard bottom parts. It is regarded the part of the plow bottom which slides along the face of the furrow wall and helps to counteract the side pressure exerted by the furrow slice on the moldboard. It also helps to steady the plow while it is being operated (Smith and Wilkes, 1990).

Uneven plowing depth affects plant growth directly, since it affects the quality of final seedbed. Uniform tillage depth is required to produce an adequate and level seedbed to favor seedling emergence (Plouffe *et al.*, 1995).

Because of that, this study was carried out to obtain the optimum landside length for each bottom, with the optimum plowing speed to reduce the fuel consumption to the minimum and to get the depth stability, which will certainly decrease costs and improve the tillage quality.

2. MATERIALS AND METHODS

A field experiment was conducted at the College of Agriculture, Mu'tah University in Raba town, during summer 2004 after wheat harvest. Raba town is located at the southern part of Jordan as a semi-arid region, depends on rainfall to plant seed crops with an average of 300 mm annual rainfall. For plowing a sandy clay loam soil with 10% moisture content, a 2-bottom, moldboard plow was used. The plowing depth was adjusted at about 25 cm with three plowing speeds. The speeds were 5, 7 and 9 km/hr. Three lengths, 20, 25 and 30 cm. of landside for the front and rear bottoms were used in the study. The plow was attached with a 60.4 kW at 2600 rpm Kubota tractor model M8030 (4WD) manufactured in 1993, with four strokes and four cylinders diesel engine model V4300-1A capacity 4292 cm^3. During the experiment rear wheels were driving wheels.

The design of this experiment was a complete randomized block, with three replications for each treatment (Steel and Torrie, 1980). The factors were three landside lengths for the front bottom, three landside lengths for the rear bottom and three plowing speeds. The tractor speed was controlled by tractor gearbox, and the engine speed was kept constant about 1500 rpm, which was controlled by the speed control lever. Tractor speed was determined by measuring the time necessary to plow a block of 100 m length. After plowing the block, the tractor was stopped completely, engine turned-off and the fuel consumption was measured by special measuring cylinder which was connected with fuel injection pump and injectors. Plowing depth was measured randomly by a ruler in 40 locations in each block.

3. RESULTS AND DISCUSSIONS

Fig.(1) shows that increasing the plowing speed from 5 to 9 km/hr increased the fuel consumption from 15.12 to 17.72 l/ha, because increased speed increases the draft, mainly because of more rapid acceleration of any soil that is moved appreciably (Kepner *et al.,* 1982) . This is in agreement with the results reported by Plouffe (1995) using two types of moldboards. He found that increasing plowing speed increased draft force which consequently resulted in increasing fuel consumption.

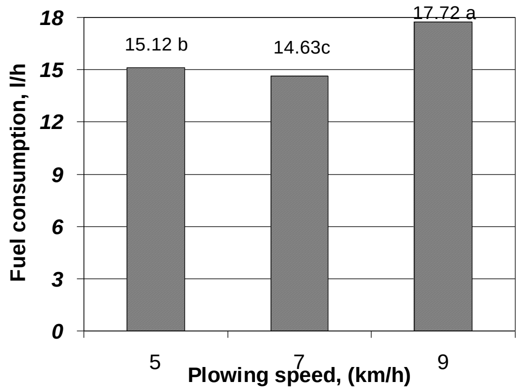

Fig.(1): Effect of plowing speed on fuel consumptiom

Fig. (2) shows that increasing the length of the front bottom landside increases tractor fuel consumption. This trend could be explained by that contact area between the landside and the furrow wall increases consequently results in increasing frictional resistance.

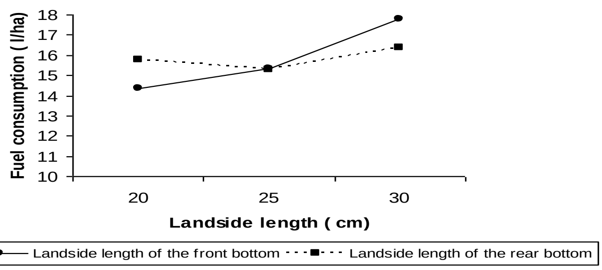

Fig.(2): Effect of bottom landside length on fuel consumption.

It is commonly known that resultant of all forces acting upon the last bottom more than forces acting upon other plow bottom, thus increasing the rear bottom landside length gives more plow stability at the beginning which positively affected fuel consumption. For this reason, there are many plows that have longer landside of the rear bottom.

Fig. (3) shows a significant interaction of the front bottom landside length and plowing speed on fuel consumption. It can be seen that fuel consumption increased when front bottom landside length and plowing speed increased. This can be explained by increasing the friction between the landside and the furrow wall as a result of increasing soil acceleration and contact area.

The fuel consumption which was increased because of increasing plowing speed could be explained by the quantities and directions

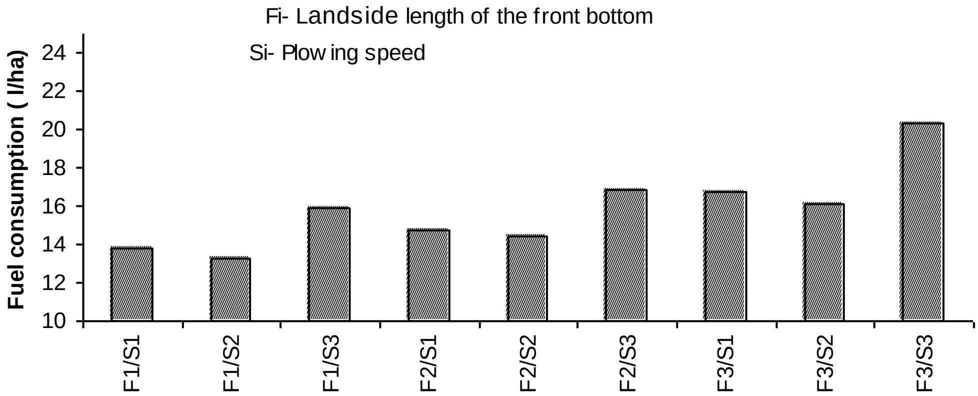

Fig.(3): Effect of the front bottom landside length on fuel consumption at different plowing speed.

Fig. (4) revealed that there was no significant effect (P< 0.05) of rear bottom landside length with plowing speed on fuel consumption. It can be seen that fuel consumption was constant under different combination of rear bottom landside length and plowing speed.

variation of the soil reactions upon the plow bottom. These results are in agreement with those reportedly by Plouffe (1995) who found that increasing speed results in changes of the resultant soil force acting on the plow bottom.

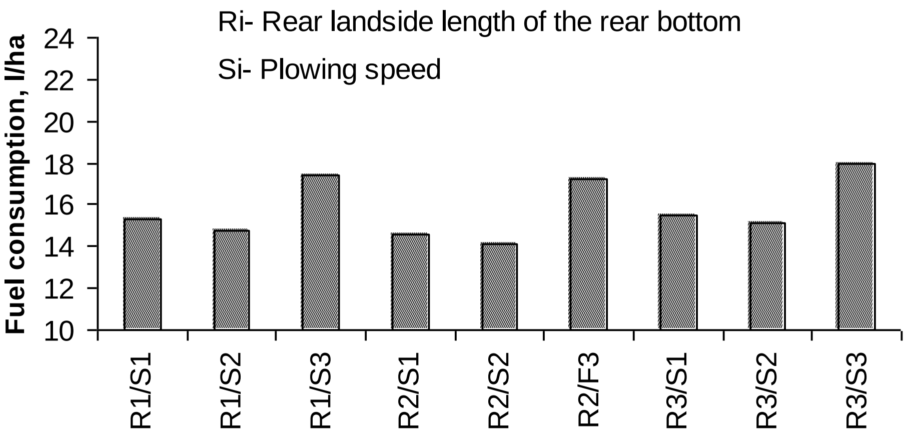

Fig.(4) Effect of the rear bottom Landside length on fuel consumption at different plowing speed

Table (1) shows a significant effect of front bottom and rear bottom landsides length with plowing speed on fuel consumption. It can be seen that an increase in fuel consumption when front and rear bottoms landside length and plowing speed were increased. The maximum fuel consumption (23.50 L/ha) was found after using the longer front and longer rear bottoms landsides at maximum plowing speed. On the other hand the minimum fuel consumption (12.60 L/ha) was found when using a 20 cm and 25 cm front and rear bottom landsides respectively, at plowing speed of 7 km/hr.

The fuel consumption increased as a result of increasing the landsides lengths could be explained by the relocating the point of soil reactions on the bottom. Increasing the landside length moves parasitic force to the rear of the moldboard, thus relocating the point of intersection of useful and parasitic forces further back on moldboard (Kepner *et al.,* 1982).

Plow stability was evaluated from the plowing depth by determining the standard deviation within each plot. To find out the depth stability, the standard deviation was determined by measuring of plowing depth variations over the 100 meter plot length and the results were analyzed.

better plow stability with longer front and rear bottoms landsides as it is shown in Table (2).

The landside slides along the face of the furrow wall and helps to counteract the side pressure, also helps to steady the plow while it is being operated (Smith and Wilkes, 1990). Thus, using longer landside gives more contact area between the plow and the furrow wall which positively affects plow stability, and this is what has been found in this study.

Table 1. Effect of front and rear bottoms landside length at different plowing speeds on fuel consumption* .

Front bottom landside Length (cm)	Rear bottom landside Length (cm)	Plowing speed (km/h)		
		5	7	9
20	20	14.50 KL	14.10 LM	15.63 FGH
	25	12.90 N	12.60 N	15.60 FGH
	30	14.03 LM	13.17 N	16.33 EF
25	20	16.10 FG	15.40 HI	18.27 CD
	25	14.20 KLM	13.83 M	16.23 EF
	30	13.90 M	14.10 LM	16.00 FG
30	20	15.20 LI	14.70 JK	17.90 D
	25	16.70 E	15.83 FGH	19.73 B
	30	18.53C	17.97 CD	23.50 A

*Means within each column followed by same letters are not significantly different according to Duncan's multiple-range test (P<0.05).

It is evident from the data in Table (2) that the stability was worse at high plowing speeds, because increasing plowing speed increases the vertical vibration plow under the soil as a result of high tractor vibration in general.

The useful soil forces acting upon a moldboard plow bottom are those resulting from the operations of cutting, pulverizing, lifting, and inverting the furrow slice. These soil forces practically always introduce a rotational effect on the plow bottom (Kepner *et al.*, 1982). In agreement with Kepner (1982), we can explain a

Table (2): Effect of the front and rear bottoms landside length and plowing speeds on plowing depth SD(CM)

Front bottom landside Length (cm)	Rear bottom landside Length (cm)	Plowing speed (km/h)		
		5	7	9
20	20	1.86	2.17	2.33
	25	1.71	1.87	1.94
	30	1.38	1.62	1.65
25	20	1.50	1.80	2.22
	25	1.17	1.66	1.80
	30	1.07	1.30	1.63
30	20	1.33	1.67	1.96
	25	1.02	1.27	1.88
	30	0.71	1.06	1.29

*Means within each column followed by same letters are not significantly different according to Duncan's multiple-range test (P<0.05).

The conclusions drawn from this study are:

- Tractor fuel consumption was increased using longer front and rear bottoms landsides and with increasing plowing speed.
- Minimum fuel consumptions equal to 12.60 l/ha were achieved using a 20 cm and 25 cm length for front and rear bottoms landsides, respectively, with 7 km/hr plowing speed.
- Maximum fuel consumptions equal to 23.50 l/ha was achieved using a 30 cm length for front and rear bottoms landsides with 9 km/hr plowing speed.
- The high plowing speeds affect negatively the plow stability and it will be better with increasing length of front and rear bottoms landsides.

The moldboard plow should not be used at a high speed, because that would increase fuel consumption, and negatively affect the depth stability.

To stabilize the plowing depth we can increase the landsides length, but that would increase fuel consumption.

Finally, it can be concluded that the optimum conditions of fuel consumption are when the plowing speed of the moldboard is 7 km/hr, with 20 cm length of front bottom landside and 25 cm of rear bottom landsides. The better plow stability is when the plowing speed of the moldboard is 5 km/hr, with 30 cm length of front bottom landside and 30 cm length of rear bottom landsides. Further studies should be conducted using different types of moldboard plows in different types of soils.

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تأثير طول المسند على استهلاك الجرار للوقود وثبات عمق الحراثة للمحراث المطرحي

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ملخص

يعتبر المحراث المطرحي من أهم الأدوات المستخدمة للحراثة في الأردن، كما يعتبر المسند من أجزاء المحراث المهمة والتي تقاوم الضغط الجانبي الناتج عن شرائح التربة التي تقلب إلى جهة اليمين وتدفع المحراث جانبا. لهذه الأسباب تم أجراء الدراسة لمعرفة تأثير ثلاثة سرعات للحراثة (5 ، 7 و 9 كم/س)، وثلاثة أطوال لمسند البدن الأمامي (20 ، 25 و 30 سم)، وثلاثة أطوال لمسند البدن الخلفي (20 ، 25 و 30 سم) على متطلبات الطاقة وثبات عمق الحراثة للمحراث المطرحي. أستخدم لحراثة تربة الموقع محراث مطرحي ذو بدنين بعرض كلي 80 سم وتم شبكه مع جرار زراعي بقدرة 60

كيلووات. وتم ضبط عمق الحراثة عند 30 سم. تم إجراء التجارب في مزرعة كلية الزراعة في جامعة مؤته الواقعة في مدينة الربة جنوب الأردن التي تعتمد فيها الزراعة على مياه الأمطار وذلك في صيف عام 2004 بعد حصاد القمح. وقد أظهرت النتائج أن استهلاك وقود الجرار يتأثر معنويا بطول كل من مسند البدن الأمامي والبدن الخلفي وكذلك بسرعة الحراثة، وقد كان اقل استهلاك للوقود حوالي 16.6 لتر/هكتار عند استخدام مسند أمامي بطول 20 سم وخلفي بطول 25 سم، عند سرعة حراثة حوالي 7 كم/س. وقد تبين أيضا أن عمق الحراثة يكون أكثر ثباتا عند زيادة طول المسند الأمامي أو المسند الخلفي، كما يكون أكثر ثباتا عند تقليل سرعة الحراثة. وتوصي الدراسة بالحراثة على سرعات منخفضة للحصول على عمق حراثة أكثر ثباتا ولتقليل استهلاك الوقود عند استخدام المحراث المطرحي.

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