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PERFORMANCE OF A SMALL COTTON TRANSPLANTER UNDER EGYPTIAN CONDITIONS

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ABSTRACT

Field experiments were carried out at the experimental farm of the Faculty of Agriculture, Ain Shams University, Kalubia Governorate to evaluate the performance of small cotton transplanter, which is disc pocket arrangement with spring holders. The field experiments of the transplanter were conducted at four forward speeds of (0.5, 0.8, 1.2and1.5km/h)and included the field capacity, field efficiency, and transplanter efficiency percentage of damaged, missed and floating seedlings. Also, transplanter slippage, fuel consumption, energy requirements and transplanting costs were studied and compared with manual transplanting.

Data indicated that the highest value of both theoretical and actual field capacities ware 0.256and 0.165fed/h at forward speed of 1.5km/h, while, the highest value of field efficiency was 83%, transplanter efficiency was 94.3%, energy requirement was 76.8kw.h/fed and cotton productivity was 9.23qintar/fed (0.4615 t/fed) at forward speed of 0.5km/h. On the other hand, the lowest value of damaged, missed and loose seedlings was 1.86, 3.15 and 0.65% respectively at 0.5km/h. Also, the total costs of mechanical transplanting were lower than those under manual transplanting by8.3, 36.0,54.0 and 60.8 % at forward speeds of 0.5, 0.8, 1.2and 1.5km/h respectively.

INTRODUCTION

Cotton is considered one of the most importance field crops not only in Egypt but also in the world. It takes a great part of the national income of its exported quantities and participating for a great deal industry. The annual production is about 3.985357 qintar (0.19927t) of cotton seeds 4.593695 qintar (0.229685t) of Ginned cotton and cultivated area is about 788812 feddans (319232.2164 ha) according

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to the Ministry of Agriculture and Land Reclamation (1999).The shortage of agriculture labor in cotton production process increased crop production costs. Therefore, the mechanization of cotton planting was very important to reduce the predicting costs and encourage the farmer who has small area to holding planting cotton. The objective of this research is the field testing of a small transplanter can be used for cotton production in small holding. El. Sayed (1992) studied the effect of transplanting on growth and yield of cotton. He found that the first node carrying fruiting branches was high for direct sowing and low for transplanting method. Salama et al. (1995) said that there is significant increase in fruit weight and number of fruits per plant under mechanical transplanting compared with manual transplanting. ASAE (1989) reported that the field efficiency decreased by increasing forward speed, so the field efficiency is the ratio of the productivity of a machine under field conditions to the theoretical maximum productivity. Harb et al. (1993) compared the mechanical transplanting by using types of machines and manual method. He found that the percentage mechanical damage was 5% for mechanical transplanters. Manual transplanting gave highest population per unit area and disc pocket arrangement transplanter gave the lowest percentage of defective hills after weeks from transplanting.

Capacity of 0.24 fed / h and field efficiency of 56% were the same for all transplanters. El-Fowal (1996) concluded that the performances of transplanters were as follows: the working forward speeds were 1.22, 1.26 and 1.51, 1.44 km/ h at slippage of 16.49, 16.84 and 10.82 and 11.85%. Field efficiency was 75.64, 74.7 2 and 58.11, 59.64% for 4-row walking and 6-row riding transplanter during the two seasons respectively. Hammed et al. (1993) said that seedling damage in planting and feeding losses increased due to increasing transplanter forward speed. El- Behairy (1988) reported that with manual planting three men were required for 6 hours to plant one feddan, whereas with mechanical transplanting a crew of three men was required to plant one feddan in ½ hour. Thus the laboeers required per feddan for planting by manual and mechanical methods were 12 man and one man/ hour respectively. Tan (1991) said that the seedling required 24 labors per hectare, which is approx. 7%of total cost of cultivation labor, and costs could be reduced by 79-81% by using transplanter respectively. El-Sahrrigi et al. (1991) indicated that the mechanical sowing and transplanting have lower cost than hand sowing or transplanting. The cost of manual transplanting of onion seedlings is 1.52 times higher than that when using transplanting machine. Also, about 2 times higher than when using 3-row transplanting machine and 2.22 times larger than that when using 5-row transplanting machine. They concluded that using mechanical sowing or transplanting methods is recommended for obtaining high yield and minimizing cost.

The objective of this study was to evaluate the performance of small cotton transplanter.

MATERIALS AND METHODS

The experiments were carried out at the experimental farm of the Faculty of Agriculture, Ain Shams University, Kalubia Governorate on an area of one fadden (84 x 50m) .The mechanical analysis of the soil is presented in Table (1). Cotton seeds (Giza 85 variety) ware planted in paper pots filled with soil and kept to grow in the nursery for 45 days then transplanted in the field manually by using labor and mechanically by using small one raw transplanter.

Table 1: Mechanical analysis of the soil in the experimental plot.

Sample depth (cm)	Particle size distribution (%)				FC (%)	WP (%)	Bd (g/cm^3)	WHC (mm/m)	Texture class
	Coarse Sand	Fine Sand	Silt	Clay					
0-30	3.3	35.2	21.2	40.3	29.0	17.0	1.3	156.0	CL
30-60	3.4	32.6	22.5	41.5	30.0	19.0	1.4	154.0	CL
60-100	4.0	30.5	26.0	39.5	28.0	18.0	1.5	150.0	CL

FC= field capacity; WP= welting point, FC and WP were determined as percentage by weight; Bd= bulk density; WHC= water holding capacity; CL= clay loam (Soil Dept. Lab).

The transplanter as shown in Fig. (1) was designed to set the transplanting vertically. This machine has a disc pocket arrangement transplanting mechanism and equipped with furrow for placing seedlings and packing wheels. These parts are mounted on a frame attached to the 3-point hitch tool bar. Seedlings are placed manually into the transplanting pockets, which consist of two rubber plates to hold the seedling. The rubber plates are opened and closed with special spring mechanism.

The closing of the rubber plates occurs as soon as the pocket enters two guide plates, which compress the spring when the pocket passes from the guide plates, the spring pressure is released, loosing the rubber and releasing the plant to slip from the pocket and remain in the soil.
The transplanter consists of one transplanting unit having the following specifications: -Wheel rim diameter, 60 cm -Radius of pocket arm, 32 cm
-Gear reduction ratio, 11/8
-Number of pockets on disc, 6 pockets.

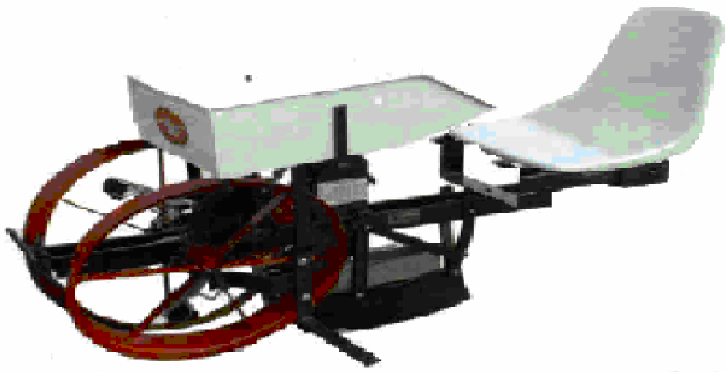

Fig. (1): Transplanter

This transplanter is mounted on a small tractor 23.5 kW as a power source.
During the field experiments, the following parameters were examined:
Four forward speeds of transplanter 0.5, 0.8, 1.2 and 1.5 km/h.
Two methods of transplanting (manually and mechanically).
The experimental measurements included the following:
1- Field capacity and efficiency:
The theoretical and actual field capacity and efficiency were determined using the following equations:

$$FC_{th.} = WxS / 4.2$$

Where:
W = working width of transplanter, m.
S = average working forward speed, km/h
$F.C_{act..}$=1/ total time, h/fed

$$\text{Total time} = T_u + T_1$$

T_u = the utilized time per fed, min.
T_1 = the summation of lost time per fed, in

Field efficiency (F.E) is the ratio of actual field capacity to theoretical field capacity expressed as follows:

$$F.E = \frac{FC_{act.}}{FC_{th.}} x100$$

1- Fuel consumption, power and energy requirements:

Fuel consumption rate (F_C) in (L/h) was determined for each forward speed of the transplanter during operation by means of refueling the tractor tank after the work according to Embaby (1985). A power requirement was calculated by using the following equation:

$$P = 4.18 F_C x P_f x C.V x \eta_{th} x \eta_m$$

Where:

P = power consumed, (kW).

F_C = fuel composition rate, L /S.

P_f = density of diesel fuel, (0.85 kg / L).

C.V= calorific value of fuel, (10000 kcal / kg).

η_{th} = thermal efficiency of engine, assumed to be 40% for diesel engine.

η_{mh} = mechanical efficiency of engine (assumed to be 80% for diesel engine).

The energy requirement (E_n) in kW.h/fed. for transplanter was calculated from the following equation:

$$E_n = P / F.C_{actual}$$

Human energy was estimated based on the power of one labor, which was considered to about 0.746kW, then, the human energy is determined using the following equation according to Chancellor (1981).

Human energy

(kW.h / fed) = 0.764 (kW) × number of laborers / $F.C_{actual}$ (fed/h).

2-Transplanter slippage:

It was calculated according to Rnan and ESCAP (1983) as follows:

$$S = (L_1 - L_2) / L_1 x100$$

Where:

S = Transplanter slippage, %

L_1= Distance without load, m

L_2= Distance with load, m

3- Damaged, missed and loosed seedlings:

Damaged, missed and loosed seedlings were counted manually in the field after each treatment and the percentage of each measurement was calculated using the following formula: $D_s = N_d / N_t \times 100$

$$M_s = N_m / N_t \times 100$$

$$F_s = N_f / N_t \times 100$$

Where:

D_s = Damaged seedlings, %

M_s = Missed seedlings, %

F_s = loosed seedlings, %

N_d = Number of damaged seedlings per unit length.

N_m = Number of missed seedlings per unit length.

N_f = Number of loosed seedlings per unit length.

N_t = Theoretical number of seedlings per unit length.

4- Transplanting efficiency:

It was determined for each treatment by using the following formula:

$$\eta = \left(1 - \left(N_d + N_m + N_f\right) / N_t\right) x100$$

5- Deviation on row:

It was measured in order to determine the distribution uniformity of seedlings within a specific area for each cotton plant and consequently the quality and size of the produce. The deviation on row was estimated according to the following formula (Snedecer and Cochran, 1967).

$$CV = \left(\sigma_{n-1} / X'\right) x100$$

$$\sigma_{n-1} = \sqrt{\frac{\sum X^2 - \left(\sum X\right)^2}{n-1}}$$

Where:

CV = Coefficient of variance, %

σ_{n-1} =Standard deviation.

X' =Average distance between seedlings on row.

$\sum X$ =Summation of distance between seedlings on row.

n=Number of readings.

6- Productivity:

Cotton yield (qintar/fed) was weighed for each treatment after manual harvesting (qintar= 0.05ton).

7- Transplanting cost:

Cost evaluation was performed considering conventional method of estimating both fixed and variable costs by using the following equation of Awady (1978):

$$C_h = \frac{C_P}{n}\left(\frac{1}{A} + \frac{I}{2} + T + M\right) + (0.9\,NxFxP) + \frac{C_L}{144}$$

Where:

C_h = Total cost in LE/h,

C_P = Price of the machine in LE,

N = Number of working hours / year,

A = Useful life in years,

T = Taxes percent,

I = Insert percent,

M = Maintenance and repairs percent,

N = Maximum engine pour in hp or kw,

F = Rate of fuel consumption for engine in l / hp.h

p = Price of liter of fuel in LE,

C_L = Operator accounting foe lubrication,

0.9 = A factor accounting for lubrication, and

144 = Monthly a very working hours.

Operating cost = Machine cost / Actual field capacity.

Manual transplanting = number of laborers for one feddan × labor wage per hour × number of hours per feddan.

RESULTS AND DISCUSSION

1- Field capacity and efficiency of transplanter:

Fig. (2) shows that the theoretical and actual field capacities of transplanter increased by increasing the forward speed. The highest value of both theoretical and actual field capacities ware 0.25 and 0.165 fed/h at 1.5 km /h forward speed, while. The lowest values ware 0.083 and 0.0.69 fed/h for theoretical and actual field capacities respectively at 0.5 km /h forward speed. On the other hand, the actual field capacity of manual transplanting was 0.047 fed/h.

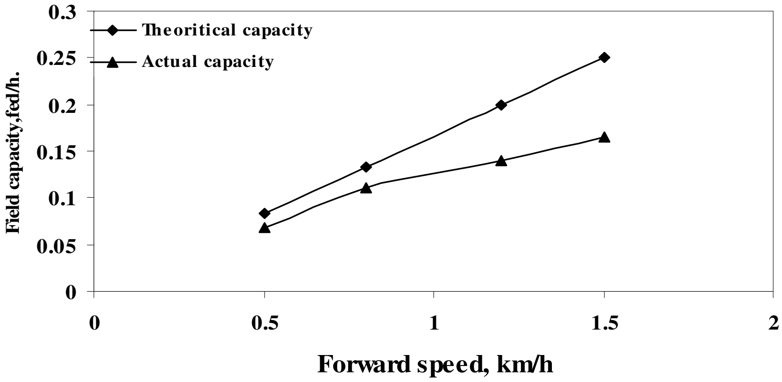

Fig.(2):The theoretical and actual field capacity of transplanter.

Fig.(3) shows also that the field efficiency of transplanting is affected by forward speed. The field efficiency decreased from 83 to 66% by increasing the transplanter forward speed from 0.5 to 1.5 km/h.

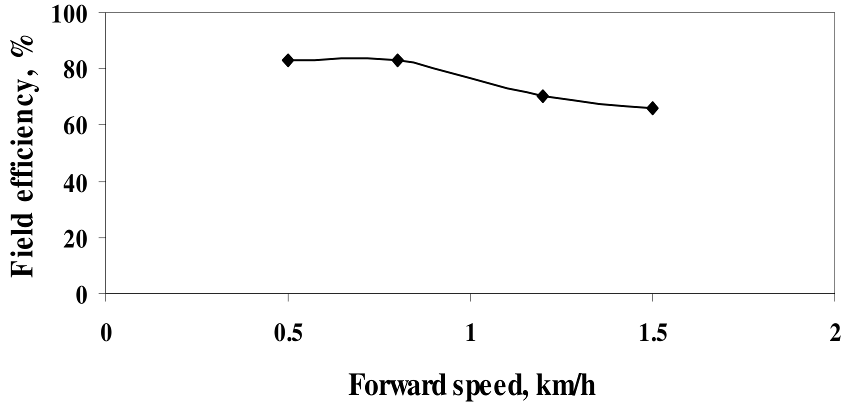

Fig.(3):The field efficiency of transplanter.

2-Slippage percent:

Fig. (4) illustrates that the transplanter slippage is very important factor in the transplanter performance, which affects distribution uniformity of seedlings. Results indicate that the slippage increased from 7.58% to 11% by increasing forward speed of transplanter from 0.5 to 1.5 km/h. This may be due to the sweeping of crushed soil under transplanter wheel as result of its loose structure and vibration of transplanter wheels caused by increasing forward speed.

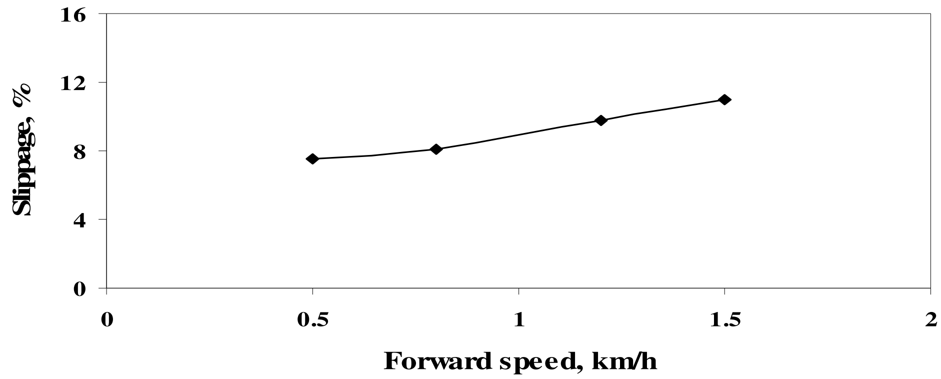

Fig.(4):The transplanter slippage.

3- Fuel consumption and energy requirements:

Fig. (5) shows that the fuel consumption increased by increasing the forward speed of transplanter. The maximum fuel consumption was 2.40 L/h at 1.5 km /h forward speed, while, the minimum fuel consumption was 1.68 L/h at 0.5 km/h. Meanwhile, the results presented in Fig.(5) show that the energy required for cotton transplanting decreased from 76.8 to 45.9 kW.h /fed. by increasing the forward speed from 0.5 to 1.5 km/h. This may be due to increasing the actual field capacity of transplanter. Meanwhile, the consumed energy during manual transplanting operation was 195 kW.h / fed.

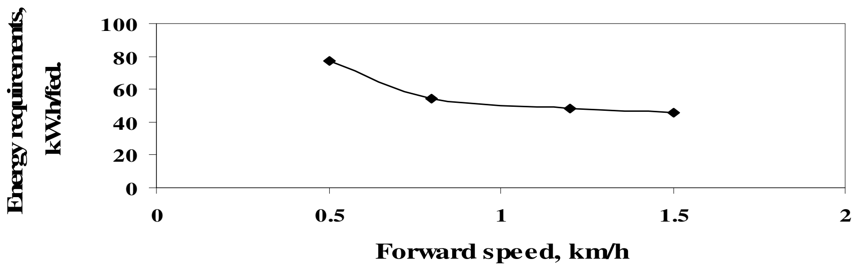

Fig.(5):The fuel consumption and energy requierments.

4-Damged, missed and loosed seedlings:

Fig.(6) illustrates that the damaged, missed and loosed seedlings percentage increased by increasing the transplanter forward speed. The lowest values of damaged seedlings were (1.86%), missed seedlings (3.15%) and loosed seedlings (0.65%)at forward speed of 0.5km/h, while the highest value of damaged seedling (4.52%), missed seedling (7.31%) and loosed seedlings (3.49%)were at 1.5 km/h forward speeds. This may be due to that the amount of soil accumulation around seedling was not suitable with high forward speeds. On the other hand, the data obtained from the manual transplanting treatment showed that the damaged seedlings percentage for manual transplanting (1.73%) was lower than when using mechanical transplanting.

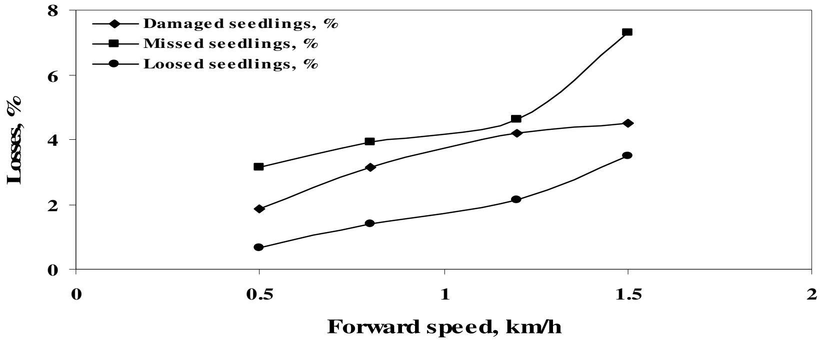

Fig.(6):The losses.

5- Deviation on row:

Fig. (7) illustrates that the distribution uniformity of seedlings is affected by the transplanter forward speed. The highest value of deviation coefficient was (6.8%) at the maximum forward speed of (1.5km/h), while the lowest value was (3.95%) at minimum forward speed (0.5 km/h). On the other hand, the deviation coefficient under manual transplanting (16.4%) was higher than that under mechanical transplanting by 58-75%.

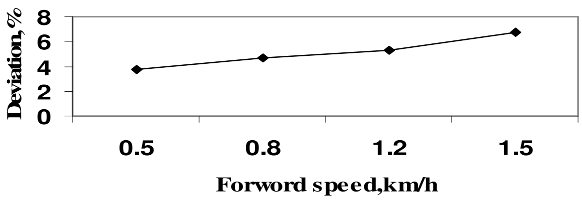

Fig.(7):Distrbution uniformity of seedlings.

6- Transplanter efficiency:

Fig. (8) shows that the transplanter efficiency decreased by increasing the forward speed. The maximum value of transplanting efficiency was (94.3%) at the forward speed of 0.5 km/h , while , the minimum value of transplanting efficiency was (87.7%) at 1.5km/h. This may be due to the high forward speed of transplanter that increased the percentage of damaged, missed and loose seedlings and consequently, decreased the transplanting efficiency. On the other hand, results the manual transplanting treatments indicated that transplanting efficiency for manual transplanting (97.5%) was higher than that when using mechanical transplanting by 3.2-13%. This may be due to increase in actual number of planted hills in the unit of area comparing with the theoretical number of hills.

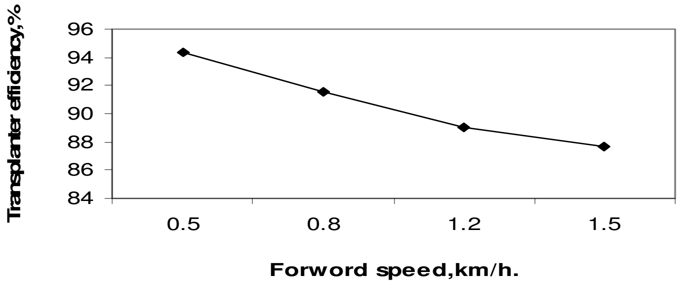

Fig.(8):The transplanter efficiency.

7- Cotton productivity:

Fig. (9) shows that the cotton yield decreased by increasing the transplanting forward speed. The highest cotton yield was 9.23qintar/fed (0.4615 t/fed) at low forward speed of 0.5 km/h. Meanwhile, the lowest yield was 7.86 qintar/fed (0.393 t/fed) at high forward speed of 1.5 km/h. This may be due to the increasing of percentage of damaged, missed and loosed seedlings per feddan. Meanwhile, the data indicated that the mechanical transplanting was higher than that manual transplanting (7.18 qintar/fed) (0.359 t/fed)
by8.6-22.2%.(qintar= 0.05ton).

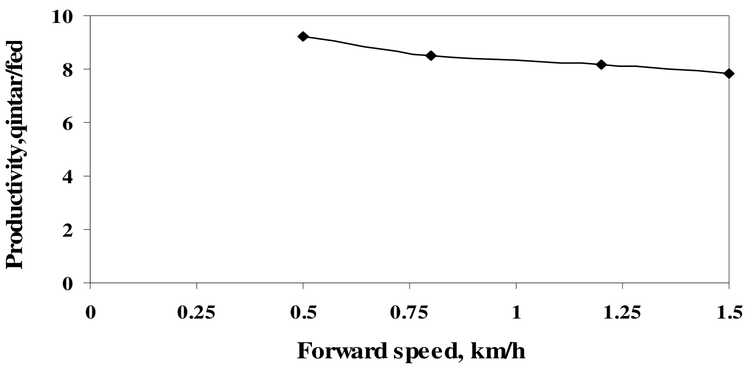

Fig.(9):Productivity.

8- Cost analysis:

Data of cost analysis illustrated in Fig. (10) show that the total costs of cotton transplanting mechanically deceased from 192.6 to82.4L.E/fed by increasing the transplanter forward speed from 0.5 to 1.5km/h. Meanwhile, the total costs for manual transplanting was higher than the mechanical transplanting by 38.4%. On the other hand, the cost of

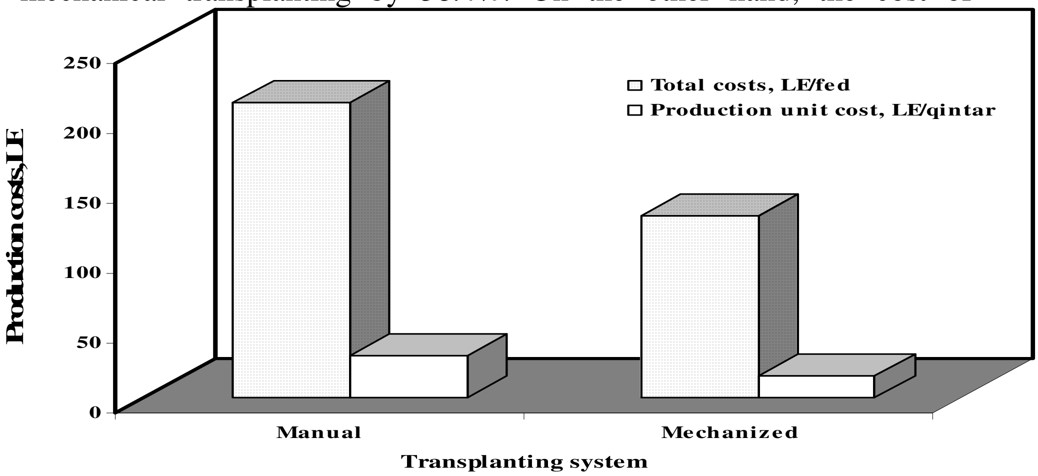

Fig.(10):The total costs of cotton transplanting mechanically.

production unit by using manual transplanting was higher than that when using mechanical transplanting by 1.4, 1.85, 2.37 and 2.54 times at forward speeds of 0.5, 0.8, 1.2 and 1.5km/h respectively.

From the previous results, it is clear that mechanical transplanting saves labor, times needed for cotton planting, energy required and costs in addition to increasing the cotton productivity compared with the manual transplanting.

CONCLUSION

This research was conducted to evaluate the cotton transplanter .Results can be concluded that:

1-The increase of forward speed from 0.5 to 1.5km/h leads to increase the field capacity, fuel consumption, slippage percent and deviation coefficient and decrease the field efficiency, the energy required, transplanting efficiency and total costs of transplanting.

2- The mechanical transplanting increases the filed capacity, efficiency and cotton yield compared with manual transplanting.

3- The mechanical transplanting decreases the percentage of damaged, missed and loose seedlings and total cost of transplanting compared with manual transplanting.

4- The mechanical transplanting decreases the cost of cotton production unit by 1.4, 1.85, 2.37, and 2.54 times compared with manual transplanting at forward speeds of 0.5, 0.8, 1.2, and 1.5 km/h.

Increase of the transplanter forward speed from 0.5 to 1.5 km/h leads to increase the field capacity, fuel consuption, slippage percent and deviation coefficient and decrease the field efficiency, the energy required, transplanting efficiency and operation cost of transplanting.

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الملخص العربي

أداء شتالة قطن صغيرة تحت الظروف المصرية

د.محمد عبد المجيد جنيدي*

أجريت تجربة حقلية في المزرعة التجريبية(مزرعة شلقان) لكلية الزراعة ، جامعة عين شمس ، بمحافظه القليوبية لتقييم أداء شتاله قطن صغيرة، حيث اختبرت عند 4 سرعات (0.5 و 0.8 و 1.2و1.5كم / ساعة). وشملت الدراسة السعة الحقلية و الكفاءة الحقلية وكفاءة الشتالة والنسبة المئوية للتلف و الشتلات المفقودة و العائمة و انزلاق الشتالة و استهلاك الوقود و متطلبات الطاقة وتكاليف عملية الشتل مقارنة بالشتل اليدوي. النتائج المتحصل عليها كانت أعلي قيمة للسعة الحقلية النظرية و الفعلية 0.256 و 0.165 فدان /ساعة بينما اعلي قيمة للكفاءة الحقلية كانت 83% وكفاءة الشتالة 94.3% ومتطلبات الطاقة 76.8 ك وات. س /فدان وكانت الإنتاجية للقطن 9.23 قنطار /فدان(0.4615 طن/فدان) عند سرعة أمامية 0.5كم/س. و من ناحية أخري أقل قيمة للتلف والشتلات المفقودة و الطليقة1.86و3.15و0.6% علي التوالي عند سرعة 0.5كم /س. أما التكاليف الكلية لعملية الشتل الميكانيكي كانت اقل من الشتل اليدوي بنسبة 8.3و36.0و54.0و60.8% عند سرعات أمامية 0.5و0.8و1.2و1.5 كم /س علي التوالي.

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