MECHANICAL TRANSPLANTING OF POTATO USING STEM CUTTING

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Abstract

Decreasing food importation is a major concern for agricultural policy makers. Therefore, a special attention should be given to all projects and programs designed to promote crop production increase. First priority is to be given to production increase through, improved varieties, adapting and appropriate technologies transfer. Self–sufficiency in potato crop production may be by applying new technological inputs in agricultural mechanization, to optimize operation timeliness, and to promote a new method for potato by stem cuttings transplanting. Potato diseases and pests can be controlled using stem cutting that prevents contact with tuber and soil. Also, one potato tuber can produce 20 to 60 cuttings, each yielding half to one kg of tubers in the field, moreover each cutting produce five or more seed tubers. The main goal of this work is to develop and construct attachments for the transplanting machine to directly obtain stem cutting suitable for potato transplanting and reducing direct cost of importing practices. The auxiliary parts attached to the transplanter for transplanting stem cutting of potato may maximize transplanting machine exploitation. The developed machine was evaluated and tested at El-Gemeza Agr. Res. Station, El-Gharbia Gov. during season 2006 – 2007. A Massey Ferguson tractor of 26.11 kW (35 hp) and modified transplanter with attachments was tested at different operating conditions, tractor forward speed (0.28 ± 0.06, $0.42 \pm 0.0.06$, 0.56 ± 0.06 and 0.69 ± 0.06 m/s), speed ratio between ground wheel and horizontal belt (1:1, 1:2 and 1:3) distance between stem cuttings (0.2, 0.25 and 0.30 m) were also tested. The results show that the optimum tractor forward speed 0.28 ± 0.06 m/s, speed ratio between ground wheel and horizontal belt 1:3 and distance between stem cuttings 0.30 m respectively. At these variable levels, the accuracy of distribution of stem cuttings and spunta tuber yield were maximized while missing seedling and operation cost was minimized. The developed transplanting machine reduced the operation costs to 50% compared to the local tubers method and saved 75% of the imported tubers costs.

INTRODUCTION

Potato (Solanum tuberosum, L.) considered one of the most important food crops all over the world including Egypt. The cultivated area of potato crop in Egypt, is about 178 685 Feddan, which produces annually 1 764 910 tons through the two seasons of cultivation winter and summer seasons (Ministry of Agriculture–Egypt, 2004).

Couvillon (1988) reported that the purpose of treating cutting with root promoters is to increase the percentage of rooted cuttings, to hasten root initiation to increase the number and quality of roots produced per cutting and to increase uniformity of rooting. Also, he found that auxins are hormones produced in plant shoot meristems that stimulate root initiation and development. Auxins are transplanted down the stems to other plant parts. The concentration of auxins in plant tissue at any one time differs from plant to others, tissue maturity, time of year and growing environment. Marinus (1993) showed that the formation of above-ground tubers on stem cuttings of eight potato cultivars was studied over three seasons. To promote tuber formation in the leaf axils, stems grown from single node cuttings were exposed to short day conditions. Tuber formation underground was reduced by covering the soil with a plastic sheet and by using single node cuttings planted with the leaf axils several centimeters above the soil surface. With all cultivars except Alpha, which produced misshapen tubers in all experiments, an average of 11 (maximum 40) tubers per cutting was harvested. Significant cultivar × year interactions were observed. El-Gamal (1992) indicated the possibility of using stem cuttings to propagate potato plants. The tested cuttings should be dipped pre-planting in potassium salt of indole butyric acid (K-IBA) solution at 6000 p.p.m for one minute. This treatment succeeded to stimulate adventitious roots production and growth. Consequently, it produced seedlings of the highest vegetative growth as well as the highest fresh and dry weights of roots. The same treatment also was the best procedure to record the highest score of roots quality. El-Moursi (1993) showed that Spunta cultivar had a significant increase in fresh weight, dry weight, number of main stems and leaf area per plant. The increase was significant in plant height, number of leaves, total yield and tuber weight per plant in both seasons followed by Alpha cultivar lastly by Draga cultivar. El-Gendy et al., (1995) mentioned that the mixture of sand + Peat moss + clay as a growing medium did not improve Begonia growth parameters. Results indicated that a reduction in top growth when compared with peat, as a single – substrate medium, and clay + sand and clay + peat, as dual –substrate media. This reduction might have been caused by exceeded aeration, which was not favorable for Begonia roots. Tawfik (1997) concluded that the possibility of potato propagation by stem cutting, the cutting was easy rooting at any time in the green house. The rooted cuttings when transplanted to the field produced vigorous and uniform plants a long with a good yield compared with plants from seed tubers. Also, he added that, the use of stem cuttings is a low cost planting material that can reduce total production cost especially in the developing countries like Egypt. One seed tuber can produce from 20 to 60 cuttings, this means that more than 90% of used tubers in the tradition asexual propagation of potato plant can save a lot of hard currency that can be paid for other proposes. The cuttings were obtained from Nili plantation after rooting, they are planted in summer plantation. Mady *et al*., (2001) indicated that using mechanical transplanting decreases the operational costs in comparison with manual transplanting. The operational cost decreases form 70 LE/fed under manual transplanting to 52. 63 LE/fed under mechanical transplanting at speed of 1.5 km /hr. It's also that increasing forward speed from 0.8 to 1.5 and 2.5 km/h decreased the operational cost from 58, 32.25 and 20 LE/fed respectively. Choi and Kim (2002) showed a new seeding pick–up device for vegetable transplanters. The connecting links join the driving link and the slider. When the slider moves a long the straight line path of the slot, it takes a seedling from a cell. When it moves a long the circular path, it transfers the seedling to the transplanting hopper. The slider is an assemblage of pick-up pins and a pin driver, which are integral parts of the device operational parameters such as seedling age, approach direction of the pins and penetration depth of the pins into the cell. Seedling holding method and extracting velocity were examined using a prototype. The device extracted 30 seedlings per minute with a success ratio of 97% using 23.day-old seedlings.

Helmy et al., (2003) showed that the using of transplanter under the lowest forward speeds gave better results under transplanting forward speed of 0.9km/h the field efficiency was 64.82% and values of longitudinal and transverse dispersion were 0.39 and 1.08cm, respectively. The percentage of void seedlings was 10.5% and transplanter studding was 9.5%. Kim (2007) mentioned that stem cuttings have been recently attempting for the rapid multiplication of basic seed potato in Korea. Stem cuttings were grown to be quality transplants under cool-white fluorescent lamps. Quality transplants can give high yield and quality after transplanting in the open fields or in the greenhouses. Also he investigated the quality characteristics of potato superior' transplants grown under controlled environment. Different levels of photoperiod, photosynthetic photons flux (PPF), and DIF were provided to analyze the quality characteristics of potato transplants. The quality of potato transplants was greatly affected by photoperiod and PPF. Potato transplants showed healthy growth at photoperiod of 16/8 h, PPF of 200 $\mu mol \cdot m^{-2} \cdot s^{-1}$, and DIF of 23/20°C.

MATERIALS AND METHODS

To grow the stem cutting for potato transplanting, the tuber yield and the behavior of transplanting machine during transplanting operations need to be determined. Therefore, this study was devoted to:

(1) Develop a simple and effective technique to produce root-stem cuttings from winter season planted potato for mechanical transplanting at summer season.

(2) Maximize the tuber yield from transplanted crop (rooted cuttings) in comparison to crop planted by seed tubers for spunta variety.

(3) Compare the cost of mechanical transplanting of stem cuttings to mechanical transplanting of tuber seed and manual transplanting.

(4) Mechanically plant potatoes with stem cuttings and compare transplanting uniformity, yield and cost when using local or imported tuber seed.

Theoretical considerations:

At different tractor forward speeds (0.28 $\pm$0.06, 0.42 $\pm$0.06, 0.56 $\pm$0.06 and 0.69 $\pm$0.06 m/s), speed ratio 1:3 between ground wheel and drum of horizontal belt and distance between seedlings 0.3 m.

V	Tm	R.S	L.S	D.m	D.M/O
0.28	3.57	0.45	0.042	0.15	0.05
0.42	2.38	0.67	0.063	0.15	0.05
0.56	1.78	0.89	0.084	0.15	0.05
0.69	1.45	1.10	0.104	0.15	0.05

V = tractor forward speed (m/s).

Tm = time of one meter on ground from wheel of transplanting machine (sec).

R.s = revolution speed for drum of horizontal belt (r/s).

L.s = linear speed for drum of horizontal belt (m/s).

D.m = distance on horizontal belt that equals one meter on ground (cm) level.

D.m/o = distance on horizontal belt for one seedling (cm).

Circumference of land wheel 1.88 m ($2\pi r$) and its radius was 0.6m.

Number of seedlings in one revolution = 1.88 x 3 seedlings (in one meter) = 5.64 cm.

The linear speed for drum of horizontal belt = circumference of drum (D =0.03m) x speed ratio (number of its rapids per each one rapid of land wheel) = linear speed of land wheel = 2x3.14x1.5x3=28.3 cm/5.64 cm = 5.02

Distance of one seedling on belt = 37.68/7.52 = 5.01 cm/one seedling.

- **The developed transplanting machine:**

This study was conducted to develop the Japanese type transplanting machine model 33 6000 using transplants up to 2" round or square peat pots. The 70 cm horizontal flat belt and 60 cm modified using vertical belt allowed for fast and effective plant placement and a wide variety of plant spacing that originally designed mainly in transplanting the cotton crop, to be suitable for transplanting the stem cuttings of potato. The following parts were fabricated and assembled for the proposed development. 1) Thirteen plates fixed on two sides around two leather rollers, each plate has one small roller to easy motion of transplants. 2) Replacing the vertical flat belt with knapping belt. 3) Change the original sprockets with others to suit distance between stem cutting on ground. It consists of group of parts as shown in figs. 1 and 2. It has gross dimensions 1.25 m. wide, 1.1 m high and 2.3 m long. Hooked to Massey Ferguson tractor of 26.11 kW (35 Hp) and gross weight of 500 kg.

The axial shaft provided with two sprockets to convert horizontal motion to vertical motion, land wheel diameter of 0.6 m.

Fig. 1. The modified transplanting machine in operation.

A, seedling before rooted, B, seedling in paper pot and C, seedling after paper pot.

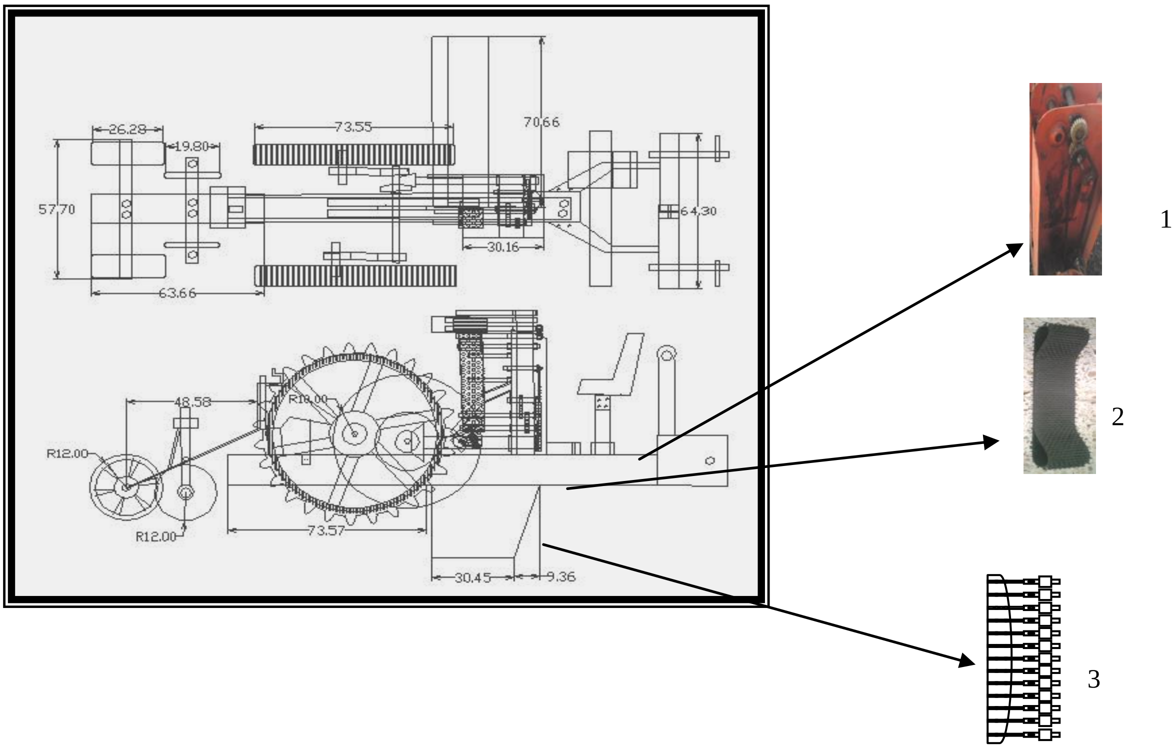

Fig.(2): Schematic diagram for modified transplanting machine.

1, 2 and 3 modified parts

- **The field experiments:**

The field experiments were carried out during season (2006 -2007) by using stem cuttings as seedlings to evaluate the performance accuracy of seedling, missing seedlings, energy and cost analysis requirement for all operations of transplanting machine. All the experimental plots were chiseled twice, the second tillage was carried out by rotary plow and leveled by land leveler before transplanting operations. Agricultural practices except methods of transplanting, such as irrigation, fertilization, pest control etc. were carried out in all treatments due to the technical recommendations. The main treatments were four levels of forward speeds (V) (0.28 ± 0.06, 0.42 ± 0.06, 0.56 ± 0.06 and 0.69 ± 0.06 m/s), speed ratio between ground wheel and horizontal belt (1:1, 1:2, and 1:3) and three levels of distance between seedlings in the row (0.2, 0.25 and 0.3 m) were also tested. Data of power requirements and cost of cutting stems of potato crop compared with traditional planting by tubers (local and imported). Observation data was recorded 21 days after transplanting. The following parameters: transplanting accuracy, energy requirements and criterion cost were computed.

- **Experimental work:**

Three stem cuttings varieties (cara, spunta and Diamont) were used to conduct two main sets of experiments performed. These were to determine the optimum variety comprising of the same three varieties seed tubers. There were no significant differences between the two methods of propagation in germination percentage of the three varieties. Seed tubers gave the highest plants than stem cuttings. While stem cuttings gave the highest number of stems/plant and leaf area/plant $(cm)^2$. The Cara and Diamont varieties gave the highest specific gravity, tuber dry matter and starch content while the Spunta variety gave the highest yield and rooting ratio. From the above experiments, the field experiments conducted on Spunta variety, was used in the next set of experiments.

- **Technique of producing potato stems cuttings**

Sprouted seed tubers of potato (spounta variety) were grown in the field on Oct. 19 Th of 2006 and 2007 season. Three replicates were cultivated using full tubers. The experimental plot area for each replicate was 5.12 m^2 comprising of 6 rows, 70 cm wide and 3.6 m long and tubers were planted at 20 cm apart. Irrigation, fertilization and other practices were followed according to recommendation of the ministry of agriculture in Arab Republic of Egypt. When the mother plants at 20 to 30 cm tall (about 45 days after planting), the apical growing point of each stem was removed. This removal stimulates growth of lateral shoots when reached 8 to 12 cm length (about 15 days after removal of the apical growing point) were used as stem cuttings, 4 to 5 cm stem below the first node was left (Bryan *et al.,* 1988). The cuttings of spounta variety were dipped into a solution of potassium salt of indole butyric acid (K-IBA) at 6000 ppm for one minute. The cuttings are left for one hour at least before planting to allow hormone penetration into cutting tissue. The cuttings were planted in media from volume proportions of washed sand, slightly moistened peat moss and screened soil, (1:1:1). The media were prepared and left for 24 hours in piles before filling the plastic bags (10 cm in diameter) to equalize the moisture through the media. The cuttings were planted in polyethylene bags on 18 th December of 2006 and 2007. Each bag had one cutting, 4 cm deep. After planting, all bags were kept for 15 days in greenhouse under mist system. The bags were not allowed to dry out by frequent slight irrigation. Pesticides, fungicides and foliar fertilizer were used to control pathogens and early vigorous growth of transplant. The transplants irrigated immediately after transplanting. Never permit the soil to dry out and over irrigated as it inhibits root formation and causes soil crusting.

- **Measurements:**

For recording the observation in all studied characteristics four samples, each replicate was selected randomly from each treatment and the data were recorded directly after the transplanting date. From each samples the following data were recorded:

- **Transplanting accuracy.**
  - Longitudinal dispersion.
  - Transverse dispersion.
  - Missing seedling.
  - Energy requirements.
  - Criterion cost.
- **The longitudinal and transverse dispersion:**

Deviations in the longitudinal and transverse direction from each replicate for mechanical transplanting method were determined by using the following equation,

$$C.V = \frac{sd}{\overline{X}} \times 100 \quad \text{.......... (1)}$$

$$sd = \sqrt{\frac{(\Sigma X - X^{-})^2}{n-1}} \quad \text{............ (2)}$$

Where:

sd = standard deviation (σ).

X = Distance between seedlings in the row, cm.

$\overline{X}$ =Mean distance between seedlings at longitudinal and transverse dispersion, cm.

n = number of observation.

- **Percent missing seedlings**

Missing seedlings percentage was calculated by using the following formula according to Hossary *et al.* (1980).

$$V_s = (\frac{N_v}{N_{th}}) \times 100 \text{ .... (3)}$$

Where:

Vs**=** Percent missing seedlings

Vn = Number of missing seedlings /m^2

N$_{th}$= theoretical number of seedlings /m^2

- **Yield data**

on April 9th 2006 and 2007 tuber yield of plants were harvested. After 90 days from transplanting (about 15 days earlier than traditional method. Tuber yield as number and weight for each plant was estimated then the yield was converted in ton/feddan.

- **Fuel consumption and Energy requirement:**

Fuel consumption rate was determined by measuring volume of fuel consumed for each forward speed of transplanter by a graduated cylinder as follow:

1. The tank was completely filled with fuel.
2. The transplanting operation was carried out and the time elapsed was measured by a stop watch, and transplanting area was also calculated.
3. After the transplanting operation had been done the fuel consumption (F_1) was measured.
4. The fuel tank refilled completely again and the consumed fuel (F_2) by tractor with transplanter was measured.

$$Fc = \frac{F_1 - F_2}{t} \times c \text{ .... (4)}$$

Where:

Fc = fuel consumption, L/h

F_1=volume of fuel consumed during the test, cm^3 for both tractor and transplanter

F_2 = volume of fuel consumed during the test, cm^3 for tractor without transplanter

t = test time, sec and c = 3.6 a constant conversion of test time.

While the fuel consumption per feddan was calculated as below:

$$Fc = \frac{F_1 - F_2}{t} \times F_{act} \text{ .... (5)}$$

Where:

F_{act} = Effective total time in sec per feddan

The engine energy required for each transplanting treatment was calculated by using the following equation (Embaby 1985):

$$E_R = (Fc \times \frac{1}{3600}) \times \frac{\rho \times L.C.V \times 427 \times \eta_{th} \times \eta_m}{75 \times 1.36 \times F_{act}} \text{ (kW.h/fed)........... (6)}$$

Where:

Fc = Fuel consumption. .... L/h - ρ = Density of fuel .. Kg/L. (0.85 kg/L. for diesel)

L.C.V = Lower calorific value of fuel... k cal/kg (L.C.Vof fuel is 10000 k cal/kg)

427 = Thermo.mechanical equivalent............... Kg.m/kcal.

η_{th} = thermal efficiency of engine (40% for diesel engine). η_m = Mechanical efficiency of engine (80% for diesel engine). - F_{act} = Actual field capacity .... fed/h.

- **Statistical analysis**

Analysis of variance and goodness of fit metering device followed during analyzing the collected data in the present study. Analysis was executed with the aid of the computerized statistical procedures of Minitab (version 5) program. Three factor randomized complete block design was employed in step wise regression equations (7, 8, 9 and 10).

RESULTS AND DISCUSSION

- **Effect of the tested factor on the coefficient of variation (C.V. %) of longitudinal dispersion of seedlings for potato crop:**

The effects of forward speed on C.V. of longitudinal dispersion of seedlings for potato crop are shown in Fig. (3). As can be seen, for the same distance between seedlings as affected by speed ratio C.V. tends to increase and there was a positive relationship between all of them. Distance between seedlings was 0.2 m at speed ratio 1:1 and forward speed from 0.28 ± 0.06 to 0.56 ± 0.06 increased the C.V. of longitudinal dispersion from 9.15 to 18.31 %. These results can be attributed to increasing the forward speed means increasing the feeding rate and decreasing the uniformity of distribution. which substantially causes an increase in the amount of seedlings and increase the C.V. of longitudinal dispersion of seedlings for potato crop. Optimum forward speed was the lower speed (0.28 ± 0.06). Data show that for the same forward speed and speed ratio increase the seedlings distance in row reduced the C. V. of longitudinal dispersion. For the same conditions of forward speed (0.28 ± 0.06) and speed ratio 1:1 increased seedling distance from 0.20 to 0.30 m decreased the C. V. of longitudinal dispersion of seedlings from 9.15 to 7.36 %. Optimum seedling distance was the (0.3 m).The lower longitudinal dispersion may reduce load of seedlings on the horizontal belt. Increasing distance between seedlings may reduce the transplanted seedlings, due to reduction in some of seedlings that did not have the chance to go into dispersion. These obvious data show that for the same distance between seedlings and forward speed increasing speed ratio increased the C. V. of longitudinal dispersion of seedlings. For the same conditions of distance between seedlings, 0.2 m and forward speed 1 km/h (0.28 ± 0.06), increasing speed ratio from 1:1 to 1:3 decreased the C. V. from 9.15 to 6.45 %. Therefore optimum speed ratio between ground wheel and horizontal belt was 1:3.

The following variables were obtained to describe the effect of the independent variables on the longitudinal dispersion (%).

Longitudinal dispersion (%) = 3.07 + 20.8 V + 3.75 S.R. -20.6 D.T. ------------- (7)

R^2 = 88.7%

Where:

V = Forward speed (m/s).

S.R = Speed ratio.

D. T. = distance between tubers (m).

- **Effect of the tested factors on the coefficient of variation (C.V. %) of transverse dispersion of seedlings for potato crop:**

The effects of different tested factors on the transverse dispersion are shown in Fig. (4). It can be noticed that higher forward speed levels resulted in higher C.V. of transverse dispersion. With a forward speed 0.69 $\pm$ 0.06 m/s, speed ratio 1:1 and distance between seedlings 0.2 m which resulted in higher transverse dispersion (22.35%). While the lower transverse dispersion (5.20%) achieved at forward speed 0.28 m/s, speed ratio 1:3 and distance between seedlings 0.3 m. as can be seen that increasing forward speed from 0.28 $\pm$ 0.06 to 0.69 $\pm$ 0.06 m/s, increased the C.V. of transverse dispersion from 9.34 to 22.36 %.The optimum forward speed was the smallest one (0.28 ± 0.06 m/s). Data show that for the same forward speed and speed ratio increasing the seedling distance in row decreased the C. V. of transverse dispersion of seedlings and there was an indirect proportionality between all of them, as an example: for the same conditions of forward speed 0.28 ± 0.06 m/s and speed ratio of1:1 increasing seedling distance in row from 20 to 30 cm decreased the C. V. of transverse dispersion of seedling from 9.34 to 7.65 %. Also, the optimum seedling distance in row was the highest one (0.30 m). These data obtain that for the same distance between seedlings, and forward speed, increasing the speed ratio decreased the C. V. of transverse dispersion of seedlings and there was an indirect proportionality between of all of them, as an example for the same conditions of distance between seedlings, 0.2 m and forward speed 0.28 ± 0.06 m/s, increasing speed ratio from 1:1 to 1:3 m decreased the C. V. of transverse dispersion of seedling from 9.35 to 7.73 %, which can be attributed to increasing the speed ratio means decreasing the C. V. of dispersion that substantially cause a decreasing in the amount of seedlings on horizontal belt and improving the uniformity of distribution. It is clear that, the optimum speed ratio was the highest one (1:3). Generally, the accuracy of the developed transplanting machine attained at a tractor forward speed 0.28 $\pm$ 0.06 m/s, 0.3 m distance between seedlings and speed ratio 1:3.

A multiple regression analysis was carried out taking transverse dispersion, as dependent variable and tractor forward speed, speed ratio and distance between tubers as independent variables.

The following equation (8) was the obtained regression equation to describe the effect of the independent variables on the transverse dispersion (%).

Transverse dispersion (%) = 5.52 + 25.3 V + 5.39 S.R. -37.6 D.T. ------------- (8)

$$R^2 = 84.6\%$$

Where:

V = Forward speed (m/s).

S.R = Speed ratio.

D. T. = distance between tubers (m).

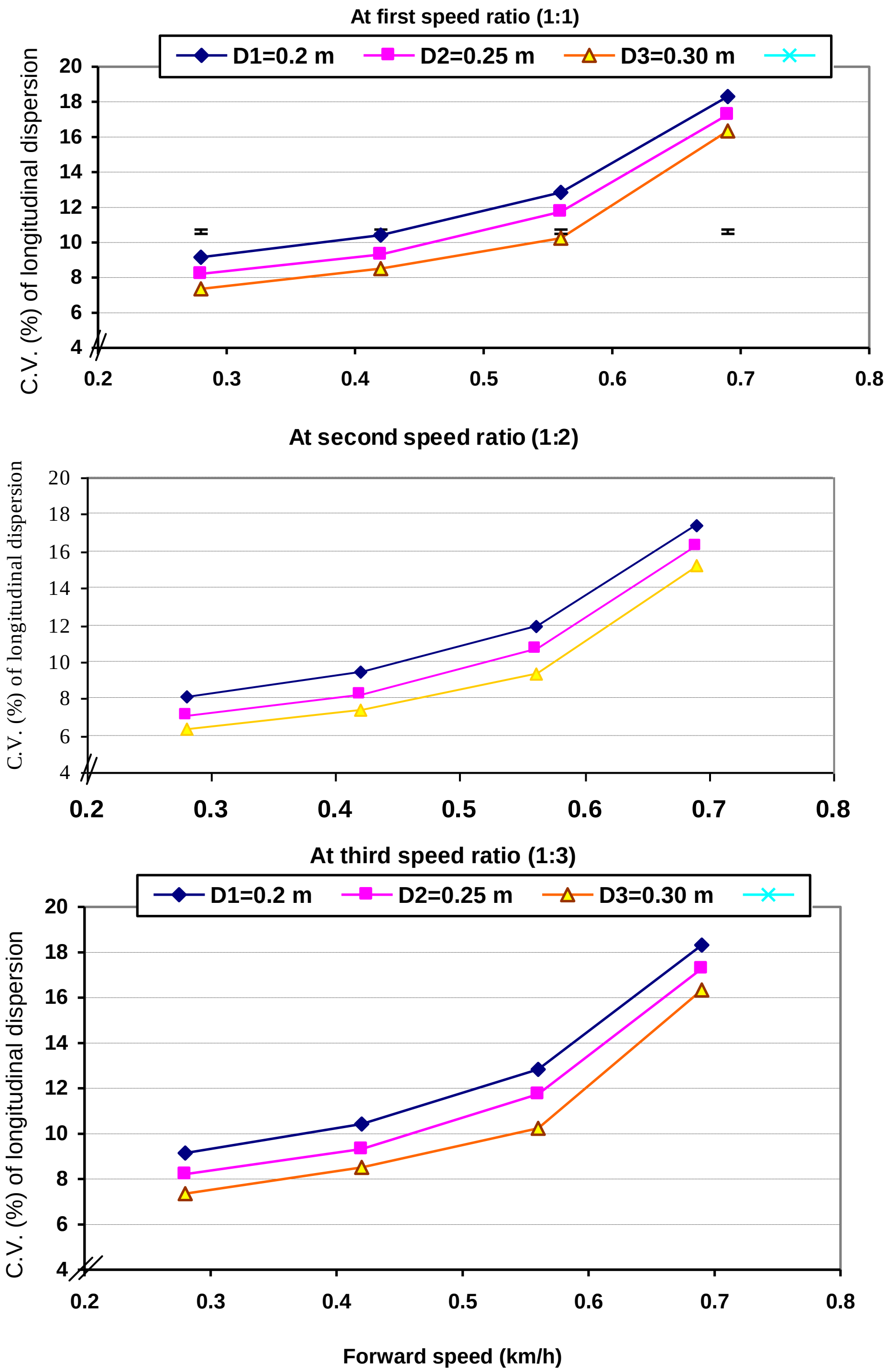

Fig.3. Effect of different tested factors on longitudinal dispersion.

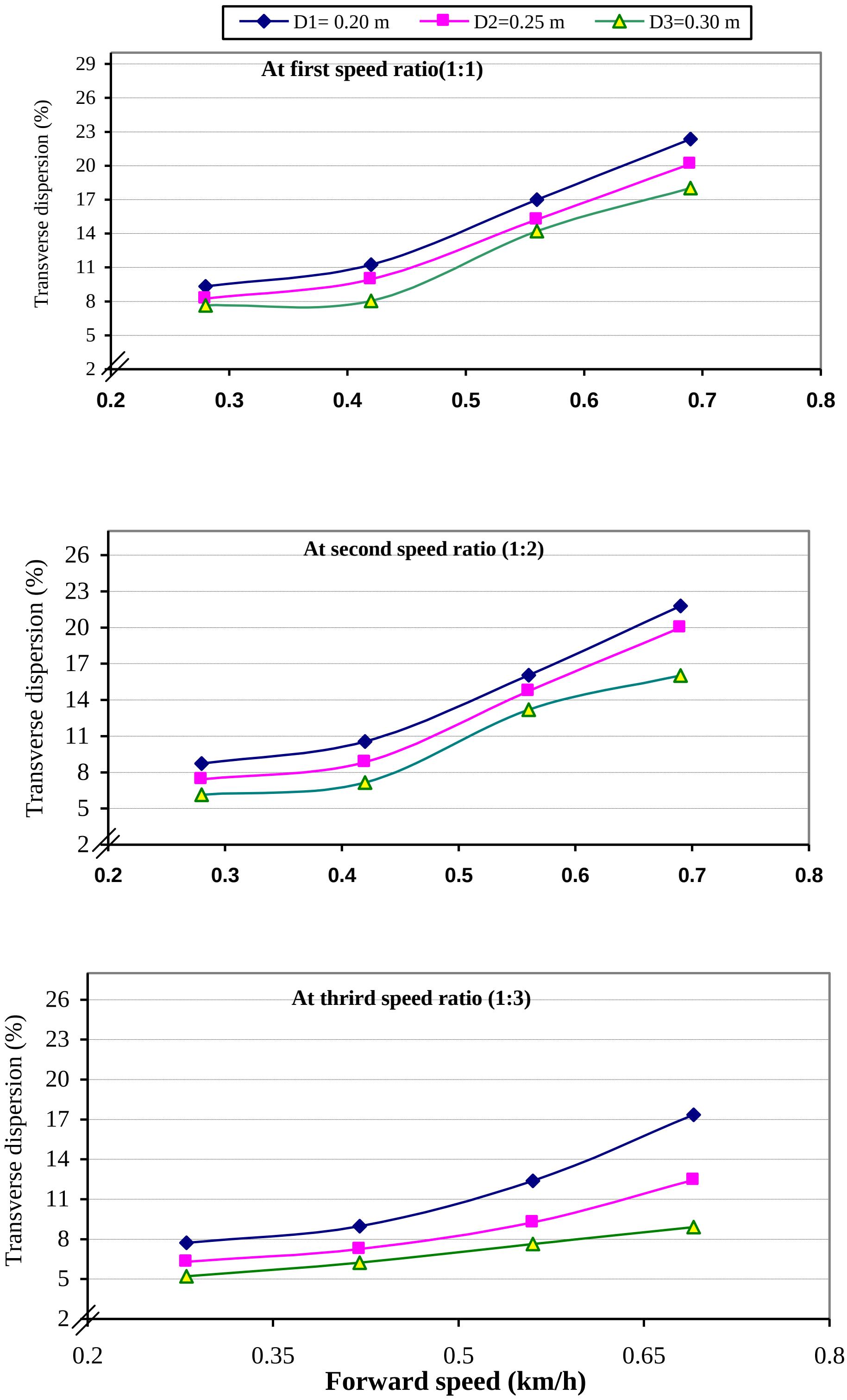

Fig.4. Effect of different tested factors on transverse dispersion.

- **Effect of tested factors on the missing seedlings:**

The missing seedlings increment linearly with increasing forward speed as shown in Fig. (5). as can be seen, increasing forward speed from 0.28 $\pm$0.06 to 0.69 $\pm$0.06 m/s increased the missing seedlings from 3.26to 6.01 % at speed ratio of 1:1 and distance between seedlings 0.20 m. This may be due to higher seedlings rate by increasing tractor forward speed. The same data clarify that the missing seedlings decreased with increasing speed ratio. While the same data indicated that decreasing of speed ratio from 1:1 to 1:3 decreased the missing seedlings from 3.26 to 3.04 % at forward speed 0.28 m/s and distance between seedlings 0.20 m. this may be due to increasing speed ratio led to increasing distance of one seedling on horizontal belt. At the same time, increasing distance between seedlings reduced the missing seedlings from 3.26 to 1.75 at forward speed 0.28 m/s and speed ratio 1:1. So the forward speed 0.28 m/s, speed ratio 1:3 and distance between seedlings 0.3 m is recommended for decreasing the missing seedlings.

The following variables were obtained to describe the effect of the independent variables on the Missing seedlings.

Missing seedlings (%) = 4.40 + 6.47 V + 0.403. R. - 15.9 D. T ------------- (9)

R^2 = 95.5%

Where:

V = Forward speed (m/s).

S.R = Speed ratio.

D. T. = distance between tubers (m).

- **Effect of tested factors on the tuber yield (ton/fed:**

From data was graphically, in Fig. (6) one can say that the highest yield of (12.40 ton) was found at the tractor forward speed (0.69 m/s), speed ratio 1:3 and distance between tuber 0.20 m. at the same time the lowest tuber yield value of (6.33 ton) was found at the forward speed (0.28 m/s), ratio 1:1 and distance between tuber 0.30 m. It can be seen that, the tuber yield increases linearly as the tractor forward speed and speed ratio increasing. These results could be explained in the view of that, as the forward speed increased as the seedlings density increase and increase the density of the tuber layer in the ground. Also the tuber yield decreased linearly as the distance between tuber increasing, this may be due to reduce tuber dense. This dense layer of the tubers significantly increases by decreasing the seedlings in unit area. That may result in increasing tuber yield. From the mentioned data, the general mean of yield was 8.5 ton/fed. for the stem cutting method, but the other methods were 10 and 14 ton/fed. for planting by local and imported methods, respectively. (Tawfik 1997).

The following stepwise regression equation was obtained to describe the effect of the independent variables on tuber yield (ton/fed.).

Yield (Ton/fed.) = 15.1 + 5.35 V- 3.82 S. R. - 10.6 D. T. ------------- (10)

$$R^2 = 85.2\%$$

Where:

V = Forward speed (m/s).

S.R = Speed ratio.

D. T. = distance between tubers (m).

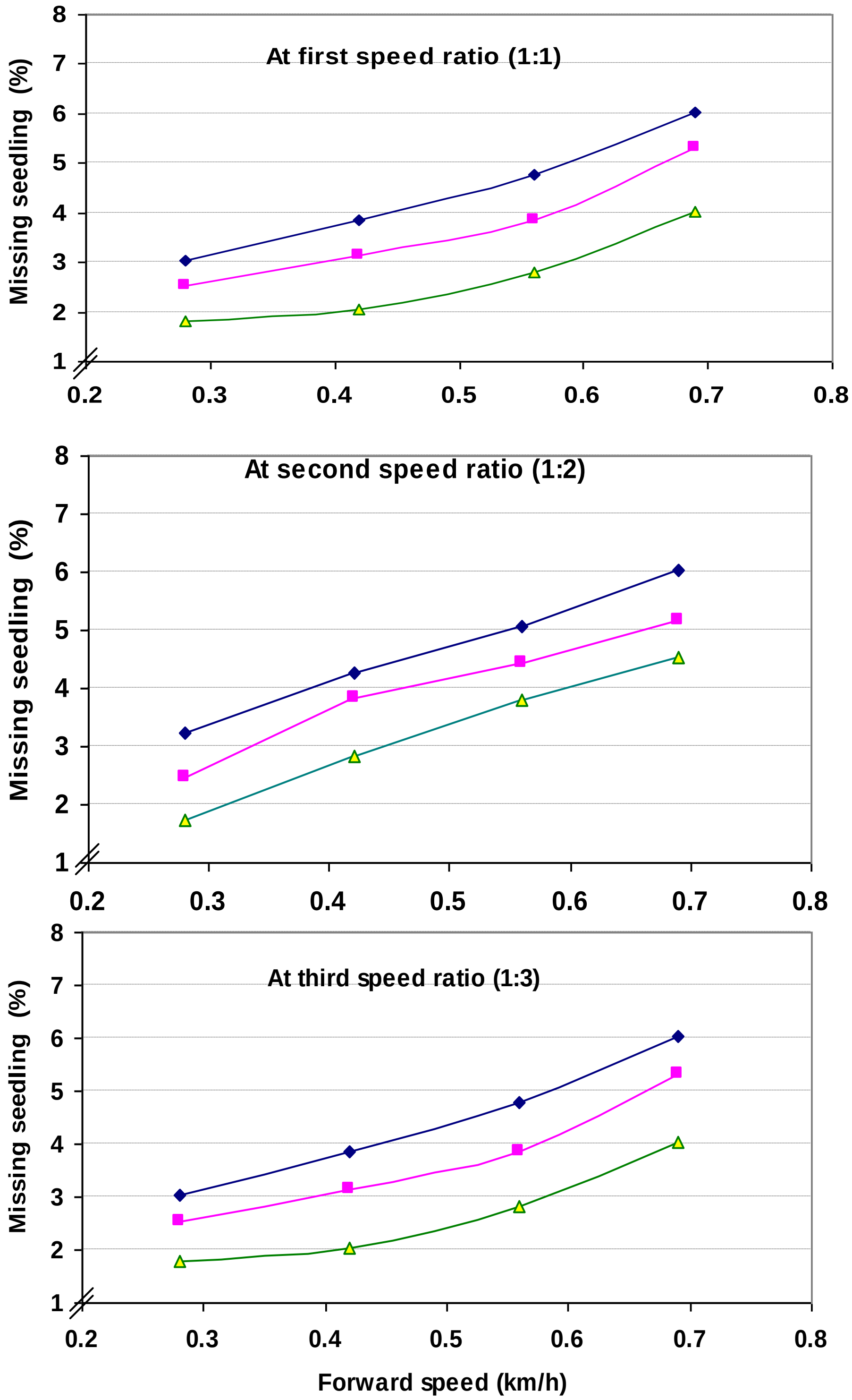

Fig.5 .Effect different tested factors on missing seedling (%).

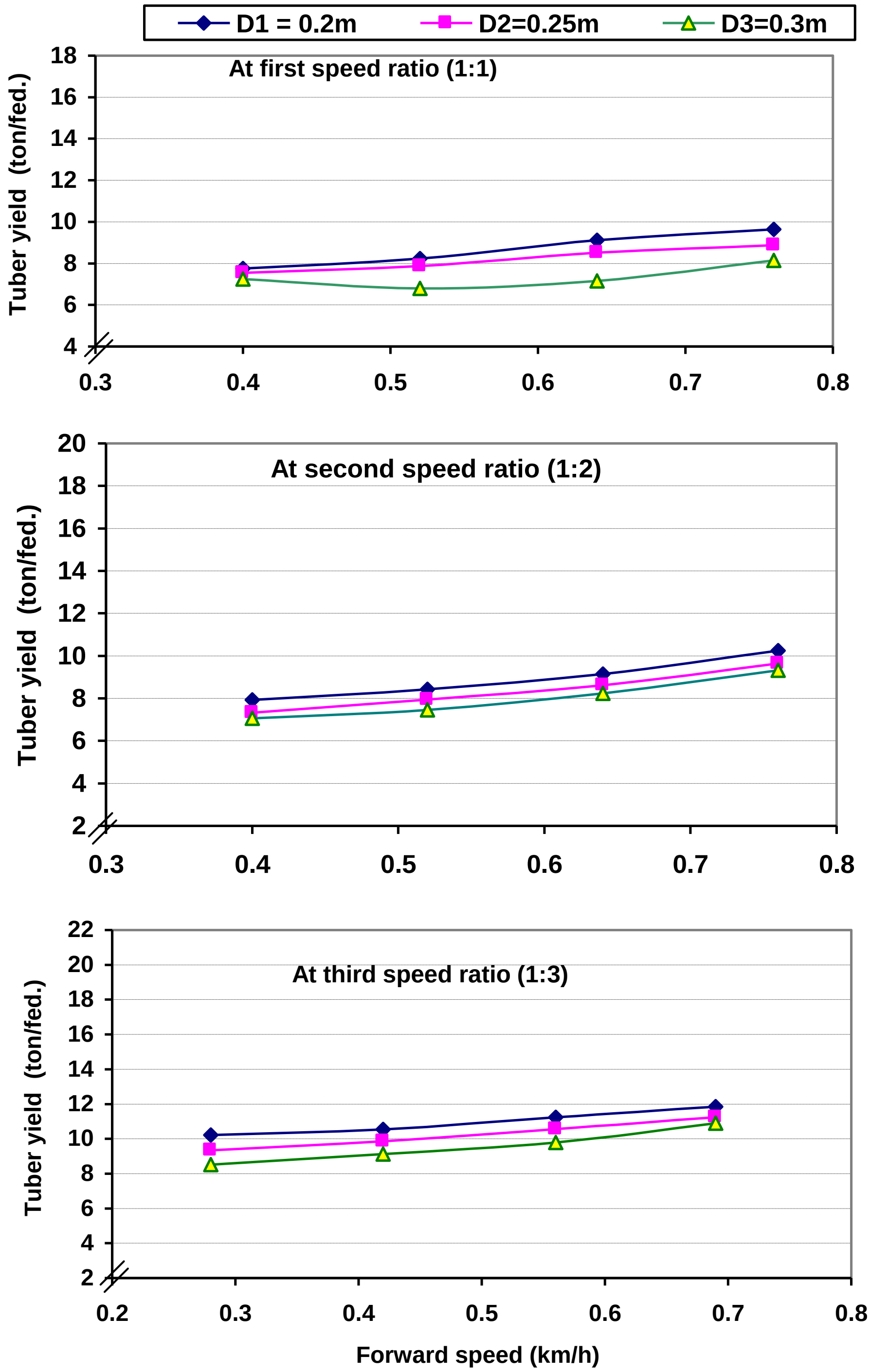

Fig.6 . Effect different tested factors on tuber yield (ton/fed).

- **Effect of tested factors on energy requirement (kW.h/ton):**

Data presented in Table (1) shows the effect of forward speed, speed ratio and distance between tubers on the energy requirement which affected by mentioned tested factors. As can be seen that the increasing the forward speed from 0.28 to 0.69 m/s decreased the energy requirement from 64.00 to 35.48 kW.h/fed for speed ratio 1:3 and distance between tubers 0.30 m. This may be due to increasing the fuel consumption by increasing the tractor forward speed and speed ratio which caused augmenting the actual field capacity (fed. /h).

Table 1. Effect tested factors on actual field capacity (fed. /h), power requirement, (kW) and energy requirement (kW.h/fed.) for developed transplanting machine.

Forward speed (m/s)	Actual field capacity (fed./h)	Fuel consumption (Liter)	Power requirement (kW)	Energy requirement (kW.h/fed.)
0.28	0.13	9.00	28.80	64.00
0.42	0.19	10.00	32.00	46.93
0.56	0.25	10.81	34.60	39.81
0.69	0.31	11.50	36.80	35.84

- **Cost analysis:**

Table 2. Yield (ton/fed.), Cost (L.E/fed.), Yield (L.E/fed.) and Net (L.E/fed.) at different propagation methods.

Propagation method	Yield (ton/fed.)	Cost (L.E/fed.)	Yield (L.E/fed.)	Net (L.E/fed.)
Stem cuttings	8.5	3900	8500	4600
Local tubers	10	8000	10000	2000
Imported tubers	14	15000	14000	1000

*Price of one ton 1000 L.E.

* Stem cuttings at optimum parameters.

A preliminary economic analysis was performed to compare the costs of potato transplanted by stem cuttings with that of potato planting by local and imported tubers. Potato growers have to be very careful with their crop. It costs 3900, 10000 and 15000 L.E/fed. for mechanical transplanting of stem cuttings, mechanical planting of local and imported tubers respectively. The results of this analysis and that of foregoing researches are shown in table 2 for both potato planting methods the most important factor affecting potato planting cost is the price of the importing tubers. The potato planting costs of stem cuttings, local and import tubers were estimated to be 3900, 8000 and 15000 L.E/fed. respectively. Such a huge difference is due to the high price of importing tubers 18000 / ton as used for commercial applications. Table (2) shows a comparison between the materials and the manufacture costs for both of the original planning by tubers and the developed transplanting method by stem cuttings. The total costs for the developed transplanting machine was 3900 L.E /fed.

While for the local method it's was 8000 L.E. /fed. (more than twice of the developed one). For the imported tubers it’s was 15000 (more than forth of the developed one). So, the developed transplanting machine reduced the operation costs to 50% of the costs for the local tubers method (saving 75% of the costs for the imported tubers method).

CONCLUSION

1. Higher longitudinal dispersion (18.32 %) obtained at forward speed 0.69 ± 0.06 m/s, speed ratio 1:1 and distance between seedlings 0.2 m . While the lower longitudinal dispersion (4.51%) achieved at the optimum factors (forward speed 0.28 m/s, speed ratio 1:3 and distance between seedlings 0.3 m).
2. With a forward speed 0.69 ± 0.06 m/s, speed ratio 1:1 and distance between seedlings 0.2 m resulted in higher transverse dispersion (22.35%). While the lower transverse dispersion (5.20%) achieved at the optimum factors (forward speed 0.28 m/s, speed ratio 1:3 and distance between seedlings 0.3 m).
3. The forward speed 0.28 m/s, speed ratio 1:3 and distance between seedlings 0.3 m is recommended for decreasing the missing seedlings, where achieved the lowest missing seedlings (1.75%). But the highest missing seedlings obtained at the forward speed 0.28 m/s, speed ratio 1:3 and distance between seedlings 0.3 m which recommended for decreasing the missing seedlings.
4. The highest yield of tubers achieved at forward speed 0.28 m/s, speed ratio 1:3 and distance between seedlings 0.3 m is recommended for increasing yield of tubers. The lowest yield of tubers attained at the forward speed 0.69 m/s, speed ratio 1:1 and distance between seedlings 0.2 m.
5. The optimum operating conditions of the developed transplanting machine were found to be as follows:

Tractor forward speed 0.28 m/s, speed ratio 1:3 and distance between seedlings 0.3 m with stem cuttings from spounta variety of potato. The results of this article may recommend that using the new design the developed transplanting machine to be suiting small holdings that spreading in Egyptian countryside.

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الشتل الآلى للبطاطس بالسيقان المجذرة

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يعتبر محصول البطاطس من المحاصيل الاقتصادية الهامة في مصر ويزرع في مصر بكثافة فى الدلتا ومناطق الإستصلاح الجديدة. ويعتبر إستيراد التقاوى للعروة الصيفية لمحصول البطاطس من أكثر صعوبات زراعة البطاطس لحاجته لمبالغ مالية كبيرة حيث يصل سعر الطن لحوالى ١٨ ألف جنية مصرياً. خاصة فى حالة المساحات الكبيرة فى أراضى الإستصلاح الجديدة حيث ظهرت مشكلة إرتفاع سعر التقاوى المستوردة. ويهدف هذا البحث الذى أُجرى فى محطة البحوث الزراعية بالجميزة – محافظة الغربية وذلك لتطوير وتعديل نظام إنتاج التقاوى من العقل الساقية وقد إستخدم لهذا الغرض صنف أسبونتا حيث أشارت التجارب السابقة إلى أنه يعطى أكبر عدد من العقل الساقية خلال موسمى الزراعة وأفضل صفات نمو خضرى بالنسبة للعقلة الساقية (طول العقلة، عدد الأوراق، قطر العقلة ، الوزن الطازج والجاف للعقلة) . حيث أُخذت العقل الساقية لهذا الصنف وغمست فى محلول من الملح البوتاسى لإندول حامض البيوترك (K-IBA) تركيز ٦٠٠٠ جزء فى المليون لمدة دقيقة واحدة وذلك بغرض تشجيع التجذيروتركت لمدة ساعة لتشجيع عمل الهرمون ثم زرعت العقل فى بيئة نمو(رمل +بيت موس+تربة بنسبة ١:١:١)وكانت الزراعة فى بيت بوتس (أكياس ورق قطر ١٠سم) وبعد التجذير (٣٠ يوم من زراعة العقل) تم نقل العقل المجذرة إلى الحقل المستديم وشتلها بواسطة الة الشتل المعدلة لهذا الغرض. وقد تركز البحث على تقييم أداء الألة فى عملية الشتل. لذلك فقد إتجه البحث لدراسة عوامل التشغيل التى تؤثر على أداء الالة مثل النسبة بين سرعة السير الأفقى وسرعة تروس عجلة الأرض (١.١ – ١:٢ – ١:٣) والمسافة الطولية بين الشتلات(٠.٢و ٠.٢٥و ٠.٣٠ م). وقد أمكن تشغيل ألآلة بحيث يمكن التحكم فى تغيير العوامل السابقه بطريقه سهلة ودقيقه. وأظهرت النتائج أن العوامل المثلى لتشغيل آلة الشتل والتى تعطى أفضل توزيع منتظم للشتلات بإستخدام سرعة تقدم للجرار ٠.٢٨ م/ث ± ٠.٠٦ و نسبة سرعه ١:٣ ومسافة بين الشتلات ٠.٣٠ م فى التلقيم وكان متوسط إنتاجية الفدان فى هذه الطريقة ٨.٥ طن/فدان بينما كان متوسط إنتاجية الفدان فى طريقتى الزراعة بالتقاوى المحلية والمستوردة ١٠ و ١٤ طن /فدان على الترتيب (توفيق ١٩٩٧). وقد تحقق أقل إستهلاك للطاقه وأقل تكلفة عند نفس العوامل الموصى بها. حيث بلغت تكلفة الشتل بالسيقان المجذرة حوالى نصف تكلفة طريقة الزراعة الآلية بدرنات محلية وربع تكلفة الزراعة الالية بالدرنات المستوردة.