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PERFORMANCE EVALUATION OF TWO DIFFERENT SYSTEMS OF RICE TRANSPLANTING UNDER EGYPTIAN CONDITIONS

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Abstract

Field experiments were carried out at Rice Mechanization Center, Meet El-Deeba. Kafer El-Sheikh Governorate, Egypt to determine field capacity, field efficiency, slip ratio, planting accuracy, transplanter efficiency, total yield, energy requirements and transplanting cost using : a) 8-row rotary type transplanter (30 cm between rows) and 12-row crank type transplanter (20 cm between rows). They were operated at three different forward speeds using three different distances between hills within the row.

The highest value of effective field capacity was 0.91 fed./h for rotary type transplanter at forward speed of about 2.80 km/h. The highest value of total yield was (3.52 and 3.21 Mg / fed) at the same speed for crank type transplanter 12-row and 8-row rotary transplanter, respectively. The crank type transplanter 12-row which gave the highest number of hills per square meter (33hills/m^2) at forward speed of 2.80 km/h. The lowest values of missing; damaged and floating hills % were obtained at values of (1.8, 1.0 and 2.5%) with crank type transplanter 12-row. The best results of transplanter efficiency were (84.5%) obtained with crank type transplanter 12-row at 2.80km/h. The minimum cost was recorded as (40.0 and 67.50 L.E/fed) for crank type transplanter 12-row and 8- row rotary transplanter, respectively, when compared with the cost of manual rice transplanting for one feddan is 91.0 L.E/fed.

INTRODUCTION

Rice is considered as one of the most important strategic crops. In Egypt, more than one million feddan are yearly planted for rice production for local consumption and exportation.

Manual rice transplanting is a tedious and time-consuming job. It requires about 250- 300 man-hour /ha, which are roughly 25% of the total labor in addition of the labor shortage at transplanting time.

El-Sahrigi *et al.* (1993) studied the effect of nursery condition and transplanter type on transplanting efficiency and yield production and found that the max. yield of 3.5 Mg/fed. was obtained using the 4-row hand steering transplanter, in clayey nursery soil with seedling age of 22days,length of 14 cm and seedling intensity in the nursery tray of 7.4 plant/sq.cm.

El-Sahrigi, *et al.* (1991) also studied the possibility of using mat type transplanter in onion transplanting. The results indicated that the number of seedling/hill(3 to 15 seedling/hill) was considered unsuitable for producing onion bulbs, because the final yield had a considerable amount of cells (double + bolters + offshape) bulbs, which affected the marketable yield. The recommended number of seedlings for each hill was only one.

The mechanized rice transplanting is not only used to replace manual transplanting, but also to ensure optimum population of plants per hill, number of hills per unit area and planting depth for releasing high yield. Metwalli *et al.* (1980)

The mechanical transplanting gave a rice yield higher than traditional transplanting because mechanical transplanting gave a high number of panicle per unit area as well as larger, heavy panicle and vigorous-plant growth El-Keredy *et al.* (1982)

The main factors which determine the work efficiency of a transplanter, are operational speed, working width, turning time and the loading time of seedlings as indicated by Tomatsu (1982). The field efficiency for old models of walking and riding types transplanters are 80 and 60%, respectively, because the operation of the riding types is difficult in applying seedlings and turning the machine, thus require more time.

The Puddling twice produced maximum grain and straw yield, which were 4.5 and 7.0 ton / ha, respectively, Redday and Hukkeri (1983).

El- Wehishy (1983) studied the effect of four different mechanical planting methods of rice broadcasting and transplanting. In general mechanical transplanting resulted in more tillers and panicles, per square meter, and gave higher grain yield compared with other planting methods.

Morsey (1990) studied the effect of four different speeds of mechanical transplanting (1.2, 1.4, 1.6 and 1.8 km/h) under Egyptian condition. He found that the field efficiencies were 72.5, 81, 88.75 and 96% at the previous speeds, respectively. The lower missing hills percentage (4%) and higher yield (3.03 ton /fed.) were obtained at 1.2 km/h

Rice planting may be broadcasted, drilled and transplanted manually or mechanically. The latter method is more popular because of certain advantages) a) saving of the field land for about 30 days b) saving of about 1000 m3/fed of water due to limited use of irrigation water in nursery and c) Intensive care is exercised in nursery including fertilization, irrigation, manual manipulation. El-Awady (1990).

The factors affecting the performance of different transplanters were studied by El-Sahrigi *et al.* (1993). They found that when slippage increases the number of floating and missing hills increased and hill spacing decreased. Also, slippage ratio increases with the increase of plowing depth.

Kholife *et al.* (1997) studied the performance of three different types of rice transplanters. They found that the energy requirements were 5.35, 4.63 and 3.60 kW.h/fed for 8-row riding ,4-row hand driven and 8-row riding (rotary), respectively. However, transplanting cost was 54.44, 39.7 and 62.83 L.E/fed. for these types of rice transplanters, respectively.

The main objective of the present work is to evaluate two different types of rice transplanters through investigating the following items:

1. To study the effect of forward speed on the performance of these transplanters.
2. To determine the planting accuracy for the two tested types of rice transplanters.
3. To evaluate the power requirement and transplanting cost of the tested transplanters.

MATERIALS AND METHODS

Field experiments were carried out at the research farm of Rice Mechanization Center in Meet El-Deeba, Kafr El-Sheikh Governorate, during summer season of 2000 on an area of about 2 feddans planted by rice crop variety of Sakha 101.

Mechanical analysis of the experimental soil is shown in Table 1. Two different types of rice transplanters were used in the present study namely, 8-row riding rotary type (30 cm between rows) and crank type 12-row riding type (20cm between rows). Table 2. summarizes the technical specifications of the two types of rice transplanters.

Treatments were arranged in split-split plot design with three replicates. The treatments of type transplanters were arranged at random in the main plots while, the forward speeds were assigned at random in sub-plots. Inter-row distances were assigned at random in sub. sub-plots.

Table 1. Soil mechanical analysis.

Sand, %	Silt, %	Clay, %	Soil texture	Organic M, %	B. density
27.40	19.10	53.50	Clay	1.82	1.38 g/cm^3

Table 2. Technical specifications of rice transplanters.

Specification	Rice transplanter	
	8-row Rotary type	12-row Crank type
Model	S1-800 R	ARP 12
Max output, hp	8.5	6.4
Total width, cm	278.5	279.1
Total mass, kg	427	660
No. of planted rows	8	12
No. of hills/3.3m2	90/80/70/60	140/125/110
Fuel type	Diesel	Gasoline
Fuel tank capacity, liter	8	6
Planting mechanism	Rotary	Reciprocating
Row spacing, cm	30	20
Hill spacing, cm (adjusted)	12/14/16/18	8/9.5/11
Seeding height, cm	8-25	8-25

Miscellaneous instruments:

a) Cone plumb to measure penetrating depth.

b) Soil penetrometer.

c) Stop watches.

d) Wooden frame (1x1m) used to determine the number of hills per square meter.

e) Ruler and measuring tape.

f) Calibrated cylinder.

Machines used:

1) Tractor

2) Chisel plow (7-tines)- 175 cm.

3) Wooden puddler: (300 x 30 x 20 cm) was used for levelling the wet soil .

The hardpan depth was measured using cone plump penetration instrument. It ranged from 10-15cm for all treatments. However, the soil penetration resistance was 20 to 25 kg/cm^2. The water depth ranged from 2-3 cm. The seedling conditions in nursery before transplanting is considered an important factor in the performance of the rice transplanters. The average plant height, number of plants per square meter and number of leaves of plant in the field at transplanting time were 18.38cm, 18.0 plant and 2-3 leaf respectively.

Slippage, (%) of the transplanter wheel was determined using the following formula:

$$\frac{L1 - L2}{L1} \times 100 \text{ , (\%)}$$

Where:

L1 = The advance distance per 10 revolutions of land - wheel under no load, m

L2 = Advance distance per 10 revolutions of land-wheel under load, m.

The following equation of El-Awady (1978) was used to determine the cost per hour for the two different types of the rice transplanters.

$$C = p/h\ (1/L + I/2 + a + r) + (0.9w.f.u) + b/144$$

Where:

C = Cost per hour of operation, L.E/h;

P = Estimated price of the machine, L.E;

H = Estimated yearly hours operation (450);

L = Life expectancy of the machine (5 Years);

I = Annual interest rate (10%);

a = Annual taxes and overheads (2%);

r = Annual repair and maintenance (18%);

0.9 = A correction factor for rated load ratio and lubrication;

w = Engine power, hp;

f = Specific fuel consumption L/hp. h;

u = Fuel price L.E/l;

b = Hourly labor wage L.E/h considered as (3 pounds/hour).

144 = Is the monthly average labor- working hours.

Price of the machines was taken as follows

For 8- row riding type transplanter (rotary) = 55000 L.E.

For 12-row riding type adjusted rice transplanter (crank type) = 25000 L.E.

Estimation of the required engine power (W or Ep) for the two different types of rice transplanters were carried out by accurately measuring the decrease in fuel level in the fuel tank using a graduated flask. The following formula was used to estimate the engine power.

$$Ep = (Fc.\ 1/60x60)\ \rho_f \times L.C.V \times 427 \times \eta_{th} \times \eta_m \times 1/75 \times 1/1.36, \quad kW$$

Where:

Fc = fuel consumption, L/h;

ρ_f = density of the fuel kg/l (85 and 73 kg/l for diesel and gasoline fuels, respectively);

L.C.V = lower calorific value of fuel, Kcal/kg (average L.C.V. of fuel is taken 10000 Kcal/kg);

427 = thermo-mechanical equivalent kg.m/kCal;

η_{th} = thermal efficiency of the engine, % (considered to be about 35 and 25% for diesel and gasoline engine, respectively);

η_m = mechanical efficiency of engine,% (Considered to be 80% for both diesel and gasoline engines).

The effective field capacity (E.F.C.) was calculated as follows:

E.F.C.= 1 / Total time required in hours per feddan, fed./h

Total time (T) = T1+T2+T3+T4

Where:

T1 = Transplanting time;

T2 = Turning time;

T3 = Feeding time, and

T4 = Adjustment time.

The field efficiency may be expressed as follows:

F.E. = E.F.C. / T. F. C. x 100

Planting accuracy:

a) Missed hills (M_1)

$$M_1 = N_m / N_{th} \times 100$$

Where:

N_m= Number of missed hills /m^2

N_{th} = Number of theoretical hills/m^2

b) Damaged hills (M_2)

$$M_2 = N_d / N_{th} \times 100$$

Where:

N_d = Number of damaged hills/m^2

c) Floating hills (M_3)

$$M_3 = N_f / Nth \times 100$$

Where:

N_f = Number of floating hills /m^2

d) Total missing hills (M):

M =M1+M2+M3

Transplanter efficiency (Et):

$$Et = (1 - \frac{N_{th} - N}{N} \times 100, \%)$$

Where:

N_{th} = Theoretical number of hills/m^2

N = Actual number of hills/m^2

Forward speed of rice transplanter:

The performance of rice transplanter was tested under three different forward speeds, namely; (1.50, 2.10, and 2.80 km/h).

Number of hills per square meter:

Number of hills were counted per square meter in each plot.

Plant height:

It was recorded at harvesting time as an average of ten plants from the soil surface to plant top for each treatment by using a measuring tape.

Yield, Mg/fed.

The grain moisture content at harvesting time was 14%. The yield was measured from an area of 15 m^2.

RESULTS AND DISCUSSION

1. Effective field capacity and field efficiency:

Transplanter type and forward speeds affected the effective field capacity and efficiency of rice transplanter as shown in Fig. 1 The results indicated that the forward speeds had a highly significant effect on transplanting time (effective, feeding, turning and adjusting times). Increasing transplanting forward speed tended to increase the effective field capacity and decrease the field efficiency for the two transplanters. The effective field capacity increased from 0.73 to 0.91 and 0.52 to 0.84 fed./h by increasing the forward speed from about 1.5 to 2.80 km/h for the 8-row and 12-row rice transplanters, respectively.

The field efficiency decreased from about 60.8 to 50.0 and 46.4 to 43.0% by increasing transplanting forward speeds from 1.5 to 2.80 km/h for the 8-row and 12-row rice transplanters, respectively. This agrees with the results reported by (Tamatsu, 1982 and Abd-El-Maksoud, *et al.*, 1994).

2. Planting accuracy:

a) Missing hills, %.

Fig. 2 indicates the effect of transplanting forward speed on percentage of missing hills for the tested transplanters.

In general, the percentage of missing hills increased by increasing planting speed. This may be due to the increase in slip ratio. The maximum percentage of missing hills was 4.5% and 3.0% at 2.80 km/h planting speed with the rotary and the crank type rice transplanters, respectively. While, the minimum percentage of missing hills was 3.0% and 1.8% at 1.50 km/h planting speed for the two rice transplanters, respectively. The best results of missing hills were obtained with crank type rice transplanter.

b) Damaged hills, %:

Fig. 2 indicates the effect of forward speed on percentage of damaged hills for the two transplanters. The damaged hills %, increased by increasing planting speed. The maximum of damaged hills was 2.5% and 1.9% at 2.8km/h planting speed of the rotary and the crank type rice transplanters, respectively. While, the minimum damaged hills %, was 1.5% and 1.0% at 1.5 km/h planting speed for the two transplanters, respectively. The results agreed well with (Abd-El-Maksoud, *et al.* 1994).

c) Floating hills, %:

The effect of forward speed on floating hills %, are shown in Fig. 2. The highest value of floating hills was 5.0% and 4.0% at 2.80 km/h planting speed with rotary and crank type rice transplanters, respectively. While, the minimum value of floating hills was 3,5% and 2.5% at 1.5 km/h planting speed for the two rice transplanters, respec-

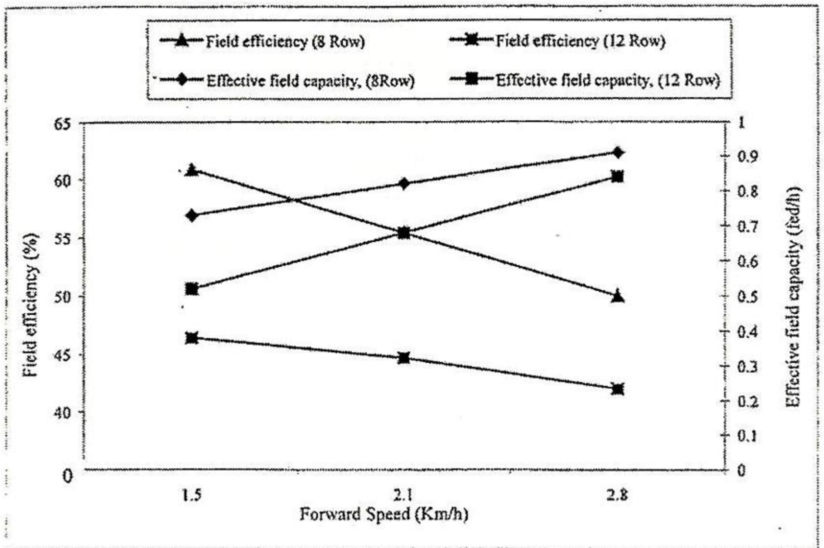

Fig. 1. Effect of transplanter type and forward speed on effective field capacity and efficiency.

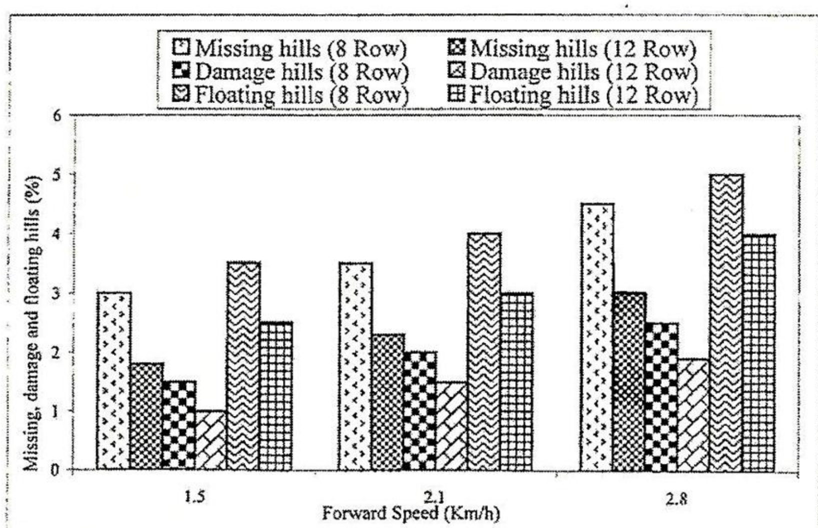

Fig. 2. Effect of transplanter type and forward speed on missing, damaged and floating hills of percentage.

tively. In general, the increase of transplanting forward speed from 1.5 to 2.80 km/h tends to increase the floating hills. This agrees well with the results reported by (Emara, 1998).

3. Slip ratio, %:

Fig. 3. shows that increasing transplanting speed from 1.5 to 2.80 km/h increased the transplanter slip from about 12.8 to 17.6 % and 15.0 to 18.9% for the rotary and the crank type rice transplanters, respectively. The minimum slippage recorded was in case when using forward speed of about 1.50 km/h for the rotary transplanter. This agrees well with (Abd-El-Maksoud *et al.*, 1994).

d) Number of hills/m2:

Figs 4 and 5 illustrate the effect of forward speed and distance between hills within the row on the number of hills per square meter. The results revealed that the rotary transplanter gave the lowest number of hills per square meter 18.0 at forward speed of about 1.5 km/h, while, the highest number of hills per square meter 21.0 was at forward speed of about 2.80 km/h. It is clear that, the decrease of distance between hills within the row from 16.0 to 12.0cm tends to increase number of hills per square meter from 15.0 to 21.0 and 17.5 to 24.5 hill at forward speeds from about 1.5 to 2.80 km/h for the rotary transplanter. On the other hand, the crank type rice transplanter gave the number of hills per square meter 30 and 33 hill at forward speed of about 1.5 to 2.80 km/h. Also, the decrease of distance between hills within the row from 11.0 to 8.0 cm tended to increase number of hills per square meter from 25.0 to 34.0 and 27.5 to 38.0 hill at forward speed of about 1.5 to 2.80 km/h for crank type rice transplanter. From the obtained data the number of hills /m2 in the crank type rice transplanter was higher than that in the rotary transplanter which may be due to the decrease in the distance between hills within the row and the increase of slip ratio in crank type rice transplanter than that of the rotary transplanter.

e) Transplanter efficiency, %

Figs 4 and 5 indicate the effect of forward speed and distance between hills within the row on transplanter efficiency. It is clear that the rotary transplanter gave the lowest transplanter efficiency (71.7%) at forward speed of about 1.5 km/h. While, the highest transplanter efficiency (83.0 %) at forward speed of about 2.80 km/h. The results revealed that increasing the transplanting forward speed tends to increase transplanter efficiency. This agrees with (Tamatsu, 1982). It is clear that, the decrease of distance between hills within the row from 16.0 to 12.0 cm tends to increase transplanter efficiency from 68.2 to 75.0 % and 79.5 to 87.5% at forward speed of about 1.5 to 2.80 km/h respectively for rotary transplanter. On the other hand, the crank type rice transplanter increased the transplanter efficiency from 77.7 and 84.5% when the forward speed increased from 1.5 to 2.80 km/h. Also, the decrease of distance between hills within the row from 11.0 to 8.0 cm tends to increase transplanter efficiency from 73.5 to 80.7% and 80.9 to 88.4% at forward speed of about 1.5 to 2.80 km /h, respectively for the crank type rice transplanter. From the obtained data, the transplanter efficiency in crank type rice transplanter was higher than that in the rotary transplanter due to increase in slip ratio and decrease in the distance between hills within the row in the crank type rice transplanter than that of rotary transplanter.

f) Energy requirements:

Fig. 6 indicates the effect of forward speed and transplanter type on fuel consumption and energy requirements. The results showed that the power consumed reached 3.79 and 6.43 kW at forward speeds of 1.5 and 2.80 km/h for rotary transplanter. Also, power-consumed reached 4.74 and 7.51 kW at forward speeds of 1.5 and 2.80 km/h for crank type rice transplanter. This agrees well with the results of (Abd-El-Maksoud *et al.*, 1994).

g) Cost evaluation:

Fig. 7 shows, the cost calculation of transplanting, for the two types of rice transplanters. The transplanting costs were 55.33 L.E/h and 67.50 L.E/Fed. for the rotary transplanter, and 27.20 L.E/h and 40.0 L.E/Fed, for the crank type rice transplanter. These may be compared with the total cost of transplanting one feddan of rice by traditional method, which requires 13 labors, average wage 7 L.E/day each, resulting in a cost of 91.0 L.E/fed.

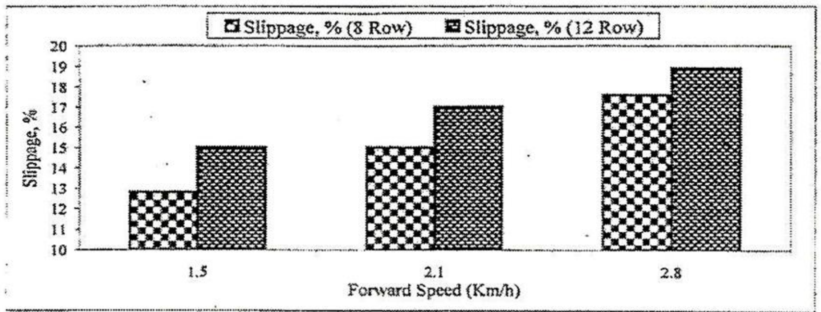

Fig. 3. Effect of transplanter type and forward speed on slippage of percentage.

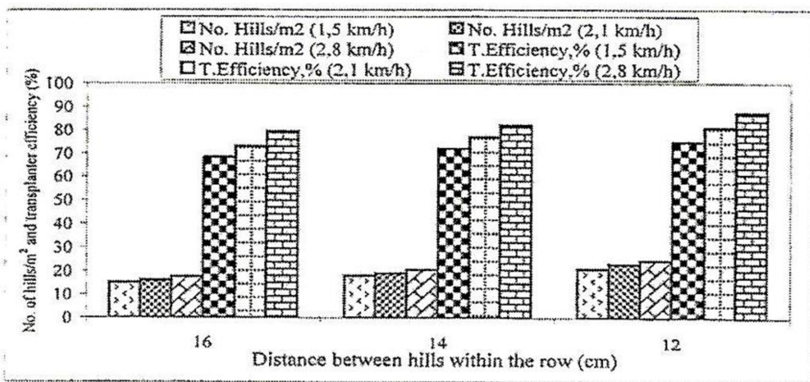

Fig. 4. Effect of forward speed and distance between hills within the row for the rotary transplanter with 8 rows.

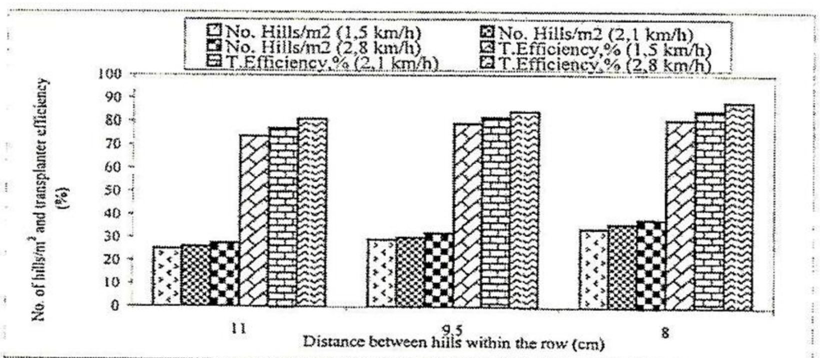

Fig. 5. Effect of forward speed and distance between hills within the row for the crank transplanter with 12 rows.

h) Yield, Mg/fed.

Fig. 8. illustrates the effect of transplanter type and forward speed on yield. The results revealed that the rotary transplanter gave a total yield of 3.10 and 3.50 Mg/fed, at forward speeds of 1.5 and 2.80 km/h respectively. While the crank type rice transplanter gave a total yield of 3.36 and 3.72 Mg/fed, at same forward speeds. It is to be noted that increasing the transplanting forward speed tends to increase the total yield, due to the increase in slip ratio. This agrees well with the results of (Emara, 1999). Note that the total yield of the crank type rice transplanter was higher than that of the rotary transplanter.

CONCLUSIONS

1. Field capacity increased from 0.73 to 0.91 and 0.52 to 0.84 fed/h by increasing the forward speed from about 1.5 to 2.80 km/h for rotary and crank type rice transplanter, respectively.
2. Increasing planting speed tends to increase the percentage of missing hills, damaged and floating hills. The optimum results were obtained with crank type rice transplanter.
3. Increasing transplanting forward speed tends to decrease the distance between hills within the row. The optimum results of number of hills /m2 were obtained with crank type rice transplanter.
4. Transplanter efficiency of the crank type was higher than that of the rotary transplanter due to the increase in slip ratio and consequently the decrease in the distance between hills within the row.
5. Energy requirements were 3.79, 6.43 and 4.74, 7.51 kw.h/fed. at forward speeds of about 1.5 and 2.80 km/h for the rotary and the crank type rice transplanters, respectively.
6. The transplanting costs were 55.33 L.E/h and 67.50 L.E/fed, for the rotary transplanter, and 27.20 L.E/h and 40.0 L.E/fed, for the crank type rice transplanter, compared with rice manual transplanting per feddan (91.0 L.E/fed).
7. The total yield of grain increased by increasing the transplanting forward speed. The total yield by crank type rice transplanter was higher than that of rotary transplanter due to the decrease in the distance between hills within the row.

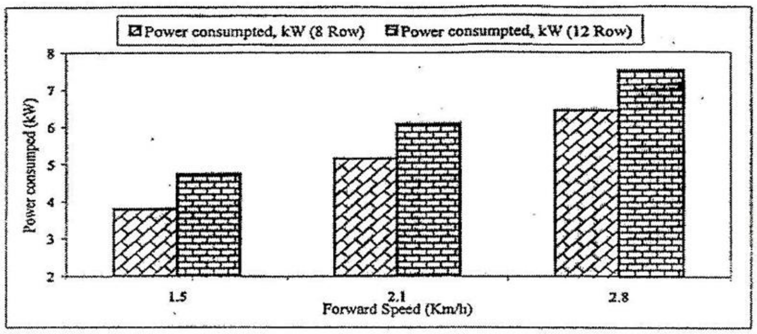

Fig. 6. Effect of transplanter type and forward speed on power speed on power consumped.

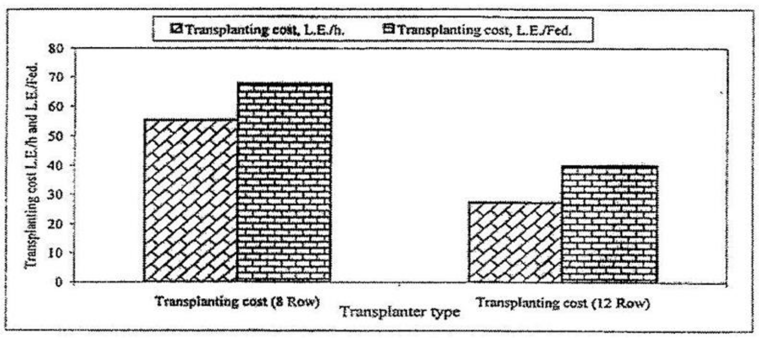

Fig. 7. Operating cost of transplanter type.

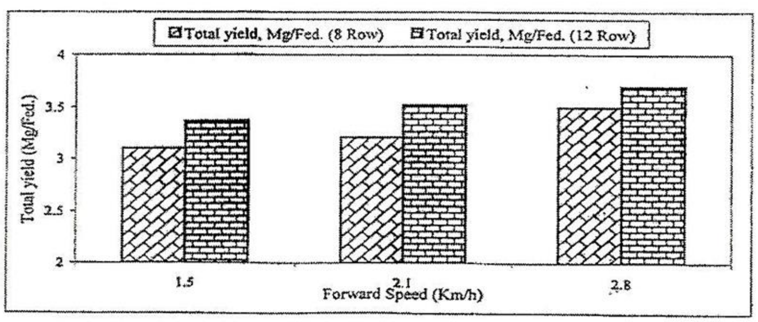

Fig. 8. Effect of transplanter type and forward speed on total yield.

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تقييم الأداء لنوعين مختلفين من شتالات الأرز تحت الظروف المصرية

أسامة محمد كامل[1] ، حمادة على الخطيب[2]

١ باحث اول بمعهد بحوث الهندسة الزراعية ومدير مركز ميكنة الأرز بميت الديبة – محافظة كفر الشيخ

٢ باحث بمعهد بحوث الهندسة الزراعية – مركز ميكنة الأرز بميت الديبة – محافظة كفر الشيخ.

اجري هذا البحث بمزرعة مركز ميكنة الارز بميت الديبة كفر الشيخ لدراسة الأداء لشتالة الأرز المعدلة لتعطي ٢٠سم بين صفوف النباتات (أثني عشر صف) وتتحرك حركة ترددية وشتالة الارز الدورانية (ثمانية صفوف). لتعطي ٣٠سم بين صفوف النباتات مع سرعات شتل أمامية ومسافات بين الكنون داخل الصف الواحد ولقد اشتملت الدراسة علي المتغيرات الاتية:

١- ثلاث سرعات امامية للشتالة (الأولى ١,٥ والثانية ٢,١ والثالثة ٢,٨ كم/ساعة)

٢- ثلاث مسافات بين الكنون داخل الصف الواحد

وكان أهم النتائج المتحصل عليها كما يلي:

١- بينت النتائج ان السعة الحقلية الفعلية زادت من ٠,٧٣ إلى ٠,٩١ ومن ٠,٥٢ إلى ٠,٨٤ فدان /ساعة بزيادة السرعة الأمامية للشتالة من ١,٥ إلى ٢,٨٠ كم/ساعة وذلك عند استخدام الشتالة الدورانية والشتالة الترددية علي الترتيب.

٢- أوضحت النتائج ان زيادة السرعة الأمامية للشتل أدت إلى زيادة النسبة المئوية للكنون الغائبة والتالفة والعائمة. كانت احسن قيم حصل عليها للنسبة المئوية للكنون الغائبة والتالفة والعائمة كانت مع الشتالة الترددية ١٢ صف بالمقارنة با لشتالة الدورانية ٨ صفوف.

٣- بينت النتائج ان زيادة سرعة الشتل أدى إلى نقص المسافة بين الكنون داخل الصف الواحد وبالتالي أدى إلى زيادة عدد الكنون في المتر المربع وكانت احسن قيمه تم الحصول عليها لعدد الكنون فى المتر المربع مع الشتالة الترددية ١٢ صف بالمقارنة بالشتالة الدورانية ٨ صفوف.

٤- أوضحت النتائج ان كفاءة الشتالة في حالة استخدام الشتالة الترددية ١٢ صف كانت اعلي من استخدام الشتالة الدورانية ٨صفوف وهذا ناشيء من نقص المسافة بين الكنون داخل الصف الواحد في حالة استخدام الشتالةالترددية ١٢ صف.

٥- أوضحت النتائج ان القدرة المستهلكة زادت من (٣,٧٩ الي ٦,٤٣ كيلو وات) ومن (٤,٧٤ الي ٧,٥١ كيلو وات) عند سرعة امامية ١,٥ و ٢,٨٠كم/ ساعة وذلك للشتالة الدورانية ٨ صف والشتالة الترددية ١٢ صف علي الترتيب.

٦- بينت النتائج ان تكاليف الشتل كانت ٥٥,٣٣ جنية/ساعة و ٦٧,٥٠ جنية/فدان وذلك للشتالة الدورانية ٨ صفوف. بينما كانت ٢٧,٢٠ جنية/ساعة و ٤٠ جنية/فدان باستخدام الشتالة الترددية ١٢ صف.بينما بلغت تكاليف الشتل اليدوى ٩١ جنيه / فدان.

٧- أظهرت النتائج ان الإنتاجية الكلية ميجا جرام/فدان زادت بزيادة السرعة الأمامية للشتل.

أوضحت النتائج ان الإنتاجية الكلية في حالة استخدام الشتالة الترددية ١٢ صف كانت اعلي في حالة استخدام الشتالة الدورانية ٨ صف وهذا ناشئ من نقص المسافة بين الكنون داخل الصف الواحد في حالة استخدام الشتالة الترددية ١٢ صف.