OPTIMUM ENGINEERING AND ECONOMIC SELECTION OF ROTARY CULTIVATORS FOR CITRUS ORCHARDS

I - ECONOMICAL COMPARATIVE STUDY

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ABSTRACT

Recently, orchards cultivation became one of the most tedious work in Egypt. Various types of rotary cultivators have, therefore, been imported. The selection of the appropriate machine became a problem. This work was then carried out to set up the optimum selection and the selection criteria of a rotary cultivator.

The economical aspect considered in this study was the determination of break even point as affected by the number of workers available at a time in the traditional hand-labour method of cultivation. The relative small values of the break even point areas indicate the inevitability of replacing the traditional hand method by any otherappropriate one. The rotary cultivator proved to be one of the best possible alternatives.

1 - INTRODUCTION:

Many types and makes of rotary cultivators have been recently imported to Egypt. The problem was latent in the selection of the appropriate type.

Field experimental tests were then carried out on four types of these cultivators. The economical considerations taken into account in these tests were as follows:

1 - Comparative economic evaluation of rotary cultivators.

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2 - Manoeuvrability in the field.
3 - Timeliness cost.
4 - Fuel consumption.

Accordingly, the type selected was a (MAB) 14 diesel engine rotary cultivator particularly because it is the mostly used type.

2 - REVIEW OF PREVIOUS WORK:

In studying the performance of any machine, such as a rotary cultivator, cost analysis should be considered. Such study requires comparing the practically alternative methods of cultivation, i.e., the use of the rotary cultivator and traditional hand method.

Cost analysis comprises the determination and consideration of the total cost of operating a machine. The total cost is composed of two main components viz., fixed and variable costs. Each one of these types of cost is composed of some relevant items. The items of the fixed cost are:[1,2]

1 - Depreciation.
2 - Interest on investiment.
3 - Taxes.
4 - Insurance.

As for the variable cost, it is composed of:
1 - Fuel.
2 - Repair and maintenance.
3 - Timeliness cost.

The industry of agriculture is characterized by its being seasonal. Consequently, the so called timeliness cost arises in this industry of agriculture[3,4].

The timeliness cost of a field operation must be considered to have an economic value. Timeliness cost arises because of the machine's inability to complete a field operation in a reasonably short time. One of the most important factors affecting the timeliness cost of any operation is the total time during which the operation has been performed, i.e, the duration of operation. The total time required for a field machine operation depends upon the number of available working days. For orchards, timeliness cost can be assumed as equal to L.E. 0.1 hr/feddan[3] and fixed costs can be assumed as equal to 13% of value[3].

SYMBOLS:

T.c	- Total cost,
F.c	- Fixed cost,
Q	- The actual area to be cultivated per year,
Q_e	- The break-even point,
V.c	- Variable cost,
	- Field efficiency,
i	- A subscript identifying specific operation,
C_i	- Theoretical rate of performance,
1	- Field efficiency for first cultivation,
2	- Field efficiency for second cultivation,
n	- Number of workers available at a time,
E	- Human energy per unit area,
P	- Worker's wage, per unit time (e.g. cost of 1 man.hr),
f	- Fuel cost,
R	- Repair cost,
t	- Timeliness cost,
H	- Actual duration of operation,
L	- Labour cost,
o	- Oil cost,

3 - RESULTS AND DISCUSSION:

As mentioned before, some experimental tests were carried out with the objective of differentiating betwenn the different makes and types of imported rotary cultivators. Furthermore, these tests served and helped having an idea about the figures of some parameters such as the rate of performance.

As an illustrative example, the following assumptions and the consequent calculations can be made-annually:

$$F.C. = 1300 \times 0.13 = L.E.\ 169$$

$$V.C. = (f + R + t + \ldots\ etc.)\ Q + H_i\ (L_i + t_i)$$

where,

$$H_i = \frac{Q}{\eta_i \; C_i} ,$$

Assuming that: η_1 = 65% , η_2 = 70%

The theoretical rate of performance depends on the width of machine and the optimum working speed. From the experimental tests, C = 1.5 fed./hr. in the first cultivation and 2 fed./hr. in the second stroke of cultivation.

L = L.E 1/hr.

$f+o$ = L.E 0.4/feddan.

Hence, total cost, T.C, per unit area can be calculated as given in equation (1) below:

$$T.C. = \frac{F.C}{Q} + f_i + O_i + \frac{L_i + t_i}{\eta_i \; C_i} \quad \ldots\ldots\ldots\ldots\ldots(1)$$

Accordingly, the following calculations can be made for a (MAB) rotary cultivator.

$$V.c = 0.4 + \frac{2\ (1+0.1)}{\frac{0.65 \times 1.05 \times 0.4 \times 60 \times 60}{4200 \times 1000} + \frac{0.7 \times 1.05 \times 0.5 \times 60 \times 60}{4200 \times 1000}} \; 2000$$

= L.E. 4.29/year/feddan.

Hence, for MAB, F.C. = 169 + 4.29 Q ....(2)

Following the same procedure for some other types of rotary cultivators the following results are obtained.

For (REKORD), T.C = 162.5 + 3.3 Q ....(3)
For (FARRIA), T.C = 169 + 4 Q ....(4)
For (DAEDONG), T.C = 22775 + 4 Q ....(5)

It might be shown from the above equations that the (REKORD) cultivator is the least cost of all. Nevertheless, the (MAB) cultivator was the one chosen for further study instead of the (REKORD). This is because the (MAB) is the most widely used type of cultivator in Egypt.

For hand labour, $T.C = Q\ (P(E_i)) + \frac{E_i}{n}\ t_c)$ ....(6)

Assuming that,

E_1 for first cultivation operation = 160 m.hr/feddan,

E_2 for second cultivation operation =120 m.hr/feddan.

P = L.E 0.25 per hour.

Taking the timeliness cost as previously assumed to be L.E 0.1/fed./hr.,

$$T.C = \varphi\left(0.25\ (160 + 120) + \frac{(160 + 120)}{n} \times 0.1\right),$$

Assuming: n = 4,

$$T.C = \varphi\ (70 + 7) = L.E\ 77\ \varphi \quad \ldots\ldots\ldots\ldots\ldots(6)$$

The graphs of equations (2), (3), (4), and (5) and (6) are plotted as shown in Fig. (1).

Hence, T.C. in the case of traditional method equals T.C in rotary cultivator at the break even point as shown in the figure.

$$\text{Hence, } 77\ \varphi_e = 169 + 4.29\ \varphi_e \text{ for (MAB)} \quad \ldots\ldots\ldots\ldots\ldots(7)$$

From which the break even point φ_e = 2.3 feddan beyond which the hand labour will be more expensive.

Following the same procedure at n = 10 and φ_e = 2.5 feddan, it may be, thus, shown that the break even point φ increases with n. However, the relationship between the simultaneously available number n of workers and the break-even point can be considered. In some more detail for some given value of the other parameters, n can be taken as a variable versus which φ_e is the dependent variable Equating T.c in case of rotary cultivator with T.c in case of using the traditional hand method,

Hence, $F.C + (V.C).\ \varphi_e = \varphi_e\ \left(P.E_1 + \frac{E_1}{n}\ t\right)$

from which,

$$\varphi_e = \frac{F.C}{P.E_1 + \frac{E_1}{n}\ t - V.C} \quad \ldots\ldots\ldots\ldots\ldots(8)$$

For the previously assumed values, the graph of the relation between n and φ_e can be plotted according to equation (8) as shown in Fig. (2).

Such graphs can be constructed according to the initial conditions under which the values of the other parameters differ. It should be noted here that the graph of the relation represented by equation (8) passes through the origin. This means that if it is impossible to obtain any workers at all, hence any area, whatsover small it is should be cultivated by machines such as the rotary cultivator.

For areas less than the calculated break even point, the total annual cost in the case of using the rotary cultivator is higher than that in the case of using man power. Notwithstanding it is justified to have a rotary cultivator for areas less than the break even point on the grounds that the cultivation can be utilized by hiring when not in use. So it will cover 140-150 feddan/year. By equation (1) and taking the depreciation equal to L.E. 1, the total cost/feddan can be worked out for different makes of rotary cultivators as shown in Fig. (3) as follows, for (MAB) = L.E. 6.49, for (FERRARI) = L.E. 6.2, for (REKORD)L.E 6.2 and for (DAEDONG) = L.E 6.62 . So it is recommended to use rotary cultivators for citrus orchards even in the small cooperatives, in the form of service stations, or in the form of private ownership.

4 - <u>CONCLUSIONS:</u>

1 - The cost of operation can be thoroughly investigated and worked out in both cases of using the power-driven rotary cultivator and the traditional hand method.

2 - The traditional hand method of cultivation turned out to be remarkably more expensive even at relative small areas. This phenomenon justifies and explains the resort to using the rotary cultivators.

3 - The timeliness cost is one of the most important factors affecting the break even point and interrelationships between the involved variables.

4 - The less the number of workers simaltaneously available the less the break-even point.

5 - The greater the timeliness cost the less the break-even point.

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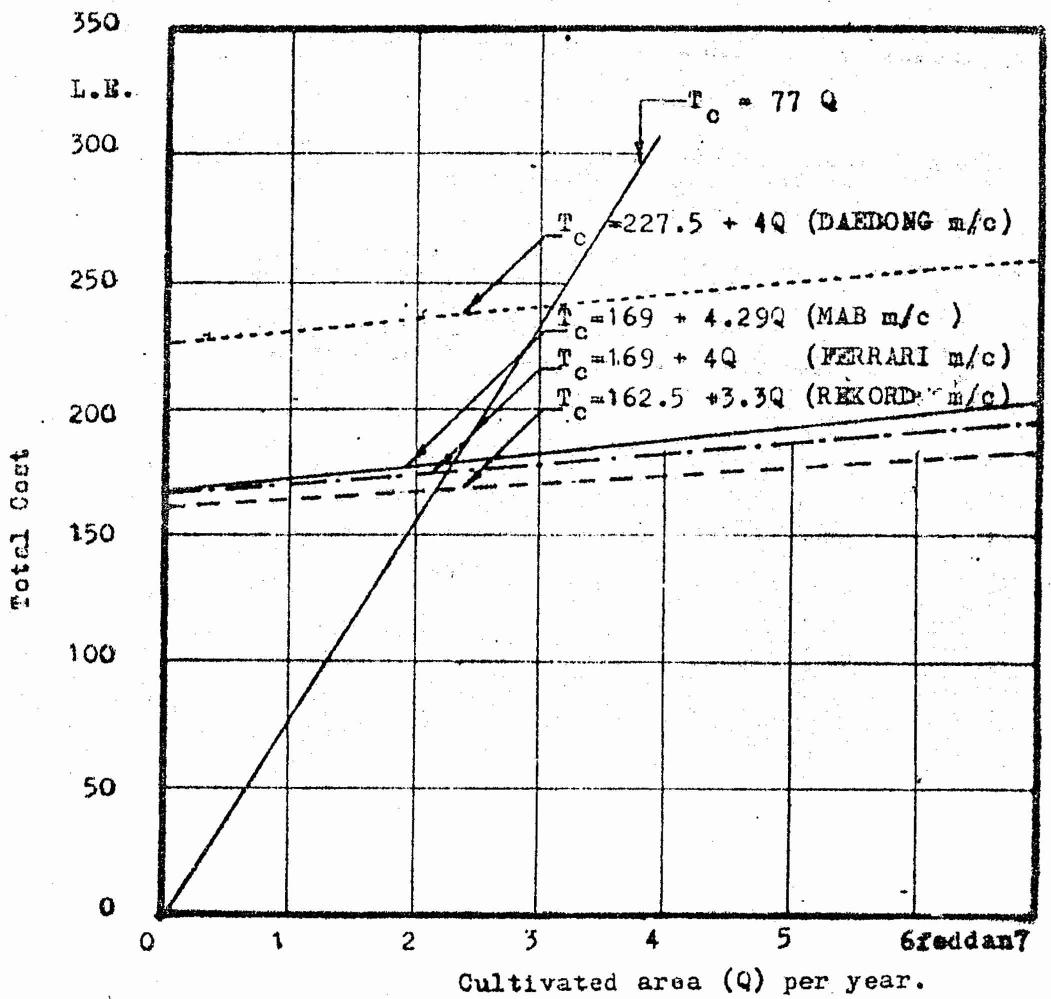

Fig. (1) The relation between cultivated area and total cost for differnet types of rotary cultivator.

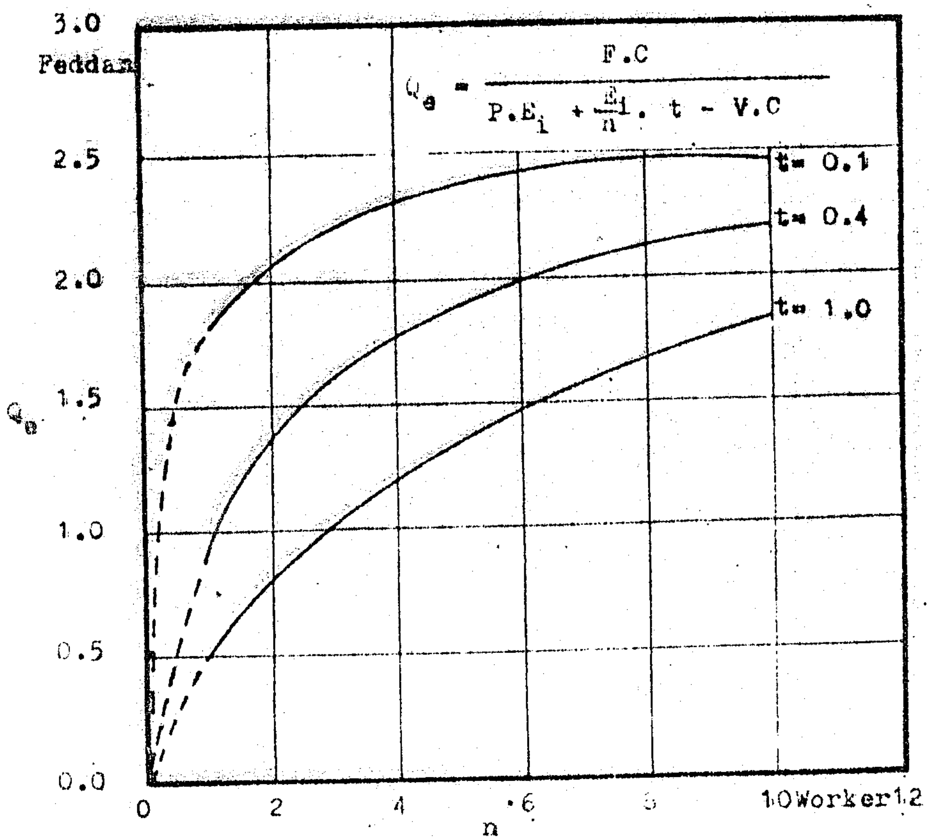

Fig. (2) The effect of (n) on (Q_e) at various levels of (t) .

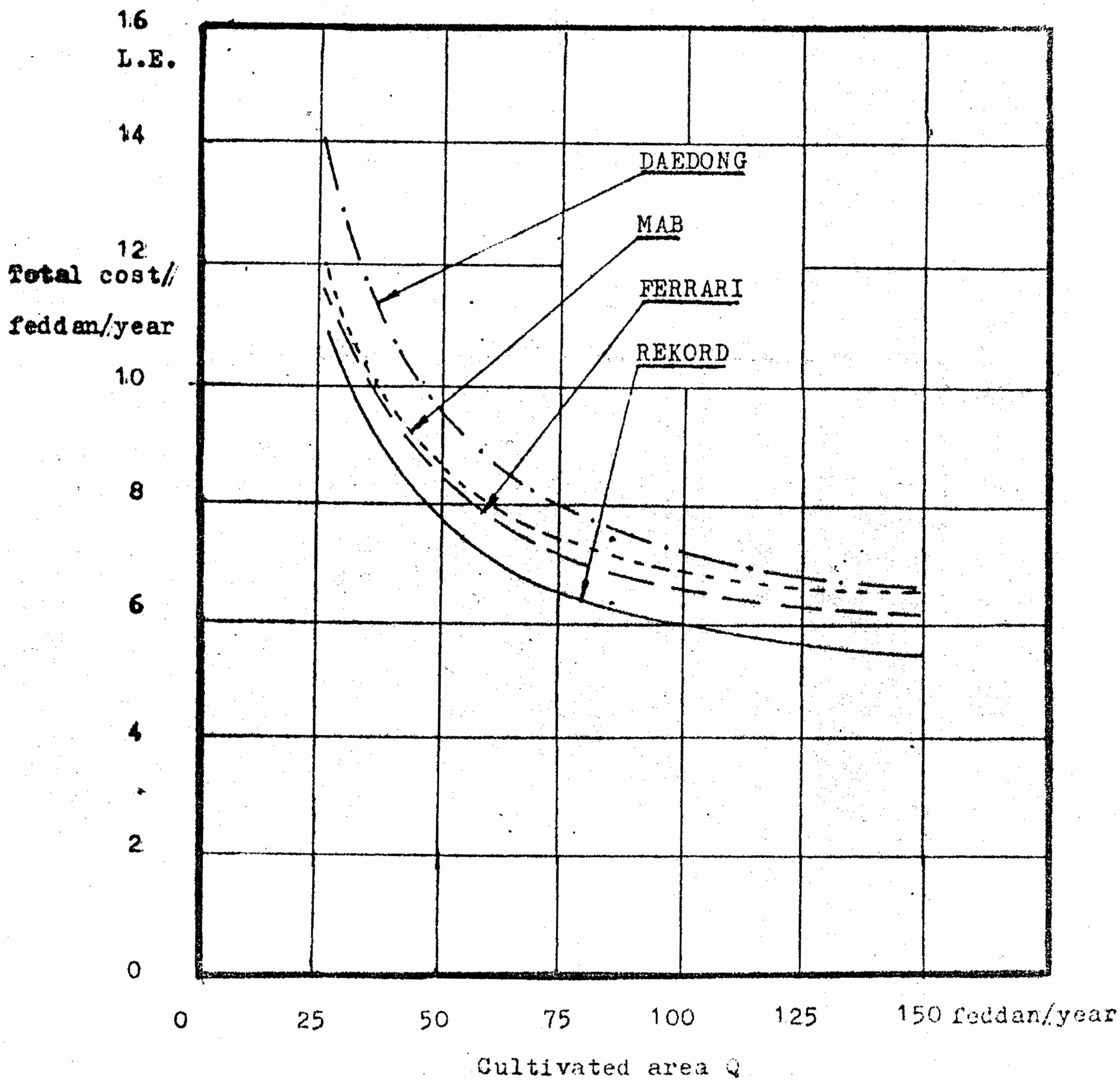

Fig. (3) The cost per unit area vs. the area cultivated for different machines.

الاختيار الهندسي والاقتصادي الأمثل للعزاقات التي تخدم حدائق الموالح

١ – دراسة مقارنة اقتصاديـــة

١ – أ٠د٠ عبدالهادي عبدالباري ناصر ٢ – أ٠د٠ عثمان الخولي
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الملخص

نظرا لأنه تم استيراد أنواع كثيرة من ماكينات العزاقات لاستعمالها في عملية العزيق للبساتين بدلا من العمل اليدوي ٠ فان اختيار الماكينة الأنسب أصبح مشكلة ويهدف هذا البحث الى دراسة المعايير التي يتم على أساسها اختيار النوع الأنسب آخذا في الاعتبار اقتصاديات التشغيل ٠

والاعتبارات الاقتصادية تتلخص في حساب نقطة التعادل ومدى تأثرهـــا بعدد العمال المسموح تواجدهم في ذلك الوقت ومقارنة التكاليف بين العزيـــق بالماكينة والعزيق اليدوي حيث تصل تكاليف الفدان بالعمل اليدوي من ٢٥ – ٥٠ جنيه في حين تصل تكاليفه من ٦٫٤٩ – ٦٫٦٩ جنيه وذلك باستعمال الماكينـــة التي يصل معدلها من ١٤٠ – ١٥٠ فدان في السنة ٠