Misr J. Ag. Eng. 19 (3): 541 – 555

STUDY ON THE COMPATIBILITY OF MECHANICAL TRANSPLANTING FOR SHORT LIFE VARIETIES OF RICE

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ABSTRACT

In Egypt, rice transplanting is done by manual transplanting of rice seedlings in well-prepared puddled soil. At transplanting time, there is a sharp labor shortage. This results in increased labor wages, a delayed transplanting operation and non-uniform and inadequate seedling population. At last years, the rice breeding researchers produced short life and high production varieties of rice. These varieties are different in planting density compare with the old varieties.

Therefore, the main objectives of this study were to study the compatibility of mechanical transplanting for short life varieties of rice and to determine the suitable mechanical adjustments of rice transplanter.To realize these objectives, three different p.t.o gear settings (70, 80 and 90 hills/3.3 m^2) and three cutting area of hill (120, 168 and 196 mm^2) were applied under four different rice short life varieties (Giza 177, Giza 178, Sakha 101 and Sakha 102) using the Japanese rice transplanter.

The obtained results reveal the following: (1) It is recommended that, for transplanting Giza 177 variety, the planting density should be adjusting on p.t.o gear setting of 90 hill/3.3 m^2 and cutting area of hill on 196 mm^2. However for other varieties it is better to adjust the planting density of 80 p.t.o gear setting and 168 mm^2 cutting area of hill. (2) The maximum values of rate of work and work efficiency were 0.84 fed/h and 71.35 %, respectively. (3) It could be obtain the recommended number of seedlings/m^2 for each variety under the study by using available mechanical adjustments in p.t.o gear settings and cutting area of hill in the Japanese rice transplanter. Therefore, the rice transplanter was compatible to transplant the short life varieties of rice.

[Key words] rice transplanter, mechanical adjustment, p.t.o gear settings, rice, short life varieties.

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INTRODUCTION

Rice is the most important staple food after wheat for Egyptian people. The area planted to rice is 20 % of the total agricultural area. In 1999, rice is grown on an area of 1.6[3] million feddans (about 0.65 million hectare) during the summer season. With a total production of about 5.80 million Mg and the national average yield was about 3.74 Mg / fed. (8.97 Mg / ha).

At last years, the rice breeding researchers produced short life and high production varieties of rice. These varieties are different in planting density compare with the old varieties. These disadvantages pushed the demand for development of suitable equipment and necessitates the need to introduce mechanized rice transplanting in order to assess the quality of hand-transplanting rice crop and the labor availability situation during the peak rice transplanting season for timely and better crop stand.

El-Sahrigi (1983), reported that, the goal of mechanized transplanting of crops is not only to increase labor productivity and reduce labor costs but also to include systems, which would ensure optimum number of plants per hill, number of hills per unit area and required planting depth for realizing high yields.

Hong and Lee (1976), studied the effect of mechanical transplanting on rice production. They concluded that the use of mechanical transplanters not only reduced the labor cost, but also increased rice production per unit area.

Metwalli et. al. (1980), reported that mechanical transplanting increased the yield per unit area compared with the traditional methods as well as seed drill method.

EL-Keredy (1982), reported that mechanical transplanting gave higher brown rice yields than traditional transplanting. Also, he mentioned that the high number of panicle per unit area and vigorous growth could explain the high yield with mechanical transplanting.

Rice can be drilled or transplanted. However, the latter is more popular and more widespread due to (1) saving of the field land for up to 30 days, (2) saving of some 1000 m^3/fed. of water due to limited use of water

[3]Technical recommendation yearly book for rice crop, 2001

in nursery, (3) intensive care is possible in the nursery including fertilization, irrigation, and manual manipulation *(El-Awady, 1990).*

Tsuga (1992), reported the rice transplanter become widely used in Japan might be due to many advantages of transplanting comparing with direct sowing.

El-Awady, et al (1993), said that mechanical transplanting of crops is not only to replace manual work, but also to ensure optimum population of plants per hill, number of hills per unit area and planting depth.

Goarg et. al, (1982), found that, the transplanting machine work at a forward speed of 1.0 km/h to achieve the recommended plant spacing. Machine transplanted on an average 25 hills/m^2 with an average of 4 plants/hill. The recommended number of hills/m^2 was achieved higher than the manual transplanting.

Nguu and Datta (1979), studied the effect of plant density and plant geometry on grain yield of rice under various levels of soil nitrogen. The grain yield of IR 36 and IR 26 increased by 0.6 Mg/ha as the plant density increased from 2 to 10 plants/hill. The yield of rice planted in rectangular of (20x10) spacing pattern was significantly higher than of rice planted of (40x5) spacing.

Hussein (1993), studied the effect of plants density per hill and per unit area and the reciprocating speed of the finger on the rice grain yield in Egypt using four types of transplanters. The rake of the machine was adjusted to reciprocate with 124 stroke/min, and the forward speed of 0.5 m/s, plant density was 86 plants/m^2, 4.6 plant/hill and the distance between hills was 16.7 cm, when used these parameters the yield increased to 4.55 Mg/fed.

MATERIALS AND METHODS

Field experiments were carried out at the research farm of Rice Mechanization Center at Meet El-Dyba, Kafr El-Sheikh Governorate, during the summer season 2001 in an area of about 2 feddans.

The experimental field was prepared by using conventional tillage practice (plowing by chisel plow two passes) followed by using wooden puddler drown by animals. The rising of nursery was prepared according to RMC technical recommendation. While the agricultural treatments were done according to the Agro-Technical recommendations. The mechanical rice transplanter was done by Japanese rice transplanter and it's specifications are listed in Table 1.

Table 1: Specifications of rice transplanter

Item	Specification
Model	Yanmar ARP-8
Planting mechanism type	Crank type
No. of rows	8
Row spacing, cm. (fixed)	30
Hill spacing, cm. (Adjustable)	12, 14, 16.
No. of hills/3.3 m^2. (Adjustable)	90, 80, 70.
Planting speed, m/s.	0.25 – 0.75 m/s
Engine type	Gasoline
Rated power, kW/rpm	4.7 / 1650 (Max. power 5.9 kW)
Working capacity, (h/fed).	1.0 – 1.75

Independent variables: -

1- p.t.o gear settings:

Three different p.t.o gear adjusting settings (in order to control the number of hill/m^2) namely, 70, 80 and 90 hill/3.3 m^2 (standard by the transplanter maker) were used to adjust hill spacing, 16, 14 and 12 cm within row, respectively.

2- Cutting area of hill:

Three different cutting areas of hill namely, 120, 168 and 196 mm^2 by adjusting the hill width on 10 and 14 mm and the hill length on 12 and 14 mm in order to control the number of seedlings cutting area.

3- Rice varieties:

Four different rice varieties namely, Giza 177, Giza 178, Sakha 101 and Sakha 102 were used in this study.

Measurements:

The present research was to evaluate the effect of the pervious independent variables on the following indices:

1. Rate of work and efficiency:

a. Rate of work:

It is defined as the working area per time unit (fed/h). It is calculated by the following equation:

$$RW = \frac{A}{t_1 + t_2 + t_3 + t_4} = \frac{A}{T} \quad \text{.....(1)}$$

Where:

RW = rate of work, fed/h;
A = transplanted area, fed;
t_1 = actual transplanting time, h;
t_2 = turning time, h;
t_3 = feeding time, h;
t_4 = adjusting time, h and
T = total time ($T = t_1 + t_2 + t_3 + t_4$), h.

b. Working efficiency calculation:

Working efficiency defined as the ratio of actual transplanting time (t_1) to machine total time (T). The working efficiency (WE) was calculated from the equation (2).

$$WE = \frac{t_1}{T} \times 100 \quad \text{.....(2)}$$

2-Transplanting density:

The transplanting density such as number of seedling/hill, number of hill/m^2 and number of seedling/m^2 were measured under different mechanical adjustments of the transplanter for each rice variety.

3. Consumption of seedlings trays per feddan:

The number of seedlings trays were consumed per feddan under different treatments of this study were counted and calculated.

4. Grain yield:

The grain yield of rice crop was measured and calculated on basis of 14 % grain moisture content (wet basis).

5. Cost estimation:

The hiring cost was 2.5 LE/seedling tray (Rice Mechanization Center hiring price), this cost includes the seedling trays rising cost and rice transplanter operation. The price of seedling tray was multiplied by actual number of seedling trays were consumed per feddan. The net income was calculated by equation (3).

$$N = (Y \times P) - C \quad \text{.....(3)}$$

Where:

N = net income, LE/fed.
Y = grain yield, Mg/fed.
P = grain price, LE/Mg
C = transplanting total cost, LE/fed.

The prices of rice grain were 500 LE[4] /Mg for Giza 177, Sakha 101 and Sakha 102 varieties and 450 LE/Mg for Giza 178 variety.

Statistical analysis

The Split-Split plots design with three replications was used. The main plots were occupied by four different rice varieties (Giza 177, Giza 178, Sakha 101 and Sakha 102). The sub plots were occupied by cutting area of hill (120, 168 and 196 mm^2). The sub-sub plots were p.t.o. gear settings (70, 80 and 90 hill/3.3 m^3).

RESULTS AND DISCUSSION

1. Rate of work and working efficiency:

Fig. 1 and 2 show the work rate and efficiency of transplanter under different p.t.o gear settings and rice varieties. From this results it can be concluded that, by changing p.t.o gear settings from 70 to 80 or from 80 to 90 the rate of work and work efficiency were decreased. This decrement because of increased the consumption of seedling trays/fed, which increases the feeding, time (non-productive time) and total time of transplanting with changing p.t.o gear settings.

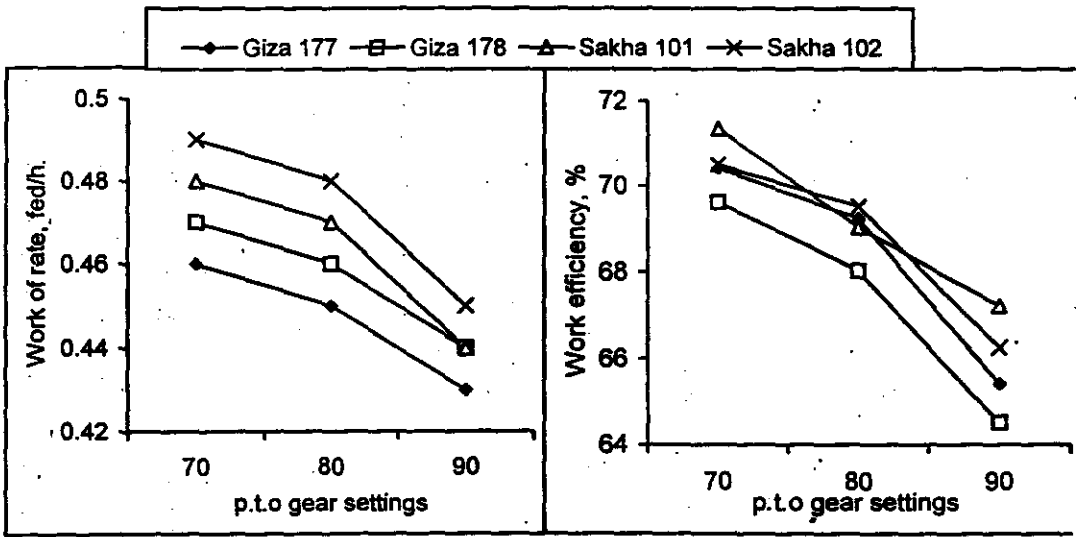

Fig.1 : Effect of p.t.o gear settings on work rate rice transpinter under different rice varieties.

Fig.2 : Effect of p.t.o gear settings on work efficiency rice transpinter under different rice varieties.

[4]US $ = 3.9 LE

The maximum values of work rate and work efficiency were 0.49 fed/h and 71.35 %, respectively, under 70 p.t.o gear setting. While, the minimum values were 0.43 fed/h and 64.51 %, respectively, under 90 p.t.o gear setting.

2-Transplanting density:

A- Number of seedlings per hill.

The effects of cutting area of hill on the number of seedlings/hill with different varieties of rice were shown in the Table 2. The results showed that, the cutting area of hill had a highly effect on the number of seedlings/hill. While the p.t.o gear settings adjusting of rice transplanter had no effect on the number of seedlings/hill. The results also demonstrated that the 168 mm^2 cutting area of hill gave the optimum number of seedlings/hill, which gave the maximum values of rice yield for all rice varieties.

Table 2: Effect cutting area of hill on the number of seedlings/hill under different rice varieties.

Rice variety	Cutting area of hill, mm^2		
	120	168	196
Giza 177	5.07	6.60	7.56
Giza 178	4.49	6.23	7.11
Sakha 101	4.35	6.09	6.94
Sakha 102	4.29	5.95	6.79

B- Number of hills per square meter:

The number of hills/m^2 for rice varieties under different p.t.o gears adjusting settings comparing with recommended[3] number of hills/m^2 for each rice variety are shown in Fig. 3.

The results indicated that, there is a positive correlation between p.t.o gear adjusting settings (70, 80 and 90) and the number of hills/m^2. It can be also noted that, the recommended number of hills/m^2 could be obtained by the p.t.o gear setting of 80 for Giza 178, Sakha 101 and 102 rice varieties. While the 90 p.t.o gear settings gave higher number of hills/m^2 than the recommended number of hills/m^2 for the above mentioned varieties.

However, in the case of rice variety Giza 177 it could not be reached the recommended number of hills/m^2 under the available adjusting gear settings of p.t.o because this variety needs intensive density.

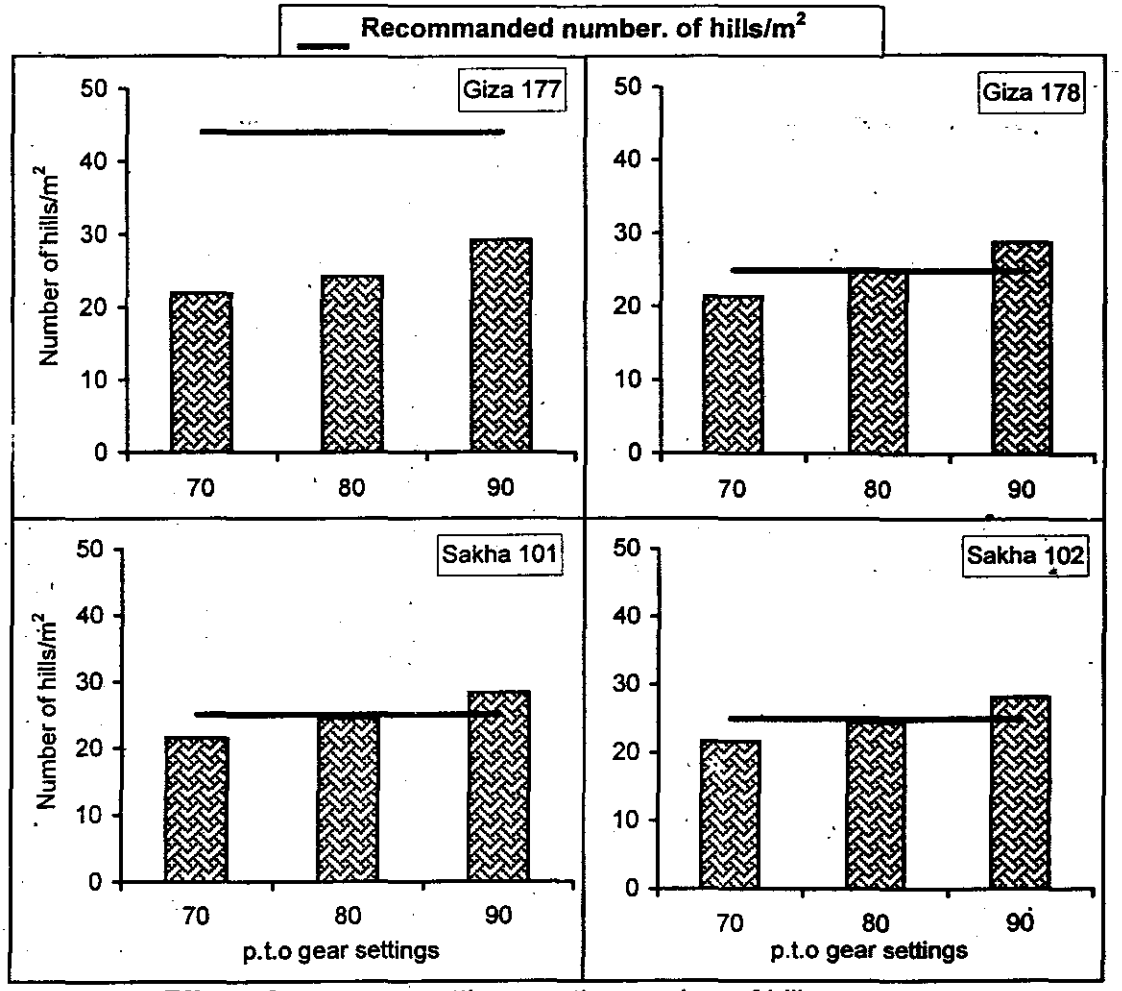

Fig. 3: Effect of p.t.o gear settings on the number of hills per square meter for different rice varieties.

C- The number of seedlings per square meter:

The number of seedlings/m^2 was determined after transplanting operation for all rice varieties under different cutting areas of hill and p.t.o gear settings for all the previous the previous rice varieties. The obtained results in Fig. 4 showed that, an increase in cutting area of hill gave an increment in the number of seedlings/m^2 at all the p.t.o gear settings and rice varieties.

The results also, showed that, by increasing cutting area of hill from 120 mm^2 to 196 mm^2 increases the number of seedling/m^2 from 148 to 221 when adjusting p.t.o gear setting on 90 and using Giza 177 variety. However, the corresponding values for Sakha 102 were from 121 to 192 at.

the same position of p.t.o gear settings. This results may be due to increase the number of seedlings/hill.

From Fig.4 it can be also observed that the number of seedlings/m^2 influenced significantly by changing p.t.o gear settings. The p.t.o gear setting of 90 hills/3.3 m^2 gave the highest values of the number of seedlings/m^2 compared with the other settings at any given cutting area of hill and rice variety.

The maximum values of number of seedlings/m^2 (166, 183 and 221) were obtained by adjusting p.t.o gear setting on 70, 80 and 90, respectively, at higher level of cutting area of hill 196 mm^2 for Giza 177 variety.

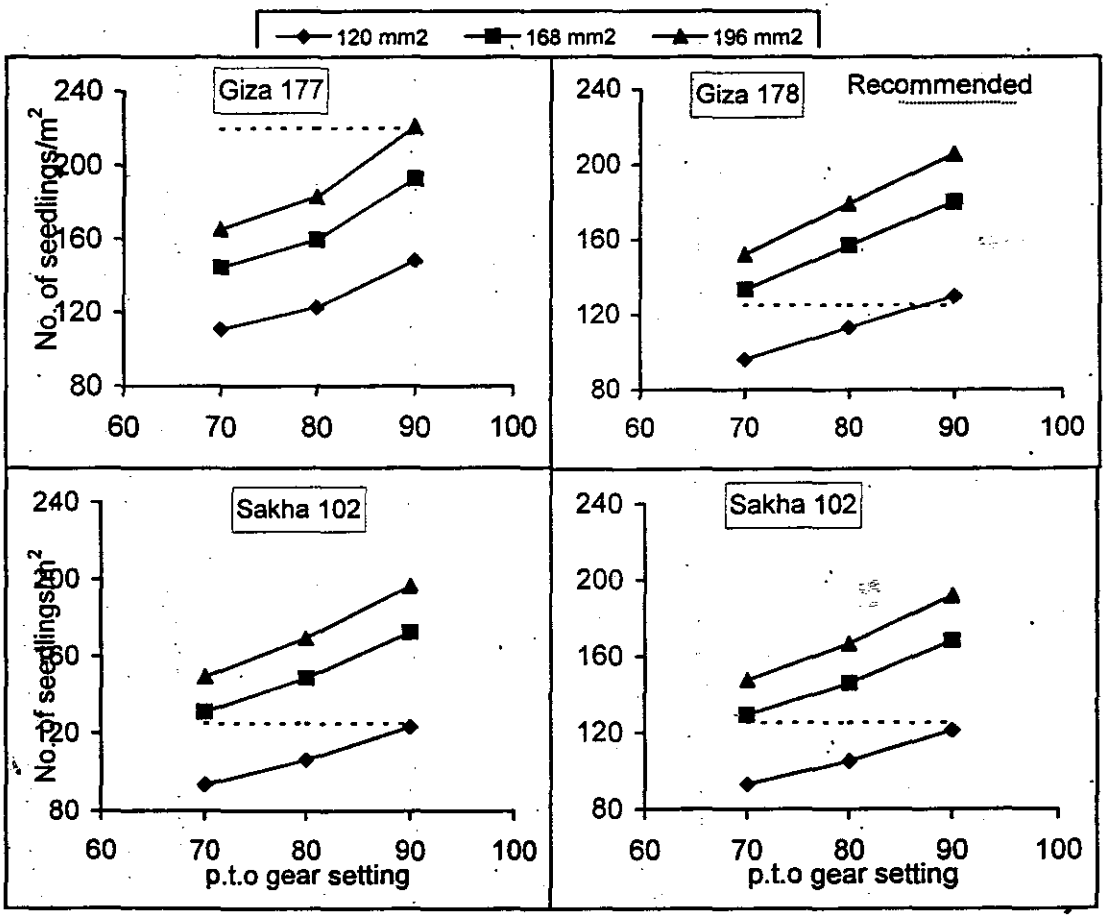

Fig.4 : Effect of p.t.o gear settings and cutting area of hill on the number of seedlings per square meter for different varieties under study.

However, the minimum values of number of seedlings/m^2 (147, 166 and 192) were obtained at lower level of cutting area of hill when adjusting p.t.o gear setting on 70, 80 and 90, respectively, and with Sakha 102 variety. It can be concluded that the 90 p.t.o gear settings is considered the best position of adjusting the rice transplanter where it gave the recommended number of seedlings/m^2 (220 seedlings/m^2) for Giza 177 variety.

3. Consumption of seedlings trays per square meter:

The number of seedling trays were consumed per feddan under different p.t.o gear setting and cutting area of hill for all rice varieties under study were calculated and listed in Table 3.

The results indicated that there is a positive correlation between p.t.o gear setting and consumption of seedling trays per feddan. On the other wards, by increasing p.t.o gear setting from 70 to 80 or from 80 to 90 hills/3.3 m^2 increases the consumption of seedling trays/feddan for all rice variety. Also, it is quit clear that, the consumption of seedling trays/fed was increased with an increase in cutting area of hill at any given p.t.o gear settings of rice transplanter.

The maximum values of consumed seedling trays/fed of 117, 124 and 121 were obtained with the 196 mm^2 cutting area of hill and 90 p.t.o gear settings compared with the other cutting areas and p.t.o gear settings. On the other hand, the 120 cutting area of hill gave the minimum values of consumed seedling trays/fed. for all the p.t.o gear settings and rice varieties.

Table 3: Effect of p.t.o gear settings and cutting area of hill on the consumption of seedling trays/fed under different rice varieties.

Rice variety	p.t.o gear settings	Cutting area, mm^2		
		120	168	196
Giza 177	70	69.76	87.20	95.92
	80	87.12	96.80	106.48
	90	89.60	108.00	117.20
Giza 178	70	70.48	88.10	96.91
	80	87.03	97.54	107.29
	90	89.75	112.25	123.48
Sakha 101	70	68.08	85.10	93.61
	80	75.39	94.24	103.66
	90	84.42	105.28	108.21
Sakha 102	70	68.85	86.06	91.67
	80	76.93	96.16	105.76
	90	88.06	110.08	121.09

4. Grain yield:

The obtained data of grain yield, which was affected by p.t.o gear settings and cutting area of hill, were illustrated in Fig. 5. This Figure show that the grain yield was highly affected by the p.t.o gear settings. Increasing p.t.o gear from 70 to 80 the grain yield increased for all rice varieties under study.

However, by increasing p.t.o gear setting from 80 to 90 the grain yield only increased for Giza 177 variety only but, it decreased for the other varieties. This trend was due to high competition between plants in case of 90 hills/3.3 m^2 and using Giza 178, Sakha 101, Sakha 102 varieties. Also, it could be attributed to the late tiller development under the dense planting condition of 90 hills/3.3 m^2 of the previous mentioned varieties. However, the opposite trend was obtained in case of Giza 177 at p.t.o gear of 90 hills/3.3 m^2 due to decrease the tillers development of this variety therefore, there is no competition between plants at this planting density which gave high yield comparing with the other densities.

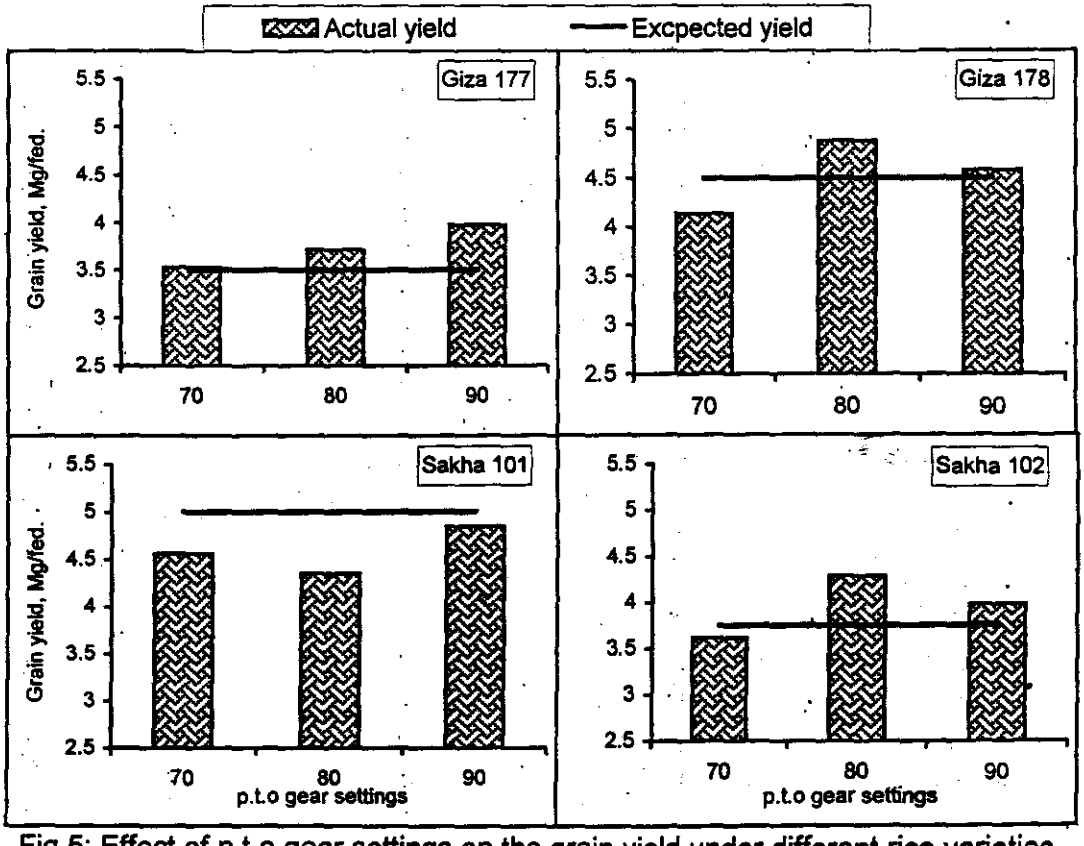

Fig.5: Effect of p.t.o gear settings on the grain yield under different rice varieties.

It can be concluded that, by adjusting the p.t.o gear setting of rice transplanter on 80 the optimum level of grain yield of Giza 178, Sakha 101 and Sakha 102 varieties were obtained. While, in case of Giza 177 variety even could not be reach the recommended level of the number of hill/m^2 by the transplanting machine, was obtained with Giza 177 variety. Therefore, the highest value of grain yield was at the optimum level of grain yield of Giza 177 variety when adjusting p.t.o gear settings on 90 hills/3.3 m^2. This means that, the rice transplanter is compatible to transplant the short life varieties of rice successfully.

5. Total transplanting cost and net benefit:

The total cost of mechanical transplanting included the cost of preparing the nursery seedlings and machine operation. It was estimated under different p.t.o gear settings and rice varieties shown in Fig.6. The results indicated that, increasing p.t.o gear settings from 70 to 80 or from 80 to 90 tends to the average total cost for all rice varieties under study. Also, it can be noted that the higher average of total transplanting cost was obtained for Giza 177 variety followed by Giza 178, Sakha 101 and Sakha 102, respectively.

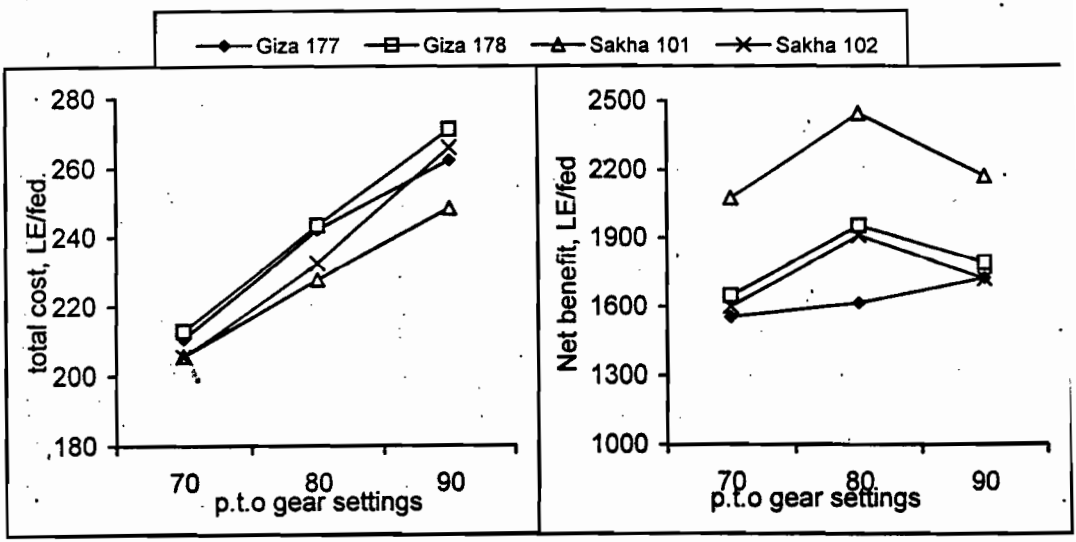

Fig. 6: Effect of p.t.o gear settings on total cost rice transplnter under different rice varieties.

Fig.7: Effect of p.t.o gear settings on net income rice transplnter under different rice varieties.

The results of net benefit were plotted in Fig. 7. These results cleared that at p.t.o gear setting of 80 the net benefit values were higher than that obtained at the p.t.o gear settings of 70 and 90 for Giza 178, Sakha 101 and Sakha 102 rice varieties. While, this trend varied in case of Giza 177 variety, which increased by increasing p.t.o gear setting from 70 to 80 or from 80 to 90. This results because grain yields and total cost of seedling trays highly affected on the net benefit. The highest value of net income was obtained for Sakha 101 variety at any given p.t.o gear settings.

CONCLUSION

From the previous results it can be concluded to:

1. The planting density was highly affected by changing the cutting area of hill and p.t.o gear setting. The maximum numbers of seedling/m^2 (193, 213 and 237) were obtained by adjusting p.t.o gear setting on 70, 80 and 90 respectively, at higher level of cutting area of hill (196 mm^2) for Sakha 102 variety.
2. It could be obtain the recommended number of seedlings/m^2 for each variety under the study by using available adjustments in p.t.o gear settings and cutting area of hill in the Japanese rice transplanter: For example Giza 177, the recommended number is 220 and the obtained number was 221 Therefore, the Japanese rice transplanter is compatible to transplant the short life varieties of rice.
3. The optimum level of grain yield of Giza 178, Sakha 101 and Sakha 102 varieties was obtained by adjusting the p.t.o gear setting of rice transplanter on 80. While in case of Giza 177 variety even could be reaching the optimum level of grain yield when adjusting p.t.o gear settings on 90 hill/3.3 m^2.
4. The best values of net benefit were 1616, 1953, 2449 and 1910 LE/fed at p.t.o gear setting 80 for rice varieties Giza 177, Giza 178, Sakha 101 and Sakha 102, respectively.
5. It is recommended that, when using rice transplanter for transplanting Giza variety, it should be adjusting the planting density on the p.t.o gear setting on 90 hills/3.3 m^2 and cutting area of hill on 196 mm^2. However for other varieties it is better to adjust the planting density of rice transplanter on 80 p.t.o gear setting and 168 mm^2 cutting area of hill.

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" دراسة مدى موائمة الشتل الميكانيكي لأصناف الأرز قصيرة العمر "

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الملخص العربي

يعتبر محصول الأرز من المحاصيل الغذائية الاستراتيجية الهامة في مصر، وقد حدث في السنوات الأخيرة استنباط أصناف قصيرة العمر عالية الإنتاجية تختلف في كثافتها الزراعية عن الأصناف السابقة . مما تطلب الأمر إلى :

- دراسة تأثير استخدام طريقة الشتل الميكانيكي للأرز على إنتاجية الأصناف قصيرة العمر
- وكذلك التوصل إلى أنسب ضبط لآلة شتل الأرز بغرض الحصول على العدد الأمثل للكنون لوحدة المساحة الذي يعطى أعلى إنتاجية.

أجرى البحث بالمزرعة البحثية بمركز ميكنة الأرز بميت الديبة - كفر الشيخ خلال موسم ٢٠٠٠م ، وقد استخدمت ٤ أصناف من الأرز قصير العمر (جيزة ١٧٧ ، جيزة ١٧٨ ، سخا ١٠١ وسخا ١٠٢) وثلاثة كثافات زراعة ٧٠ ، ٨٠ و ٩٠ لكل ٣,٣م^{2} (قياسى بالنسبة لشتالات الأرز اليابانية) لكل صنف وثلاثة مساحات لمقطع الكن (١٢٠، ١٦٨ و١٩٦ مم٢) باستخدام شتالة الأرز اليابانية.

وقد أظهرت النتائج ما يلى:

١. عند استخدام شتالة الأرز اليابانية لشتل الصنف جيزة ١٧٧ يوصى بضبط أوضاع سرعة الـ p.t.o على ٩٠ كن/٣.٣ مم٢ ومساحة الكن المقطوع لصنية الشتلات على ١٩٦ مم٢ ، ولكن عند استخدامها لشتل الأصناف الأخرى يجب ضبطها على سرعة الـ p.t.o التى تعطى ٨٠ كن/٣,٣م٢ ومساحة مقطع الكن ١٦٨ مم٢.

٢. أعلى قيم لمعدل الأداء والكفاءة الحقلية كانت ٠,٨٤ فدان/ساعة و٧١,٣٥% على الترتيب عند وضع سرعة الـ p.t.o التى تعطى ٧٠كن/٣.٣ م٢ لصنف الأرز ١٠١.

٣. أمكن الوصول لعدد النباتات الموصى به لوحدة المساحة باستخدام الإمكانيات المتاحة لضبط أوضاع سرعة ال p.t.o التى تتحكم فى عدد الكنون فى المتر المربع وكذلك مساحة الكن المقطوع من صنية الشتلات فى شتالة الأرز اليابانية ، ولذلك كان هناك توافق فى استخدام شتالة الأرز اليابانية للأصناف قصيرة العمر.

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