Zagazig J.Agric. Res., Vol. 32 No. (2) 2005 615 -634

PERFORMANCE EVALUATION OF SOME CULTIVATORS

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Accepted 4 / 1 / 2005

ABSTRACT: Field experiments were carried out to evaluate the performance of different cultivators during secondary tillage operation in case of preparing soil for planting maize (*Hagin 3/310*) variety and compare the used cultivators from the economic point of view.

Selection of cultivator size was done taking into consideration both time requirements and fuel consumption. While evaluation of the different cultivators was carried out with reference to field capacity and efficiency, some soil physical properties, crop yield, energy requirements, and operational cost.

The experiment results revealed:

1- **Use Motor-hand operated cultivator (small size, 110 cm. width) in plot areas of less than 0.5 feddan, medium-rear mounted cultivator (125 cm. width) can be used in plot areas of between 0.5 to 1.0 feddan, while large-rear mounted cultivator (145 cm. width) can be used in plot areas of more than 1.5 feddans.**
2- **Operate medium and large-rear mounted cultivators at a forward speed of approximately 3 km/h.**
3- **Operate motor-hand operated cultivator at forward speed of approximately 2.2 km/h.**
4- **Operate the used cultivators at a depth of 5 cm.**

Key words: Cultivators, cultivation, tillage, ploughing, seedbed preparation

INTRODUCTION

Secondary tillage operations are carried out using harrows, rotary hoes, and others. Rotary cultivator is a limit use equipment. It is used in crop fields only between rows in a limited stage of plant growth. It is also used in horticulture between trees under special care to remove and cut weeds which may regrowth intensively. For this reason the rotary cultivator was selected to increase its rate of use in the secondary tillage operation.

The rotary cultivator is one of the multi powered rotary tillage implements. The rotary cultivator performs complex motions. For example, a translatory motion with the machine and a relative motion due to the positive drive from the power-take-off (PTO) shaft of the tractor. Positive drive produces dynamic interaction between the tools and the soil and the plant roots. Therefore, the rotary cultivator can be used to break humps of soil, to process severely weed infested soils, and to cut stalks and plant shoots. Added to that rotary cultivators have many other merits such as: small units are self-propelled, they are generally light and cause no appreciable soil compaction, and they can perform secondary tillage operation in only one pass.

Klein *et al.* (1999) carried out investigations for several years to determine the number of cultivator classes required for over all tillage in the Non-Black soil zone of the Russian Federation. The investigation results prove the sufficiency of 3 classes that could be roughly determined as follows: light cultivators to be used to cultivate ploughed fields (8-10 cm) deep, with post rigidity C= 600-700 Nm/rad; medium cultivators to be used to cultivate ploughed fields (16 cm) deep, post rigidity C= 2800-3000 Nm/rad; heavy cultivators to be used to cultivate fields after autumn ploughing up to (25 cm) deep, post rigidity C= 7700-8000 Nm/rad. Investigation results have been used to design a number of cultivators for mass production in Russia.

Kalinan *et al.* (2000) designed 2-Layered surface cultivators, suitable for shallow and deep cultivation. The effect of autumn ploughing was investigated, using a plough PN-4-35, a serial surface cultivator KPG-250, and 2-Layered surface cultivator KPG-

250-U. Data are presented on soil water levels, soil nutrients in fodder maize fields, weeds and crop yield, and profitability. The results showed that with surface cultivation crop residues were mixed with the upper soil layer which resulted in faster mineralization of crop residues, thus improving soil fertility better than after mould board ploughing. More soil moisture was retained after surface cultivation. A 2-Layered surface cultivation resulted in teh availability of more soil nutrients compared with 1-Layered surface cultivation. Surface cultivators showed higher labor productivity, and lower fuel consumption and total production costs.

Hendric (1971) reported that total power requirements for operating rotary cultivator increased with the tillage depth, but the specific power requirement in general decreased.

Abd El-Wahab (1994) noticed with the use of cultivator that the fuel consumption (lit/fed) decreased as the travel speed increased and this was due to the increase in the field capacity (fed/h) i.e. to the increase in the forward speed, and showed that the increase in the travel speed resulted in an increase in slip, draft and consumed energy.

Awady (1986) completed the construction of a rotary cultivator. The rotavator can operate with two to four tine rotors with changeable engines ranging in power between 3 and 7 kW respectively. The big power and 4-rotor arrangement are suitable for orchard cultivation, while the small power and 2-rotor arrangement are suitable for inter-raw cultivation. The rotavator has been tried with 4-rotors, and with 2-rotors with promising results.

Ying Yibin (1998) designed a small rotary cultivator and planted in China. The implement is small, simple, light, cheap, reliable, easy to steer and very suitable for soil tillage in vegetable production. The machine weights only 0.2-0.5 as much as other rotary cultivators of similar productivity. The depth of cultivation is 10-20 cm at a work rate of 0.09 hm2/h.

Wang *et al.* (1999) designed a new dual purpose machine for both ditching and rotary cultivating based on the rotary cultivator. The kinematic and kinetic properties of the machine, its operating quality and economic benefits were analyzed. Trials with the machine show its merits for operating quality and simplicity.

Adel *et al.* (2002) developed the rotary cultivator as multi purposes machine to be used with grain crops. The planting and fertilizing unit is connected with the rotary cultivator by means of angle-iron frame. A seat was made and fixed on the angle-iron frame between the cultivating units in such a case to enable the driver to operate the developed machine. The experimental results reveal that the use of the rotary cultivator after development for cultivating, planting and fertilizing grain crops minimizes both energy and cost added to the improvement of soil properties under the following conditions.

1. Operate the developed machine at forward speed of 4km/h which corresponded to kinematic parameter of 2.2 and tilling pitch of 10cm.

2. Operate the developed machine at soil moisture content of 23%.

3. Operate the developed machine at depth of 6cm.

Suslov *et al.* (1998) studied the effect of 10 different factors on the energy consumption in rotary cultivation. These factors are: presence of soil loosening tines in front of the cultivator, design of the working organ, number of knives on each disc, soil type, speed of advance, rotation speed, direction of rotation, soil condition, angle of blade setting and cutting angle. The relative importance of the various factors is determined. The most important factor is the presence of soil loosening tools in front of the cultivator; the least important factors are the direction of rotation and the speed of advance. Some laboratory studies are made on several designs and geometric parameters (length of drum sections, numbers of knives on it and clearance angle) of the cultivator on the energy consumption during operation. Torque increased nearly linearly with increasing number of knives (from 1 to 4) and decreased with increasing clearance angle (from 6° to 18°).

Zangaladaze (2000) gave details of the design and mode of operation of a rotary cultivator. The working organ executes a progressive and a rotary movement. The kinematics of the blade movement are elucidated. The analysis shows that the cutting speed is variable and is independent of the copying unit under certain conditions. Accordingly the speed of cutting can be reduced, thus improving the efficiency and reliability of soil cultivation.

So, such care had to be taken to use rotary cultivators in performing secondary tillage operation and to improve its performance to carry out the operation with high efficiency and minimum cost.

The objectives of this study are:

1. Evaluating the performance of three different types of cultivators during secondary tillage operation.
2. Selecting optimum cultivator size suits for a certain field size.
3. Optimizing cultivator forward speed and operating depth to achieve high efficiency.
4. Comparing the used cultivators from the economic point of view.

MATERIALS AND METHODS

The main experiments were carried out through tow successful seasons of 2002 and 2003 at Zankloun village, Sharkiya Governorate to evaluate the performance of different types of cultivators during secondary tillage operation.

The mechanical analysis of the experimental soil was classified as Clay (Table 1). Soil mechanical analysis was determined according to the hydrometer method. Black, et al. (1965).

Soil moisture content was determined on dry basis with the oven method at 105c for 24 hours.

Mechanical analysis and moisture content were done in laboratory of Agriculture College, Zagazig University.

Materials:

The following machines were used to carry out the secondary tillage operation:

1. Tractor

A four – wheel tractor (Kubota MX 5000) of the standard type, 50 hp (37.3 kW) was used in this study.

2.Cultivators

Three different types of cultivators were used. The specifications of the used cultivators are tabulated in Table (2).

Table (1): Soil mechanical analysis of the experimental soil.

Soil fraction %			Soil classification	Soil moisture content %
Clay	Silt	Sand		
42.60	30.50	26.90	Clay	14

Table (2): Specifications of the used cultivators.

	Motor – hand operated cultivator	Medium –rear mounted cultivator	Large –rear mounted cultivator
Model:	Lamobardidi	Maschio S.p.A	Maschio S.p.A
Made in:	Italy	Italy	Italy
Engine type:	Diesel air cooling, one cylinder		
Power at rated speed:	14HP (10.3K.W)		
Gear box:	3 forward speeds + 1 reverse		
Working width:	110cm	125cm	145cm
Total height:	94.7cm		
Total length:	179.4cm		
Total width:	82.5cm		
Fuel:	solar		
Number of wheels:	2	2	2
Wheel size:	14*63cm		
Mass:	163kg	255kg	277kg

Methods:

Two main experiments were carried out using different types of cultivators to do secondary tillage operation during preparing soil for planting maize (Hagin 3/310) variety.

The first experiment:

The first experiment was conducted to select optimum cultivator type suits for a certain field size.

Three different cultivators (Motor–hand operated cultivator, Medium rear–mounted cultivator, and Large rear–mounted cultivator) were used in this investigation.

The experimental area of the first experiment was about 12 feddans divided into three equal plots (4 feddans each). Every cultivator was used for secondary tillage operation in one of the mentioned plots. The area of 4 feddans was classified into five subplots areas with different sizes of 0.25, 0.50, 0.75, 1.00 and 1.50 feddans.

All the experimental plots were treated by two chiseling secondary tillage by the above mentioned cultivators and leveled by land leveler before planting. Planting, fertilizing, irrigation and weed control were the same in all treatments according to the technical recommendations. In this experiment, the three cultivators were operated at constant forward speed of 3 km/h and constant operating depth of 5cm.

Selection of cultivator size was based on the following indicators:

Time requirements:

Time per plot area (min) for the secondary tillage operation was measured for every plot area.

Time per feddan (min/fed) was determined by using the following formula:

$$\text{Time per Feddan} = \frac{\text{Time per plot area (min)}}{\text{Field Size (fed)}}$$

Fuel consumption:

Fuel per plot area (L) for the secondary tillage operation was measured for every plot area.

Cultivator fuel consumption during the secondary tillage operation was calculated by measuring the quantity of fuel required to refill the fuel tank after the working period. A graduated glass cylinder was used to measure the added quantity of fuel.

Fuel per feddan (L/fed) was determined using the following equation:

$$\text{Fuel per feddan (L/fed)} = \frac{\text{Fuel per plot area (lit)}}{\text{Field size (fed)}}$$

The second experiment:

The second experiment was conducted to evaluate the performance of the different cultivators.

The experimental area of the second experiment was about (3 feddans) divided into three equal plots (1 feddan each). Each one of the three plots was prepared by motor – hand operated cultivator, the other by medium – rear mounted cultivator and the third by large – rear mounted cultivator.

The performance of the cultivators was measured under four different forward speeds of 1.1, 2.2, 3 and 3.9 km/h. and two different cultivating depths of 5 and 10 cm.

Evaluation of the different cultivators was done taking into consideration the following indicators:

Field capacity and field efficiency:

Effective field capacity is the actual average working rate of area, which was calculated by using the following equation:

$$EFC = 1 / Te$$

Where:

EFC: effective field capacity, fed/h.

Te: effective time for harvesting one feddan, h / fed.

Field efficiency was calculated using the following equation:

$$\eta_f = EFC / TFC * 100$$

Where:

η_f: field efficiency.

TFC: theoretical field capacity, fed/h.

(Calculated by multiplying machine forward speed by the effective working width of the machine).

Soil bulk density (ρ):

Soil bulk density was obtained according to the standard method. Soil bulk density was determined before and after each operation. The percentage of reduction in bulk density ($\Delta\rho$ %) was calculated using the following formula:

$$\Delta\rho \% = \rho_1 - \rho_2 / \rho_1 * 100$$

Where:

ρ_1: soil bulk density before secondary tillage.

ρ_2: soil bulk density after secondary tillage.

Soil penetration resistance (R):

Soil penetration resistance was measured using the penetrometer. Penetration resistance values are measured directly using the above mentioned penetrometer. Soil penetration resistance was calculated according to the following formula:

$$R = S (W_1)^2 / L (W_1+W_2) A$$

Where:

R: resistance of soil to compaction, kg/cm^2.

S: disk fall distance, S = 50cm.

L: probe penetration depth in soil, cm for each trial.

W_1: disk mass, W_1 = 0.49kg.

W_2: mass of the vertical shaft, W_2 = 0.665kg.

A: the surface area of the probe, A = 3.12cm^2.

Soil penetration resistance was measured before and after each operation.

The percentage of reduction in the soil resistance (ΔR %) was calculated from the following formula:

$$\Delta R \% = R_1 - R_2 / R_1 * 100$$

Where:

R_1: soil resistance before secondary tillage.

R_2: soil resistance after secondary tillage.

Yield and its components:

The following components were measured:

- Average seed yield, (ton/fed).
- Average total yield, (ton/fed).

Energy requirements:

Energy requirements can be calculated by using the following equation:

$$\text{Energy requirements, (kW.h/fed)} = \frac{\text{Power required, (kW)}}{\text{Effective field capacity, (fed/h)}}$$

Estimation of the required power to operate each cultivator was carried out by accurately measuring the decrease in fuel level in the fuel tank immediately after executing each operation. The required power was calculated by using the following formula (Barger et al, 1963).

$$P\ (kW) = W_f * C.V * \eta_{th} * 427 / 75 * 1/1.36.$$

Where:

W_f : rate of fuel consumption, (kg/s).

C.V: calorific value of fuel by kcal/kg. (average C.V of fuel is 10000 kcal/kg).

427: thermo-mechanical equivalent, (kg.m/kcal).

η_{th} : thermo efficiency of the engine. (considered to be 30% for diesel engine).

Cost analysis:

The machine cost was determined according to the following equation. (Awady, 1978).

$$C = P/h\ (1/a + i/2 + t + r) + (0.9W.S.F) + m/144$$

Where: c: hourly cost.

p: price of the machine.

h: yearly working hours.

a: life expectancy of the machine.

i: interest rate / year.

t: taxes overheads ratio.

r: repairs and maintenance ratio.

W: power. S: specific fuel consumption. F: fuel price.

m: operator monthly salary.

0.9: factor according for ratio of rated power and lubrications.

144: the monthly average working hours.

The operating cost was determined using the following equation:

$$\text{Operating cost / fed} = \frac{\text{Machine cost / h.}}{\text{Effective field capacity, (fed/h).}}$$

RESULTS AND DISCUSSION

The main results obtained from both the first and the second experiments are summarized under the following main points.

Results of the first experiments:

1-1- Effect of cultivator size on time requirements:

The required time for secondary tillage of one feddan differs from one cultivator to another; their values are 105.3, 68.2, and 66.7 min/fed using motor hand-operated, medium and large-rear mounted cultivators respectively. This emphasizes the high effect of cultivator size on time requirements. (Fig. 1)

Increasing the plot area from 0.25 to 1.0 feddan decreased cultivating time per feddan from 88 to 68.2 min/fed using medium cultivator and from 86 to 66.7 min/fed using large cultivator, while increased cultivating time from 98 to 105.3 min/fed using motor hand-operated cultivator. As the plot area increased more than one feddan up to 1.5 feddans, the time requirements values decreased to 65.5 min/fed using large cultivator, while increased to 120 and 71 min/fed for both motor hand-operated and medium cultivators respectively.

1-2- Effect of cultivator size on fuel consumption:

During secondary tillage operation of one feddan, motor hand - operated cultivator consumed minimum amount of fuel (3.210 lit/fed), medium cultivator consumed (8.500 lit/fed), while large cultivator consumed maximum amount (8.920 lit/fed). (Fig. 2)

Increasing the plot area from 0.25 to 1.0 feddan, decreased fuel per feddan from 9.760 to 8.500 lit/fed using medium cultivator, also decreased fuel from 9.800 to 8.920 lit/fed using large cultivator. While increased fuel consumption from 2.960 to 3.210 lit/fed using motor hand-operated cultivator. As the plot area increased more than 1.0 feddan up to 1.5 feddans, the fuel consumption values decreased to 8.500 lit/fed using large cultivator, while increased to 3.600 and 8.800 lit/fed using both motor hand-operated and medium cultivators respectively.

Results of the second experiments:

2-1- Field capacity and field efficiency for different cultivators:

The highest field capacity values under using motor-hand operated cultivator were 0.57 fed/h under operating depth of 5cm and forward speed of 3.0 km/h. In addition, the lowest field capacity values under using motor-hand operated cultivator were 0.24 fed/h under operating depth of 10cm and forward speed of 1.1 km/h. (Fig. 3)

While field efficiency value were 72.5 % and 84 % respectively under the same previous conditions.

At the same time, the highest field capacity values under using medium-rear mounted cultivator were 1.05 fed/h under operating depth of 5cm and forward speed of 3.9 km/h. In addition, the lowest field capacity values under using medium-rear mounted cultivator were 0.29 fed/h under operating depth of 10 cm and forward speed of 1.1 km/h.

While field efficiency value were 90.4 % and 87.7 % respectively under the same previous conditions.

As to, the highest field capacity values under using large-rear mounted cultivator were 1.1 fed/h under operating depth of 5cm and forward speed of 3.9 km/h. In addition, the lowest field capacity values under using large-rear mounted cultivator were 0.32 fed/h under operating depth of 10cm and forward speed of 1.1 km/h.

While field efficiency value were 81.7 % and 82.9 % respectively under the same previous conditions.

2-2- Effect of cultivator type on some soil physical properties:

-Soil bulk density:

Bulk density generally decreased due to secondary tillage operation and the used cultivator. The maximum percentage of reduction in bulk density of 28.013% was observed under medium-rear mounted cultivator at operating depth of 10cm and forward speed of 1.1 km/h. While the minimum percentage of reduction in bulk density was 1.937% under the use of motor-hand operated cultivator at forward speed of 3.9 km/h and operating depth of 5cm (Fig. 4)

-Soil penetration resistance:

The maximum reduction in soil penetration resistance was 50 % under the use of medium-rear mounted cultivator at operating depth of 10cm and forward speed of 1.1 km/h. While the minimum percentage of reduction in soil penetration resistance was 3.33% under the use of motor-hand operated cultivator at forward speed of 3.9 km/h and operating depth of 5cm. (Fig. 5)

2-3- Effect of cultivator type on crop yield and yield components:

The maximum yield were 7.204 ton under operating depth of 10cm and forward speed of 3.0 km/h under using large-rear mounted cultivator. While the minimum yield were 6.500 ton under operating depth of 5cm and forward speed of 1.1km/h under using motor-hand operated cultivator (Fig. 6)

2-4- Effect of cultivator type on fuel, power and energy requirements:

Using large-rear mounted cultivator at operating depth of 10 cm and forward speed of 1.1 km/h required the highest value of fuel 21.9 lit/fed and energy 75.75 kW.h/fed. While using motor-hand operated cultivator at operating depth of 5 cm and forward speed of 3.9 km/h required the lowest value of fuel 2.740 lit/fed and energy 20.9 kW.h/fed. (Figs. 7 and 8)

2-5- Effect of cultivator type on the operational cost:

Results reveal that for areas less than 0.5 feddan the motor-hand operated cultivator might be more economical than large and medium-rear mounted cultivators. Meanwhile for areas more than 1.0 feddan the large-rear mounted cultivator might be economical than motor-hand operated cultivator and medium-rear mounted cultivator. As to areas of approximately between 0.5 to 1.0 feddan medium-rear mounted cultivator can be used as the economical one in relation to motor-hand operated cultivator and large-rear mounted cultivator (Figs. 9 and 10).

CONCLUSION

The experimental results revel to the following recommendations:

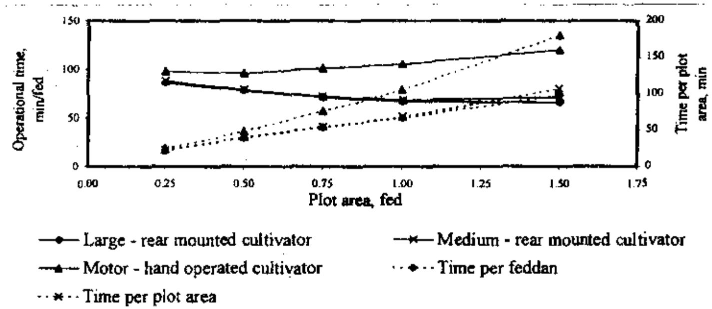

Fig (1): Effect of cultivator size on time requirements

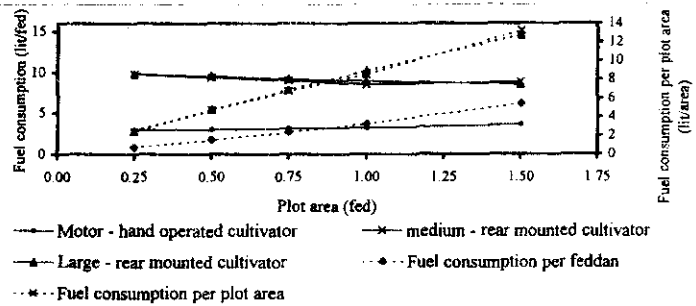

Fig (2): Effect of cultivator size on fuel consumption

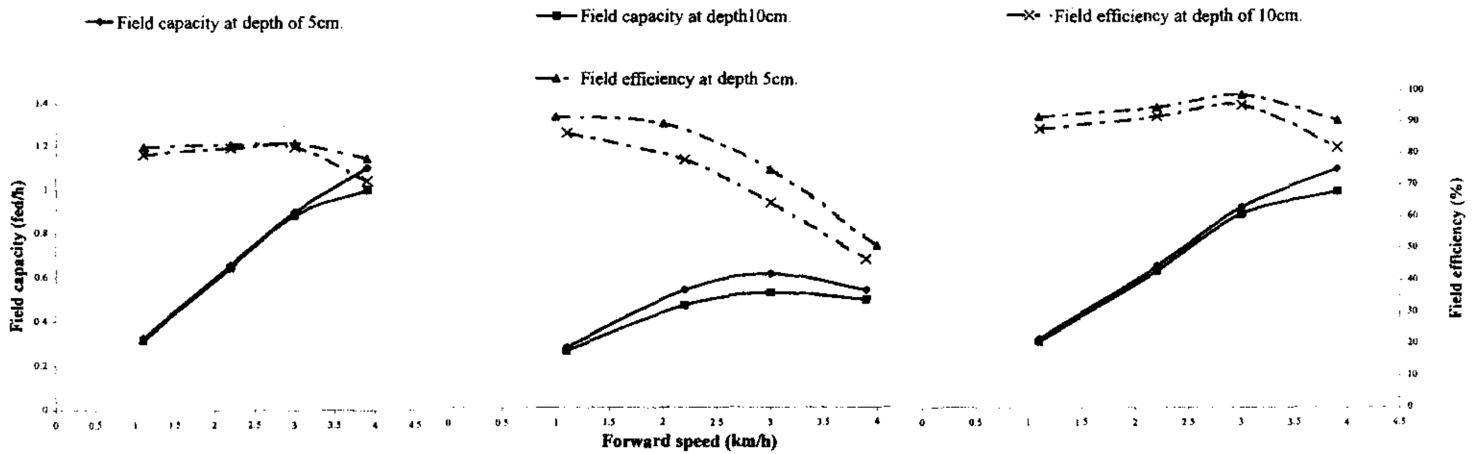

Fig (3): Actual Field Capacity and Field efficiency for different types of Cultivators

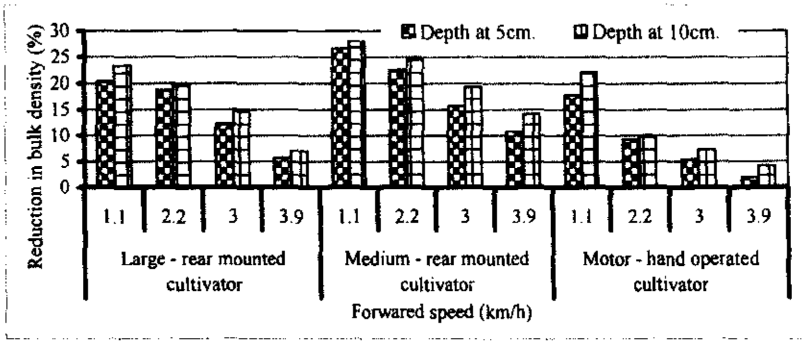

Fig (4): Effect of cultivating machin, cultivating depth and forward speed on the reduction in bulk density

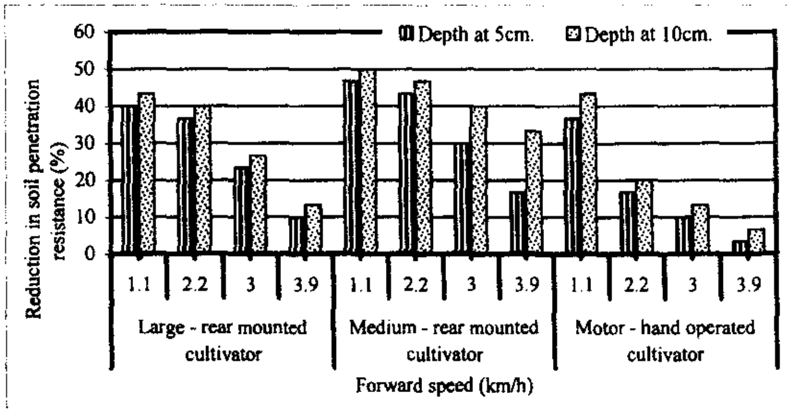

Fig (5): Effect of cultivating machin, cultivating depth and forward speed on the reduction in soil penetration resistance

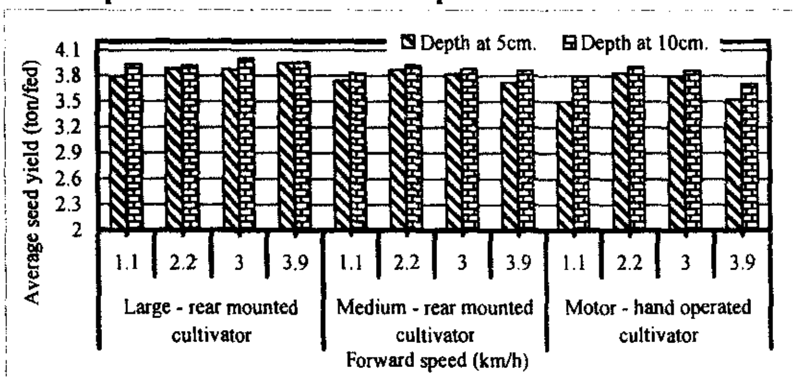

Fig (6): Effect of cultivating machin, cultivating depth and forward speed on crop yield

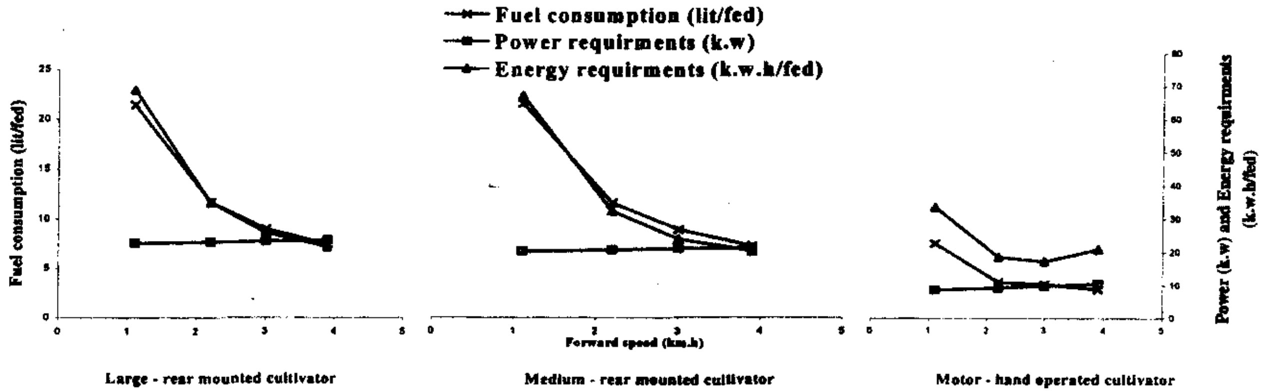

Fig (7): Fuel consumption, power and energy requirements for different kinds of cultivators at operating depth of 5 cm

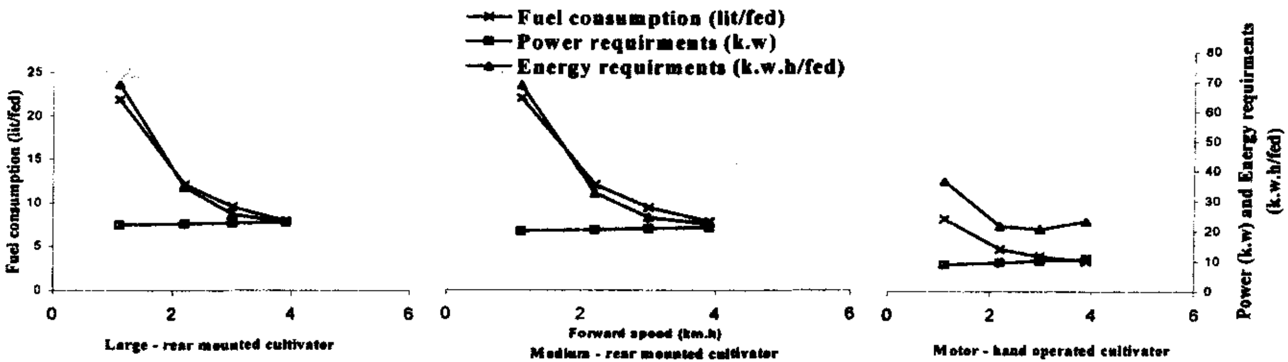

Fig (8): Fuel consumption, power and energy requirements for different kinds of cultivators at operating depth of 10 cm

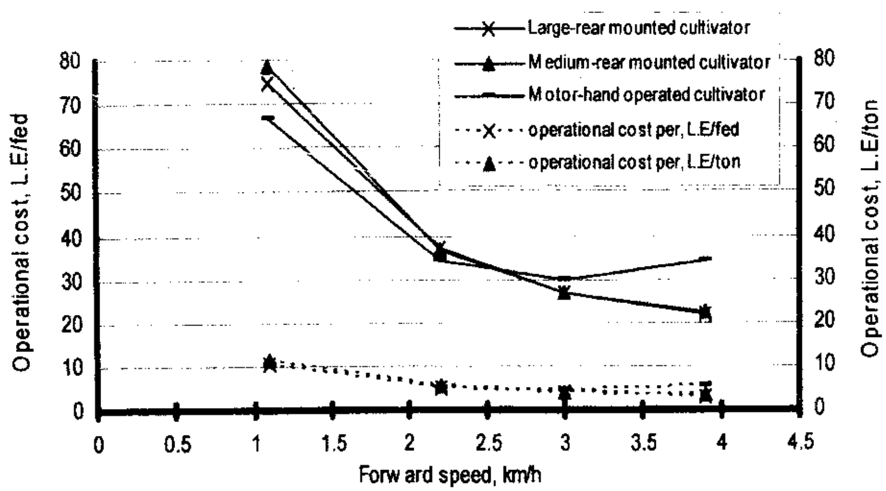

Figure 9: Operational cost requirements for different cultivators under different forward speeds.

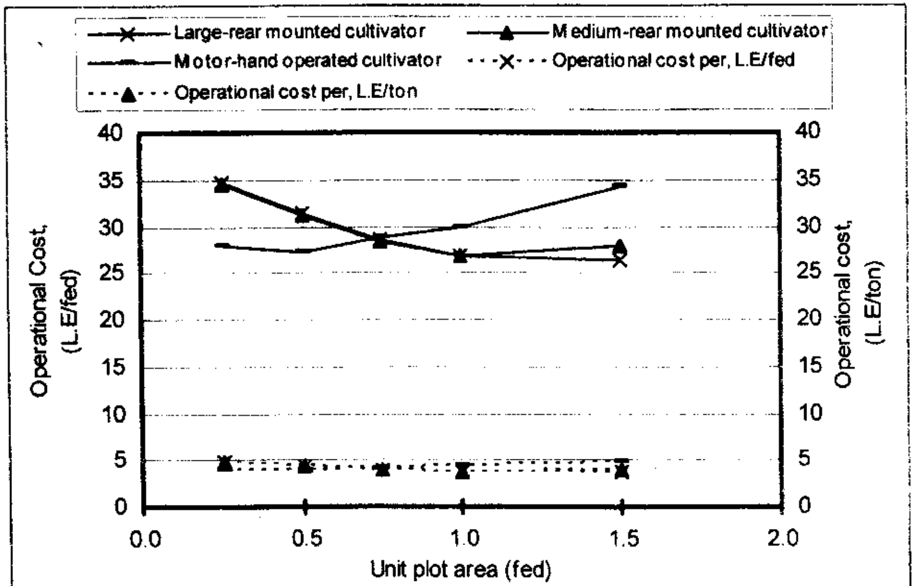

Figure 10: Operational cost requirements for different cultivators under different unit plot areas.

1- It is recommended to use Motor-hand operated cultivator (small size, 110 cm. width) in plot areas of less than 0.5 feddan, medium-rear mounted cultivator (125 cm. width) can be used in plot areas of between 0.5 to 1.0 feddan, while large-rear mounted cultivator (145 cm. width) can be used in plot areas of more than 1.5 feddans.

2- It is recommended to operate medium and large-rear mounted cultivators at a forward speed of approximately 3 km/h.

3- It is recommended to operate motor-hand operated cultivator at forward speed of approximately 2.2 km/h.

4- It is recommended to operate the used cultivators at a depth of 5 cm.

REFERENCES

Abd El-Wahab, M.K. (1994): Minimum tillage by a simple combination. Misr J. Ag. Eng., 11 (3): 711-723.

Adel, A.I.E. (2002): Development of a rotary cultivator to be operated as a multy purposes machine. Ph.D. Thesis, Faculty of Agric., Zagazig University.

Awady M. N. (1978): Tractor and farm machinery, test. Book-Fac. of Agric. Ain-Shams University, Pp. 164-167.

Awady, M.N. (1986): Mechanization of soil cultivation appropriate to Egyptian agriculture. Misr J. Ag. Eng., 3 (2): 27-37.

Barger E. L., Liljedahl, W. M. Carleton and E. G. Mckibben (1963): Tractor and their power units. Wiley Eastern Private Limited, New Delhi, Second Edition.

Black C. A., D. D. Evan, J. L. White, L. E. Ensimenger and F. E. Clark (1965): Methods of soil analysis part 1, American Sos. of Agronomy. Inc. publisher, Wisconsin, U.S.A.

Hendric, J.G. and William, R.G. (1971): Rotary tillage design parameters. Part 1, Direction of rotation. Part 2, Depth of tillage. Part 3, Ratio of peripheral and forward velocities. Trans. ASAE 14 (4): 669-683.

Kalinin, A.T. and Khrulev, A.V. (2000): Subsurface cultivation of soil. Kukuruza i Sorgo 5: 2-5.

Klein, V.and Sergeyev, A. (1999): Justification of the number of cultivator classes used for surface soil tillage. Instytut Budownictwa, Mechanizacji i Elektryfikacji Rolnictwa, 302-306.

Suslov, G. V. and Maksimov, V. P. (1998):Energy consumption in subsurface rotary cultivation. Mekhanzatsiya i Elekrifikatsiy a Sel'skogo khozyaistva No. 12, 6-7.

Wang, H. X.; Qiu, Z. J.; Ying, X. F.; Xu, Z. M. (1999): Study on dual purpose machine for ditching and rotary cultivating. Journal of Zhejiang University (Agriculture and life science) 25(4): 439-442.

Ying Yibin (1998): Design of 1GXZ-50 small rotary cultivator. Journal of Zhejiang Agricultural University, 24(3): 308-312.

Zangaladaze, D. Ya. (2000): Kinematic analysis of the movement of the blade of a rotary cultivator. Traktory i Sel'skokhozyaistvennye Mashiny No. 11, 28-29.

تقييم أداء بعض آلات العزيق

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قسم الهندسة الزراعية – كليه الزراعة – جامعة الزقازيق.

أجريت التجربة في قرية الزنكلون بمحافظة الشرقية في أرض طينيه لتقييم أداء بعض العزاقات من خلال استخدامها في عملية الحرث الثانوي للتربة لتجهيزها لزراعة الذرة الشامية صنف (هجين ثلاثي /٣١٠).

وكانت أهداف الدراسة:

١- تقييم أداء بعض العزاقات من خلال استخدامها في عملية الحرث الثانوي للتربة.

٢- اختيار أنسب عرض تشغيل للعزاقة مع أنسب مساحة للأرض.

٣- تحديد أنسب سرعة و أنسب عمق للحرث للحصول على أعلى كفاءة حقلية.

٤- مقارنة العزاقات المستخدمة من وجهة النظر الأقتصادية.

وبناءً على مقارنة استهلاك الوقود والاحتياجات الزمنية للعملية تم اختيار أنسب عرض تشغيل للعزاقة مع انسب مساحة. أما تقييم أداء هذه العزاقات فقد تم بناء على السعة والكفاءة الحقلية، بعض الخواص الطبيعية للتربة، إنتاجية المحصول، احتياجات الطاقة، وتكاليف التشغيل.

وقد أسفرت النتائج على أن استخدام العزاقات الدورانية خلال عملية الحرث الثانوي للتربة تقلل من استهلاك الطاقة كما انها تخفض من تكاليف العملية الزراعية بالأضافة إلى تحسين بعض خواص التربة الطبيعية تحت الظروف الآتية:

١-فدان،قة الدورانية المدفوعة باليد (١١٠ سم عرض) يفضل استخدامها في المساحات أقل من ٠,٥ فدان، أما العزاقة الدورانية المجرورة ذات عرض التشغيل المتوسط (١٢٥ سم عرض) يفضل استخدامها في المساحات ما بين ٠,٥ و ١,٠ فدان، بينما العزاقة الدورانية المجرورة ذات حجم التشغيل الكبير (١٤٥ سم عرض) فيفضل استخدامها في المساحات اكبر من ١,٥ فدان.

٢- تشغيل العزاقات الدورانية الكبيرة والمتوسطة بمتوسط سرعة ٣ كم / الساعة.

٣- تشغيل العزاقة الدورانية المدفوعة باليد بمتوسط سرعة ٢,٢ كم / الساعة.

٤- تشغيل العزاقات الدورانية المستخدمة على عمق حرث ٥ سم.