Misr J. Ag. Eng., 26(2): 644- 666

A MODIFIED ∆-SHAPE CHISEL PLOW (EVALUATION AND PERFORMANCE TEST)

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ABSTRACT

The main objective of this investigation is to rearrange the tines of chisel plow as Δ-shape to reduce draft force required for plowing and to avoid jamming of soil clods and crop residues which frequently occurred when using the common chisel plow of tines arranged in 2 rows. The performance of the modified Δ-shape chisel plow was evaluated compared to other 2 and 3 rows of chisel plow. The performance tests were carried out at two different pervious crops of experimental field with three levels of soil moisture content (25.20, 20.25 and 17.30% for rice field and 20.77, 16.92 and 14.38% for soya bean field). Two different levels of plowing depth (10 and 20 cm) were included in the tests. The obtained results indicated that:

- *The lowest values of draft force and the highest values of field capacity were recorded with the modified Δ-shape chisel plow (4 rows) compared with other shapes of chisel plow (2 and 3 rows) at any given study parameters. Meanwhile, the highest values of draft force and the lowest values of field capacity were obtained with 2 rows chisel plow.*
- *Using the modified 4 rows chisel plow saved about 23 up to 59% in the power consumption and about 30 up to 58% in the energy requirements compared with other shapes of chisel plow (2 & 3 rows) at any given study parameters, in addition to obtain highest degree of plowing quality.*
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t is recommended to locally fabricate and operate the modified ∆-shape chisel plow (4 rows) for the Nile delta soil conditions. This modification may be develop the production of chisel plow to be more suitable for agricultural business in Egypt, especially the Egyptian government encourages and facilitate the local manufacture to move the country

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import dependency to self sufficient. Where, the local manufacturing still making similar copy from imported one without standardization.

INTRODUCTION

Tillage is the soil process of soil conditioning by an implements, to reach the desired soil conditions. Plant growth is directly affected by the tillage, which improve soil environment conditions, soil moisture content, aeration, nutrient distribution, weed control and soil strength. An efficient tillage system is that minimizes energy consumption and perform efficiency. therefore, it is important to develop high efficient tillage equipments that consume less energy. Meanwhile, providing a satisfactory soil environmental condition for seed germination and plant growth has become apparent. (***Gvrbachan and Singh, 1986***). The variation in fuel consumption or draft/power consumption and energy requirements for primary tillage could be attributed to many variables including soil, soil type and its conditions (soil moisture and density), depth and width of cut, tool shape and geometry, manner of tool movement, previous treatments and crops, ground cover, tillage system and operation speed as indicated by ***Baloch et al.* (*1991*)** and ***Mouazen and Ramon* (*2002*)**.

***Grisso et al.* (*1996*)** and ***Chandon and Kushwaha* (*2002*)** reported that the draft force and tillage energy required during tillage using chisel plow is linear function with operation speed, directly proportional to plowing depth and width, tool characteristics, and soil properties. On the other side, ***Kirisci et al.* (*1993*)** found that the relationship between force and depth is linear for chisel plow. However, ***Awady* (*2001*)** indicated that the draught varies according to a second degree polynomial with speed. ***Backingham* (*1984*)** stated that typical power **or** draft required for chisel plow is 270-1100 N/m/cm of width or 50-160N/m/cm of depth at 5.5-10.5 km/h typical speed, and typical range of field efficiency from 74 to 90%. Using the ***ASAE Standard D. 2303*, (*1985*),** section 4, the maximum draft force for chisel plow in 3625 N per shank at a depth of 20 cm and speed of 2 km/h, which is less man measured in plowing hard c!od-forming soils. ***Khalilian et al.* (*1988*)** studied the draft energy for chisel plow compared with other plow types on loamy sand soil at two different depths of 25 and 35 cm. They concluded that the draft per shank for chisel plow was 2.25 kN at 25 cm depth.

***Bowers* (*1989*)** measured the tillage draft and fuel consumption for the major implements used in crop production systems in 12 soils series at north Carolina. It was found that the tillage draft was about 8.24 kN for depth ranged between 0.5 to 0.65 m, where, the fuel consumption ranged from 25.96 to 40.39 l/ha. ***Iqbal et al.* (*1994*)** determine the draft requirement of selected primary and secondary tillage implements in a silty loam soil using the field speed of 2.5 km/h, found that the draft consumed by chisel plow increased linearly with the increase in depth of cultivation. Increasing the depth from 7 to 47 cm increased the total drawbar power from 1.35 to 14.11 kW for the chisel plow.

***Zein Al-Din* (*1985*)** and ***Younis et al.* (*1991*)** found that the energy required (kW.h/fed.) for seedbed preparation generally increased with increasing plowing depth. They also found that the minimum energy required was obtained with chisel plow due to its high actual field capacity and low slip during the plowing**. *Abd El-Wahab* (*1994*)** reported that more than 50% of the power required for agricultural production is consumed in soil tillage. ***El-Sayed and Ismail* (*1994*)** found that the energy required for traditional, minimum and improved tillage treatment was 48.64, 25.13 and 67.38 kw.h/fed., respectively. ***Al-Janobi and Wahby* (*1998*)** found that the chisel plow had the smallest value of specific energy for forward speed from 6.3 to 9.3 km/h compared to moldboard and disc harrow tillage treatments. ***Metwalli* (*1999*)** found that the energy requirement was increased at all tillage treatments as the tractor forward speed increased.

EI-Nakeib and Fouad* (*1990*)** studied the effect of tillage speed and depth on physical properties of soil They found that soil bulk density decreased after tillage and the effects was much greater in the top layers than the lower ones and minimum mean-weight diameter was found at a depth of 10 cm. They also reported that the penetration resistance was minimum after tillage at the smallest depth. ***EI-Raie et al.* (*1993*)** studied the effect of different systems of tillage on the physical properties of the soil. They found that the bulk density was decreased for all tillage treatments. On the other hand, the total porosity and void ratio increased. ***Nasr et al.* (*1998*)** recommended that the optimum plowing speed were 3.15 and 3.56 km/h for chisel plow one pass and chisel plow two passes, respectively. ***Helmy et al. **(*2001*)** reported that field capacity was affected by tillage systems and working depth. They found that field capacity was 0.91, 1.08, 1.27 and 1.33 fed./h for (moldboard plough + disc harrow), rotary plough, chisel plough one pass and chisel plough two passes, respectively. From the empirical evidence, the chisel plow has been manufactured locally and has been imported. ***El-Sahrigi and Shepley*** **(*1985*)** stated that over 96% of the surveyed farms used mechanical methods in cotton tillage. The most common methods for seedbed preparation consists of two or three passes with a tractor-drawn chisel plow. Both of these implements are currently made locally in Egypt.

Problem statement and research idea

In Egypt, chisel plow is the popular plow in agricultural around the country. The plow is fabricated from locally available materials. The 2 rows tine arrangement is the most common type of the chisel plow. However, the 3 rows tine arrangement plow is less popular than the previous one. Chisel plow may face some problems especially in the heavy clay soils in the north Delta due to big size of soil clods, high soil penetration resistance and high draft force of chisel plow. Improving performance of chisel plow by modifying the shape of tines arrangement on plow frame as **Δ-** shaped frame (a triangle frame). Where, the 7 tines of modified **Δ-**shape chisel plow were arranged in 4 rows by fixing 1, 2 , 2 and 2 tines (from front to rear) on the 1st, 2nd , 3rd and 4th row, respectively as indicated in Fig. (1).

Under these arrangements, the first front row tine will penetrate the hard (unplowed) soil only. While, the following tines in the 2nd , 3rd and 4th row will penetrate the hard soil from one side (outside) only while the other side (inside) which plowed with the previous front tine. These means that reducing the total soil resistance on chisel plow tines and results in less plowing draft. The 7 tines of other chisel plows were arranged on 2 rows shape (3 – 4 tines) from front to rear on the 1st and 2nd row, respectively as indicated in Figure (1) or 3 rows shape (2 - 2 – 3 tines) from front to rear on the 1st, 2nd and 3rd row, respectively as indicated in Figure (1). These means that tow tines (for 3 rows plow shape) or three tines (for 2 rows plow shape) will penetrate the hard soil at the same time which cause increasing soil resistance, consequently, increasing draft force in comparison with the modified **Δ**- shape chisel plow.

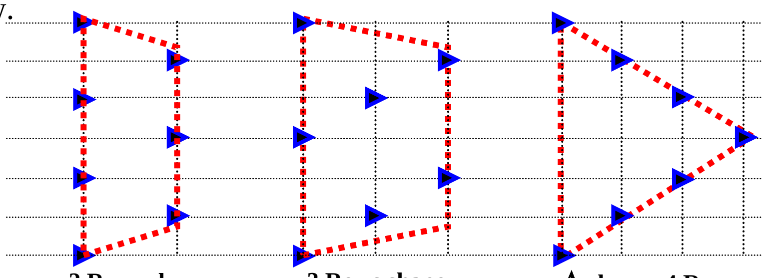

Figure (1): Arrangements of the 7 tines of modified **Δ**- shape chisel plow (4 rows) compared with 2 and 3 rows shapes of chisel plow.

MATERIALS AND METHODS

The main objective of the modified Δ-shape chisel plow chisel plow as **Δ**-shape is to reduce draft force consumed throw plowing land and to avoid the plow jamming with big soil clods and the remained crop residues in the field especially in case of using the common shape 2 rows of chisel plow. Activities of this study includes modifying and fabricating a **Δ**-shape chisel plow (four row tines) , compare its plowing performance with two different shapes of chisel plows (2 and 3 rows). The study was carried out under the following variables:

1- Three forms of tines arrangement for chisel plow, namely; four (modified plow), three and two rows.
2- Two different pervious crops for experimental field rice and soya bean
3- Three different levels of soil moisture content (25.20, 20.25 and 17.30% "db." for rice field and 20.77, 16.92 and 14.38% "db." for soya bean field).
4- Two different levels of plowing depth: 10 (d1) and 20 cm (d2).

The fabricating modified Δ-shape chisel plow was carried out at the workshop and research farm of Rice Mechanization Center (RMC), Kafr El-Sheikh Governorate, Agricultural Engineering Research Institute. While, the test performance of chisel plows was carried out at RMC farm during 2007 growing season.

1- Materials

1- Modified Δ-shape chisel plow

The modified Δ-shape chisel plow is a mounted chisel plow 1.75 m width, 7 tines of pointed blades. The modified chisel plow consists of a tri-angle frame, three hitch points, shanks and tine shares as indicated in the Fig. (2).

During modify, the main dimensions of Δ-shape chisel plow shanks and frame, distance between two consecutive blades and shape of tines were kept similar to that other chisel plows used in the study as indicated in Table (1). The technical data and dimensions of the three studied chisel plow shapes are summarized in Table (1).

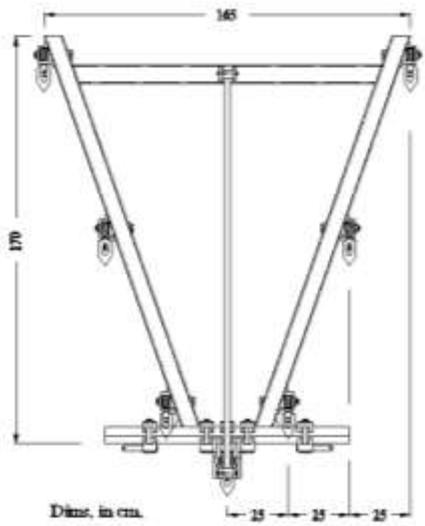

Fig. (2): Modified Δ-shape chisel plow (4 rows).

Table (1): The technical data and dimensions of the three chisel plows.

Item	Δ-shape (4-rows shape)	3-row shape	2-row shape
No. of shares / No. of rows	7-shares / 4 rows	7-shares / 3 rows	7-shares / 2 rows
Working width (cm)	175		
Share spacing (cm)	25		
Overall width (cm)	165	180	176
Overall length (cm)	170	150	115
Total mass (kg)	325	350	300

2- Tractors

Two different tractors namely, Nasr 60 and Duetz were used in this study (Fig. 3). The locally made Nasr tractor with diesel engine of 45 kW at 2500 rpm (4 cylinders) used as a mobile tractor for tested chisel plows. While the imported Duetz tractor with diesel engine of 100 kW at 2500 rpm (6 cylinders) was used to pull the Nasr tractor with each plow during measuring draft force under different given testing variables.

3- Measuring draft force system

A Measuring draft force system was used to record and draw the measured draught force represented by mli-volt signal line on recording paper. A strain gauge load cell was coupled between two tractors (pull tractor in the front and mounting chisel plow tractor in the rear) as shown in Fig. (3).

Fig. (3): Measuring draft force system during adjustment operation.

The measuring draft force system consists of the following devices as indicated in Fig. (4):

1- Tractor battery (12V) 2- DC-AC UPS 425 Convertor

3- Strain amplifier, DSA 603 4- Portable paper recorder New type 3057

5- Load Cell (Kyowa model, Capacity: 2000 kg_f, Type : LT-2 TG, Japan made)

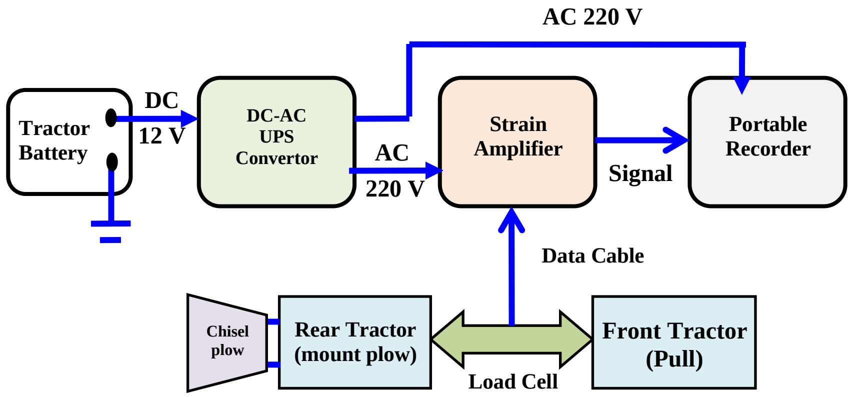

Fig. (4) Flow diagram of draft force measuring system.

Measuring procedure

The DC-AC UPS convertor was used to convert the DC 12 V current of battery tractor to AC current 220 V required to operate both of the strain amplifier and portable recorder during field tests. The output signal from the load cell was connected to the strain amplifier to amplify the signal (micro-volt, μV) as a linear amplifying, in addition to avoid the vibration during measuring. The output cable of strain amplifier was connected in the portable recorder to draw the transformed signal on recording paper.

The speed of recorder paper can be adjusted as a ratio according to the tractor speed which ranged from 1mm/s to 1 mm/h. The measuring accuracy of recorder can be adjusted according to signal transforming it which ranged from 1 μV /cm to 10 μV /cm of record paper.

The draft measuring system was calibrated with known weights to determine the convert factor which used to calculate the draft force from drawn line represented on recording paper as indicated in Fig. (5). A sufficient number of reading were taken at time intervals of 10 seconds to obtain an accurate average draft force estimation.

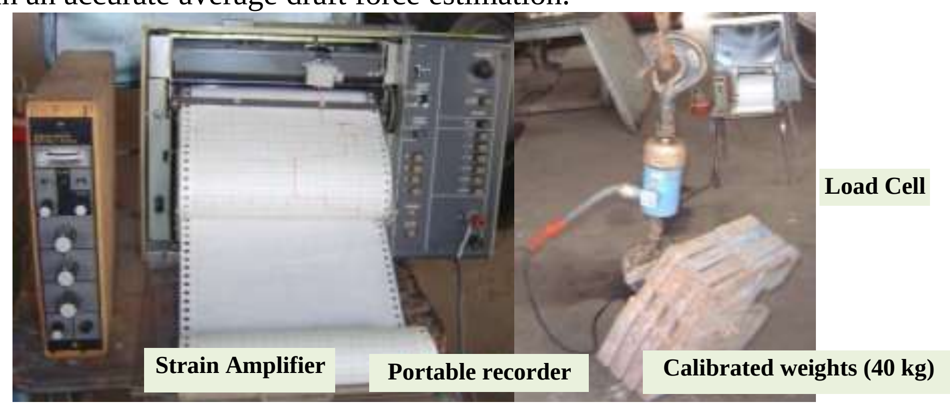

Fig. (5): Calibrating measuring draft force system.

2- Measurements:-

The soil physical properties such as soil moisture content, soil mechanical analysis and soil bulk density were measured before and after plowing operations as follows:

1- Soil moisture content

The moisture content of the soil was determined using an electric oven adjusted to (105^{o}c) for 24 hours. Soil samples were taken at different soil depths of 0-10 and 10-20cm (three replicates for each sample) by screw auger immediately before plowing . The soil moisture contents were carried out at laboratory of Rice Mechanization Center on dry bases using the ***Black et al.* (*1965*)** method.

2- Soil mechanical analysis

Five soil samples from the experimental field were collected through the depth (0-30 cm) and analyzed in "Soil, Water and Environment Research Institute" to obtain the soil mechanical analysis and soil textural type. The average of the obtained data were summarized in Table (2).

Table (2): Soil mechanical analysis of the experimental field.

Clay %	Slit %	(Clay + Slit) %	Sand %	$Caco_3$ %	Organic matter %	Soil type
53.32	17.63	70.95	29.05	1.3	1.71	Clay

3- Soil bulk density

Soil samples were taken using cylindrical core sampler (100 cm^3 volume) at different soil depths of 0-10 and 10-20 cm before and after plowing to determine soil bulk density of soil samples which dried at (105^{o}c) for 24 hours.

4- Degree of plowing quality

Soil surface relief was measured using surface profilemeter. This consisted of a set of vertical rods, spaced at 25cm intervals, sliding through an iron bar of 100 cm length. The soil plowing degree of soil was calculated from the recorded data of soil surface profilemeter to determine the plowing quality using the following equation:

$$P_d = \frac{h_s}{d} \times 100$$

Where : P_d = Soil plowing degree (%).

d = plowing depth (cm)

h_s = average increase in height above soil surface after plowing (cm)

Good plowing degree is ranging from 20 to 30% (***Cravcence et al. 1978 and Helmy 1980***).

5- Slip ratio and field capacity

The slip ratio of the mount plow tractor wheels was measured and calculated using the standard method by measuring the distance travelled (10 revolutions) of the driving wheel with and without load in the experimental field.

The effective field capacity of the modified chisel plow compared with other 2 and 3 row shapes of chisel plow were calculated by using ***Kepner et al. (1978***) method under the experimental field conditions.

6- Rolling resistance and draft force

Rolling resistance is the force required to pull both of the tractor and chisel plow in the lifted position over the tested soil. It is a proportional to equipment weight (***Hunt, 1983***). Estimating the rolling resistance of the tractor is necessary to calculate the net plowing draft force required for the chisel plows at operating speeds.

The rolling resistance of a tractor equipped with mounted chisel plow determined at no load, while the plowing draft force was determined during plowing operation. Forty readings were recorded by the draught measuring system (three replicates) at the plowing speed of 3.4 km/h and the mean was calculated. The net draft force was calculated as follows:

Net plowing draft force (F) = Plowing draft force – Rolling resistance force (RR)

7- Power Consumption and energy requirements:

The power consumed by different chisel plows (one pass) under study were calculated as follows:

$$P = (F \times V) / C$$

Where: P = Power consumption (kW)

V = Plowing speed (km/h)

F = Net plowing draught force (kN)

C = Constant (3.6)

The energy required (ER) for plowing one pass using different shapes of chisel plow was estimated using the following equation:-

$$ER = \frac{Power\ consumption\ (kW)}{Actual\ \ field\ capicity\ (Fed/h\ )}, kW.h/Fed$$

RESULTS AND DISCUSSION

1- Draft force

The measuring data for draft force (kN) through evaluating the modified 4 rows chisel plow compared to other plows (2 and 3 rows) under two plowing depths in fields after soybean and rice at different conditions of soil moisture content for each crop field were illustrated in Fig (6). It is clear that the lowest values of draft force were recorded with modified 4 rows chisel plow compared with other chisel plows at any given study parameters. Meanwhile, the highest values of draft force were obtained with 2 rows chisel plow as indicated in problem statement paragraph. Also, it could be indicated that, increasing soil moisture content during plowing soybean crop from 14.38 to 20.77% decreased the draft force by 47.38% at 10 cm plowing depth for modified 4 rows chisel plow. The same trend was obtained with other chisel plow shapes and plowing depths.

The average values of measuring draft force recorded through plowing soybean crop field were found to be lower than that obtained through plowing rice crop field for all used chisel plows and depths. With respect to the effect of plowing depth, it could be seem that the highest values of draft force (8.56 and 8.97 kN) were obtained at plowing depth of 20 cm when using 2 rows shape of chisel plow for plowing soybean and rice crops fields, respectively. While, the lowest values of draft force (2.31 and 2.79 kN) were obtained at plowing depth of 10 cm when using modified chisel plow for plowing soybean and rice fields, respectively at any given soil moisture content under study.

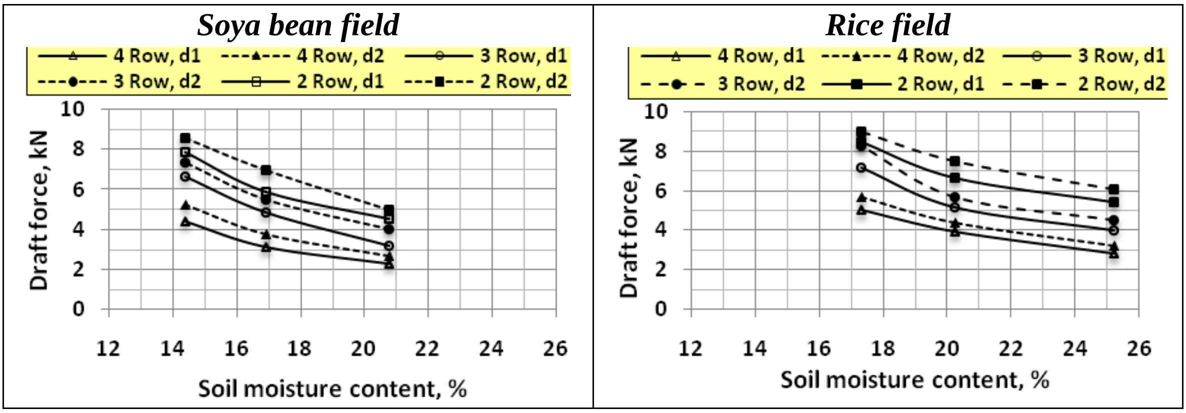

Fig. (6): Effect of using chisel plow shapes and plowing depths on draft force under different fields and soil moisture contents.

2- Field capacity

The effect of different chisel plow shapes, plowing depths as well as previous crop fields with different soil moisture content on field capacity are indicated in Fig. (7) . The data presented in this figure showed that the highest values of field capacity were recorded with modified 4 rows chisel plow under plowing depths and previous crop fields with different levels of soil moisture contents. The field capacity increased from 0.728 to 0.904 fed/h and from 0.815 to 0.904 fed/h when using modified 4 rows chisel plow instead of 2 and 3 rows chisel plows, respectively for plowing soya bean field at soil moisture content of 20.77% and plowing depth of 20 cm. On the other hand, the field capacity increased by 26.66 and 8.93% when modified 4 rows chisel plow used in a comparison with 2 and 3 rows chisel plows, respectively at 20.25% soil moisture content of rice field and plowing depth of 20cm. This results may be due to decrease the required draft force for modified chisel plow, consequently, increasing forward speed and field capacity.

Also, the results indicated that increasing plowing depth from10 to 20 cm decreased the field capacity from 0.942 to 0.904 fed/h, from 0.852 to 0.815 fed/h and from 0.753 to 0.729 fed/h for 4, 3 and 2 rows chisel plows, respectively at soybean soil moisture content of 20.77. The rice field had the same trend under study parameters.

Increasing the soil moisture content from 14.38 to 20.77% increased the field capacity by 13.02, 6.67 and 7.62% using 2, 3 and 4 rows chisel plow, respectively for plowing soya bean field at plowing depth of 20cm. With respect to rice field, the soil moisture content of 20.25% gave the maximum values of field capacity at any given chisel plow and plowing depths. Increasing or decreasing soil moisture content from 20.25% tends to decrease the field capacity.

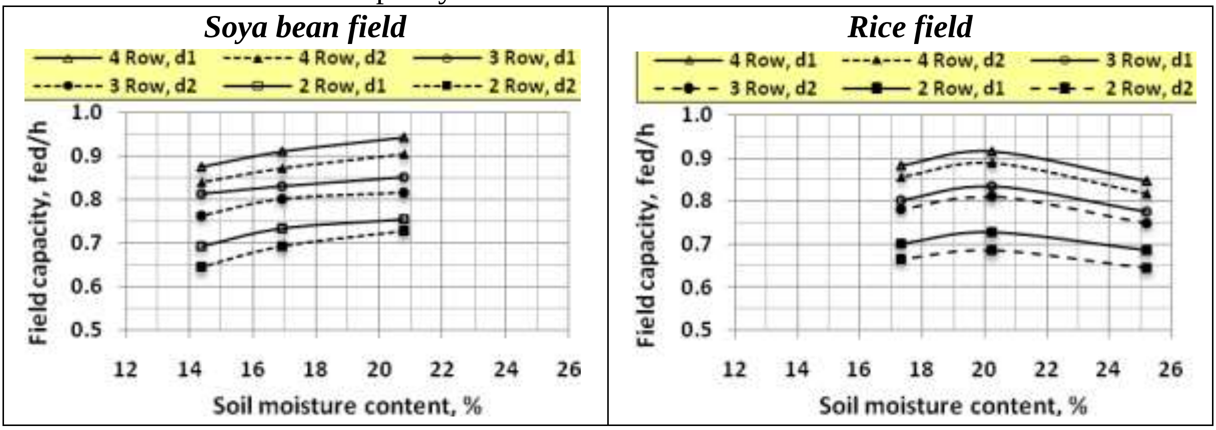

Fig. (7): Effect of chisel plow shapes, plowing depths and previous crop fields with different soil moisture content on field capacity.

3- Power consumption and energy requirements.

The total power consumed and energy required for modified chisel plow (4 rows) compared with other shapes of chisel plow (2 and 3 rows) under the study parameters were measured, calculated and illustrated in Fig (8). The obtained results indicated that the power consumption and energy requirements were highly affected using different shapes of chisel plow at any given study parameters. The consumed power decreased from 6.521 and 5.517 to 3.655 kW due to using modified 4 rows chisel plow instead of 2 rows and 3 rows chisel plows, respectively at plowing depth of 10 cm for plowing soya bean field (14.38% soil moisture content - one pass). However, the power consumption was decreased from 7.073 and 5.972 to 4.168 kW for plowing rice field (17.30% soil moisture content - one pass) at the same previous conditions, respectively. The same trend was obtained for soya bean and rice fields at plowing depth of 20 cm under other different soil moisture contents.

Also, the data presented in Fig (8) showed that the modified 4 rows chisel plow give the lowest values of power consumption which decreased by 46.50 and 59.50 % compared with 2 rows chisel plow shape for plowing soybean field with two levels of soil moisture contents of 16.92 and 20.77 %, respectively at plowing depth of 20cm. While, it was decreased by 45.90 and 46.59 % due to using the modified chisel plow instead of 2 rows chisel plow for plowing rice field with two levels of 20.25 and 25.2% soil moisture contents at the same plowing depth of 20 cm.

Increased moisture content tends to decrease the plowing power consumption for all shapes of chisel plow, plowing depths and two crop fields under study. The power consumption decreased by 48.96 % when the moisture content increased from 14.38 to 20.77% at plowing depth of 20 cm and modified chisel plow when the tillage operation accomplished after soybean field. In case of rice field, increasing the soil moisture content from 17.3 to 25.2% increased the plowing power by 44.24 %, respectively at the same above conditions. This results may be due to increase the draft force as the soil moisture content decreased.

With respect to energy requirement, it could be noticed that using modified chisel plow saving the energy requirement by 55.53 and 38.44 % compared with 2 rows chisel plow shape, at plowing depths of 10 and 20cm, respectively and plowing soya bean field one pass at 14.38% soil moisture content. While, it was 53.11 and 36.47 % at the same above conditions for plowing rice field one pass at 17.30% soil moisture content.

The energy requirement was decreased from 4.888 to 2.883 kW.h/Fed and from 5.731 to 3.599 kW.h/Fed due to using modified chisel plow instead of 3 rows chisel plow at plowing depths of 10 and 20 cm, respectively for plowing soybean field (16.92% soil moisture contents). While, it was increased from 5.143 to 3.599 kW.h/Fed and from 5.829 to 4.101 kW.h/Fed due to using modified chisel plow instead of 3 rows chisel plow shape at 10 and 20 cm plowing depths, respectively for plowing rice field (20.25% soil moisture content).

From these results it could be recommended that using modified 4 rows chisel plow instead of other 2 and 3 rows shapes of chisel plow at the soil moisture content of 20.77 and 20.25 % for plowing soya bean and rice fields, respectively to save power consumption and energy requirement at both given plowing depth 10 and 20 cm.

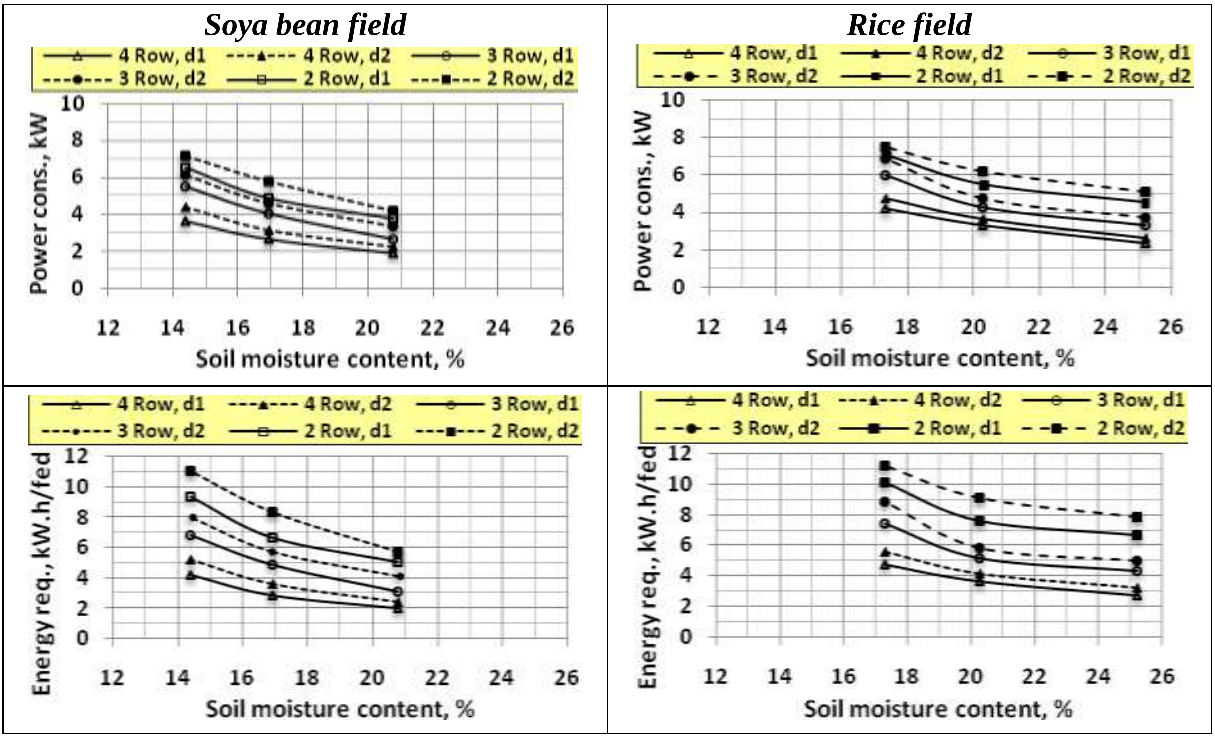

Fig. (8) : Power consumption and energy requirements for plowing operation using different shapes of chisel plow under different study parameters.

4- Degree of plowing quality

The relationship between degree of soil plowing quality and soil moisture content under tow levels of plowing depth when using modified 4 rows chisel plow compared with 2,3 rows chisel plows for plowing operation after two previous crops are shown in Fig. (9). It could be found that using modified 4 rows chisel plow gave the highest degree of soil plowing quality compared with the other two plows (2 and 3 rows) for all plowing depths, soil moisture contents and previous crop fields under study. This results may be due to frequently plow jamming in the adjacent closed distances between tines in the same row for 2 or 3 rows chisel plows by increasing the quantity of remained previous crop residues and big soil clods of plowed soil, which make the plow could not penetrate the soil and affected on plowing quality degree.

Also, it could be indicated that the soil moisture content of 14.38% gave the highest value of plowing quality degree for plowing soya bean field comparing with the other two soil moisture contents of 16.92 and 20.77 % at any given plowing depth and used chisel plow. While, in case of rice field, the soil moisture content of 20.25% gave the maximum values of plowing quality degree at any given parameter under study. These results may be due to increasing the disturbed soil volume at those soil moisture contents for each previous crop fields.

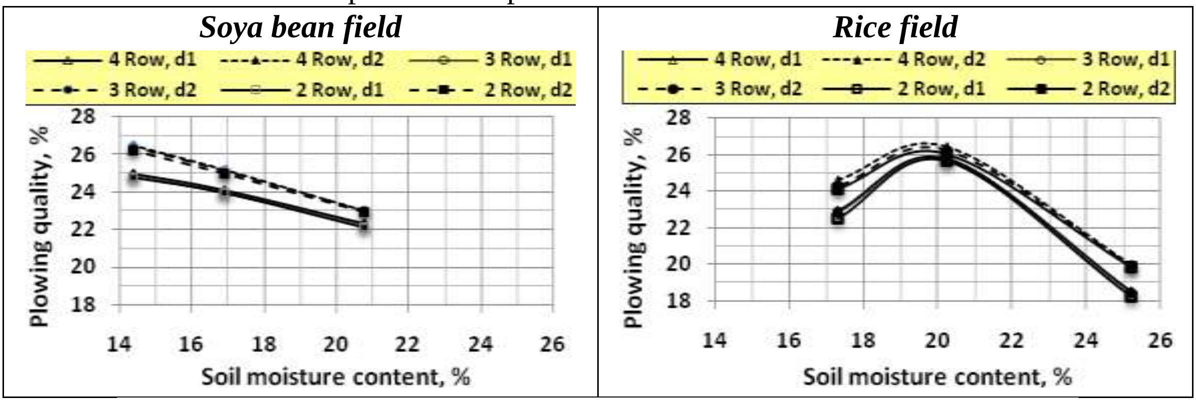

Fig. (9): Degree of soil plowing quality by using different shapes of chisel plow under different soil moisture contents and plowing depths.

Increasing the rice soil moisture content from 20.25 to 25.2% tends to decrease the degree of plowing quality from 26.45 to 19.99 at plowing depth of 20cm and modified 4 rows chisel plow. However, decreasing the moisture content from 20.25 to 17.3% tends to decrease the soil plowing degree from 26.45 to 24.6 at the same above mention conditions. It is also obvious that the degree of plowing quality increased by 3.35 and 2.17% when the plowing depth increased from 10 cm to 20 cm at soil moisture content of 20.77% for soya bean field and 20.25% for rice field, respectively using 3 rows chisel plow.

5- Slip ratio.

The relationship between slip ratio of tractor wheel and soil moisture content using three shapes of chisel plow for plowing rice and soybean previous crops at different plowing depths are illustrated in Fig (10). By comparing the values of slip ratio in this figure between different shapes of chisel plows it could be indicated that, the minimum values of slip ratio were recorded with modified chisel plow and the maximum values were recorded with 2 rows chisel plow at any given soil moisture content, plowing depth and crop fields. This trend may be due to increase the draft force for 2 rows chisel plow. Increasing soil moisture content from 14.38 to 20.77 tends to decrease the slip ratio from 10.23 to 8.89% for plowing soya bean field at plowing depth of 20 cm with modified 4 rows chisel plow. On the other hand, increasing soil moisture content from 17.3 to 25.2% tends to decrease the slip ratio from 13.82 to 9.9% for rice field at the same previous conditions. The results also showed that the slip ratio increased by about 12.40% when the plowing depth increased from 10 to 20 cm at soil moisture content of 16.92% for plowing soybean field., while, it increased by 24.95% at soil moisture content of 14.3 for plowing rice field using modified 4 rows chisel plow.

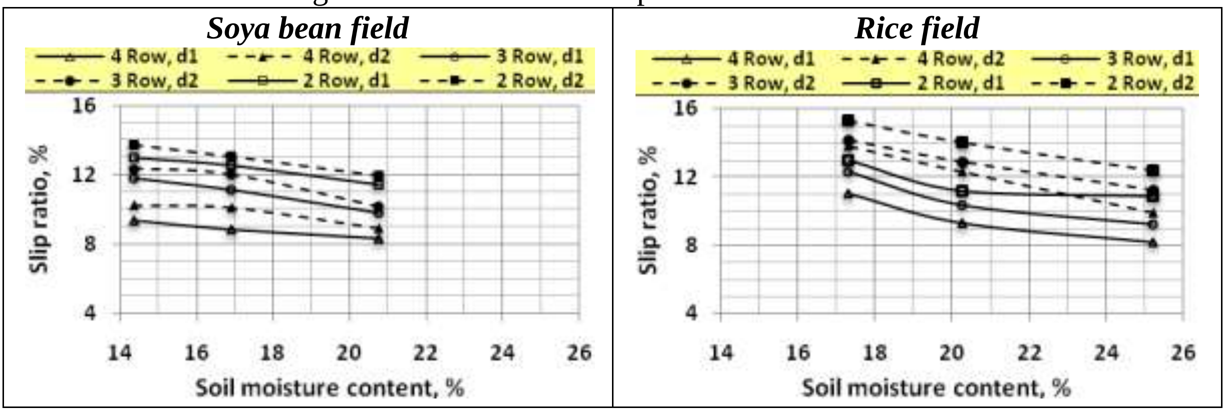

Fig. (10): Effect of using of chisel plow shapes and plowing depths on tractor wheel slip ratio.

6- Soil bulk density

The obtained data of the soil bulk density as affected by soil moisture content, plowing depths and three shapes of chisel plow before and after plowing soya bean and rice fields (one pass) with different soil moisture contents were summarized in Table (3). It could be concluded that the values of soil bulk density were decreased after plowing operation compared with those before plowing at any given parameters under study. The soil bulk density decreased by 12.5, 9.7 and 12.9 % when the tillage depth increased from 10 to 20 cm at soybean field, 16.92% soil moisture content and 2,3 rows chisel plows compared with modified 4 rows chisel plow, respectively.

The soil bulk density in case of rice field had the same above mentioned trend but, at all treatments the bulk density values were higher than soybean previous crop. It clear also that at all plowing depths, chisel plows and previous crops, increasing the soil moisture content tends to increase the soil bulk density. As regards field with soybean residues, decreasing soil moisture content from 20.77 to 14.38% the soil bulk density decreased by 28.8, 34.2 and 26.6% at plowing depth of 20 cm and 2, 3 rows chisel plows compared with modified chisel plow, respectively. With respect to rice field, decreasing soil moisture content from 25.2 to 17.3 % the soil bulk density decreased by 34.19, 33.9 and 38.12 % at the same above conations. Also, it could be concluded that using modified chisel plow had a little effect on soil bulk density compared with other 2 and 3 rows chisel plows.

Table (3): Recorded data of soil bulk density before and after using chisel plows.

Plowing depth	Chisel plow shape	***Soya bean field***			***Rice field***		
		20.77%	***16.92%***	***14.38%***	***25.2%***	***20.25%***	***17.3%***
10 cm	before plowing	1.45	1.35	1.25	1.45	1.35	1.25
	after 4 Rows (Δ-shape)	1.21	1.01	0.86	1.47	1.18	0.96
	after 3 Rows	1.25	1.02	0.92	1.42	1.15	0.99
	after 2 Rows	1.29	1.05	0.9	1.43	1.16	0.92
20 cm	before plowing	1.55	1.45	1.35	1.55	1.45	1.35
	after 4 Rows (Δ-shape)	1.35	1.160	0.99	1.6	1.22	0.99
	after 3 Rows	1.43	1.13	0.94	1.65	1.28	1.09
	after 2 Rows	1.35	1.2	0.96	1.55	1.18	1.02

CONCLUSION AND RECOMMENDATIONS

The main results of this study can be concluded as follows:

1- The highest values of field capacity were obtained with modified 4 rows chisel plow comparing with other two shapes of 2 and 3 rows of chisel plow.

2- The power consumption decreased by 46.50 and 35.30 % by using the modified **Δ**-shape chisel plow instead of 2 and 3 rows chisel plow, respectively at plowing depth of 10 cm and soil moisture content of 16.92% in soya bean field.

3- The minimum value of energy requirements (2.041 kW.h/fed.) recorded with **Δ**-shape chisel plow, 10 cm plowing depth and 20.77% soil moisture content of soya bean field. However, the maximum values (11.219 kW. h/fed.) was obtained with 2 rows chisel plow, 20 cm plowing depth and 17.3% soil moisture content of rice field.

4- Using the modified chisel plow (4 rows) saved about 23 up to 59% in the power consumption and about 30 up to 58% in the energy requirements compared with other shapes of chisel plow (2 and 3 rows) at any given study parameters, in addition to obtain highest degree of plowing quality.

5- The different shapes of chisel plow had a slight effect on degree of plowing quality and highly affected by plowing depth. The highest values of degree of plowing quality were obtained with 14.38 and 20.25% soil moisture content of soil bean field respectively.

6- It is recommended to locally fabricate and operate the modified Δ-shape chisel plow (4 rows) for the Nile delta soil conditions instead of 2 and 3 rows chisel plows to decrease the draft force and save power consumption and energy requirements for plowing operation, in addition to solve the main problems of 2 rows shape of chisel plow.. This modification may be develop the production of chisel plow to be more suitable for agricultural business in Egypt, especially the Egyptian government encourages and facilitate the local manufacture to move the country import dependency to self sufficient. Where, the local manufacturing still making similar copy from imported one without standardization

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الملخص العربى

محراث حفار مطور ذو اطار مثلث الشكل (التقييم واختبار الأداء)

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تتميز أراضى الدلتا بأنها أراضى طينية ثقيلة ، ومحتواها من المادة العضوية قليل ، وأثناء عملية الحرث بالمحاريث الحفارة ٧ سلاح ذو صفين فى مثل هذه الاراضى تنتج نسبة عالية من القلاقيل كبيرة الحجم خاصة فى التربة ذات المحتوى الرطوبى المنخفض . حيث تؤدى هذه القلاقيل الكبيرة الحجم بالإضافة إلى متبقيات المحصول السابق إلى التكتل بين الأسلحة وتقليل كفاءة أداء المحراث لعملية الحرث بالإضافة إلى زيادة قوة الشد المطلوبة لعملية الحرث فى هذه الحالة. لذلك كان الهدف الرئيسى لهذا البحث هو تطوير محراث حفار ٧ سلاح يعاد توزيع الأسلحة فيه على هيكل مثلث الشكل فى أربع صفوف لتخفيض قوة الشد والطاقة اللازمة للحرث وللتغلب على مشكلة تكتل القلاقيل الكبيرة مع متبقيات المحصول السابق بين أسلحة المحراث واختبار وتقييم معدل أداء المحراث المطور مقارنة بالمحاريث الحفارة (٢ صف ، ٣ صفوف).

وقد تمت عملية التقييم بدراسة تأثير شكل ترتيب وتوزيع الأسلحة على هيكل المحراث (٢ ، ٣ ، ٤ صف) لأداء عملية الحرث بعد محصولى فول الصويا (عند محتويات رطوبية للتربة ١٧,٣ ، ٢٠,٢٥ ، ٢٥,٢٪) والأرز (عند محتويات رطوبية للتربة ١٤,٣٨ ، ١٦,٩٢ ، ٢٠,٧٧٪) وعمقى حرث (١٠ ، ٢٠ سم) على قوة الشد والقدرة المستهلكة ومتطلبات الطاقة لكل فدان ودرجة جودة الحرث بالإضافة إلى بعض الخواص الطبيعية للتربة. أجريت عملية تصنيع المحراث المطور بورشة مركز ميكنة الأرز بميت الديبة – فرع معهد بحوث الهندسة الزراعية بكفر الشيخ. بينما أجريت الاختبارات الحقلية بالمزرعة البحثية التابعة لنفس المركز. وقد كانت أهم النتائج المتحصل عليها كما يلى:-

١- أعلى قيم للسعة الحقلية وقوة الشد اللازمة للمحراث تم الحصول عليهما باستخدام المحراث الحفار المطور (٤ صف) مقارنة بالمحاريث الأخرى عند جميع عوامل الدراسة بينما سجل المحراث الحفار ٢ صف اقل قيم للسعة الحقلية وأعلى قيم لقوة الشد المطلوبة للحرث.

٢- زادت القدرة المستهلكة فى عملية الحرث بنسبة ٨٤,٩٤ ،٤٦,٤١٪ باستخدام المحراث

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المطور ٤ صف بدلا من المحراث الحفار ٢ ، ٣ صف على التوالى لحرث ارض فول الصويا عند محتوى رطوبى ١٦,٩٢٪ وعمق حرث ٢٠سم.

٣- سجلت اقل قيم للطاقة المطلوبة (٢,٠٤١ ك وات. ساعة/فدان) مع المحراث الحفار المطور وعمق حرث ١٠ سم عند محتوى رطوبى (٢٠,٧٧٪) لحرث حقل فول الصويا بينما كانت أعلى قيمة للطاقة المطلوبة (١١,٢١٩ ك وات.ساعة/فدان) مع المحراث الحفار ٢ صف وعمق حرث ٢٠ سم لحرث حقل الأرز عند محتوى رطوبى ١٧,٣٪.

٤- لم تتأثر درجة جودة الحرث كثيرا باستخدام المحراث الحفار المطور ٤ صفوف حيث كانت الفروق فى درجات جودة الحرث قليلة لجميع المحاريث المستخدمة . بينما تأثرت درجة جودة الحرث بشكل واضح بعمق الحرث حيث زادت من ٢٤,٩٥ إلى ٢٦,٥٢ بزادة عمق الحرث من ١٠ إلى ٢٠ سم باستخدام المحراث الحفار المطور ٤ صفوف عند محتوى رطوبى ١٤,٣٨٪ لحقل فول الصويا.

٥- توصى الدراسة باستخدام المحراث الحفار المطور فى أراضى الدلتا وخاصة الاراضى التى بها كميات كثيفة من متبقيات المحصول السابق لكفاءة استخدامه فى مثل هذه الظروف وتوفير نسبة كبيرة من القدرة المستهلكة (من ٢٣ إلى ٥٩٪) والطاقة المطلوبة (من ٣٠ إلى ٥٩٪) لعملية الحرث مقارنة بالمحراثين ٢ صف أو ٣ صف مع ضرورة تصنيعه وإنتاجه محليا لتشجيع التصنيع المحلى تحت الظروف المصرية.