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CONSUMED ENERGY FOR TRANSPLANTING OF SOME VEGETABLE

S.E. Abdel - Aal,* S. E. Badr,** and A. Lotfy **

ABSTRACT

The vegetable production still the challenge for Egyptian farms.To face this challenge the experiments were carried out during 1999/2000 and 2000/2001 seasons in two different sites at El-Gemmiza and El-Serw Research Stations, El-Garbia and Damiatta Governorate. The objective of the present study is to evaluate the effect of transplanting systems i.e., manual and mechanical transplanting (New-Holland and Lännen Roulette transplanter) at forward speed i.e., 0.92, 1.4, 1.9 and 2.4 km/h on some vegetables productivity (tomato, cabbage, eggplant, onion and lettuce) and energy requirements.The results showed that, the higher power requirements, actual field capacity and total losses of seedlings (missed, floated and damaged) were resulted by increasing forward speed, while field efficiency and yield production were decreased. The lowest consumed energy of 821.25 MJ/fed was recorded in the case of using Lännen transplanter with tomato transplanting at forward speed of 2.4 km/h, while the highest values was 7021.82 MJ/fed by using New-Holland transplanter for onion and lettuce transplanting at forward speed of 0.92 km/h. The lowest consumed energy per unit yield production of 16.0 kW/ton was recorded in the case of using Lännen transplanter with cabbage transplanting at forward speed of 2.4 km/h, while the highest value was 333.99 kW/ton by using New-Holland transplanter for lettuce transplanting at forward speed of 0.92 km/h.The use of manual transplanting was followed with lower yield than mechanical transplanting for all varieties and the production of El-Gemmiza farm was higher than El-Serw. Mechanical transplanting by Lännen raulette transplanter at forward speed of 2.4 km/h increased the total yield and decreased consumed energy compared with other transplanting.

INTRODUCTION.

The goal of agriculture should be increase and maintain high yield levels of food crops per unit of area, water, energy input and time.

To achieve this goal, many attempts were executed in many directions such as improving soil fertility, introducing new promising varieties or cropland expansion and new improved technical methods. Vegetables are considered a unique crop in its adaptability to different methods of transplanting. Morsey (1990) used four speeds of transplanter for mechanical transplanting under Egyptian condition to find out the proper transplanter speed for soil conditions. He found that the minimum missing rate of 4% and the high yield of 3.03

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ton/fed recorded under 1.2 km/h speed. The increase of forward speed led to an increase of longitudinal and transverse scattering for direct seeding and transplanting (Metwalli et al 1998). Increasing of forward speed increased the fuel consumption during planting operations (Mostafa et al 1993). The total yield of onion decreased by 17.62% when transplanting forward speed increased from 0.9 to 2.0 km/h, but the net power requirement of transplanting increased from 9.01 to 17.6% with increasing forward speed from 0.9 to 2.0 km/h (Desouki 1997). El-Sahrigi et al. (1991) found that the cost of manual transplanting of onion seedling are about 1.52, 2.0 and 2.22 times larger than that when using 2, 3 and 6 rows transplanting machine. Also 2 times larger than when using 6 rows transplanting machine. They concluded that using mechanical sowing or transplanting methods is recommended for obtaining high yield and minimizing cost. Mostafa et al. (1996) found that the production costs of mechanical and half mechanical methods were cheaper than manual transplanting by 56.3 and 46.9% respectively. Also manual transplanting gave 31.2% and 4.70% higher in net profit than mechanical and half mechanical methods of transplanting. The average number of plants per m^2 was higher with manual transplanting (68.205 plant/m^2), whereas in mechanical treatment (36.205 plant/m^2) and half mechanical (54.79 plant/m^2). Harb et al. (1993) found that the coefficients of variation on row spacing were 7.13, 26.01 and 35.14% under the disc pocket transplanter, disc transplanter and manual transplanting respectively. The consumed energy of production operation for some main crops was discussed by El-Shazly (1989). He concluded that energy requirements can be managed using proper sizes of tractors required by different agriculture operations. The energy input of transplanting some vegetables were calculated for cabbage, eggplant and lettuce of 31764.72, 37870.67 and 31344.67 MJ/fed (Khalil 1999). AbdEl-Mageed (1999) and Mady et al (2001) found that the hand transplanting cost per unit production was 3 times of mechanical transplanting.

This research aimed to evaluate transplanting systems and forward speed on some vegetable production under study to select the proper system for transplanting some vegetable in respect to minimizing the energy requirements and maximizing yield production and profit.

MATERIALS AND METHODS

Field experiments were carried out during 1999-2000 and 2000-2001 seasons in an area about 3.0 feddan in two sites at El- Gemmiza and El-Serw Agricultural Research Stations El-Garbia and Damiatta Governorate to evaluate transplanting operation for some vegetable crops named tomato, cabbage, eggplant, onion and lettuce by systems:

1- Manual transplanting.

2- Mechanical transplanting by using two semi-automatic transplanters. i.e., New-Holland transplanter (Fig.1) and Lännen Roulette transplanter (Fig.2) under forward speeds of 0.92, 1.4, 1.9 and 2.4 km/h.

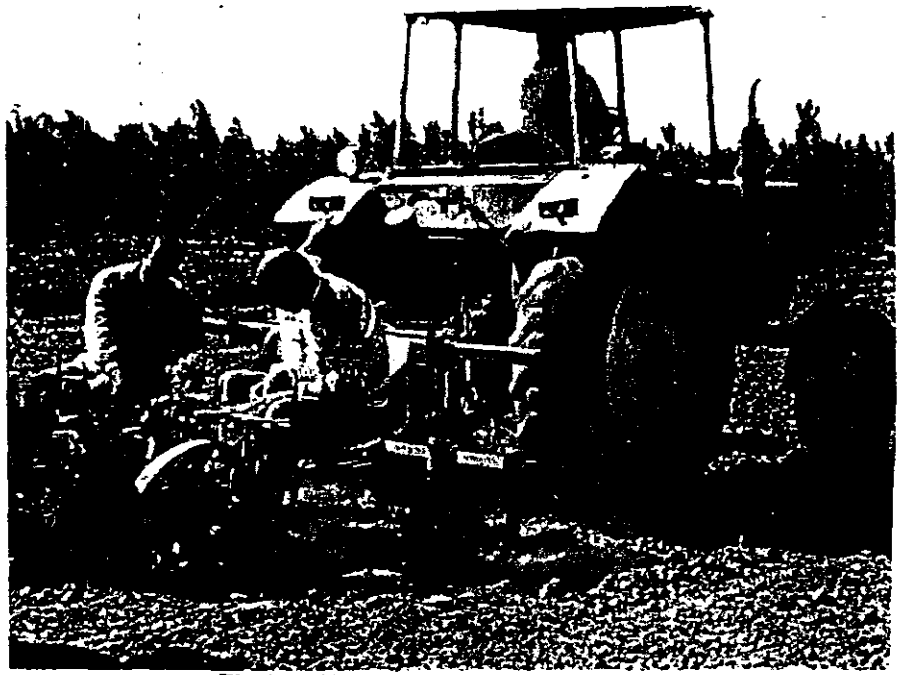

Fig (1) : New-Holland transplanter.

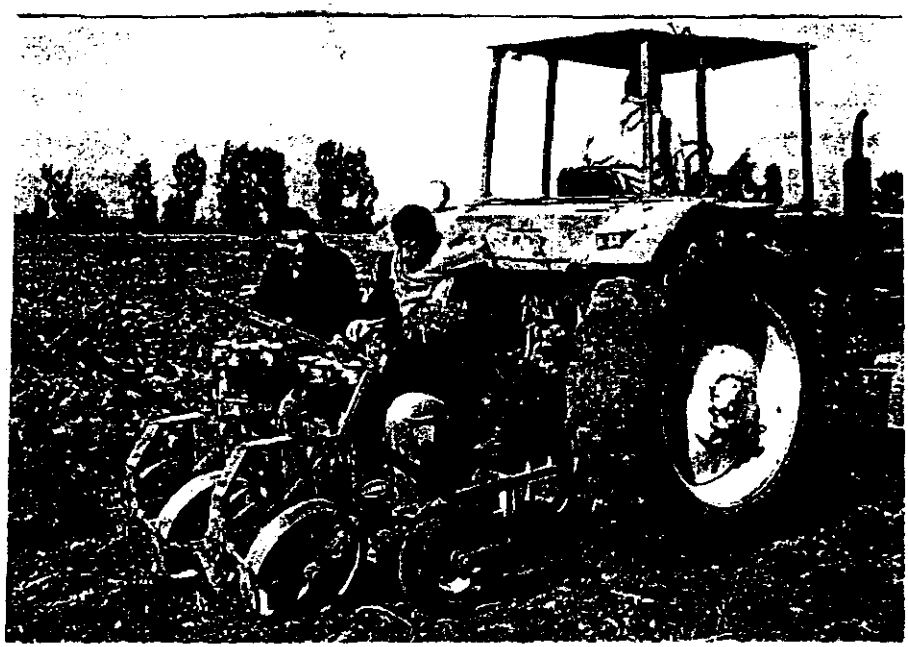

Fig.(2): Lännen Roulette transplanter

The technical specification of the transplanters and tractor are tabulated in table (1).

Table (1): Transplanting machines and tractor specification

Type of machine	Tractor	Transplanters	
		New-Holland	Lännen
Manufacture	Egypt	USA	Finland
Model	Nasser-60	1700	Rt-2
Engine type	Diesel	--	--
Power kW at 2200 rpm	46	--	--
Total Length cm	340	130	130
Total width cm	190	245	240
Total height cm	205	90	120
Total mass kg with operators	2255	430 (4 operators)	290 (2 operators)
Hitching type	3 points	3 points	3 points
Number of planting rows	--	2	2

Plant density:

Transplanters were adjusted as the technical recommendations for different crops for row spacing and seedlings with the row were 100 x 40, 60 x 40, 60 x 40, 30 x 20 and 30 x 20cm for tomato, cabbage, eggplant, onion and lettuce respectively.

Experimental procedure:

The experimental seed bed preparation was managed by chisel plow two passes with 20 cm depth followed by rotary–tiller with depth 15 cm and leveling with hydraulic scraper.

The transplanted area for each crop was 2100 m^2 divided into 8 experimental plots. Data for each crop were analyzed with split-split plot design. The measurements were divided into three sections as follow:

1- Field capacity and efficiency:

The theoretical, effective field capacity and efficiency were estimated by using the following equations (Hanna et al 1985):

$$F_{ct} = (S \times W)/4200 \quad (1)$$

$$F_{ca} = 60/(T_u + T_L) \quad (2)$$

$$E = (F_{ca}/F_{ct}) \times 100 \quad (3)$$

Where: F_{ct} : theoretical field capacity (fed/h), **E** : field efficiency (%),
F_{ca} : actual field capacity (fed/h), **S** :forward speed (km/h),
T_u : the utilized time/fed (min), **W** : transplanter width (m),
T_L : the summation of lost time/fed (min).

2- Damaged, Missed and Floated seedlings:

The total losses of damaged (D_s), missed (M_s) and floated (F_s) seedlings were counted manually in the field after each treatment and the percentage of losses were calculated as follows:

$D_s = (Nd/Nt)x100$ (4)

$M_s = (Nm/Nt)x100$ (5)

$F_s = (NF/Nt)x100$ (6)

Where: Nd : number of damaged seedlings per length unit,
Nm : number of missed seedlings per length unit,
NF : number of floated seedlings per length unit,
Nt : theoretical number of seedlings per length unit.

3 – Consumed energy :

Consumed energy per feddan was calculated through measuring the fuel consumption for each field operation, energy requirement of machinery and human labor energy.

3 -1 Energy requirements of machinery:

It can be calculated by using formula as follow:

$E_M = C_M / F.c\ (W_T/TDL + WM/MDL)$ (7)

where: E_M : energy requirement of machinery (MJ/fed),
C_M :energy input coefficient used to represent the embodied energy in a piece of equipment or tractor =101 MJ/kg (Pimmental et al 1973 and Lower et al 1977),
W_T : mass of tractor (kg), WM : mass of machine (kg),
TDL : tractor design life (h), MDL : machine design life (h),
F.c : field capacity (fed/h).

3 -2 Fuel energy requirement:

It can be calculated by using the next formula:

$E_F = (C_F / F.c) \times P \times F_E$ (8)

where: E_F : energy used as fuel (MJ/fed),
C_F : energy input coefficient used to represent the energy values of the fuel = 47.2 MJ/L (Lower et al 1977),
P : power used (kW),
F_E : fuel efficiency (L/ kW. h) = $(2.64X + 3.91) - 0.2\sqrt{788X + 173}$
X : load factor = 0.2 to 0.8 for transportation and agricultural operation (Shaibon 1985).

3-3 Human labor energy :

$E_{HL} = (C_{HL}/ F.c) \times N_L$ (9)

where: E_{HL} : human energy labor (MJ/fed),
C_{HL} : energy input coefficient represents the human labor energy = 2.3 MJ/man. h (Lower et al 1977),
N_L : number of labors required to perform any operation.

4- Productivity:

The yield production (ton/fed) was massed for each treatment to determined the proper system for each crop after harvesting.

RESULTS AND DISCUSSION

1- Seedling losses:

The seedling losses divided into the missed, damaged and floated seedlings from table (2), the missed seedlings was high in lettuce and the lowest one in onion in all transplanting methods. The damaged seedlings was high in lettuce and low values under eggplant. The higher floated seedlings values was in lettuce and the lowest values in tomato. The percentage of seedling losses by using Lännen transplanter was lower than that by using New-Holland transplanter, as seen in table (2), this is due the easiest of Lännen transplanter feeding system.

Table (2): Effect of transplanting method on percentage losses of missed (M), damaged (D) and floated (F) seedlings

Transplanting method	Forward speed km/h	Tomato			Cabbage			Eggplant			Onion			Lettuce		
		M	D	F	M	D	F	M	D	F	M	D	F	M	D	F
New-Holland trans.	0.92	2.4	4.2	1.2	2.3	2.4	1.4	2.6	1.4	0.9	1.9	4.7	2.1	2.1	5.2	2.4
	1.4	2.8	4.6	1.7	2.9	4.1	2.4	2.7	2.2	1.8	2.6	5.3	2.8	4.2	5.9	3.6
	1.9	4.9	4.8	3.4	5.0	6.1	5.8	4.4	5.7	3.9	5.1	7.2	5.7	4.8	8.6	6.9
	2.4	7.2	7.2	6.6	8.1	8.5	7.3	8.7	6.1	7.8	8.1	9.4	7.8	10.6	9.1	7.7
Lännen trans.	0.92	2.3	2.8	1.0	1.8	1.9	1.0	2.2	1.0	0.6	1.6	3.8	1.6	1.9	4.2	2.1
	1.4	2.4	2.9	1.5	2.3	3.1	1.9	2.1	1.6	1.4	2.2	3.6	2.5	3.7	3.8	2.6
	1.9	3.2	3.7	3.1	3.2	3.6	4.7	3.1	4.1	3.8	3.6	4.9	4.8	4.2	5.7	5.5
	2.4	6.4	4.9	4.8	6.8	7.1	5.4	7.5	4.8	4.2	7.0	7.1	6.6	8.1	7.8	6.5
Manual trans.		9.2	3.7	7.2	7.8	2.9	6.5	8.1	2.9	5.7	10.2	5.1	8.2	9.7	7.4	9.8

The missed and floated seedlings increased by increasing forward speed, decreasing seedling spacing and with untrained workers, but the damaged seedlings mainly caused according to the plant stem structure, it was strong in eggplant followed with cabbage, onion, tomato and very weak in lettuce. The missed, damaged and floated seedlings values were about 34.1, 40.9 and 25.43% for tomato; 32.39, 37.5 and 30% for cabbage; 38.2, 31.97 and 29.88% for eggplant; 27.83, 41.77 and 28.89% for onion and 30.48, 40.49 and 28.97% for lettuce from total losses respectively.

In general, the missed seedlings as seen in table (2) were higher in the New-Holland transplanter than Lännen transplanter this due to the easiest

feeding system of Lännen transplanter, but the damaged seedlings was the lowest in manual transplanting than the mechanical transplanting.

2- Field capacity and efficiency:

Fig (3) shows that the highest actual field capacity of 0.93 fed/h was remarked with forward speed of 2.4 km/h for tomato transplanting, but the lowest value was 0.11 fed/h at forward speed of 0.92 km/h for onion or lettuce transplanting.

The transplanting field efficiency was affected by transplanting conditions (forward speed, row spacing, kind of crop, operator skill and transplanting system). Fig (4) shows that the highest field efficiency of 93.18% was remarked with forward speed of 0.92 km/h for tomato transplanting. While the lowest percentage was 76.47% at 2.4 km/h for onion or lettuce transplanting because the cabbage and eggplant have the same row distances (60×40cm) also onion and lettuce have the same row distances (30×20cm).

This is due to that theoretical and actual field capacity increased, while field efficiency decreased by increasing forward speed, also increasing row spacing increased field capacity and efficiency.

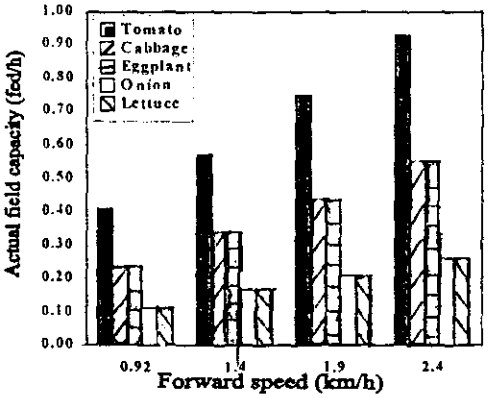

Fig. (3): Effect of forward speed on actual field capacity.

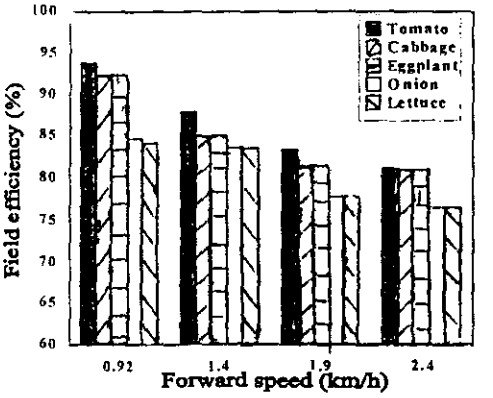

Fig. (4): Effect of forward speed on field efficiency.

3- The production

The effect of transplanting method and forward speed on productivity of the vegetables under experiments was tabulated in table (3) in both experimental areas. Data indicated that:

1-The yield production under manual transplanting was lower than mechanical transplanting. The average values of total yield under Lännen transplanter increased by 16.87, 13.74, 15.19, 6.9 and 15.28% compared with manual trasplanting for tomato, cabbage, eggplant, onion and lettuce respectively.

2-The production of different transplanted vegetables by using Lännen transplanter was more than new-Holland transplanter. Increasing forward speed from 0.92 to 2.4 km/h, decreased the yield production of tomato, cabbage, eggplant, onion and lettuce by 29.84 and 32.21%; 18.9 and 26.54%; 37.37 and 37.47%; 39.58 and 37.37% and 39.42 and 39.30% under New-Holland and Lännen transplanter respectively. This is due to increasing losses and the amount of soil accumulation around seedling not enough to fixed seedling.

3-The production in El-Gemmiza station was higher than El-Serw station, this is due to the differences in soil fertility.

Table (3): Effect of transplanting methods on yield production (ton/fed)

Transplanting method	Forward speed (Km/h)	El-Gemmiza station					El-Serw station				
		Tomato	Cabbage	Eggplant	Onion	Lettuce	Tomato	Cabbage	Eggplant	Onion	Lettuce
New-Holland trans.	0.92	15.45	28.09	7.68	7.15	7.56	13.52	24.84	6.11	5.90	5.84
	1.4	13.24	26.12	6.43	6.06	6.16	11.88	22.72	4.85	4.72	4.39
	1.9	11.92	24.61	5.38	5.03	5.37	10.15	19.86	4.17	3.84	3.75
	2.4	10.84	22.78	4.81	4.32	4.58	8.78	16.77	3.52	3.49	3.12
Lännen trans.	0.92	17.14	32.82	9.18	7.84	7.94	14.73	27.92	7.62	6.19	6.89
	1.4	14.97	29.76	7.46	6.62	6.52	12.91	25.47	5.83	5.11	5.42
	1.9	12.48	26.56	6.58	5.57	5.46	10.76	22.24	5.29	4.26	4.87
	2.4	11.62	24.11	5.74	4.91	4.82	9.51	20.17	4.67	3.72	4.11
Manual trans.		11.68	25.42	6.14	5.81	5.24	9.54	22.41	5.21	4.36	4.12

4–Total consumed energy:

The effect of transplanting method and the crop transplanting conditions (row and seedling spacing) on total consumed energy are shown in Fig.(5) for New-Holland and Lännen transplanters. Data show that, the energy inputs including machinery, fuel and human labor energy for different crops by using mechanical transplanting were decreased with increasing forward speed and row distances..

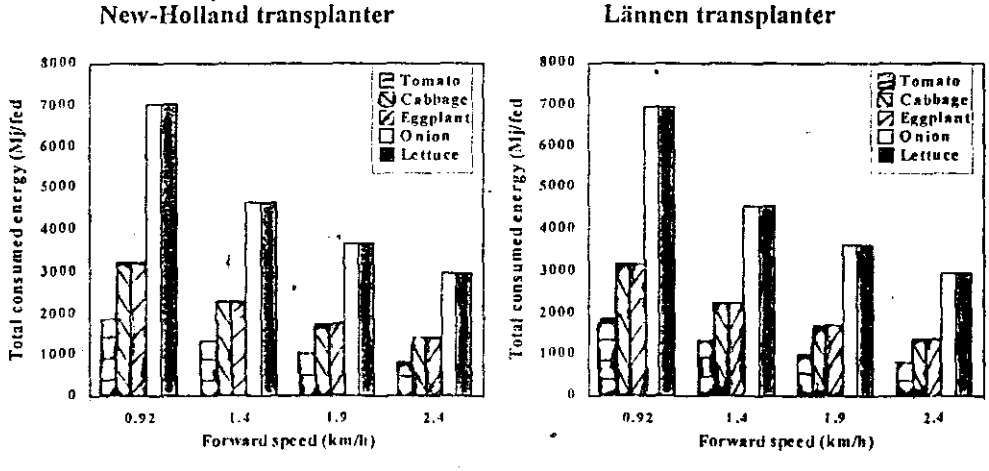

Fig. (5): Total consumed energy for mechanical transplanting under different forward speeds.

Increasing forward speed from 0.92 to 2.4 km/h, the total consumed energy was decreased by 65.3, 66.4, 66.4, 59.12, and 59.12% for tomato, cabbage, eggplant, onion and lettuce under New-Holland transplanter respectively

The consumed energy was the same value for both cabbage and eggplant because they have the same row distance, also the consumed energy was the same value for both onion and lettuce due to the same reason.

Increasing forward speed and row spacing, decreased the consumed energy due to the increase of effective field capacity and vice-versa. The lowest total consumed energy of 821.25 MJ/fed was recorded with tomato transplanting by Lännen transplanter and the highest value was 7021.82 MJ/fed with new-Holland transplanter under forward speed of 0.92 km/h and 30 cm row spacing for onion and lettuce.

5- Consumed energy per unit production

The consumed energy per yield production (kW. h/ ton) was estimated to evaluate the transplanting systems. From table (4), it can be seen that the average consumed energy per unit production by using New-Holland transplanter were higher than Lännen transplanter by 9.48, 11.67, 16.92, 9.98 and 4.67% for tomato, cabbage, eggplant, onion and lettuce at EL-Gemmiza farm respectively.

Table (4): Effect of transplanting method on consumed energy per unit yield production (kW. h/ton)

Transplanting method	Forward speed (km/h)	El-Gemmiza station					El-Serw station				
		Tomato	Cabbage	Eggplant	Onion	Lettuce	Tomato	Cabbage	Eggplant	Onion	Lettuce
New-Holland trans.	0.92	33.87	31.83	116.40	272.8	258.0	38.71	35.99	146.31	330.59	333.99
	1.4	28.43	24.16	98.14	212.01	208.57	31.69	27.78	130.11	272.20	292.66
	1.9	24.00	19.81	90.64	203.12	190.26	28.19	24.55	116.94	266.07	272.45
	2.4	21.28	17.13	81.10	191.02	180.18	26.28	23.26	110.83	236.45	264.49
Lännen trans.	0.92	30.19	26.93	96.30	246.01	242.91	35.13	31.66	116.01	311.58	279.93
	1.4	24.86	21.01	83.65	191.90	194.85	28.83	24.50	107.03	248.61	234.39
	1.9	22.67	18.16	73.78	181.38	185.03	26.29	21.68	91.15	237.15	207.45
	2.4	19.63	16.00	67.20	166.19	169.32	23.99	19.12	82.60	219.35	198.54

CONCLUSION

The results of the present study indicated that the use of Lännen transplanter was the suitable method for mechanical transplanting of most vegetables than the other methods, it has less consumed energy per yield production, total seedling losses and high field efficiency and total yield production.

The cabbage and eggplant have best transplanting condition followed by tomato and onion, but lettuce needed a special skills.

The mechanical transplanter still unsuitable for use with present conditions. It must be developed to increase field capacity and ability of transplanting most of vegetables.

REFERENCES

Abdel-Mageed, I. A. (1999): The visibility of rice transplanter in onion transplanting in small fields. M.Sc. Th., Fac. of Agric., Zagazig Univ.

Desouki, N.A. (1997): A study on mechanical transplanting of onion crop. M.Sc Th. Fac. of Agric., Mansoura Univ.

EL-Sahrigi, A. F., Ibrahim M. M. and Hegazy K. S. (1991): The possibility of utilizing mechanical planting of onion crop under Egyptian conditions. Misr, J. Ag. Eng., 8(3) :162-171.

El-Shazly, M. A. (1989): The energy requirements for producing main crops under Egyptian conditions. Egypt J. Appl. Sci., 4(2) :268-281.

Harb, S. K., Abdel-Mawla H. A. and Salama G. M., (1993): Comparison between mechanical and manual transplanting of tomato. Minia J. Agric. Res., and develop (special issue) (15): 361-375.

Khalil, N A. (1999): Energy consumed for producing some crops in Sharkia Province. M.Sc Th., Fac. of Agric., Zagazig Univ.,: 1-75.

Lower, O. J., Smith E. M., Burgess S., Wells L.G. and Bebertine D. (1977): Production of beet with minimum grain and fossil energy inputs. Vol. I, 2 and 3 reports to NSF.

Mady, M. A., Radwan S. M. and Badr S. A., (2001): Study on mechanical transplanting of tomato. Misr, J. Ag. Eng., 18 (1): 17-28.

Metwalli, M. M., El-Gindy A., Khalifa E. M. A. and Yousef I. S. (1998): performance evaluation of some planting machinery of sugar beet. Misr. J. Ag. Eng., 15(1): 57-68.

Morsey, E. M., (1990): A study on selecting the proper system of rice mechanical planting under Egyptian condition. M.Sc. Th., Fac. of Agric. Zagazig Univ.

Mostafa, A. K., Abdoh F. E. and Ibrahim M. Y. (1996): Onion bulb productivity as affected by mechanical transplanting and tillage system. Proc. 7th. Conf. Agr., 9-10sept., : 643-652.

Mostafa, M. M., El-Gindy A., Saif El-Yazal N. and El-Khteeb S. (1993): Laser land leveling efficiency and power requirements. Misr, J. Ag. Eng., (5 – 10 April) :58-75.

Pimmental D., Hurv B., Pellotte C., Forfter H. J. and Whitmen, R. G. (1973): Food production and the energy crisis science: 443-449

Shaibon, M. A. (1985): Effect of size and scattering of land holding on costs of mechanized service under Egyptian conditions. Misr, J. Ag. Eng.,2 (2): 15 -28

الملخص العربي

الطاقة المستهلكة في شتل بعض محاصيل الخضر

السادات إبراهيم عبد العال* سامي السعيد بدر** عبد المحسن لطفي **

أجرى هذا البحث في محطتي بحوث الجميزة والسرو التابعة لمركز البحوث الزراعية بمحافظتي الغربية ودمياط على مساحة ٣ فدان لدراسة تأثير طرق الشتل على كفاءة الشتل والسعة الحقلية واستهلاك الوقود والإنتاجية والطاقة الكلية واللازمة لانتاج الطن من المحصول. حيث تم دراسة طريقتين للشتل هما الشتل اليدوي والشتل الميكانيكي باستخدام آلتي الشتل ذات المواسك والأقماع (New Holand and Lännan Roulette transplanter) مع استخدام ٤ سرعات للشتل الآلي وهي ٠,٩٢ ، ١,٤ ، ١,٩ ، ٢,٤ كم/ساعة لمحاصيل الطماطم، الباذنجان، البصل، الكرنب ،الخس. وقد أظهرت نتائج الدراسة ما يلي:

أدت زيادة السرعة الأمامية من ٠,٩٢ إلى ٢,٤ كم/ساعة إلى نقص الكفاءة الحقلية من ٩٣,١٨ إلى ٨١,٠٨% ، ٩٢,٣١ إلى ٨٠,٨٨% ، ٩٢,٣١ إلى ٨٠,٨٨ % ، ٨٤,٦ إلى ٧٦,٤٧% ، ٨٤,٦ إلى ٧٦,٤٧% بينما زادت السعة الحقلية من ٠,٤١ إلى ٠,٩٣ فدان/ساعة ، ٠,٢٤ إلى ٠,٥٥ فدان/ساعة ، ٠,٢٤ إلى ٠,٥٥ فدان/ساعة، ٠,١١ إلى ٠,٢٦ فدان/ساعة ، ٠,١١ إلى ٠,٢٦ فدان/ساعة ، ونقص في الطاقة المستهلكة بنسبة ٤٤,٠٩ ، ٥٦,٣٦ ، ٥٦,٣٦ ، ٥٧,٦٩ ، ٥٧,٦٩ % لمحاصيل الطماطم والكرنب والباذنجان والبصل والخس على الترتيب.

كما أوضحت الدراسة زيادة الطاقة اللازمة لانتاج الطن من المحاصيل السابقة عند استخدام الشتالة New-Holland بنسبة ٩,٤٨ ، ١١,٩٧، ١٦,٩٢ ، ٩,٩٨ ، ٤,٦٧% عن الشتالة Lännen Roulette transplanter

كما أوضحت الدراسة أن أقل طاقة لازمة لانتاج الطن هي ١٦ كيلووات.ساعة/فدان لمحصول الكرنب عند استخدام الشتالة Lännen Roulette transplanter على سرعة ٢,٤كم/ساعة،بينما كانت أعلى قيمة طاقة٣٣٣,٩٩ كيلووات.ساعة/فدان لمحصول الخس عند استخدام الشتالة New-Holland على سرعة ٠,٩٢كم/ساعة.كما أدي استخدام الشتل الآلي الي زيادة كمية الحصول بنسبة١٦,٨٧ ، ١٣,٧٤، ١٥,١٩ ، ٦,٩٠ ، ١٥,٢٨%مقارنة بالشتل اليدوي.

وتوصي الدراسة باستخدام الشتل الآلي باستخدام الشتالة Lännen Roulette transplanter على سرعة ٢.٤كم/ساعة في شتل محاصيل الخضر وذلك لقلة الطاقة المستخدمة وزيادة الإنتاجية

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