A STUDY ON TRANSPLANTING MACHINES UNDER LOCAL CONDITIONS

PERFORMANCE DEVELOPMENT OF VEGETABLE TRANSPLANTER UNDER LOCAL CONDITIONS

By

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INTRODUCTION

Tomato and sweet potato are considered as the most important and widely cultivated vegetables in Egypt due to their nutrition's value. The total annual cultivated area are of about 401329 and 20141 feddans*, producing about 5873441 and 120323 megagrams of tomato and sweet potato, respectively. (Annual statistical book, 1998).

Tomato is grown in Egypt allover the year, its production takes place during three seasons, summer, winter and Nilie or all seasons.

The previous crops are transplanting by traditional method, (manual transplanting) which have some disadvantages. It needs to high labor requirement in a short period of time. The labors walking inside the wet fields to transplant vegetable crops like tomato, sweet potato... etc, they will be infected by schestosoma which is the most dangerous decease widely speared in Egypt country. Also, traditional transplanting can not achieve the requirement of the planting uniformity within the field and there after non uniformity of growth. Nowadays, mechanical transplanting becomes a necessary method to increase crop yield and minimize both of operating time and production cost.

The goal of mechanized transplanting of crops is to increase labor productivity and to 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 yield.

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*One feddan (fed.) = 4200.83 m^2

The aim of the current study was devoted to modify the manual feeding vegetable transplanter performance (Holland type M-1600), to achieve the following objectives:

1- To transplant seedlings and build ridges in one operation.
2- To increase the benefit as a result to increase operation hours per year through using the transplanter to transplant many vegetable crops.
3- To reduce the times of pathing equipment above soil.

The performance of modified transplanter was compared with the performance of transplanter before modification. To achieve the previous objectives a successive field experiments were conducted during the agricultural seasons of 1997/98, on transplanting tomato and sweet potato using the transplanter before and after modification.

Some technical performance parameters of the transplanters such as type of transplanter and working forward speed were investigated. Other technical performance indicators were also studied for the two-tested transplanters in comparison with the traditional transplanting.

2- REVIEW OF LITERATURE

2-1. Transplanting methods:

Wilson and Hutton (1983) remembered that there are two common types of transplanting system presently available to the farmers.

a- Conventional hand transplanting.

b- Mechanical transplanting.

Ismail and El-Sheikha (1989) said that there are three common types of transplanting systems; conventional hand transplanting, manual feeding (transporting mechanism with disc types or dick with grabs) and power feeding. Conventional hand transplanting is slow and costly. Also, power-transplanting machines are expensive for small Egyptian farmers.

2-1-1 Conventional hand transplanting:

Splinter and Huang (1968) mentioned that vegetables crops such as tomato, celery, and cabbage as well as field crops such as tobacco and rice are crops of considerable economic importance. These crops must be transplanted into the field. The transplanting operation requires considerable hand labor in the pulling of the plants and setting them in the field. He added that the conventional hand transplanting has the following disadvantages:

1- High labor requirement in a short period of time.
2- Weather hard often causes farmers to miss the best period of transplanting, which will affect on the yield.
3- During the transplanting operation, plant losses are to be expected and missing plants need to be rest; therefor, extra labor is required.

4- Unavoidable human error results in non-uniformity of stands and missing plants, which consequently affects on mechanical harvesting.

5- The human error studies show that error increases exponentially with planting rate, and from a human engineering standpoint, the transplanting speed is definitely limited to less than 1.5mph. (2.4 km/h).

Girst (1974) stated that manual transplanting entails considerable time and labor, expenditure and is extremely tiring. For these reasons, we must use transplanting machines to plant in one individual row about 43–60 seedling per minute, that is 5 to 6 times more faster than by using traditional transplanting.

2-1-2 Mechanical transplanting:

Werken (1991) said that the transplanting of plants is one of the major operation carried out by growers. It is therefore very important to minimize the time and labor involved in this process. For the system to be attractive to the growers, it has to be simple in use, reliable, possess a high transplanting capacity with good quality of the transplanting work and must do all this at reasonable cost.

Huang and Splinter (1968) found that the results of hand transplanting are not always satisfactory, in that the stands may suffer high mortality or non uniformity of growth. As the plant is uprooted for transplanting, the major part of the fine root system supplying the plant with water and nutrients is stripped off. Loss of these roots drastically reduces the absorbing surface of root system.

Nicholes (1977) tested several methods of transplanting and found that, the total labor requirements to transplant 1 ha. (From seedling to transplanting time) were 56 man-hours with power machine system, 95.7 with the manual machine system, and 143.2 for the conventional hand system, but seedlings preparation consumed 36, 46, 23 man-hours per ha. for power, manual transplanter and hand transplanting, respectively. Also, he found that the economical cost for transplanting machines is less than conventional hand transplanting.

Saleh (1990) said that the main objective of mechanization is to increase the out put per man. Mechanized transplanting crops is not only to replace manual work by using mechanical transplanter but also to include systems which would ensure optimum number of plants per hill, number of hills per unit area and planting depth for realizing high yields.

Harb *et al.* (1993) staded the following points:

1- Mechanical transplanters place seedlings more uniform than hand transplanting. The uniformity of placing seedlings by the mechanical transplanters attributed to the transplanting mechanism design more than the operation condition.
2- Mechanical transplanters plant seedlings deeper and roots at uniform depth compared to hand transplanting.
3- The percentage of mechanical damage was 5% for mechanical transplanting and gave the lowest percentage of defective hills.
4- Seedling uniformity helps to use the modern drip irrigation system in the newly reclaimed area.

Harb (1995) compared between methods of planting pepper the compared included direct seed sowing, manual and mechanical transplanting. He indicated importance of mechanical transplanting use for its several advantages such as length of root system, number of secondary roots and rate of branches.

2-2 Vegetables transplanting machines:

Robertson (1974) said that the essential elements of a machine for planting out growing plants are, a furrow opener, mechanism for placing the plant in the furrow and something to press the soil firmly around the roots of the transplant. The furrow opener is in the form of v shaped share, usually adjustable for both width and depth of furrow. The soil firming mechanism common to all planters is a pair of steel wheels commonly around 350mm diameter by 50mm wide. These wheels are placed in the form of an incomplete V at an included angle of approximately 0.523 rad (30 deg.). The bottom of the V share is at ground level and there is an adjustable gap between which the plants can pass. These presser wheels carry the rear of each transplanter unit, together with the weight of the operator who is seated over the top of them (on a standard steel pan seat). The point at which different types of planter vary is in the plant placing mechanism.

Fordham and Biggs (1985) showed that there is a type of machine available for planting bar-rooted transplants. It is usually hand feed but part of the process can be mechanized to increase output. Operators sit on low seats on the tractor-mounted planter and drop each plant directly into a furrow which is then closed by a pair of press wheels. Speeds are slow and will usually be 1 to 2km/h depending on spacing within the row. Planters differ in the number of rows they can handle in one pass but typically consists of two-row systems with one person planting each row and third handing plants to them. Modifications permit operators to place plants into various transfer devices on an endless conveyor, following which remainder of the planting operation is automated. The operation is thus simplified and planting rates can be increased.

Verma (1984) classified mechanical transplanters into two groups, pot type (root washed) transplanter and mat type transplanter, depending upon the type of producing seedlings in the nursery. Pot type is used widely with big seedlings, which is suitable for vegetable crops such as tomato, cabbage and tobacco.

Sugges (1979) recognizing that five or six loading stations were needed to optimize feeding rate, the first design (Fig 2-1) utilized a cross feed belt fitted with divider strips 3.5cm high at 5cm intervals which formed plant pockets. This mechanism was constructed and attached to a Powell transplanter. The belt dropped the plants onto the plant tray which consists of hinged spring loaded fingers which could fold back and allow the cam actuated plant hands to pass through the space and pick up the plants. Plants were placed in an open furrow when arms rotated into their lowest position. This design optimized feeding rate but the transfer from the belt to the plant tray and planting hands caused problems. Most plants were transferred properly but some would hang on the belt or fall onto the near or far edges of the tray where they would be missed or improperly picked up by the planting hands. In the second design, plant transfer was eliminated by causing the plant pockets (plant clips) to move from the loading area to a position directly over the open furrow where the plants were released (Fig 2-2). This was accomplished by mounting the plant clips on a chain which is flexible in two planes. As the vertical strand of chain leaves the planting area it is turned side ways onto a table where the plants are loaded into the clips. The chain is then turned downward to the planting area. Clips, upside down as they leave the planting area, are turned upright

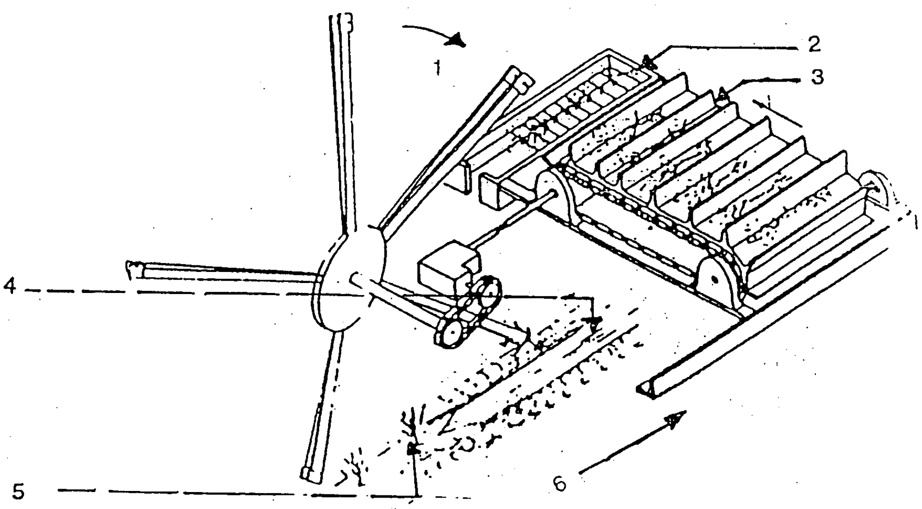


Fig. 2-1: Multiple Loading station transplanter utillzing cross belt and plant transfer.

1- Plant hand
2- Plant tray
3- Cross- feed belts W/dividers
4- Furrow open
5- Furrow closed
6- Direction of travel

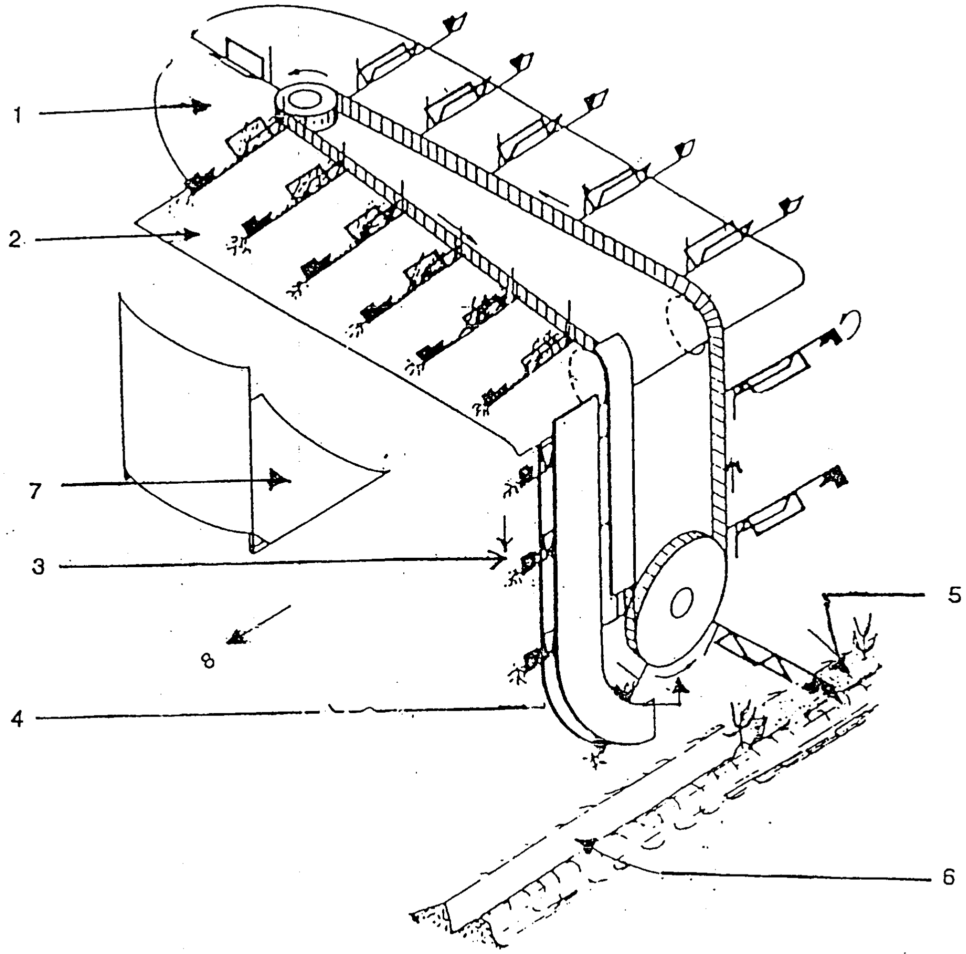


Fig. 2-2: Multiple Loading station transplanter utillzing chain mounted clip which stores and plants seedling without transfer .

1- Table　　2- Clips Loaded　　3- Clips closed
4- Clips opens　　5- Furrow closed　　6- Furrow open
7- Seat　　8- Direction of travel

as they approach the table. As they start down they are prevented from further rotation and closed to hold the plant until it reaches the lowest position where it opens and releases the plant in the furrow just before the soil is pressed around the plant roots.

Chow *et al.* **(1980)** designed a transplanter to transplant lettuce seedlings that had 8.26cm diameter and either 5.08 or 7.62cm tall soil blocks. Their results of the laboratory tests indicated that by increasing both of the forward speed and feeding angle reduced the planting error.

Minglee *et al.* **(1982)** improved the transplanter which was designed by **Chow** *et al.* **(1980).** These improvements included the modification of the original transplanter to use 5cm in height and 3cm in diameter seedling blocks and the addition of an automatic feeding mechanism to eliminate hand feeding of the seedling blocks.

Chen *et al.* **(1982)** found that a conventional mechanical transplanter positions the slips vertically and is unable to handle long slips needed for the horizontal method. Instead of designing a new transplanter an existing transplanter was modified to accomplish the goal of horizontally transplanting long slips. A commercially available transplanter was modified for horizontal transplanting of sweet potatoes. The available transplanter was a Holland transplanter model 1600. The basic parts of this equipment are furrow opener, pockets for plants, packing wheels and automatic watering device. These four parts are mounted onto a common frame attached to the 3 point hitch tool bar.

Plants are placed manually into the transplanting pockets which consists of two rubber plates to hold the plant. The rubber plates are opened and closed with a special spring mechanism. The closing of the rubber

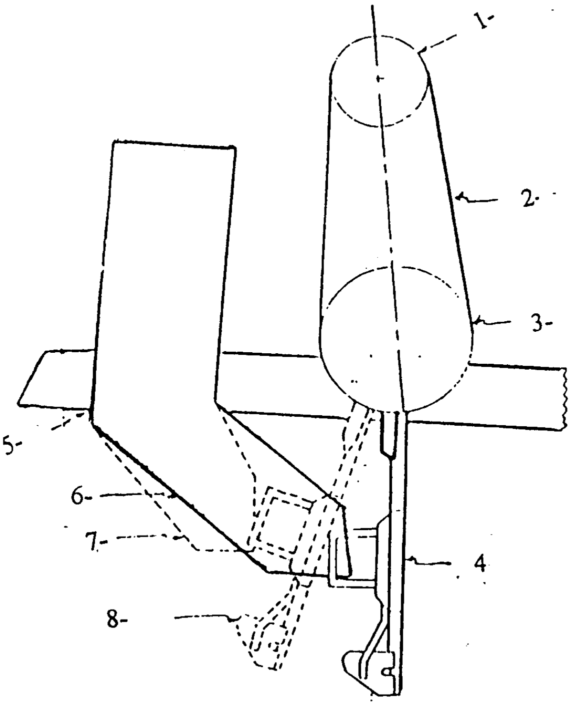


Fig. 2-3: Releasing position of the pocket for the conventional and modified transplanter.

1- Upper conveyor roller.	2- Conveyor chain
3- Drive sprocket	4- Pocket position for vertical releasing
5- Frame	6- Original guide plate
7- Modified guide plate	8- Pocket position for horizontal releasing

plates occurs as soon as the pockets enters two guide plates which compress the spring. When the pocket pass from the guide plates, the spring pressure is released, loosing the rubber plates and releasing the plant to slip from the pocket. Therefore, the releasing time is controlled by the shape of the guide plates. The guide plates of the original transplanter were designed for vertical transplanting. To achieve horizontal transplanting, a modification was made to change the release position of plant. This modification was a change in the guide plate shape, a slotted hole was made in the new plate to fix the plate on the main frame, as shown in Fig. 2-3. The horizontal planting resulted in a yield increase of about 2.6 tons/fed more the vertical planting.

Hawker and Keenlyside (1985) mentioned that one important type of planting mechanism is consists of two flexible steel discs each is mounted at the end of a short shaft and at an angle to each other so that the disc are pressed lightly together over almost half their circumference. The discs positioned vertically and they are driven from the press wheels. The operator can insert a plant in the gap between the discs at the top of their revolution with its root protruding up – wards. As the discs turn they come together, lightly gripping the plant lying between the discs where they are protected and carried around until it is held with its roots in the soil that flows around the roots. The discs are parted as they continue their revolution, releasing the plant plastic markers that can be bolted to one of the discs to indicated the operator where each plant should be inserted (Fig. 2-4).

Bosoi *et al.* (1987) mentioned that the machines according to principle of operation are divided into automatic. semiautomatic and simple machines. Automatic and semiautomatic machines have planting apparatus.

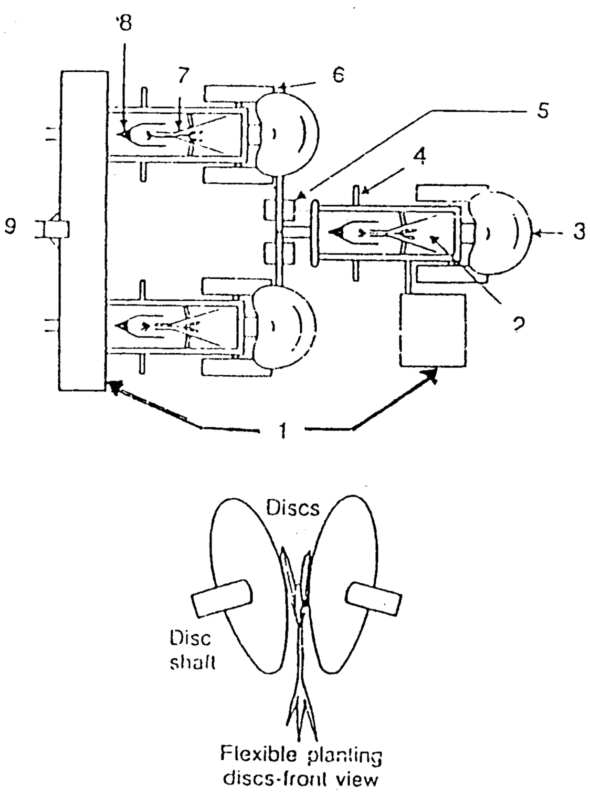


Fig. 2-4: Three-Row Transplanting Narrow-Rows.

1- Racks for carrging plants boxes 2- Plants

3- Seat 4- Foot rest

5- Support wheels and attachment for rear planter

6- Press wheels 7- Planting discs

8- Coulter 9- Attachment points for tractor linkage

According to the method of hitching the machines may be trailed or mounted (Fig 2-5) is a diagram of the transplanter base model SKNB-4A. The machine functions in this way: during the motion of the machine on the field, the boots (6) open the furrow, the seedling is placed in it, water is fed continuously or in portions under the plant roots and then the roots are covered with earth and pressed by covering rolls (5).

According to the planting process, the machine consists of a working part and auxiliary equipment. The working part of the machine is mounted on the three – point linkage of the hydraulic system of the tractor and consists of a frame with carrier driving wheels (9) and four planting sections. Each section in its turn, has a frame on which are mounted a planting apparatus (3) of the tray type with seeding carriers a boot (6), covering rolls (5), a seat (4) for the planter operator, shelves (2) for boxes with seedlings, a ripper (7) and a reduction unit (11). The function of the machine working part is to transplant seedling by the adopted planting method. Auxiliary equipment is mounted on the tractor frame and consists of two tanks (1) for water, the water distribution system (10), the rack attachment (12) and markers (8).

Saleh (1990) tested the possibility of using an original transplanter that, (88000 plant/fed), and modify it to increase the plant density three times more than to reach the optimum plant density/fed. The available transplanter is American disc transplanter Powell, model 15, this machine was designed to set the plant vertically.

A single section is diagrammatically shown in Fig. 2-6. Plants are placed manually into transplanting mechanism which, consists of two spring disc. The transplanter was modified to decrease the spacing between

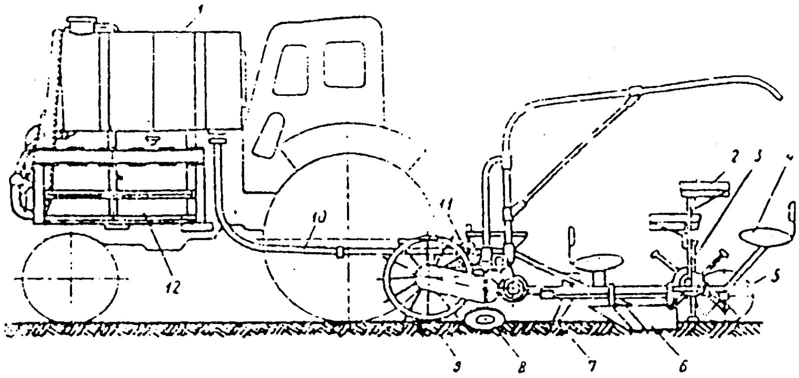


Fig. 2-5: Schematic diagram of the transplanter SKNB-4A.

1- Two tanks	2- Shelves	3- Planting apparatus
4- A seat	5- Covering rolls	6- Poots
7- A ripper	8- Markers	9- Driving wheels
10- Water distribution system	11- Reduction unit	12- Rack attachment

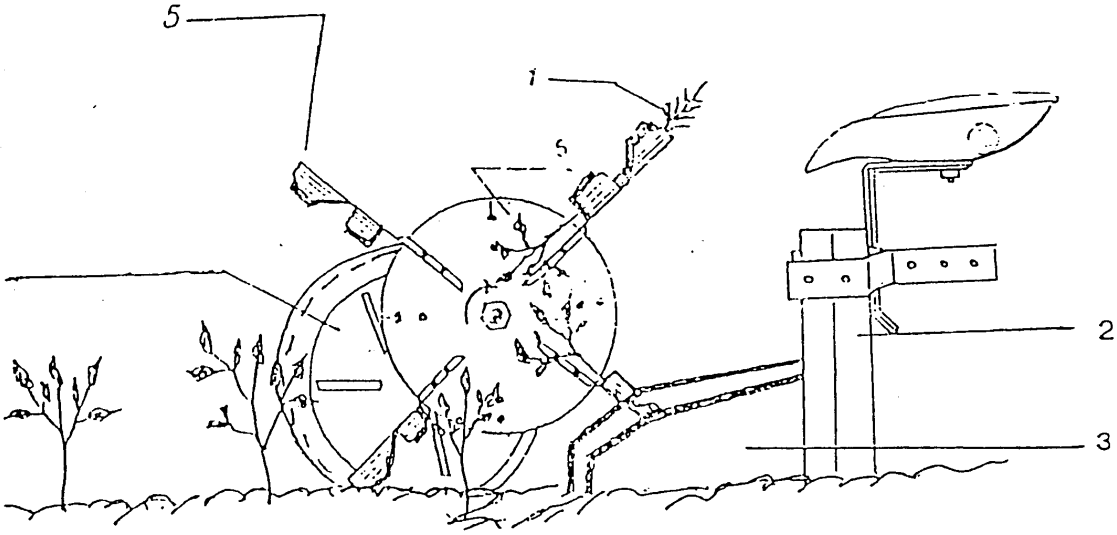


Fig. 2-6: The disc pocket arrangement transplanting mechanism of the Holland transplanter.

1- Plant 2- Fram 3- Furrow opener

4- Press wheels 5- Disc poeket 6- Disk

seedlings hills from 17.8cm to 7.83cm to produce the optimum plant density/fed. He also, investigated the possibility of using rice Japanese transplanter (4-10w walking type, yanmar yp – 400) in onion transplanting. For the duration of the transplanting process the transplanter was adjusted to give 12cm distance between each two alternative hills, and 10x10mm size of kin (portion of seedling). The number of seedlings per hills (3 to 5 seedlings per hill) was considerable unsuitable for producing onion bulbs, while the recommended number of seedlings for each hill is one only, so this machine was unaccountable for use in planting onion seedlings under Egyptian condition.

Werken (1991) developed a finger-tray transplanter as show in Fig. (2-7). A strip containing 20 plants is fed into the machine, after which they are automatically transplanted. The transplanter also collects the empty plastic strips. The transplanting machine consists of a furrow opener (a), with an in built gripper (b) for pulling out the plugs and two press wheels (c), which follow the gripper. The finger-tray strips (d) is fed into the machine at an angle of 45 by a mechanism, which provides a steady feed. When the first plant in the strip has reached point (e) on the diagram, the pendulum gripper (b) removes the first plug of the strip and pulls it together with the plant through the hole. Then the gripper pivots 45° around point (f) on the diagram to a horizontal position, whereupon the plug pusher (h) moves the plug with the plant, in the direction of the press wheels. The gripper can pass the plug pusher strip because the width of this strip is less than the minimum diameter of the plug. In the mean time the strip has been indexed forward ready for the next plug to be pulled out by the gripper.

This process is repeated until the whole strip has been emptied. The strip then curves through 45 to a horizontal position, when it is pushed out

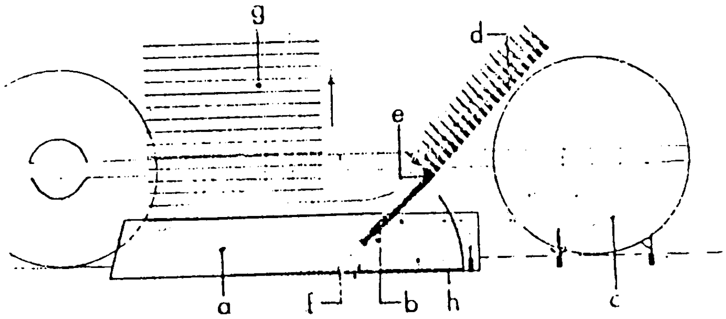


Fig. 2-7: Diagram of the finger-tray transplanting system.

a- Furrow opener

b- pendulum gripper

c- Two press wheels

d- Finger tray strip

e- First plant

f- Gripper pivots

g- Empty tray collector

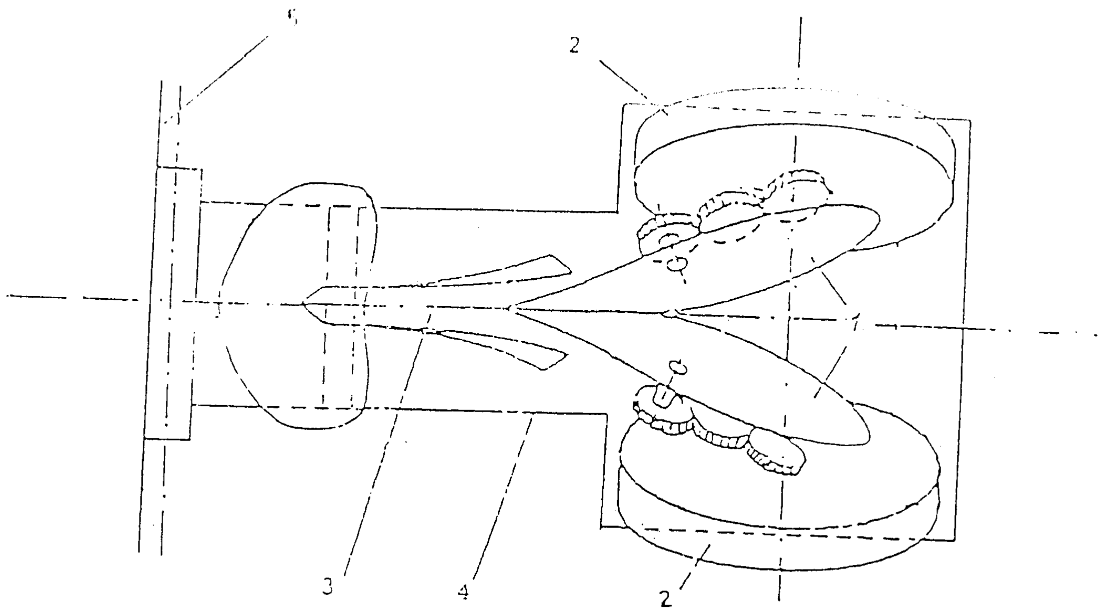
h- Pluge pusher

and deposited in the empty tray collector (g). The transplanter moves forward at a constant speed. The press wheels firm the plugs in the soil. The feeding of the strips into the machine can be carried out by hand or automatically. Pneumatic cylinders are used for all the positioning and indexing movements. The cylinders are controlled by pneumatic valves.

Valve timing is achieved by a camshaft controller one revolution of the shaft corresponds to the planting of one plant in the field. The controller shaft is driven by a variable speed of 12 V, d.c. motor.

Harb *et al.* (1993) compared the mechanical and manual transplanting of tomato. Two types of transplanters were used in their experiments. The first transplanter has a disc pocket arrangement transplanting mechanism and the second transplanter has a flexible disc transplanting mechanism as shown in Fig. 2-8. The results showed that, the coefficient of variation of the in row spacing which represents transplanting uniformity was 7.13, 26.01 and 35.14 for the disc pocket arrangement transplanting, disc transplanter and manual transplanting respectively. The average depth of the seedling roots from the soil surface was 9.4, 9.3 and 5.75 cm for the disc pocket arrangement transplanter, disc transplanter and manual transplanting, respectively.

Namikawa (1996) reported that planting accuracy is affected by pulverization of the field. If there is large size clod, contact between the soil of the field and that of seedling is insufficient and this inferiority affects the plant growth. Leveling of the field is important for avoiding too shallow and too deep transplanting. For the upland transplanter, handling of seedling is important. There are several methods to handle the seedling, as follows.



PLAN

Fig. 2-8: A single section for disk transplanter:

1- Elastic disk, 2- Press wheels; 3- Furrow opener,

4- Frame, 5- Cross beam.

The semi-mechanical method.

The holder type; holder that has a grip with rubber lining is laid on a disk radially or rotating chain. On upper position the grip is opened so seedling is set in the grip (Fig. 2-9). According to the downward movement, part of the grip contacts with the guide plat, then the grip closes and holds the seedling. When the grip approaches the field surface and the seedling leaves from the grip and drops down into the furrow, as following soil is gathered and pressed.

Disk type; A pairs of rubber disks held by spring fingers are opened at the top by a small roller and seedling is inserted. It rotates and approaches the field, and disks open and leaves the seedling (Fig. 2-10). A transplanter to use planting disk is widely used for beet cultivation in Japan, but the structure differs a little.

Horizontal rotary disk type; seedling is fed by hand on the feeding disk that rotates horizontally then dropped form the holder. The holder pushes in the field and then seedling is dropped and covered by the soil (Fig. 2-11). The semi-mechanical type is necessary for handling of the seedling by the operator, so travelling speed is limited by handling speed and it is about 0.2 - 0.5m/s (0.72 - 1.8 km/h).

The mechanical method.

This machine does not require human work for feeding the seedling. Seedling is raised on the soil block made by paper partition, and the transplanter tine to generate elliptic locus takes up this seedling and sets it in the hole is made by reciprocating finger. In some machines, one seedling is pushed out from the soil block or cassette and transplanted by pincette type finger or dropped on the furrow.

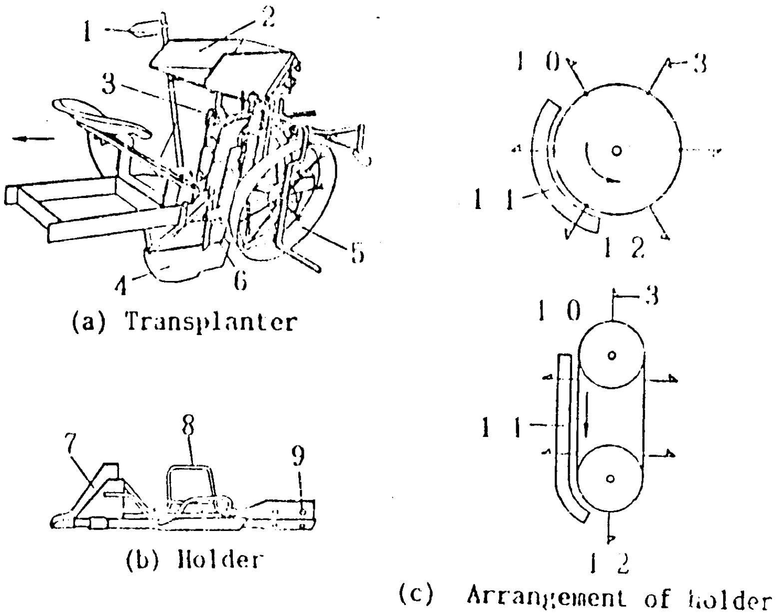


Fig. 2-9: Holder type transplanter.

1- Marker,	2- seedling hopper	3- Holder
4- Opener	5- Press wheel	6- Nozzle for irrigation
7- Grip	8- Lever for opening and shuttering	
9- Fitting hole	10- Feeding of seedling	11- Guide
12- Setting to field.		

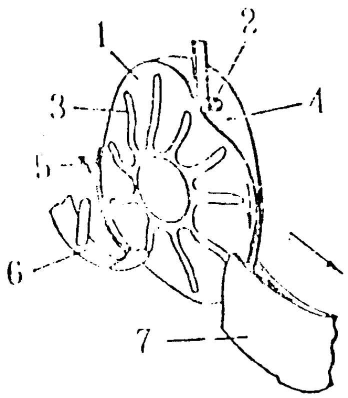


Fig. 2-10: Planting wheel for transplanter.

1- Flexible rubber disk
2- Spreading rollers
3- Spring
4- Insertion point
5- Bracket for lower spreading rollers
6- Press wheel
7- Furrow opener

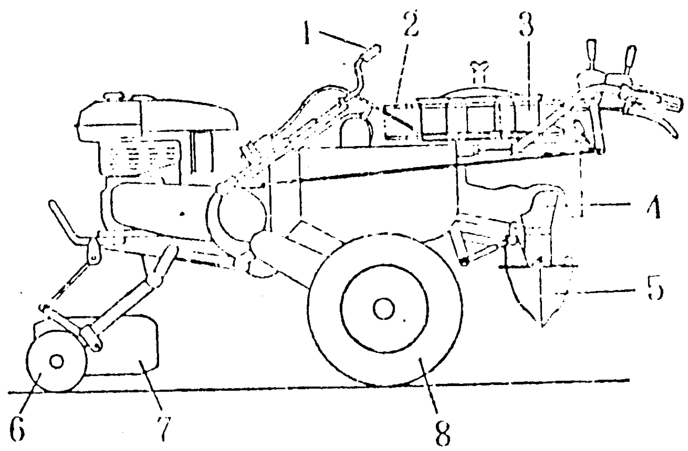


Fig. 2-11: Hopper type transplanter.

1- Handle
2- Seedling hopper
3- Seedling cup
4- Seedling pipe
5- Planting hopper
6- Front wheel
7- Guide
8- Wheel tyre

Mansour (1997) used two semi automatic transplanters to transplant onion seedlings. The first transplanter (Holland type) was designed to transplant vegetables seedlings and the second was Lannen roulette transplanter, it intended for transplanting ball seedlings on well prepared fields. The results showed the following points:

1- Stand plants density were 37.63 and 31.15 plant/m for Holland and Lannen roulette transplanter, respectively.
2- Total yield by Holland and Lannen roulette transplanter were 11.87 and 9.73 Mg/ fed, respectively.
3- The power requirements were 14.2 and 13.18 kW for Holland and Lannen roulette transplanter, respectively.
4- The row deviation for Holland transplanter was 19.96% and it was 21.88% for Lannen roulette transplanter.

2-3 Effect of transplanter forward speed:

Chow *et al.* (1980) tested a hand feed chute type transplanter. The results indicated that decreasing the speed and increasing the angle of feeding a limited planting error (3%) at planting rate of 9500 plan/h for 30.5cm planting spacing.

Ismail (1981) designed and tested a manual feeding transplanter. The machine was reported by **Hamad *et al* (1983)** their experimental results showed that, increasing transplanter forward speed and soil moisture content increases seedling damage, faulty in planting and feeding losses. The maximum field efficiencies were obtained at ground speed of 0.6km/h. soil moisture content of 22% and feeding rate of 1.1 hill/s. Under these conditions, the field efficiency was 68%.

Ismail and El-sheikha (1989) concluded that the optimum operating condition for a manual transplanting machine is feeding rate of 60 seedling/min and 20cm long of feeding zone peripheral speed (Vs) of 0.6m/s and travelling speed (Vm) of > 0.46, < 0.75 m/s and v_s/v_m ratio of > 0.8, < 1.3 are used.

Culpin (1992) said that hand-fed planters must normally be pulled very slowly, speeds as low as 1 to 2 km/h (0.625 to 1.875 mph) often being called for. The forward speed at which any planter can work naturally depends on the spacing of the plants and on the number of operators who can work on one row.

Harb *et al.* (1993) showed that the ground speed of 0.9 km/h was suitable for transplanting tomatoes seedlings by using mechanical transplanter. At this speed the field efficiency was 56%.

Mansour (1997) found that increasing the transplanter forward speed decreases both plant density and total yield. Also, he added that the effective field capacity increased by increasing forward speed, but the field efficiency decreased.

El-Hadidi *et al.* (1998) advised producers of tomato crops for better results of yield and appropriate level of operation costs to use the transplanting machine with forward speed of 1.0km/h, which reduced the human planting error (4.7%), damaged hills (0.4%), and produced a proper transplanting efficiency which was 91.9%. Also, in the meantime this speed consumed energy of 79.78 kWh/fed.

Metwalli *et al.* (1998) evaluated the performance of some planting machinery of sugar beet. The experimental results showed that by increasing transplanter forward speed from 0.97 to 3.55 km/h, the longitudinal scattering increased from 2.75 to 18.92cm and transverse scattering increased from 2.1 to 7.89cm. Also, they found the number of plants per squared meter decreased by increasing transplanter forward speed.

2-4- Effect of distance between hills:

Work and Carow (1955) said that tomatoes are spaced at widely ranging distances according to varieties and soils; Short-branching early varieties may be set as closely as 2 by 3 feet. Most varieties call for 12-18 square feet per plant. It has been shown that close spacing increases yield with no harm to the product. It is wise to make spacing between the rows wider than in the rows, for example, 2.5 by 6 rather 4 by 4 feet. This is desirable for weed control, for economy in spraying and for convenience and avoidance of damage to vines in picking. Spacing 3 by feet requires about 2900 plants per acre. They added for planting sweet potatoes the field is marked out with rows 3 to 4 feet a part, adjusting according to variety, soil fertility, and moisture supply. Spacing in the row varies from 9 to 18 or 24 inches. Close spacing is desirable in rich soil, otherwise roots are likely to be too big, a serious market defect.

Gautz *et al.* (1974) showed that narrow rows and plant spacing can increase lettuce yield per acre, but spacing too closely will lengthen the time for the plant to reach maturity and may decrease the quality of lettuce in terms of head density and size. Therefore, close planting tolerance is necessary if close plant spacing is to be beded.

Eunis *et al.* (1974) indicated that when onion were transplanted at spacing of 5, 10, 15 or 20cm in row and 20 cm a part between rows, the closest spacing produced the highest yield.

Moustafa (1979) indicated that the greatest yield (13.7±0.09) Mg/fed for marketable onion bulbs was obtained from transplanting onion at 5 to 7.5 cm distance between seedlings on row, while the wider spacing 10cm between seedlings caused a significant decrease in marketable yield of onion bulbs (9.57 Mg/fed).

El-Shamma (1980) found that widening distance between pepper plants from 35 to 45cm enhanced the growth and dry matter content of pepper plant. Reducing distance between pepper plants from 45 to 35cm decreased the growth and dry matter content of pepper plants.

Mohamed (1982) reported that distance between rows or ridges and distance between plants in the row depends on the following parameters:-

a) variety of plants,

b) type of soil,

c) method of planting (mechanical or manual) and

d) available moisture content (water).

Bosoi *et al.* (1987) mentioned that the plant should be transplanted vertically (permissible deviation from the vertical is not greater than 15^{o}). Plant rows must be straight; allowed deviation of the main rows should not be greater than ± 2 - 4 cm. Deviation from the cross rows in case of square planting is ± 2-4cm. Deviation of separate plants from the row axis must not exceed ± 3cm. Deviation of the distance between plants must not be greater than ± 1cm in planting with a step up to 20 cm and ±2 cm for planting with a step greater than 20 cm.

Legess (1996) said that in a field experiment in 1990-93 at Awasa and Areka, sweet potatoes were planted at inter row spacings of 20, 30, 40 or 50cm and inter row spacing of 20, 40, 60, 80 or 100 cm. At both cities, tuber yields were highest at row spacing of 20 x 20cm (34.7 Mg/ha at Awasa and 17.6 Mg/ha at Areka). Another experiment investigated the effect of planting a whole vine or 1, 2, 3 or cut vines with double nodes.

Data are not presented, but it is reported that planting 2 cut vines slanted at 0.785 rad (45°) gave the highest plant population and yield.

2-5 Ridges:

Bernacki (1972) said that certain root crops (especially potatoes) are cultivated in ridges. Ridging is carried out with a view to pulverizing soil and to heaping it along the plants, which then produce a higher number of stolons and set more tubers. At the same time, ridging destroys weeds. Also, He showed that the speed of travel of the ridger exerts a certain influence on the shape of ridges. The ridges are more uniform at higher speeds, since there occurs more significant shifting to the sides of the pulverized soil by means of furrowers. Sharp ridge is produced at higher speed of travel which is undesirable because then the stolons in the lower parts of the ridge might be laid bare. The profile of the ridge should be gently rounded. The furrower should not compact the bottom and the sides of the ridge. The ridge surface should be uniformly slightly pulverized after ridging operation to prevent water evaporation.

Krause *et al.* (1984) mentioned that a large number of crops, such as potatoes, groundnuts, maize, sunflowers, sugar beet, cotton and many types of vegetables, are grown on beds or ridges. The ridges (and furrows) are usually formed immediately before sowing or planting but can also be constructed after the previous crop has been harvested. Small ridges may even be created during the growing period, e.g. as part of the weeding operation. The tillage operation employed to construct the ridges may be carried out for various reasons:

- Water and temperature control in the soil;
- Furrow irrigation;
- Erosion control; and
- To improve the efficiency of the harvesting methods.

2-6. Economical evaluation:

Bowers (1975) mentioned that total cost of performing a field operation includes charges for the implement, the tractor power utilized and labor. Implement and tractor costs are divided into two categories: fixed costs and variable costs. Fixed costs are related to machine ownership and occur regardless of whether or not the machine is used, and include depreciation, interest, taxes, insurance, and shelter. Operating costs are directly related to the amount of use, and include repairs and maintenance, fuel and lubricants, and labor.

Kepner ***et al.*** **(1982)** illustrated that the machine costs can be market out on the basses of two items.

(A) Fixed costs. (B) Variable (operating) cost.

Fixed costs include:

(a) Depreciation,

(b) Interest on capital, and

(c) Housing and insurance,

Variable costs include:-

(a) Labor costs;

(b) Fuel and lubricant costs; and

(c) Repair and maintenance costs.

El-Saharigi *et al.* (1991) indicated that mechanical sowing and transplanting of onion have lower cost than hand sowing or transplanting. The costs of manual transplanting of onion are about 1.25 times larger than using 2 row transplanter. Also, about 2 times larger than that when using 3-row transplanter, and about 2.22 times larger than when using 5-row transplanter. They recommended to use mechanical sowing or transplanting methods for obtaining high yield and minimizing cost.

Harb *et al.* (1993) showed that cost of manual transplanting of tomato was 36 LE/ fed and the cost of mechanical transplanting was 67.25 LE/fed.

Mansour (1997) found that the costs of transplanting onion were 111.27 and 140.57 LE/fed by using Holland and Lannen roulette transplanters, respectively. In relation to the manually transplanting, the cost was 155LE/fed.

El-Hadidi *et al.* (1998) remembered that the costs of transplanting tomato by using transplanting machine was 88.82 LE/fed, and was 210 LE/fed in tomato planting manually.

3- MATERIALS AND METHODS

The field experiments were carried out at the Research farm of the Faculty of Agriculture, Kafr El-Sheikh Governorate, Egypt during season of 1997/1998. The aim of the present work was to modify the vegetable transplanter and study its performance before and after its modification over flat and furrow lands. The experiment field prepared by using chisel plough twice followed by rotary tiller and then leveled by hydraulic scraper to create an ultimate smooth surface. All agricultural practices such as fertilizing, irrigation and pest control were performed in a similar manner to that commonly practiced at the Egyptian farms. The soil samples were taken from the experimental area and analysis in the laboratory. The mechanical analysis data of the experimental soil are shown in Table 3-1.

Table 3-1. The mechanical analysis of the experimental soil.

Particle size distribution, %				$Caco_3$, %	Soil textural class
Clay	Silt	Fine sand	Coarse sand		
38.2	33.8	22.78	2.22	3.0	Clay loam

Tomato and sweet potato crops were used in the present study and transplanted at the end of April 1998.

The seedlings of tomato and sweet potato, which used had some qualifications as shown in Table 3-2.

Table 3-2. Some qualifications of tomato and sweet potato seedlings:

Crops	**Variety**	**Qualifications of seedlings**	
		Average height, cm	**Average thickness, mm**
Tomato	Supper streen	17	3
Sweet potato	Abes	22	5

Traditional (Manual)				Transplanter before modification T. B. M				Transplanter after modification T. A. M				Treatment
D_4	D_3	D_2	D_1	D_4	D_3	D_2	D_1	D_4	D_3	D_2	D_1	
											R_1	S_1
											R_2	
											R_3	
												S_2
												S_3

D- Transplanting distances for mechanical and traditional method.

S- Operating speed (3 speeds for mechanical transplanting).

R- Replicates (3 replicates for mechanical and manual transplanting)

Fig. 3-1 : split-split plot design for field experiments.

The experiments were carried out as split-split plot design as shown in Figure 3-1. Since the main plots was transplanting machines, sub plots were transplanting forward speed and the sub-sub plot to transplanting distances.

3-1 MATERIALS:

The materials used in the present study are indicated as follows:

3-1-1 Transplanter:

The available transplanter is an American made transplanter. The transplanter as shown in Figure 3-2 was designed to set the seedling vertically and its specifications are indicated in Table 3-3.

The basic parts of the equipment are; furrow opener, pocket for plants, packing wheels and plant boxes. These parts are mounted onto a common frame attached to the 3-point hitch tool bar. Plants are placed manually into the transplanting pockets that consists of two rubber plates in order to hold the plant. The rubber plates are opened and closed by using a special spring mechanism. The closing of the rubber occur as soon as the pocket enters two guide plates which compress the spring. When the pocket passes from the guide plates, the spring pressure is released, loosening the rubber plates and releasing the plant to slip from pocket and remain it in the soil. The transplanter consists of two transplanting units.

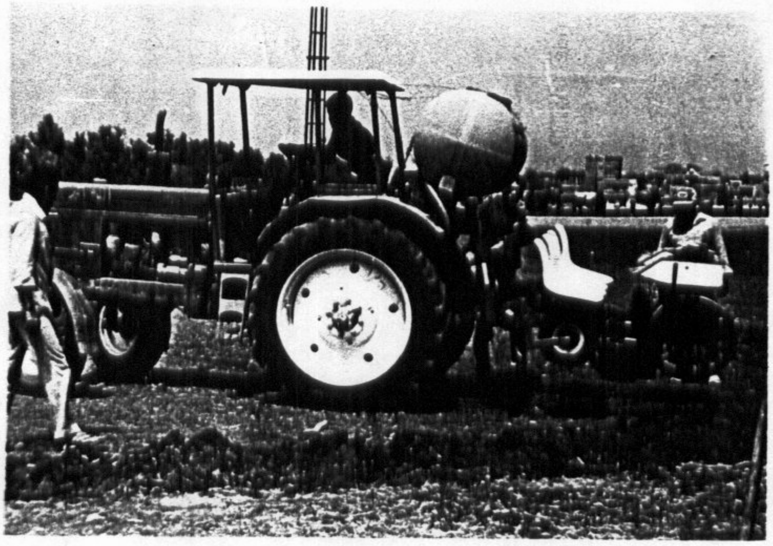


Fig. 3-2: The Holland type transplanter before modification.

Table 3-3: The specifications of the transplanter used.

Specification	Transplanter
Manufacture	U. S. A
Model	Holland type 1600
Total length, cm	130
Total width, cm	245
Total height, cm.	90
Total mass, kg.	150 Before modification 174 After modification
Hitching type	3 Point
Number of units	2
Wheel rim diameter, cm.	60
Radius of pocket arm, cm	32

3-1-2: The agricultural tractor:-

40.4 kW Fiat tractor was used to pull the transplanter during field experiments. Its specifications are shown in Table 3-4.

Table 3-4: The specifications of the tractor used.

Specification	Tractor
Manufacture	Italy
Model	Fiat 55-66 Dt
Power, kW	40.4
Total length, cm.	328
Total width, cm.	144.5
Total height, cm	240.5
Total mass kg.	2600
Hitching type	3 Point
Number of cylinders	3

3.1.3. Measuring instruments:

The following measuring instruments were used in the present study:

a) Stop watch: to measure the operation time, turning time, adjusting time ... etc for all treatments.

b) Measuring tape: 30-meter length and 1cm accuracy.

c) Blastic rope: four blastic ropes 25meter length each were used to show the desired interplant distances in manual transplanting.

d) Graduated steel tank: to measure the fuel consumption.

e) Balance (Reading up to 20 kg and its accuracy is 1 g) used to estimate mass of sweet potatoes and tomatoes yield.

3-2 METHODS

The aim of the present work was to modify the vegetable transplanter and study its performance in order to use it to seedling both of tomato and sweet potato on flat and furrow land.

3.2.1. Modification operation:

The vegetable transplanter was modified to transplant seedlings and built ridges or furrow in one operation. The following procedure was done to modify the transplanter. Three ridging units were added at the front of the transplanter to built ridges as shown in Figure 3-3. These units can be removed and adjusted to obtain a suitable distance between ridges (80 cm in the present study).

3.2.2. The distance between hills within the row:

The distance between hills within the row was adjusted by changing both of pockets number on the transplanting mechanism and number of

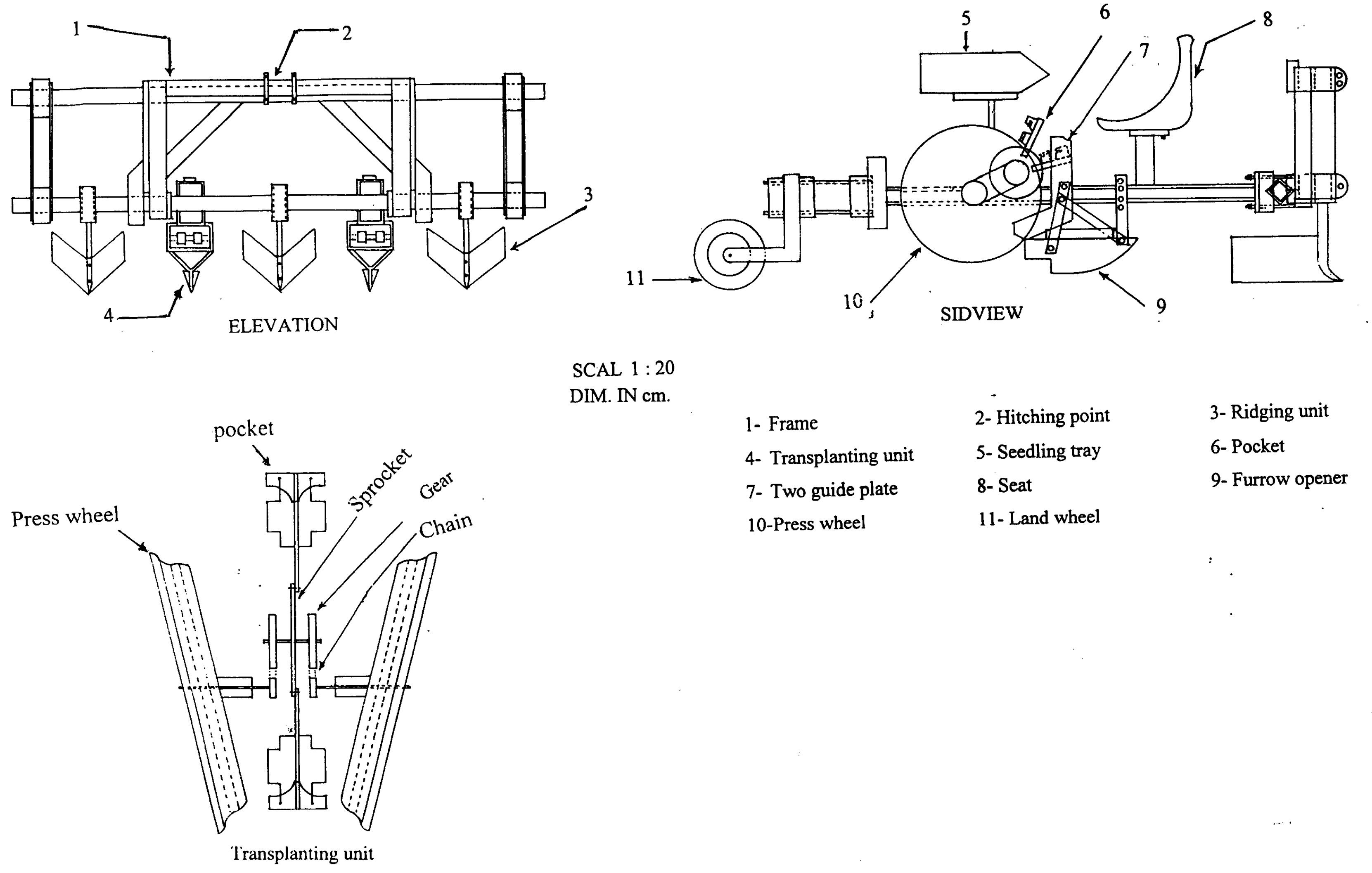


Fig. 3-3: The Holland type transplanter after modification.

sprocket teeth on the packing wheels. The present work included on four different of distances between hills with in the row as follows:

a) 27, 31, 34, and 38 cm for tomato that obtained by using 6 pockets on the transplanting mechanism and using sprockets have 7, 8, 9 and 10 teeth
b) 18, 23, 25, and 28 cm for sweet potato, which obtained by using 8 pockets on the transplanting mechanism and using sprocket, have 7, 9, 10 and 11 teeth.

The previous distances were also used to transplant tomato and sweet potato manually by using four blastic ropes.

3.2.3. Forward speed:

Three transplanting forward speeds were used in the present work. Their values were 0.9, 1.5 and 2 km/h which obtained by measuring elapse time of travelling distance for twenty five meters long.

3.2.4. Measurements:

The experiments were conducted to study the effect of transplanting forward speed on the performance of modified vegetables transplanter. The performance of vegetables transplanter which used in the present work as follows:

3-2-4-1 Longitudinal scattering:

The distance between 20 hills along the row for all treatments was measured. The Longitudinal scattering of seedlings placement was determined statistically by the standard deviation of the distance between seedlings with in the row by using the following formula.

$$\xi_{n-1} = \sqrt{\frac{\Sigma x^2 - (\Sigma x)^2/n}{n-1}} \qquad (1)$$

Where:

ξ_{n-1} = Standard deviation cm.

X = Distances between hills with in the row, cm.

n = Number of observaitbn.

3.2.4.2 Transverse scattering:

Transverse scattering was calculated by the same method mentioned with longitudinal scattering, but around the centerline of row. **(Metwalli *et al*, 1998)**

3.2.4.3 Seedling depth:

20 seedlings pulled out randomly from the soil and measured the seedling depth.

3.2.4.4 Missing hills:

The percentage of missing hills were calculated by using the following formula (Hossary, 1980).

$$M_R = \frac{N_m}{N_{th}} x100 \qquad (2)$$

Where :

M_R = Missing hills, %,

N_m = Number of missed hills/m^2 and

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

3.2.4.5 Crop yield:

The following procedure was done to estimate the total crop yield.

For sweet potato the whole of crop was harvested in one time after 150 day from transplanting date. Tomato crop was harvested 4 times. The period between each time was a week. The yield of tomato and sweet potato was estimated by kg per square meter and then transferred into Mg/feddan.

3.2.4.6 Slip ratio:

It was calculated for the tractor and transplanter according **RNAM** and **ESCAP (1983)** as follows:

$$S = \frac{A - B}{A} \times 100 \qquad (3)$$

Where:

S = Slip ratio, %,

A = Distance of 10 revolutions of wheel without load, m and

B = Distance of 10 revolutions of wheel with load, m.

3.2.4.7 Fuel consumption rate:

The following procedure was followed to measure fuel consumption rate through transplanting operation:

1- The tank was completely filled with fuel.

2- The transplanting operation was carried out, the time needed was recorded with a stop watch, and transplanting area was also calculated.

3- After the transplanting operation had been, the fuel consumption (F_1) was measured by using a graduated steel tank which connected between the injection pump and fuel filter.

4- The fuel tank refilled completely again and the consumed fuel (F_2) for tractor with out tranplanter was measured.

5- The net fuel consumption for transplanting operation was calculated as follows:

$$F.c = \frac{F_1 - F_2}{T} \times C \qquad (4)$$

Where:

F. c = Net fuel consumption rate l/h;

F_1 = Volume of fuel consumed through transplanting operation, cm^3,

F_2 = Volume of fuel consumed, cm^3;

T = Required transplanting time in sec and

C = constant equals to 3.6.

3.2.4.8 The field efficiency:

The field efficiency was calculated by using the following formula

$$\eta = \frac{E.F.C}{T.F.C} x100 \qquad (5)$$

Where:

η = Field efficielcy %,
E. F. C = Effective field capacity, Fed/h. and
T. F. C = Theortieca l field capacity, Fed/h.

3.2.4.9 The effective field capacity:

The effective field capacity determined from the following formula

Where:

$$AFC = (T)^{-1}, Fed/h \qquad (6$$

T = Effective transplanting time per feddan in hours.

3.2.4.10 Estimation of theoretical field capacity.

The theoretical field capacity was determined by using the following formula:

$$T.F.C = \frac{W \times S}{4200} \times 10^3, \text{Fed/h} \qquad (7$$

Where:

T. F. C = Theoretical field capacity, fed/h;

W = Rated width of transplanter, m and

S = Forward speed, km/h.

3.2.4.11 Power and energy requirement:

Estimation of the required engine power (E. P.) for transplanting operation carried out by accurately measuring the decrease in fuel level in the fuel tank. The following formula was used to estimate engine power (Embaby, 1985)

$$E.P. = \frac{F.C}{60 \times 60} \rho_f \times L.C.V. \times 427 \times \eta_{th} \times \eta_m \times \frac{1}{75} \times \frac{1}{1.36}, \text{ kW.} \qquad (8)$$

Where:

$F.C.$ = Fuel consumptio n, l/h,

ρ_f = Density of fuel Kg /l (0.85) for diesel fuel;

L.C.V = Lower calorific value of fuel, kcal/kg $= 10^4$;

η_{th} = Thermal efficiency of the engine, it is about 35% for diesel engine and

η_m = Mechanical efficiency of the engine, it is about 80% for diesel engine.

The energy requirement were estimated by using the following formula (El-Hadidi, et al. 1998)

$$\textit{Consumed}\ \text{energy} = \frac{\text{E.P}}{\text{E.F.C.}}, \quad \text{kW h/fed.} \qquad (9)$$

Where :

E.P = Engine power kW and

E. F. C = Effective field capacity, fed/h.

3.2.4.12. Cost analysis and benifit:

In the present study, the cost analysis was performed considering the conventional method of estimating both fixed and variable costs.

Fixed costs:

1- *Depreciation* was calculated by using sum of the years-Digits method. In this method the depreciation value is different for each year of the machine life.

$$D = \frac{L-n}{YD}(P-S) \qquad (10)$$

Where:

D = Depreciation value,

YD = Sum of the years-Digits,

P = Purchase price,

S = Salvage price (normally 10% of purchase price),

L = Machine life in years and

n = Number representing age of the machine in years from a begnning year.

2- *Interest,* was calculated by using the following formula.

$$\text{Interest} = \frac{P+S}{2} \times r \qquad (11)$$

Where:

$\frac{P+S}{2}$ = Average investment and

r = Interest rate.

3- *Taxes, insurance and housing* were considered to be 2% of purchase price.

Calculation of variable costs:

1- Fuel cost was calculated by multiply mean fuel consumption rate of the transplanter (litre/fed) x fuel price (L E/ litre).

2- Grease and lubricant consumption per feddan was calculated as 15% of the fuel cost per feddan (L E/fed) **(Bowers, 1975).**

3- Repair and maintenance cost was calculated as a percentage of depreciation. The percentage of 100% was used in the present study. **(El – Hadidi *et al* 1998).**

4- The cost of labor was calculated according to the frequent wage rate for local labours which was found to be 1.5 L. E/h

5- The following assumption were considered:

- Price of Fiat tractor (40.4 kW) = 40000 L E.
- Price of Holland transplanter (non-modified transplanter) = 3000 L E.
- Price of modified Holland transplanter = 3200 L E.
- Interest rate = 12%.
- Number of working hours for tractor per year = 1000.
- Number of working hours for transplanter per year = **1000 (El Hadidi *et al,* 1998).**
- Fuel price = 0.4 L E/ l (Desiel fuel).

6- Manual transplanting cost = Labor cost (LE/h) x number of labors/Effective field capacity (Fed/h).

Net benefit:

To calculate the benefit, LE/fed, for different transplanting methods the following equation is used:

$$P = yn \times d - Ct, \text{ LE/fed.} \qquad (12)$$

Where:

P = Net benefit for different transplanting methods;

y_n = Net crop yield, Mg/fed,

d = crop price, LE/fed, and

Ct = Total cost, LE/fed.

4- RESULTS AND DISCUSSION

The experimental observation was used to evaluate the performance of vegetables transplanter after and before modification comparing with traditional transplanting (manual transplanting). The present study was carried out to indicate the effect transplanting forward speed on the performance of vegetables transplanter as follows:

4.1. Effective field capacity:

Figure 4 -1 shows that the effective field capacity was affected by transplanting forward speed. It can be noticed that the effective field capacity increased from 0.2164 to 0.2298 fed /h by increasing transplanting forward speed from 0.9 to 1.5 km/h, and increased to 0.2564 fed/h when transplanting forward speed increased to 2.0 km/h in case of transplanter after modification (T. A. M). Increasing transplanting forward speed from 0.9 to 1.5 km/h tended to increase the effective field capacity from 0.2222 to 0.2392 fed/h. Also, the effective field capacity increased to 0.2631 fed/h by increasing transplanting forward speed from 1.5 to 2.0 km/h in case of transplanter before modification. It is clear that, the average values of effective field capacity in case of transplanter after modification slightly less than the average values in case of transplanter before modification because the transplanter weight increased when ridgers units added and the soil resistance increased consequently.

4.2. Field efficiency:

Figure 4-1 shows that the transplanting forward speed had an opposite effect on field efficiency and illustrated that the greatest value of field efficiency in case of transplanter after modification 63.13% was obtained

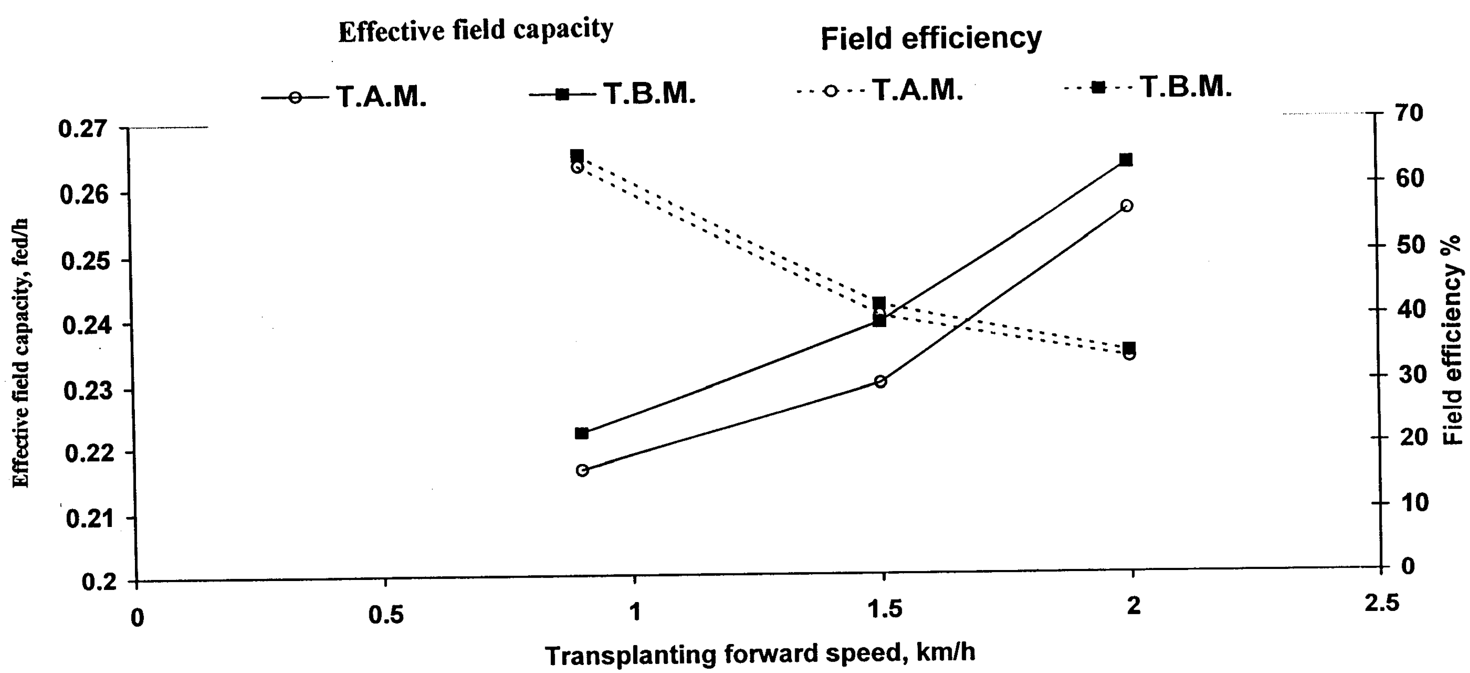


Fig. 4-1: Effect of transplanting forward speed on transplanter field capacity and efficiency before and after modification.

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under transplanting forward speed of 0.9 km/h. While increasing transplanting forward speed from 0.9 to 1.5 and 2.0 km/h were followed by a decrease of about22.91 and29.48 % in the field efficiency. On the other hand the results indicated that the greatest value of field efficiency in case of transplanter before modification was 64.82% obtained under transplanting forward speed of 0.9 km/h. While the field efficiency decreasing by22.96 and30.29 % when transplanting forward speed increased from 0.9 to 1.5 and 2.0 km/h, respectively. In general, increasing of transplanting forward speed tends to decrease in the field efficiency, because the increasing rate in effective field capacity was less than the increasing rate in theoretical field capacity. Intersect between effective field capacity and field efficiency curve as shown in Figure 4-1 gave the optimum transplanting forward speed. The optimum values of transplanting forward speed were 1.55 and 1.62 km/h for the transplanter before and after modification, respectively.

4.3. Fuel consumption rate:

Figure 4-2. Illustrate the effect of transplanting forward speed on fuel consumption rate for the transplanter before and after modification. The values of consumption rate in case of transplanter before modification were 21.59, 20.69 and 19.95 l/fed at transplanting forward speeds of 0.9, 1.5 and 2.0 km/h, respectively. While these values were 22.57, 21.75 and 20.68 l/fed for transplanter after modification at the previous transplanting forward speed. Commonly, the fuel consumption rate l/fed decreased by increasing transplanting forward speed as a result of effective field capacity which, increased by increasing transplanting forward speed. Table 4-1 Shows the relationship between transplanting forward speed and fuel consumption rate l/h.

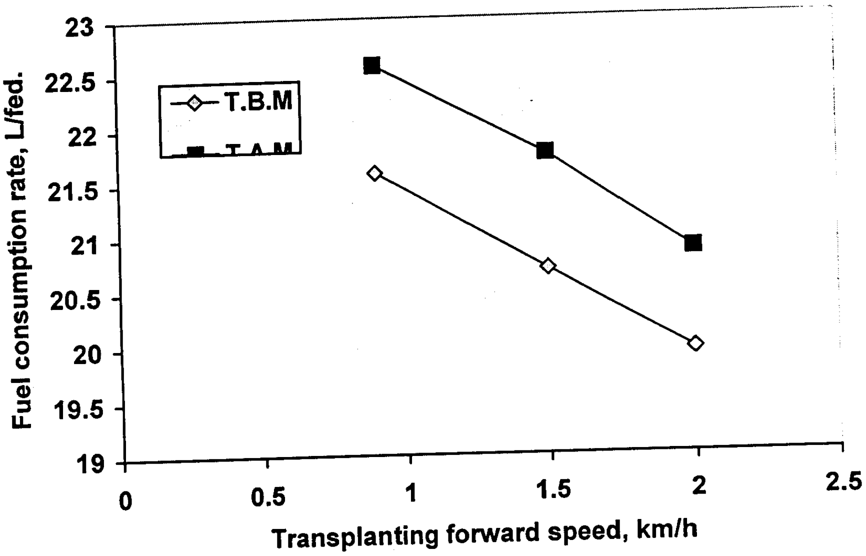


Fig. 4-2: Effect of transplanting forward speed on fuel consumption rate for the transplanter before and after modification.

Table 4-1: Effect of transplanting forward speed on fuel consumption rate (l/h) for the transplanter before and after modification.

Transplanting forward speed, km/h	Transplanter	
	Before modification	After modification
0.9	4.79	4.885
1.5	4.95	5.0
2.0	5.25	5.35

It can be noticed that the fuel consumption rate l/h in case transplanter after modification was higher than the fuel consumption rate in case of transplanter before modification because the modified transplanter built ridges and transplant seedlings in one operation. The values of fuel consumption rate in case transplanter before modification were 4.79, 4.95 and 5.25 l/h, at transplanting forward speeds of 0.9, 1.5 and 2.0 km/h, respectively. While these values in case transplanter after modification were 4.885, 5.0 and 5.35 l/h at the previous transplanting forward speed.

4.4. Power requirement:

Figure 4-3 declared that the power requirement needed for transplanting operation tended to increase by increasing transplanting forward speed for the transplanter before and after modification because the fuel consumption rate l/h, increasing by increasing transplanting forward speed. The results showed that the values of power requirement in case of transplanter after modification was higher compared with the values in case of transplanter before modification. The average values of power requirement for modified transplanter were 13.519, 13.838 and 14.807 kW at transplanting forward speed of 0.9, 1.5 and 2.0km/h, respectively. These

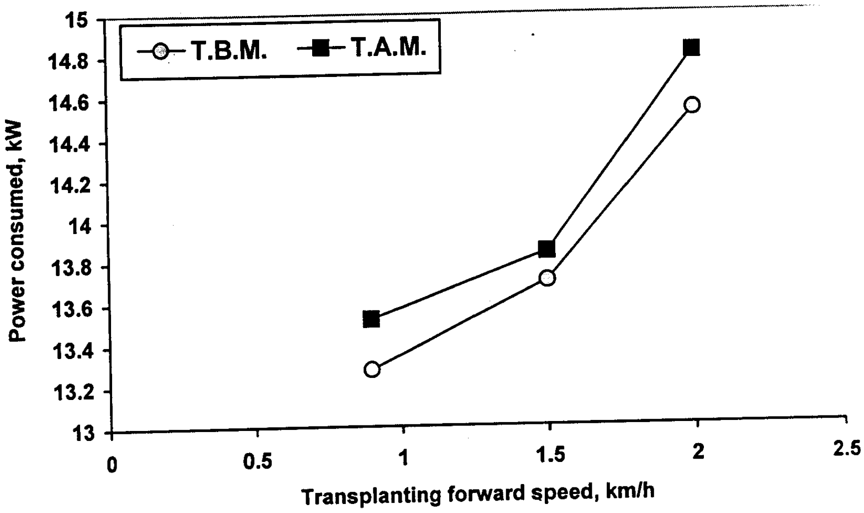


Fig. 4-3: Effect of transplanting forward speed on power consumed for the transplanter before and after modification.

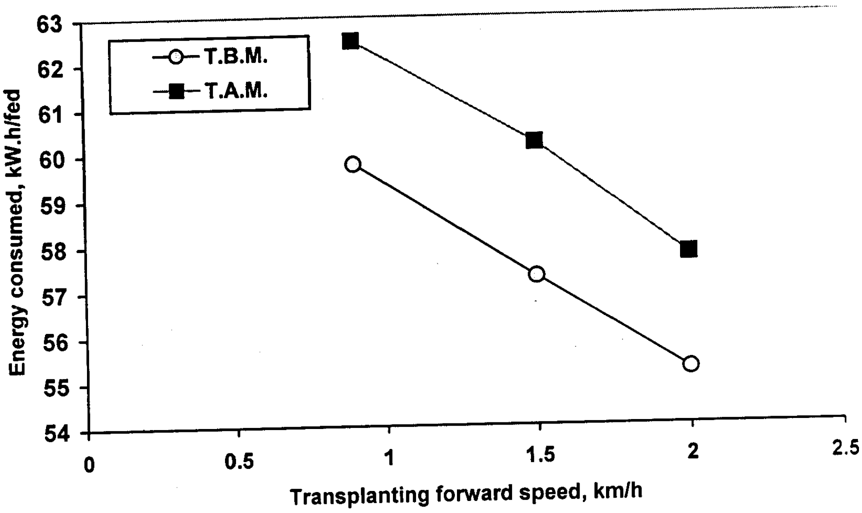


Fig. 4-4: Effect of transplanting forward speed on energy consumed for transplanter before and after modification.

values were 13.276, 13.699 and 14.529 kW for the transplanter before modification at the previous transplanting forward speeds.

4.5. Energy requirement

Figure 4-4 illustrates the relation between transplanting forward speed and required energy for transplanting operation. It is clear that increasing of the transplanting forward speed tended to decrease the required energy. The results show that the values of required energy in case transplanter after modification was higher compared with the values in case of transplanter before modification. The average values of energy for transplanter after modification were 62.472, 60.191 and 57.749 kWh/fed at transplanting forward speeds of 0.9, 1.5 and 2.0 km/h, respectively. On the other hand these values for transplanter before modification were 59. 748, 57.27 and 55.22 kWh/fed at the previous transplanting forward speeds.

4.6. Slip ratio:

4.6.1. Transplanter slip:

The degree of seedling slope angle with soil surface and its distribution uniformity were affected by transplanter slippage. In general, increasing of the transplanting forward speed tended to increase the transplanter slip as shown in Figure 4-5. The obtained results shows that the slip values in case of modified transplanter were higher comparing with the values in case of transplanter before modification because the sweeping of crushed soil under transplanter land wheel as a result of its loose structure and also due to vibration of transplanter wheel caused by increasing transplanting forward speed. The average values of slippage for modified transplanter were 10.12, 10.95 and 11.88% at transplanting forward speeds of 0.9, 1.5 and 2.0km/h, respectively. These values were

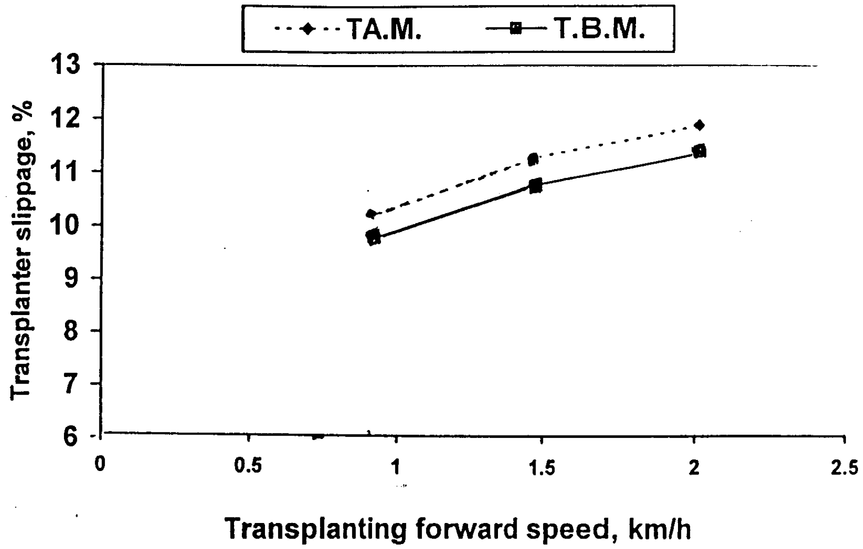


Fig. 4–5: Effect of transplanting forward speed on transplanter slippage for the transplanter after and before modification.

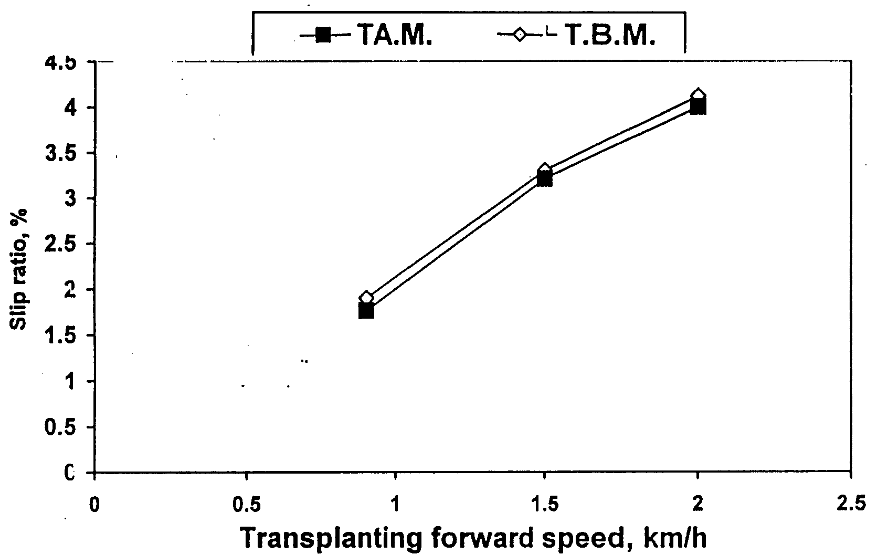


Fig. 4–6: Effect of transplanting forward speed on slip ratio of tractor wheel for transplanter before and after modification.

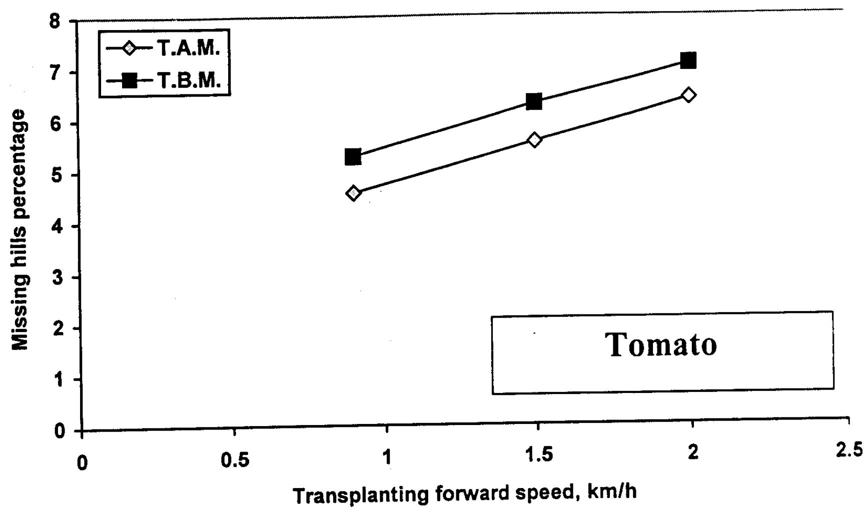
9.6, 10.45 and 11.34% for the transplanter before modification at the previous transplanting forward speeds.

4.6.2. Slip ratio of tractor wheel.

Figure 4-6 shows the relationship between transplanting forward speed and the slip ratio of tractor wheel. Generally the slip ratio of tractor wheel increased by increasing transplanting forward speed. The obtained results show that the values of slip ratio of tractor wheel in case of modified transplanter were lower compared with the values in case of transplanter before modification. This may be due to the specific pressure in case of modified transplanter was higher than the specific pressure in case of transplanter before modification. The average values of slip ratio of tractor wheel in case of modified transplanter were 1.76, 3.21 and 4.0% at transplanting forward speeds of 0.9, 1.5 and 2.0km/h, respectively. These values were 1.9, 3.3 and 4.12% in case of transplanter before modification at the previous transplanting forward speed.

4.7. Missing hills:

Figure 4-7 indicates the effect of transplanting forward speed on the missing hill percentage of tomato and sweet potato plants. The values of the missing hills were increased by increasing transplanting forward speed because the operator can not feed seedlings into the transplanting pockets at higher transplanting forward speed. It is clear that, the average values of tomato missing hills in case of modified transplanter were lower compared with the values in case of transplanter before modification. The average values of tomato missing hills for modified transplanter were 4.55, 5.53 and 6.37% at transplanting forward speeds of 0.9, 1.5 and 2.0 km/h, respectively. These values were 5.26, 6.275 and 7.04% for the transplanter



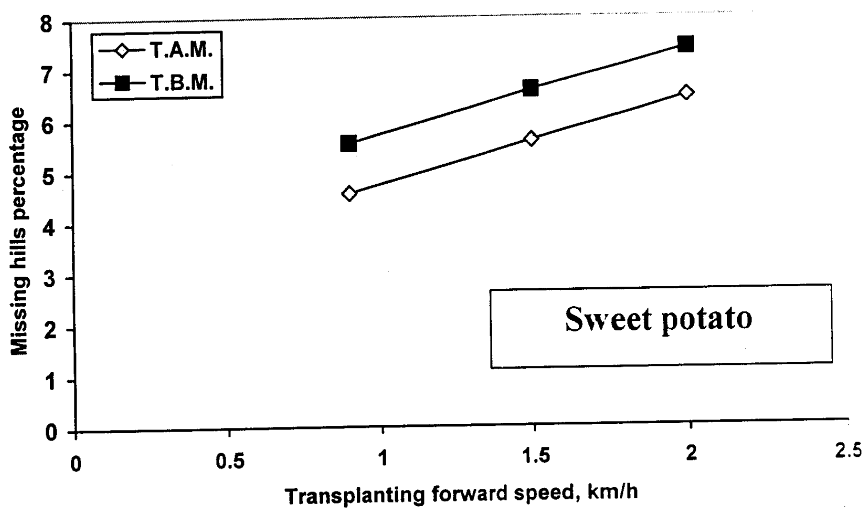


Fig. 4-7: Effect of transplanting forward speed on missing hills percentage for transplanter before and after modification.

before modification at the previous transplanting forward speed. The similar results were obtained for sweet potato plants. Whereas the average values of sweet potato missing hills for modified transplanter were 4.56, 5.58 and 6.43% at transplanting forward speeds of 0.9, 1.5 and 2.0 km/h, respectively. These values were 5.54, 6.57 and 7.38% for the transplanter before modification at the previous transplanting forward speed. One the other hand the highest value of missing hills was observed with manual transplanting which was 10.77%. This is may be due to the increase in the damaged hills as a result of the worker foothold on the seedling during transplanting operation **(El- Hadidi *et al.*, 1998).**

4-8. Scattering:

4-8-1 Longitudinal scattering:

The transplanter was adjusted to gave 27, 31, 34 and 38 cm distance between hills with in the row in case of tomato seedling and 18, 23, 25 and 28 cm in case of sweet potato seedlings. The longitudinal scattering describe the change in the previous distances with factors under study. It increased by increasing transplanting forward speed for the transplanter before and after modification as shown in Figures 4-8 and 4-9. Results illustrated that values of longitudinal scattering in case of modified transplanter were lower compared with values in case of transplanter before modification. This due to modified transplanter have the less vibration and skipping because of ridgers units make the transplanter more stationary on the soil. The lowest values of longitudinal scattering were 0.93, 0.89, 0.91 and 0.92 cm at distances of 27, 31, 34 and 38 between hills with in the row for the transplanter after modification at transplanting forward speed of 0.9 km/h. These values were 2.55, 2.63, 2334 and 2.59 cm for transplanter before modification at the previous transplanting forward speed. The

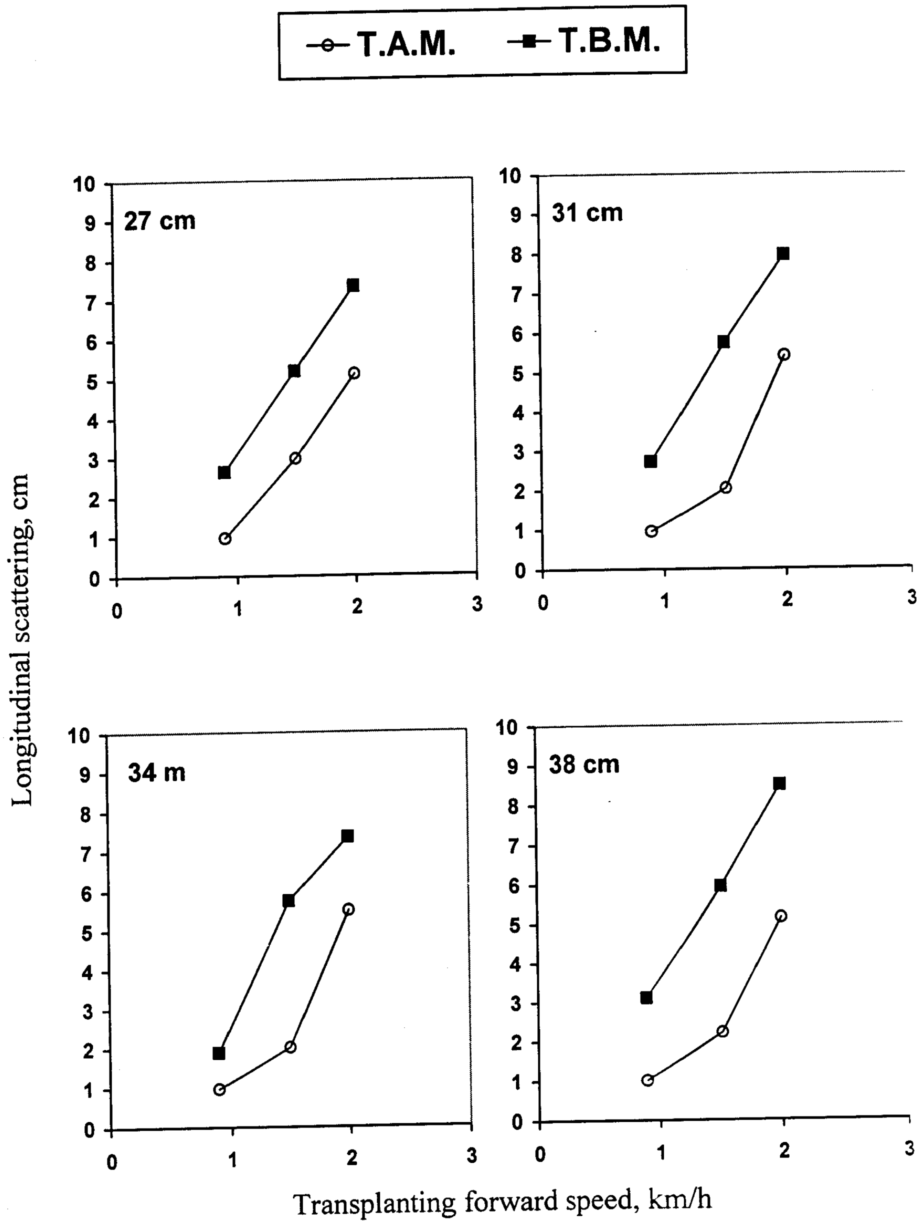


Fig. 4-8: Effect of transplanting forward speed and distance between hills within the row on the longitudinal scattering for tomato plants for the transplanter before and after modification.

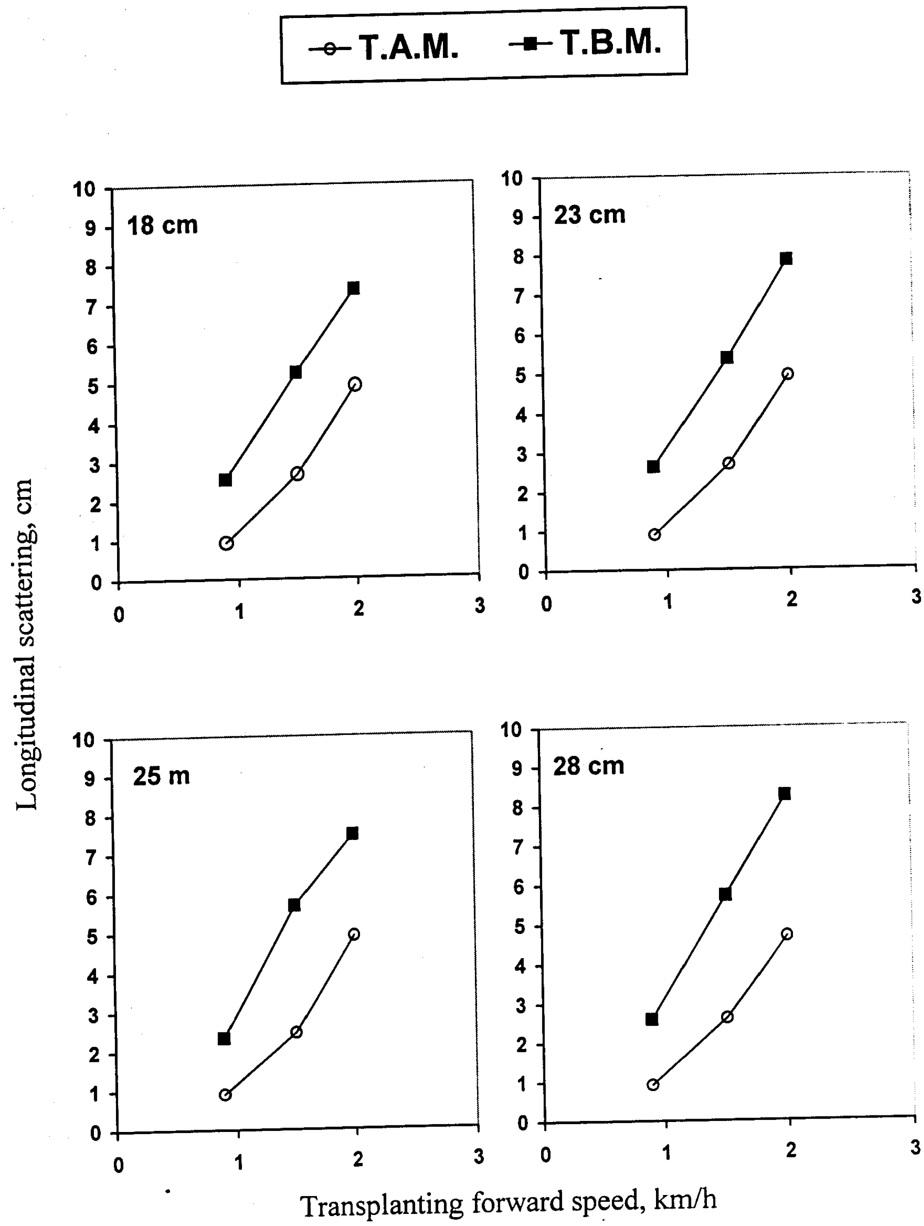
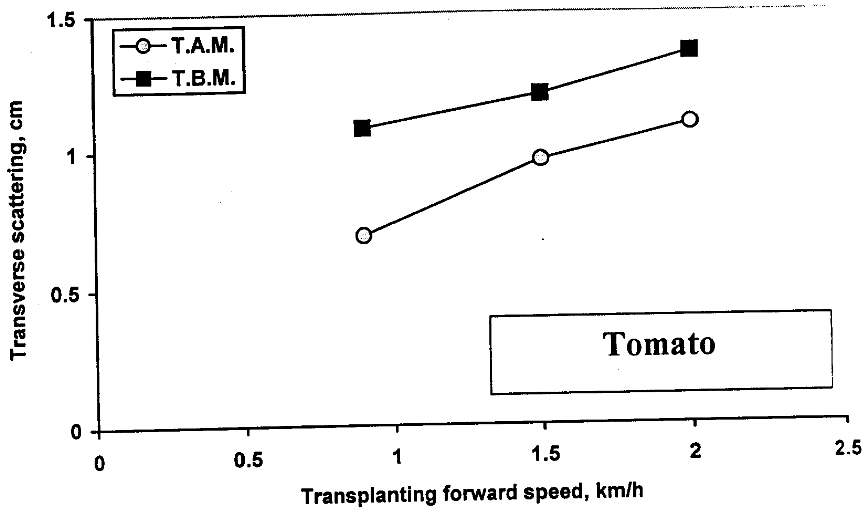


Fig. 4-9: Effect of transplanting forward speed and distance between hills within the row on the longitudinal scattering for sweet potato plants for the transplanter before and after modification.

highest values were obtained under transplanting forward speed of 2 km/h. These values were 5.4, 5.4, 5.48 and 5.14 cm for the transplanter after modification. While these values in case of transplanter before modification were 7.32, 7.94, 7.35 and 8.48 cm. Similar results were obtained in case of sweet potato as shown Figure 4-9. On the other hand, the results indicated that the longitudinal scattering values of manual transplanting were 1.73 and 1.58 for tomato and sweet potato plants respectively.

4.8.2 Transverse scattering:

Figure 4-10 indicates the effect of transplanting forward speed on transverse scattering around the centerline of row for tomato and sweet potato plants. In general increasing transplanting forward speed tended to increase the transverse scattering because the transplanter vibration increased by increasing the transplanting forward speed. The transverse scattering values were lower in case of modified transplanter comparing with transplanter before modification. The average values of transverse scattering of tomato seedling were 0.69, 0.96 and 1.09 cm at transplanting forward speeds of 0.9, 1.5 and 2.0 km/h, respectively for modified transplanter. These values were 1.08, 1.2 and 1.35 cm for the transplanter before modification at the previous transplanting forward speeds. The transverse scattering values of sweet potato seedling were 0.67, 0.95 and 1.08 cm for transplanter after modification at transplanting forward speeds of 0.9, 1.5 and 2.0 km/h, respectively. While these values were 1.05, 1.25 and 1.3 cm for transplanter before modification at the previous transplanting forward speed. On the other hand, the transverse scattering value in case of manual transplanting was 1.6cm. From the previous results



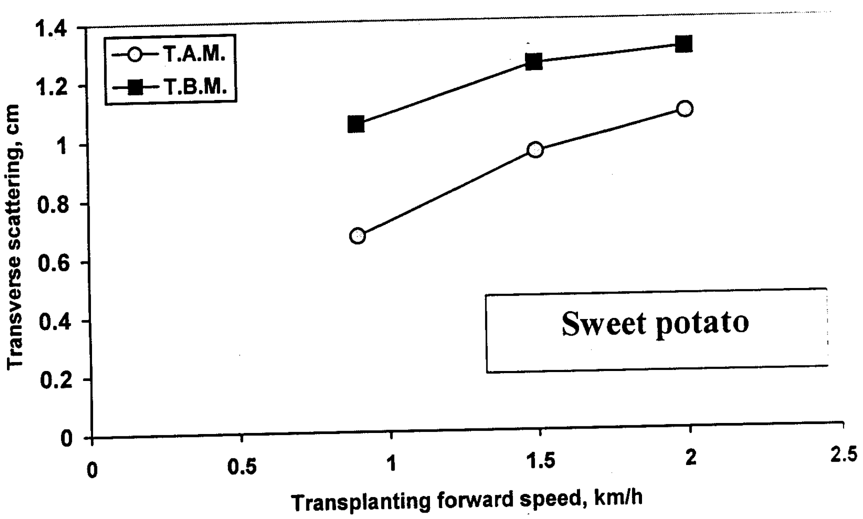


Fig. 4-10: Effect of transplanting forward speed on transverse scattering for transplanter before and after modification.

it is cleared that the modified transplanter plant seedling more uniform than hand transplanting.

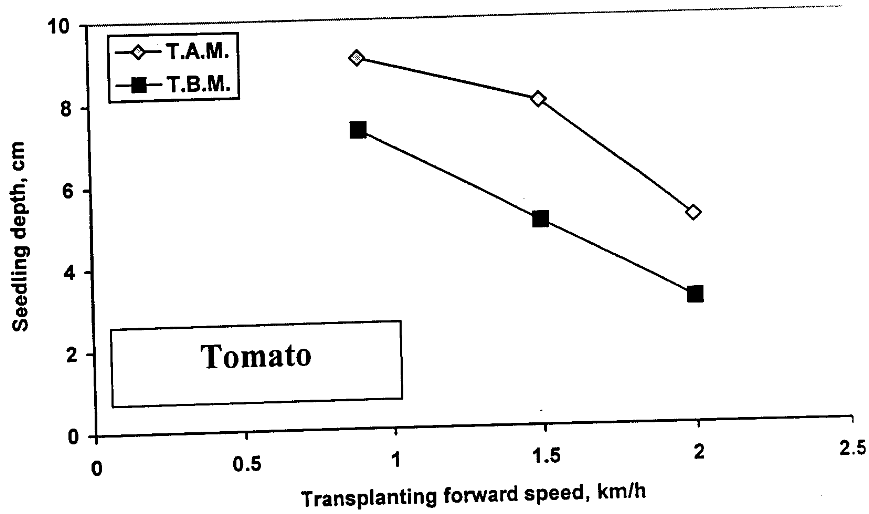
4-9 seedling depth:

Figure 4-11 shows the effect of transplanting forward speed on the seedling depth for tomato and sweet potato plants. The values of seedling depth were decreased by increasing transplanting forward speed because the furrow openers at high speed tend to floats near the soil surface under action of vertical forces component. It is clear that the average values of tomato seedling depth in case of transplanter after modification were higher compared with the values in case of transplanter before modification, these values were 9.05, 7.94 and 5.07 cm for the transplanter after modification at transplanting forward speeds of 0.9, 1.5 and 2km/h. These values were 7.3, 5 and 3.058 cm for the transplanter before modification at the previous transplanting forward speed. Results also indicated that, the values of sweet potato seedling depth were 10.64, 8.3 and 5.05 cm for modified transplanter and were 8.64, 6.39 and 3.58

cm for the transplanter before modification at transplanting forward speeds of 0.9, 1.5 and 2 km/h. Tables 4-2 and 4-3 illustrate that both of transplanting forward speed, transplanters used and their interaction had a significant effect on seedling depth.

Table 4-2: The final results of statistical analysis of tomato seedling depth.

Transplanting Forward speed, km/h	Transplanter	
	After modification	Before modification
0.9	9.05 a	7.3 ab
1.5	7.937 ab	5.00 bc
2.0	5.075 bc	3.085 c



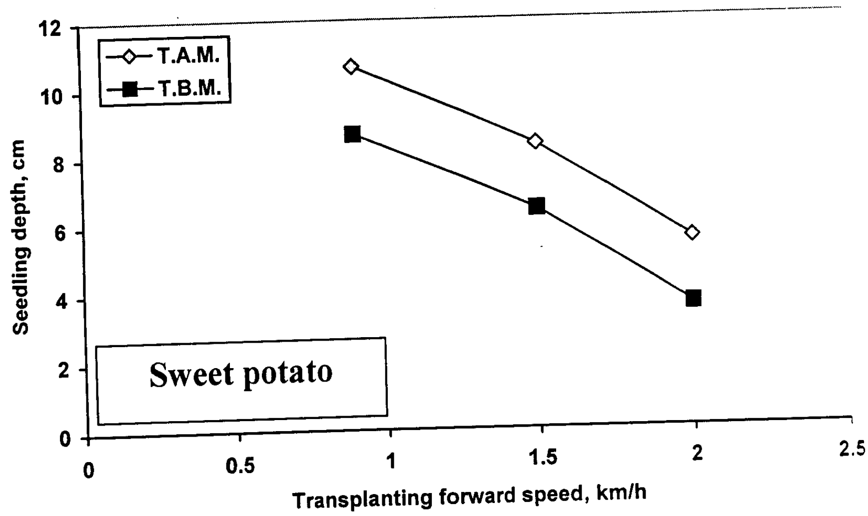


Fig. 4-11: Effect of transplanting forward speed on seedling depth for the transplanter before and after modification.

L.S.D at 5% = 0.43

Table 4-3: The final results of statistical analysis of sweet potato seedling depth.

Transplanting Forward speed, km/h	Translanter	
	After modification	Before modification
0.9	10.64 a	8.645 b
1.5	8.3 c	6.37 d
2.0	5.505 E	3.58 F

L.S.D at 5% = 0.18

Meanwhile, the lowest value of seedling depth was 4.99 and 5.12 cm for tomato and sweet potato, respectively that, occurred under manual transplanting. In general, the mechanical transplanting transplant seedlings deeper in the soil comparing with manual transplanting.

4-10 Total crop yield:

Figures 4-12 and 4-13 indicate that, increasing of transplanting forward speed the total yield of tomato and sweet potato decreased for the transplanter after and before modification at different distance between hills with in the row. The highest value of tomato crop yield was 19.97 Mg/fed for modified transplanter at 27 cm distance between hills with in the row at transplanting forward speed of 0.9 km/h. the lowest value of tomato crop yield was 2.71 Mg/fed at 38 cm distance between hills with in the row for transplanter before modification at transplanting forward speed of 2km/h. On the other hand the manual transplanting of tomato gave the following values of total yield 10.853, 9.149, 8.597 and 7.925 Mg/fed at transplanting distances of 27, 31, 34 and 38 cm distances between hills with in the row.

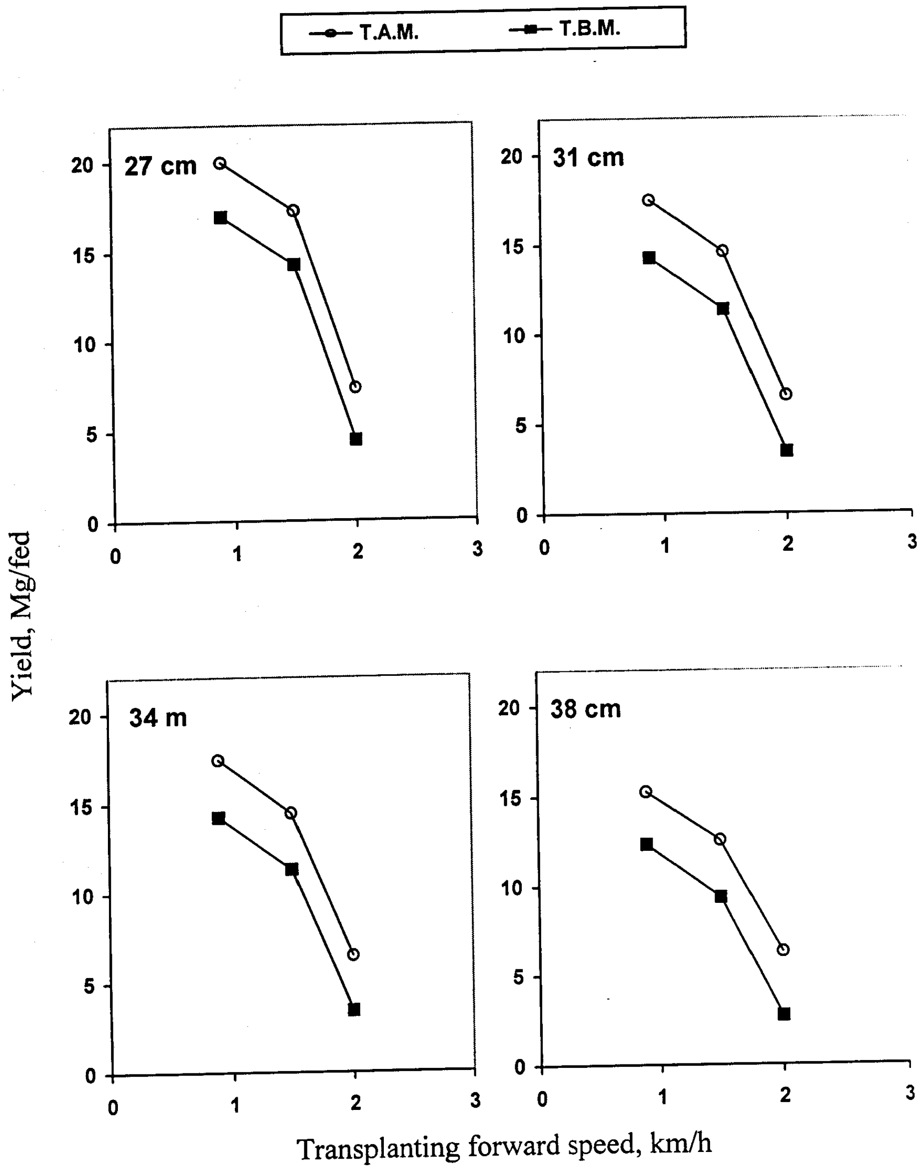


Fig. 4-12: Effect of transplanting forward speed and distance between hills within the row on the yield of tomato for the transplanter before and after modification.

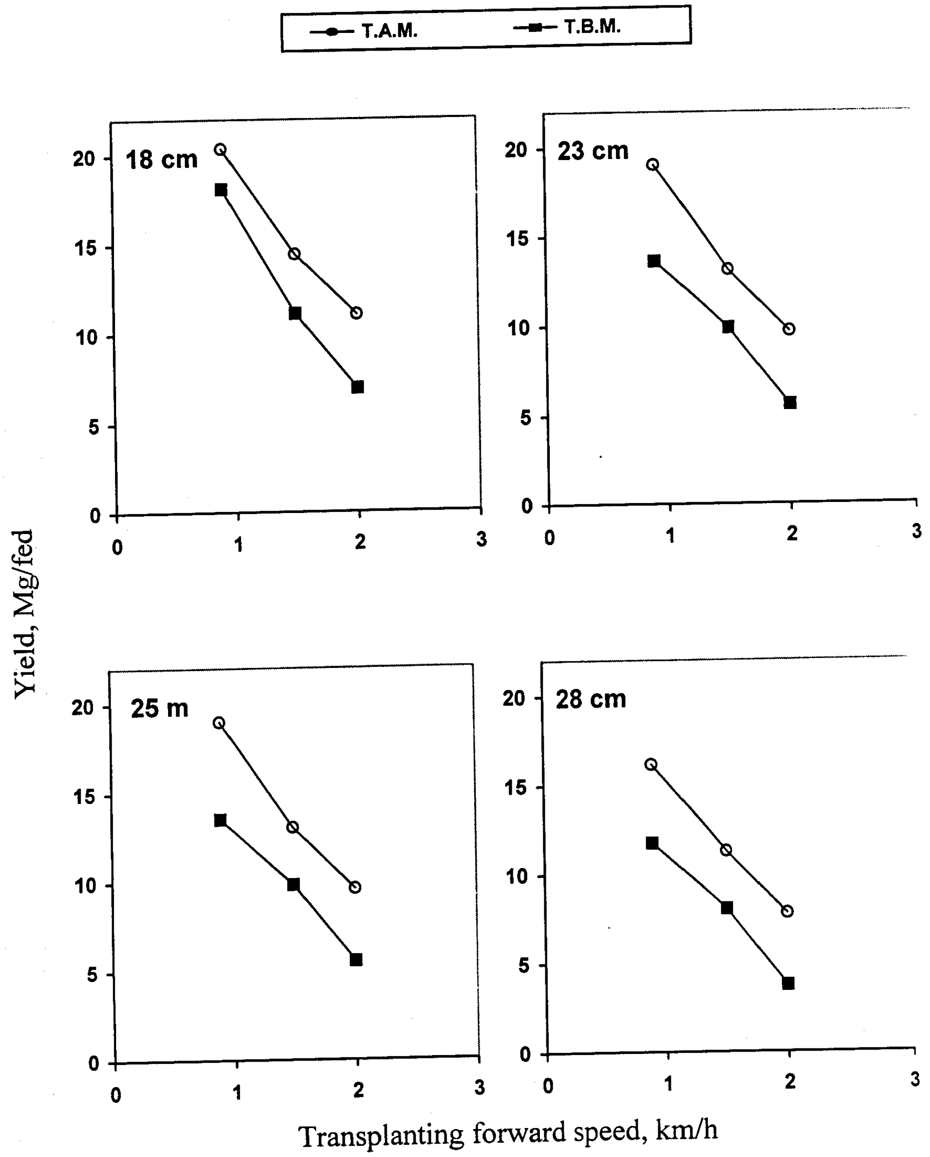


Fig. 4-13: Effect of transplanting forward speed and distance between hills within the row on the yield of sweet potato for the transplanter before and after modification.

Tomato yield in case of modified transplanter was higher than the yield in case of non modified transplanter and manual transplanting because seedling in modified transplanter was deeper in the soil, so the root system increased and branching rate increased. These leads to increase number of fruits on the plant (Harb, 1995).

The highest yield of sweet potato were 20.39 and 18.1 Mg/fed for transplanter after and before modification, respectively, at 18 cm distance between hills with in the row and transplanting forward speed of 0.9 km/h. While the lowest values of yield were 7.79 and 3.73 Mg/fed occurred at transplanting forward speed of 2 km/h and 28 cm distance between hills with in the row for transplanter after and before modification because increasing transplanting forward speed tends to increase the missing hills and the plant density per feddan decreased. While the root yield of sweet potato were 9.854, 8.798, 8.195 and 7.144 Mg/fed for manual transplanting at 18, 23, 25 and 28 cm distance between hills with in the row. Transplanter after modification gave the highest value of root yield because the seedling that transplanting was deeper and more nodes were planted under soil surface and root initiation can occur at each nod while in case of the transplanter before modification and manual transplanting the first two nodes were only placed under soil surface (Chen et al., 1982).

The statistical analysis showed that both of forward speed, transplanters used and their interaction had a significant effect on yield of tomato and sweet potato as shown in Tables 4-4 and 4-5

Table 4-4: Effect of transplanting forward speed on tomato crop yield for transplanter before and after modification.

Transplanting Forward speed, km/h	Transplanter	
	After modification	Before modification
0.9	3.3397 a	2.7535 ab
1.5	2.8058 ab	2.206 bc
2.0	1.2101 c	0.6647 f

L.S.D at 5% = 0.0389

Table 4-5: Effect of transplanting forward speed on sweet potato crop yield for transplanter after and before modification.

Transplanting Forward speed, km/h	Transplanter	
	After modification	Before modification
0.9	3.555 a	2.7148 ab
1.5	2.4717 b	1.8509 bc
2.0	1.8465 bc	1.536 c

L.S.D at 5% = 0.447

From the previous results, it can be mentioned that the transplanter after modification caused an increase in yield with percentage of 20. 64 and 38.1 for tomato and sweet potato respectively. While the transplanter before modification increases the yield by 7.22% and 13.34% for the previous crops.

Increasing the distance between hills with in the row was followed by decreasing in total crop yield as shown in Tables 4-6 and 4-7 while the plant density per feddan was decreased.

Table: 4-6. Effect of distance between hills with in the row on tomato crop yield (Mg/fed).

Distance between hills with in the row, cm	Transplanter	
	After modification	Before modification
27	14.8716	11.8958
31	12.8670	9.6761
34	12.7988	9.6635
38	11.3708	8.1340

Table 4-7: Effect of distance between hills with in the row on sweet potato crop yield (Mg/fed).

Distance between hills with in the row, cm	Transplanter	
	After modification	Before modification
18	15.2906	12.0419
23	13.9623	9.6973
25	13.8978	9.6395
28	11.7516	7.8440

4.11. Cost analysis and benefit:

The transplanting operation cost of tomato and sweet potato crops were differents according to the transplanting methods. The manual transplanting required the highest number of labor than the mechanical transplanting. Figure 4-14 indicates the effect of transplanting forward speed on transplanting cost for modified and nonmodified transplanter. The transplanting operating cost of non modified transplanter was lower than the operating cost of modified transplanter. The transplanter before

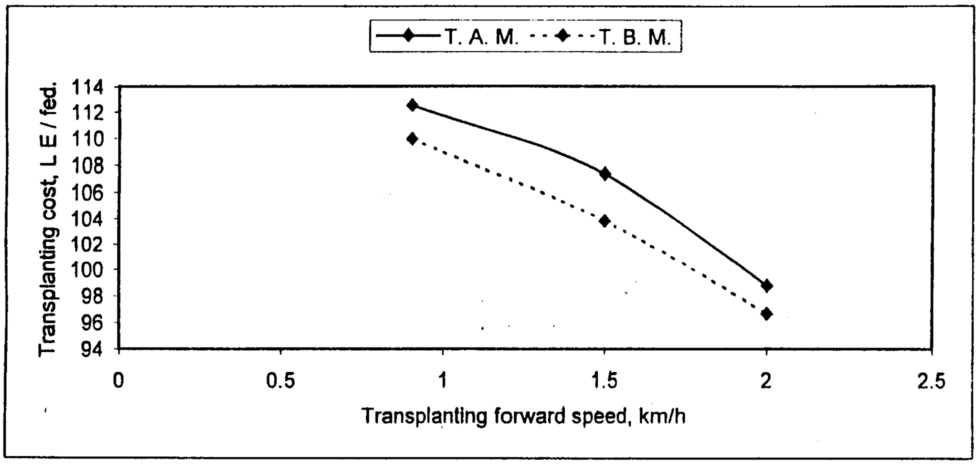


Fig. 4-14: Effect of transplanting forward speed on transplanting cost for transplanter before and after modification.

Table 4-8: Effect of transplanting forward speed on total cost of different transplanting methods for tomato crop:

Transplanting method	Transplanting forward speed, Km/h	Total cost, in L E./fed.					
		Land preparation + transplanting	Seedling price Herbicides + fertilizer + irrigation	Hand weeding + labor	Harvesting + transporting	Land wages	Total cost
Transplanter before modification	0.9	152.9	1202	120	485	500	2459.95
	1.5	145.55	1202	120	785	500	2452.55
	2	136.94	1202	120	485	500	2170.06
Transplanter after modification.	0.9	155.97	1202	95	785	500	2437.57
	1.5	149.79	1202	95	485	500	2431.79
	2	139.49	1202	95	485	500	2421.42
Manual transplanting	-	185	1202	95	485	500	2467

Table 4-9: Effect of transplanting forward speed on total cost for different transplanting methods for sweet potato crop:

Transplanting method	Transplanting forward speed, Km/h	Total cost, in L E./fed.					
		Land preparation + transplanting	Seedling price Herbicides + fertilizer + irrigation	Hand weeding + labor	Harvesting + transporting	Land wages	Total cost
Transplanter before modification	0.9	152.4	635	100	255	500	1642.9
	1.5	145.55	635	100	255	500	1635.55
	2	145.55	635	100	255	500	1626.94
Transplanter after modification.	0.9	155.97	635	75	255	500	1620.97
	1.5	149.79	635	75	255	500	1614.79
	2	139.49	635	75	255	500	1604.49
Manual transplanting	-	185	635	75	255	500	1650

modification at transplanting forward speeds of 0.9,1.5 and 2km/h, decreases the operating cost with percentage of 10.08,16.21 and 23.38 comparing with the manual transplanting. While the modified transplanter at the previous transplanting forward speed decreases the operating cost by 7.52, 12.67and 21.26% comparing with manual transplanting cost which was 120 L E/fed. The total cost of tomato and sweet potato was calculated and summarized in Tables 4-8 and 4-9 at different transplanting forward speed. The total cost included the seedling price, fertilizers, irrigation, hoeing, herbicides and harvesting cost beside cost of land wages

It is clear that the manual transplanting cost of tomato and sweet potato was higher than the mechanical transplanting cost because it required the highest number of labor. While the modified transplanter had the lowest values of cultivation cost.

Table 4-10: Effect of transplanting forward speed on net benefit L E/fed.

Transplanting method	Forward speed, Km/h	Tomato	Sweet potato
		Net benefit, LE/fed.	Net benefit, LE/fed.
Transplanter before modification	0.9	2599.35	2347.94
	1.5	1600.8	1085.21
	2	- 948.91	630.98
Transplanter after modification	0.9	3698.58	3604.95
	1.5	2723.71	2018.49
	2	- 197.94	1604.46

- Tomato price = 350 LE/Mg
- Sweet potato price = 280 LE/Mg (according to the prices of 1998).

Table 4-10 shows the effect of transplanting forward speed on net benefit for modified and non modified transplanter. Modified transplanter gave the highest value of benefit which were 2599.35 and 2347.94 LE/fed for tomato and sweet potato crops, respectively, at transplanting forward speed of 0.9 km/h.

It is clear that the net benefit was effected by transplanting forward speed. Since it was decreased by increasing transplanting forward speed because the total yield tend to decrease. The negative sign in Table 4-10 represents that the total cost for tomato production is higher than the total price of crop yield. The modified transplanter increases the net benefit by percentage of 71.96 and 54.45 at transplanting forward speeds of 0.9 and 1.5 km/h, for tomato crop yield. Also, it is increasing by percentages of 79.71, 63.86 and 54.54 for sweet potato at transplanting forward speeds of 0.9, 1.5 and 2 km/h, respectively. On the other hand, the net benefits for manual transplanting were 728.85 and 729.37 LE/fed for tomato and sweet potato yield, respectively.

SUMMARY AND CONCLUSION

The vegetables transplanter (Holland type) which used to transplant tomato, onion, peeper and sweet potato on the flat land was modified to built ridges and transplant seedling in one operation. Three ridging units were added at the front of the transplanter to built ridges. These units were flexible and adjusted to obtain a suitable distance between ridges (80 cm in this study). The filed experiments were carried out in Faculty of Agriculture farm, kafr EL-Sheikh Governorate, Egypt, during season of 1997/1998.

The aim of the present study was to study the performance of vegetable transplanter before and after modification to transplant both tomato and sweet potato under the following conditions:

1- Transplanting forward speed, the present study included three transplanting forward speeds (0.9, 1.5 and 2km/h).
2- Four different distances between hills with in the row, (27, 31, 34, 38 cm for tomato and 18, 23, 25 , 28 cm for sweet potato).
3- Manual transplanting (control).

The previous variables were effect on the following factors:

1- Effective field capacity and field efficiency.
2- Fuel consumption rate.
3- Power and energy required for transplanting operation.
4- Slip ratio for transplanter and tractor.
5- Missing hills percentage.
6- Longitudinal and transverse scattering.
7- Seedling depth.
8- Total crop yield.

9- Transplanting cost and net benefit.

The results were summarized as follows:

Effective field capacity:

The average values of effective field capacity were 0.2164, 0.2298 and 0.2564 fed/h at transplanting forward speeds of 0.9, 1.5 and 2km/h respectively in case of modified transplanter While these index values were 0.2222 , 0.2392 and 0.2631 fed/h in case of non-modified transplanter at the previous transplanting forward speed.

Field efficiency:

In case of modified transplanter the average values of field efficiency were 63.13, 40.21 and 33.65% at transplanting forward speeds of 0.9, 1.5 and 2km/h, respectively. While these index values were 64.82, 41.86 and 34.53% for non-modified transplanter at the previous transplanting forward speed.

Fuel consumption:

The values of fuel consumption rate in case of modified transplanter were 4.825, 5.0 and 5.35 L/h at transplanting forward speeds of 0.9, 1.5 and 2km/h. These values index were 4.79, 4.95 and 5.25l/h for non-modified transplanter at the previous transplanting forward speed.

Power requirement:

The values of power requirement were 13.276, 13.699 and 14.529 kW for transplanter before modification at transplanting forward speeds of 0.9, 1.5 and 2km/h. While the power requirement for transplanter after modification were 13.519, 13.838 and 14.807 kW at the previous transplanting forward speed.

Energy requirement:

The energy required for transplanting operation at transplanting forward speeds of 0.9, 1.5 and 2km/h were 59.748, 57.29 and 55.22 kW.h/fed for non-modified transplanter. While these index values were 62.472, 60.191 and 57.749 kWh/fed for modified transplanter at the previous transplanting forward speed.

Slip ratio:

The values of transplanter slippage were 10.12, 10.95 and 11.88% at transplanting forward speeds of 0.9, 1.5 and 2km/h, for modified transplanter. These index values were 9.6, 10.45 and 11.34% for non-modified transplanter at the previous transplanting forward speed.

The slip ratio of tractor 1.76, 3.21 and 4% in case of modified transplanter and were 1.9, 3.3 and 4.12% in case of non modified transplanter at transplanting forward speeds of 0.9, 1.5 and 2km/h, respectively the values of slip ratio of tractor in case of non-modified transplanter was higher than the values in case of modified transplanter because the specific pressure in case of modified transplanter was higher the specific pressure incase of non modified transplanter.

Missing hills percentage:

Tomato plants:

The values of missing hill percentage were 4.55, 5.53 and 6.37% for modified transplanter at transplanting forward speeds of 0.9, 1.5 and 2km/h, respectively. These index values were 5.26, 6.275 and 7.04% for non-modified transplanter at the previous transplanting forward speed.

Sweet potato plants:

The values of missing hills percentage for modified transplanter were 4.56, 5.58 and 6.43 at transplanting forward speed of 0.9, 1.5 and 2km/h, respectively. These index values were 5.54, 6.57 and 7.38% for non-modified transplanter at the previous transplanting forward speed. Also, as distance between hills within the row increased the plant density per feddan will decreased. The missing hill percentage in case of manual transplanting was 10.77. This is maybe due to the increase in the damaged hills as a result of the worker foothold on the seedling during transplanting operation. In general the mechanical transplanting gave the lowest percentage of missing hills at the previous transplanting forward speed comparing with manual transplanting.

Longitudinal scattering:

The longitudinal scattering was affected by transplanting forward speed. The lowest value of longitudinal scattering was occurred at the lowest value of transplanting forward speed. For modified transplanter, the longitudinal scattering values were 0.93, 0.89, 0.91 and 0.92 cm at 0.9km/h transplanting forward speed while the distance between hills were 27 , 31 , 34, 38cm for tomato plants and they were 2.55, 2.63, 2.34 and 2.59 cm for non-modified transplanter at the same previous conditions. While these values for sweet potato were 0.94, 0.9, 0.92, 0.93cm for modified transplanter at transplanting forward speed of 0.9km/h when the distance between hills were 18 , 23 , 25 and 28cm. These index values were 2.57, 2.6, 2.49 and 2.61cm for non modified transplanter at the same conditions. The longitudinal scattering values in case of manual transplanting were 1.73 and 1.58 cm for tomato and sweet potato plants, respectively.

Transverse scattering:

The transverse scattering increased by increasing transplanting forward speed because increasing transplanting forward speed tended to increase the vibration of transplanter. In case of tomato plants, the values of transverse scattering were 0.69, 0.96 and 1.09 cm for modified transplanter at transplanting forward speeds of 0.9, 1.5 and 2km/h, respectively. These index values were 1.08, 1.2 and 1.35 cm for non modified transplanter at the previous transplanting forward speed. While in case of sweet potato plants the values of transverse scattering for modified transplanter were 0.67, 0.95 and 1.08cm and these index values were 1.05, 1.25 and 1.3 cm for non modified transplanter at transplanting forward speeds of 0.9, 1.5 and 2km/h. Manual transplanting gave the highest value of transverse scattering which equal 1.6 cm. The modified transplanter decreasing the transverse scattering values at different transplanting forward speed comparing with non-modified transplanter and manual transplanting.

Seedling depth:

The furrow opener at high speed tend to floats near the soil surface under action of vertical forces component. This main that the seedling depth decreased by increasing transplanting forward speed. In case of tomato plants, the values of seedling depth were 9.05, 7.94 and 5.07 cm for modified transplanter and they were 7.3, 5and 3.058 cm for non modified transplanter at transplanting forward speeds of 0.9, 1.5 and 2km/h. While in case of sweet potato the values of seedling depth were 10.64, 8.3 and 5.05 cm for modified transplanter at transplanting forward speed of 0.9, 1.5 and 2km/h. These index values were 8.64, 6.39 and 3.58 for non modified transplanter at the previous transplanting forward speed. The interaction between forward speed and transplanters used was a significant at 5% the seedlings depth for tomato and sweet potato were 4.99 and 5.12 cm, respectively, for manual transplanting. In general the modified transplanter plant seedlings deeper more than non-modified transplanter and manual transplanting.

Total crop yield:

The distance between hills of 27 and 18 cm with in the row gave the highest yield of tomato and sweet potato, respectively at transplanting forward speed of 0.9 km/h for the modified transplanter. The modified transplanter gave the highest crop yield comparing with non-modified transplanter and manual transplaning. Commonly the total crop yield of tomato and sweet potato decrease as the distance between hills with in the row increase since the plant density per fedden will decrease.

The total yield of manual transplanting for tomato and sweet potato were 9.31 and 8.497 Mg/fed, respectively. Increasing the distance between hills with in the row tends to decrease the total crop yield.

Transplanting cost and net benefit:

The values of transplanting cost decreased by about 10.08, 16.21 and 23.38% at transplanting forward speed of 0.9, 1.5 and 2km/h for non-modified transplanter comparing with the manual transplanting cost. While the values of transplanting cost for modified transplanter decreased by about 7.52, 12.67 and 21.26% at transplanting forward speed of 0.9 . 1.5 and 2 km/h, respectively comparing with manual transplanting cost. Which was 120 LE/fed. The maximum total cost values of cultivation one feddan were 2459.95 and 2437.57 LE/fed for non-modified and modified transplanter respectively at transplanting forward speed of 0.9 km/h for tomato crop. While the maximum value in case of sweet potato were

1642.9 and 1620.79 LE/fed for non-modified and modified transplanter respectively at the previous transplanting forward speed.

Net benefit:

Both of total crop yield and net benefit were decreased by increasing transplanting forward speed. Using modified transplanter to transplant tomato seedling at transplanting forward speeds of 0.9 and 1.5 km/h tend to increase the net benefit by about 71.96 and 54.45% comparing with manual transplanting. While at 2km/h transplanting forward speed the total cost was higher than the total price of crop yield. In case of sweet potato, the net benefit increased by 79.76, 63.86 and 54.45% at transplanting forward speeds of 0.9, 1.5 and 2km/h comparing with the manual transplanting.

The net benefit values for manual transplanting were 728.85 and 729.37 LE/fed for tomato and sweet potato, respectively.

Applied recommendations:

According to the previous results, it is more sensitive for producers of tomato and sweet potato crop to use the vegetables transplanter after modification to transplant seedlings and built ridges in one operation for better results of transplanting uniformity, seedling depth, plant density, yield and appropriate level of operation costs, under the following conditions:

1- Transplanting forward speed of 0.9 km/h.
2- Transplanting distances of 27 and 18 cm between hills within the row for tomato and sweet potato plants, respectively.

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Table 1 : Analysis of variance for tomato plant density (m2).

SV	DF	SS	MS	F
Reps R	4	0.3163	0.07908	< 1
Treatment	23	94.7039	4.1175	51.78**
Distance (D)	3	23.1289	7.7096	96.95**
Speed (S)	2	52.928	26.4640	332.81**
Machine (M)	1	17.1007	17.1007	215.05**
DXS	6	0.7378	0.1229	1.55 ns
DXM	3	0.3222	0.1074	1.35 ns
SXM	2	0.4265	0.2132	2.68 ns
DXSXM	6	0.0595	0.0099	< 1
Error	92	7.3156	0.0795	
Total	**119**	**102.3359**		

** = significant at 1% Level.

Table 2 : Analysis of variance for sweet potato plant density (m2).

SV	DF	SS	MS	F
Factor R	4	0.404	0.101	< 1
Factor D	3	33.175	11.058	56.57**
Error (a)	12	2.346	0.195	
Factor S	2	57.837	28.919	393.79**
DXS	6	0.813	0.135	1.84 ns
Error (b)	32	2.35	0.073	
Factor M	1	15.408	15.408	435.06**
DXM	3	0.408	0.136	3.84*
SXM	2	0.204	0.102	2.88 ns
DXSXM	6	0.279	0.047	1.31 ns
Error C	48	1.700	0.035	
Total	**119**	**114.925**		

** = significant at 1%.

* = significant at 5%.

Table 3 : Analysis of variance for tomato missing plants m2.

SV	DF	SS	MS	F
Reps R	4	0.0011	0.00028	< 1
treatment	23	22.0936	0.6059	2005.5**
Distance (D)	3	0.9502	0.31676	661.33**
Speed (S)	2	19.5346	9.76733	20391.96**
Machine (M)	1	1.2348	1.23484	2578.08**
DXS	6	0.3118	0.05198	108.53**
DXM	3	0.0203	0.00678	14.16**
SXM	2	0.0408	0.02044	42.68**
DXSXM	6	0.0007	0.00012	< 1
Error	92	0.044	0.00047	
Total	**119**	**22.1388**		

** = significant at 1%.

Table 4 : Analysis of variance for sweet potato missing plants m2

SV	DF	SS	MS	F
Factor R	4	88.6	22.15	< 1
Factor D	3	50.16	16.72	< 1
Factor (a)	12	266.48	22.21	
Factor S	2	155.81	77.9	3.51*
DXS	6	117.15	19.52	< 1
Error (b)	32	710.16	22.19	
Factor M	1	38.51	38.51	1.74 ns
DXM	3	62.36	20.79	< 1
SXM	2	44.25	22.12	< 1
DXSXM	6	129.68	21.61	< 1
Factor C	48	1065.24	22.19	
Total	**119**	**2728.39**		

Table 5 : Analysis of variance for tomato seedling depth (cm).

SV	DF	SS	MS	F
Reps R	4	6.5156	1.6289	4.47**
Treatment	23	503.7980	21.9042	60.12**
Distance (D)	3	0.8710	0.2903	< 1
Speed (S)	2	340.8262	170.4131	467.76**
Machine (M)	1	149.8411	149.8411	411.29**
DXS	6	2.0369	0.3394	< 1
DXM	3	1.1050	0.3683	1.01 ns
SXM	2	7.7646	0.8823	10.66**
DXSXM	6	1.3529	0.2254	< 1
Error	92	33.5174	0.3643	
Total	**119**	**543.8311**		

** = significant at 1% level.

Table 6 : Analysis of variance for sweet potato seedling depth (cm).

SV	DF	SS	MS	F
Factor R	4	1.143	0.286	408.74**
Factor D	3	0.002	0.001	1.07 ns
Error (a)	12	0.008	0.001	
Factor S	2	521.900	260.95	7859.45**
DXS	6	0.005	0.001	< 1
Error (b)	32	1.062	0.033	
Factor M	1	113.296	113.296	1413.55**
DXM	3	0.002	0.001	< 1
SXM	2	0.041	0.021	< 1
DXSXM	6	0.004	0.001	< 1
Error C	48	3.847	0.080	
Total	**119**	**641.313**		

** = significant at 1% level.

Table 7 : Analysis of variance for tomato crop yield (kg/ m).

SV	DF	SS	MS	F
Reps R	4	0.1270	0.0317	3.21*
Treatment	23	112.4609	4.8896	494.14**
Distance (D)	3	7.28 68	2.4289	245.47**
Speed (S)	2	93.0964	46.5482	4704.12**
Machine (M)	1	10.6958	10.6958	1080.91**
DXS	6	1.3493	0.2248	22.73**
DXM	3	0.0105	0.0035	< 1
SXM	2	0.0019	0.000097	< 1
DXSXM	6	0.02009	0.00334	< 1
Error	92	0.91035	0.0098	
Total	119	113.4983		

** = significant at 1% level.

* = significant at 5% level.

Table 8 : Analysis of variance for sweet potato crop yield (kg/m).

SV	DF	SS	MS	F
Factor R	4	0.4061	0.1015	1.25 ns
Factor D	3	8.1515	2.7172	33.45**
Error (a)	12	0.9747	0.0812	
Factor S	2	58.7187	29.3594	345.65**
DXS	6	0.6167	0.1028	1.21 ns
Error (b)	32	2.7180	0.0849	
Factor M	1	16.7246	16.7246	192.82**
DXM	3	0.1862	0.0621	< 1
SXM	2	0.2564	0.1282	1.48 ns
DXSXM	6	0.4272	0.0712	< 1
Error C	48	4.1635	0.0867	
Total	**119**	**93.3438**		

** = significant at 1% level.

Table 9 : Relation among transplanting methods, forward speed and distance between hills within the row on tomato plant density per feddan.

Transplanting methods	Forward speed, km/h	Distance between hills with in the row, cm			
		27	31	34	38
Transplanter After Modification	0.9	18060	16044	13938	12390
	1.5	17052	14196	12600	11004
	2.0	14364	12810	10332	9534
Transplanter Before Modification	0.9	17052	15120	12642	11886
	1.5	14742	13230	11214	10038
	2.0	12936	11424	8988	8694
Manual transplanting		14700	14280	13020	10500

Table 10 : Relation among transplanting methods, forward speed and distance between hills with in the row on sweet potato plant density per feddan.

Transplanting methods	Forward speed, km/h	Distance between hills with in the row, cm			
		18	23	25	28
Transplanter After Modification	0.9	23100	19320	17640	14700
	1.5	18060	15120	13260	10500
	2.0	12180	10060	9660	7980
Transplanter Before Modification	0.9	18060	15540	14700	12180
	1.5	13440	12600	10500	8400
	2.0	9660	7560	7140	6720
Manual transplanting		21000	17220	17640	13860

Table 11 : The relation among transplanting methods, transplanting forward speed and distance between hills with in the row on tomato crop yield (Mg./fed).

Transplanting methods	**Forward speed, km/h**	**Distance between hills with in the row, cm**			
		27	**31**	**34**	**38**
Transplanter After Modification	0.9	19.3725	17.745	15.750	14.78575
	1.5	17.850	15.855	13.2825	12.5475
	2	4.1947	3.458	3.022	2.812
Transplanter Before Modification	0.9	17.115	15.855	13.8075	12.6
	1.5	15.33	13.965	12.0225	10.9725
	2	3.1773	2.7672	2.46802	2.2365
Manual transplanting		14.385	13.7025	13.2825	12.2325

Table 12 : The relation among transplanting methods, forward speed, and distance between hills with in the row on sweet potato crop yield. (Mg./fed).

Transplanting methods	**Forward speed, km/h**	**Distance between hills with in the row, cm**			
		18	**23**	**25**	**28**
Transplanter After Modification	0.9	20.392	19.063	19.013	16.170
	1.5	14.435	13.125	13.054	11.292
	2.0	11.045	9.699	9.609	7.793
Transplanter Before Modification	0.9	18.102	13.618	13.531	11.759
	1.5	11.101	9.885	9.843	8.041
	2.0	6.924	50589	5.544	3.733
Manual transplanting		9.854	8.798	8.195	7.144

الملخص العربي

تم تعديل شتالة الخضر (ماركة هولاند) التى تستخدم فى شتل محاصيل الطماطم والبصل والبطاطا لكي تقوم بعمليتي الشتل وإقامة الخطوط فى وقت واحد، تم التعديل بإضافة ثلاث وحدات تخطيط فى مقدمة الآلة، كانت المسافة بين هذه الوحدات ٨٠سم.

أجريت التجارب الحقلية بالمزرعة البحثية بكلية الزراعة بكفرالشيخ فى الموسم الزراعي ١٩٩٨/١٩٩٧. وتهدف التجارب الحقلية إلى دراسة الأداء الحقلي للشتالة قبل وبعد التعديل فى شتل محصولي الطماطم والبطاطا باعتبارهما من المحاصيل الهامة فى مصر وكانت عوامل الدراسة على النحو التالى:

١- ثلاث سرعات أمامية للشتالة (٠.٩ ، ١.٥، ٢كم/س)

٢- أربع مسافات بين الجور فى الصف الواحد (٢٧، ٣١، ٣٤، ٣٨ سم بالنسبة للطماطم ، ١٨، ٢٣، ٢٥، ٢٨سم) بالنسبة للبطاطا.

٣- ثلاث طرق للشتل (الشتالة قبل التعديل ، الشتالة بعد التعديل ، شتل يدوي)

<u>كان الهدف هو دراسة تأثير العوامل السابقة على الآتي:</u>

١- السعة الحقلية والكفاءة الحقلية للشتالة قبل وبعد التعديل

٢- استهلاك الوقود للشتالة قبل وبعد التعديل

٣- متطلبات الطاقة والقدرة اللازمة لعملية الشتل

٤- دراسة نسب الانزلاق لكل من الجرار والشتالة قبل وبعد التعديل

٥- نسبة الجور الغائبة

٦- التشتت الطول والعرضي

٧- عمق الشتل

٨- الإنتاجية

٩- تكاليف عملية الشتل

أهم النتائج التي تم الحصول عليها كما يلي:

السعة الحقلية الفعلية:-

كانت قيم السعة الحقلية الفعلية ٢١٦٤,. ، ٢٢٩٨,. ، ٢٥٦٤,. فدان/ساعة فى حالة الشتالة المعدلة عند سرعة تقدم ٩,. ، ١.٥ ، ٢كم/ساعة على الترتيب بينما كانت قيم السعة الحقلية الفعلية ٢٢٢٢.٠، ٢٣٩٢,.، ٢٦٣١,. فى حالة استخدام الشتالة قبل التعديل عند نفس السرعات السابقة.

ويلاحظ أن قيم السعة الحقلية الفعلية عند استخدام الشتالة قبل التعديل أعلى منها عند استخدامها بعد التعديل وذلك راجع إلى وجود الخطاطات فى مقدمة الآلة المعدلة مما يجعلها تتعرض للانزلاق مما يؤدى إلى زيادة الوقت اللازم لعملية الشتل.

الكفاءة الحقلية:-

كانت قيم الكفاءة الحقلية على الترتيب ٦٣,١٣ ، ٤٠,٢١ ، ٣٣,٦٥% عند سرعة تقدم ٠,٩ ، ١,٥ ، ٢كم/ساعة على الترتيب بينما كانت هذه القيم ٦٤,٨٢ ، ٤١,٨٦ ، ٣٤,٥٣% للشتالة بدون تعديل عند نفس سرعات التقدم السابقة.

ومن خلال دراسة مؤشرات الكفاءة والسعة الحقلية الفعلية أمكن تحديد أنسب سرعة تشغيل للشتالة حيث كان ١,٦٢كم/س للشتالة المعدلة ، ١,٥٥ للشتالة بدون تعديل:

معدل استهلاك الوقود:

بزيادة سرعة التقدم من ٠,٩ إلى ١,٥، ٢كم/س زاد الوقود المستهلك من ٤,٧٩ إلى ٤,٩٥ ، ٥,٢٥ لتر/ساعة فى حالة استعمال الشتالة قبل التعديل بينما زاد من ٤,٨٨٥ إلى ٥ ، ٥,٣٥ لتر/ساعة عند استعمال الشتالة بعد التعديل عند نفس السرعات السابقة.

القدرة اللازمة لعملية الشتل:

بزيادة سرعة التقدم من ٠,٩ إلى ١,٥ ، ٢كم/ساعة تزداد القدرة اللازمة لعملية الشتل من ١٣,٢٧٦ إلى ١٣,٦٩٩ ، ١٤,٥٢٩ كيلو وات فى حالة استعمال الشتالة قبل التعديل أما عند استعمال الشتالة بعد التعديل على نفس السرعات السابقة تزداد القدرة اللازمة للشتل من ١٣,٥١٩ إلى ١٣,٨٣٨ ، ١٤,٨٠٧ كيلو وات وذلك راجع إلى زيادة نسبة الانزلاق فى الشتالة بعد التعديل.

الطاقة اللازمة لعملية الشتل

كانت الطاقة اللازمة لعملية الشتل عند سرعات التقدم ٠,٩، ١,٥، ٢كم/س على النحو التالي:-

٥٩,٧٤٨، ٥٧,٢٧، ٥٥,٢٢كيلو وات. ساعة/فدان عند استخدام الشتالة قبل التعديل. بينما كانت ٦٢,٤٧٢، ٦٠,١٩١، ٥٧,٧٤٩كيلو وات.ساعة/فدان للشتالة بعد التعديل.

نسبة الانزلاق:

كانت نسب الانزلاق للشتالة المعدلة ١٠,١٢، ١٠,٩٥، ١١,٨٨% عند سرعات تقدم ٠,٩، ١.٥، ٢كم/ساعة بينما كانت هذه النسب ٩,٦، ١٠,٤٥، ١١,٣٤% للشتالة قبل التعديل عند نفس السرعات.

زادت نسبة الانزلاق للجرار من ١,٧٦ إلى ٣,٢١، ٤% فى حالة استخدام الشتالة بعد التعديل بينما زادت من ١,٩ إلى ٣,٣، ٤,١٢% فى حالة استخدام الشتالة قبل التعديل.
ويلاحظ أن انزلاق الجرار فى حالة الشتالة المعدلة اقل وذلك راجع إلى زيادة كتلة الشتالة المعدلة.

نسبة غياب الشتلات :-

زادت نسبة الغياب بالنسبة للطماطم من ٤,٥٥ إلى ٥,٥٣، ٦,٣٧% فى حالة استخدام الشتالة المعدلة عند سرعات تقدم ٠,٩ ، ١,٥، ٢كم/س بينما كانت هذه النسب عند نفس السرعات للشتالة قبل التعديل ٥,٢٦، ٦,٢٧٥، ٧,٠٤% أما بالنسبة للبطاطا فقد أعطت الشتالة المعدلة نسب غياب ٤,٥٦، ٥,٥٨، ٦,٤٣% وأعطت الشتالة قبل التعديل نسب غياب ٥,٥٤، ٦,٥٧، ٧,٣٨% عند سرعات تقدم ١,٥، ٢كم/س على الترتيب.

ويلاحظ بصورة عامة أن الشتالة المعدلة أعطت أقل نسبة غياب مقارنة بالشتل قبل التعديل أو بالشتل اليدوي. يلاحظ أيضاً أنه بزيادة مسافات الزراعة يقل العدد الكلى للنباتات القائمة فى الفدان نتيجة كبر الحيز (المساحة) التي يشغلها النبات الواحد.

أعطى الشتل اليدوي نسبة غياب ١٠,٧٧% وذلك راجع إلى زيادة الجور التالفة نتيجة لتعرضها لأقدام العمال أثناء عملية الشتل.

التشتت الطولي:

تأثرت قيم التشتت الطولي بسرعة التقدم وبنوعية الشتالة حيث أعطت الشتالة المعدلة أقل قيم للتشتت الطولي عند سرعة ٠,٩ كم/س وكانت هذه القيم ٠,٩٣ ، ٠,٨٩ ، ٠,٩١ ، ٠,٩٢ سم عند مسافات زراعة ٢٧ ، ٣١ ، ٣٤ ، ٣٨ فى حالة نباتات الطماطم بينما زادت هذه القيم إلى ٢,٥٥ ، ٢,٦٣ ، ٢,٣٤ ، ٢,٥٩ سم للشتالة قبل التعديل وزادت قيم التشتت الطولي بزيادة سرعة التقدم إلى ١,٥ ، ٢كم/س وقد أعطت الشتالة نفس النتائج بالنسبة لمحصول البطاطا عند الشتل على مسافات زراعة ١٨ ، ٢٣ ، ٢٥ ، ٢٨سم حيث كانت هذه القيم عند سرعة شتل ٠,٩ كم/ساعة هي ٠,٩٤ ، ٠,٩ ، ٠,٩٢ ، ٠,٩٣سم على الترتيب للشتالة المعدلة بينما زادت هذه القيم إلى ٢,٥٧ ، ٢,٦ ، ٢,٤٩ ، ٢,٦١سم للشتالة بدون تعديل تحت نفس الظروف السابقة. وأعطى الشتل اليدوي قيم تشتت طولي مقدارها ١,٧٣ ، ١,٥٨سم لكل من الطماطم والبطاطا.

التشتت العرضي:

يزداد التشتت العرضي للنباتات المشتولة بزيادة سرعة التقدم نظرا لزيادة اهتزازات الآلة وكانت قيم التشتت العرضي للآلة ٠,٦٩ ، ٠,٩٦ ، ١,٠٩ سم عند سرعات ٠,٩ ، ١,٥ ، ٢كم/س وكانت هذه القيم ١,٠٨ ، ١,٢ ، ١,٣٥ للشتالة بدون تعديل فى حالة شتل الطماطم أما فى حالة البطاطا فقد كانت قيم التشتت العرضي ٠,٦٧ ، ٠,٩٥ ، ١,٠٨ للشتالة المعدلة ، ١,٠٥ ، ١,٢٥ ، ١,٣ سم للشتالة بدون تعديل عند سرعات ٠,٩ ، ١,٥ ، ٢كم/س فى حين أن قيم التشتت العرضي للشتل اليدوي كانت ١,٦سم. يلاحظ أن الشتالة المعدلة أعطت أقل قيم للتشتتين الطولى والعرضي مقارنة بالشتل قبل التعديل أو بالشتل اليدوي وذلك راجع إلى أنها أقل اهتزازا بسبب وجود الخطاطات فى مقدمة الآلة والذى ساعد على زيادة ثبات الآلة.

عمق الشتل:

بزيادة سرعة التقدم بآلة الشتل يقل عمق الشتلة فى التربة وذلك بسبب تعرض فجاج آلة الشتل للتعويم قرب سطح التربة بسبب مركبة القوة الرأسية المؤثرة على الفجاج لأعلى وكان عمق الشتل للطماطم عند استخدام الشتالة المعدلة هو ٩,٠٥ ، ٧,٩٤ ، ٥,٠٧ سم بينما تغيرت هذه القيم إلى ٧,٣ ، ٥ ، ٣,٠٥٨ سم عند استخدام الشتالة بدون تعديل وذلك عند العمل على سرعات ٠,٩ ، ١,٥ ، ٢ كم/ساعة. أما فى حالة شتل البطاطا فقد كان عمق الشتل ١٠,٦٤ ، ٨,٣ ، ٥,٠٥ فى حالة الشتالة المعدلة أنخفض إلى ٨,٦٤ ، ٦,٣٩ ، ٣,٥٨ فى حالة الشتالة بدون

تعديل عند العمل على نفس سرعات الشتل السابقة أما عمق الشتل اليدوي فكـان ٤,٩٩ ، ٥,١٢ سم بالنسبة للطماطم والبطاطا على الترتيب.

المحصول الكلى:

تأثر محصول كل من الطماطم والبطاطا بسرعة التقدم بآلة الشتل وكذلك مسافة الزراعة.

أ- محصول الطماطم:-

أعطت الآلة المعدلة قيم أعلى بالنسبة لمحصول الطماطم حيث أنها غرست الشتلات علـى عمق كبير مما أدى إلى زيادة النمو الخضري والزهري للنباتات مما ترتب عليه زيـادة عـدد الثمار على النبات الواحد. كانت أعلى هذه القيم ١٩,٩٧ ميجا جرام/ فدان عند سرعة تقـدم ٠,٩ كم/ساعة ومسافة زراعة ٢٧سم بينما كانت إنتاجية الفدان عند نفس السـرعة ونفس مسـافة الزراعة للشتالة قبل التعديل ١٦,٩٥ ميجا جرام وأعطى الشـتل اليـدوي إنتاجيـة ١٠,٨٥٣ ، ٩,١٤٩ ، ٨,٥٩٧ ن ٧,٩٢٥ ميجا جرام/فدان عند مسافة زراعة ٢٧ ، ٣١ ، ٣٤ ، ٣٨ سم.

ب- محصول البطاطا:-

فى حالة البطاطا كانت قيم الزيادة فى المحصول عند استعمال الشتالة المعدلة أكبر منـها عند استعمال الشتالة بدون تعديل وذلك بسبب زيادة عمق الغرس وزيادة عدد العيون الدرانيـة الموجودة تحت سطح التربة مما يؤدى إلى تكوين عدد كبير من الجذور وكـانت أعلـى قيـم للإنتاجية هى ٢٠,٣٩ ، ١٨,١ ميجا جرام/فدان عند سرعة ٠,٩ كم ومسافة زراعة ١٨سم لكـل من الشتالة بعد التعديل وقبلة على الترتيب فى حين إن إنتاجية الشتل اليدوي من البطاطا كـانت ٩.٨٥٤ ، ٨,٧٥٨ ، ٨,١٩٥ ، ٧,١٤٤ ميجا جرام للفدان عند مسافات زراعـة ١٨، ٢٣، ٢٥، ٢٨سم. كما يلاحظ أن الإنتاجية (ميجا جرام/فدان) تقل بزيادة سرعة التقدم للشتالة وكذلك بزيادة مسافة الزراعة حيث يقل عدد النباتات الكلى فى الفدان.

نسبة تكاليف عملية الشتل وعائد الفدان:

أوضحت النتائج أن تكاليف عملية الشتل تقل بزيادة سرعة التقدم ويلاحظ أن الشتالة قبـل التعديل خفضت تكاليف عملية الشتل بنسبة ١٠,٠٨% ، ١٦,٩ ، ٢٣,٣٨% بزيادة سرعة التقـدم من ٠,٩ إلى ١,٥ ، ٢كم/س وانخفضـت تكـاليف عمليـة الشـتل بنسـبة ٧,٥٢ ، ١٢,٦٧ ، ٢١,٢٦% عند استخدام الشتالة بعد التعديل عند نفس السرعات وذلك مقارنة بالشتل اليدوي الذي

كانت تكاليفه ١٢٠ جنية/فدان• حيث أنه يحتاج إلى عدد كبير من العمال ووقت طويل. كما يلاحظ أن أعلى قيمة لتكاليف الزراعة كانت ٢٤٥٩,٩٥ جنية/فدان للآلة قبل التعديل بينما كانت ٢٤٣٧,٥٧ جنية/فدان للآلة بعد التعديل بالنسبة لمحصول الطماطم فى حين أنها كانت ١٦٤٢,٩ ، ١٦٢٠,٩٧ جنية/فدان للآلة قبل التعديل وبعده بالنسبة لمحصول البطاطا عند العمل على سرعة ٠,٩كم للساعة.

عائد الفدان:

يلاحظ أن صافى عائد الفدان يقل بزيادة سرعة التقدم للشتالة حيث تنخفض الإنتاجية (ميجا جرام/فدان) بزيادة سرعة الشتل (كم/س) وأوضحت النتائج أن استخدام الشتالة المعدلة فى شتل الطماطم على سرعات ٠,٩ ، ١,٥ كم/س أدى إلى زيادة عائد الفدان بمقدار ٧١,٩٦ ، ٥٤,٤٥% على الترتيب أما عند الشتل على سرعة ٢كم/س تنخفض الإنتاجية بصورة كبيرة مما يؤدى إلى زيادة تكاليف الفدان عن إجمالي ثمن المحصول.

أما فى حالة شتل البطاطا فزاد عائد الفدان بنسبة ٧٩,٧١ ، ٦٣,٨٦% ، ٥٤,٥٤% عند استعمال الشتالة المعدلة على سرعات ٠,٩ ، ١,٥ ، ٢كم/س وكان عائد الفدان للشتل اليدوي ٧٢٨,٨٥ ، ٧٢٩,٣٩ جنية لكل من والطماطم البطاطا على الترتيب.

التوصيات التطبيقية:

توصى الدراسة باستخدام شتالة الخضر بعد التعديل لشتل كلا من الطماطم والبطاطا عند سرعة تقدم ٠,٩ كم/س. حيث أعطت الشتالة عند هذه السرعة أعلى كثافة نباتية فى الفدان وأعلى إنتاجية كما أعطت أقل قيم لكلا من التشتت الطولى والعرضى وأقل نسبة غياب للنباتات وأكبر عمق شتل.

كما توصى الدراسة بشتل الطماطم باستخدام الشتالة على مسافة ٢٧سم والبطاطا على مسافة ١٨سم بين النباتات فى الخط وذلك للحصول على أعلى كثافة نباتية فى الفدان وأعلى إنتاجية.

• الدولار الأمريكى = ٣,٤٢ جنية مصرى (طبقا لأسعار عام ١٩٩٩)

• الفدان = ٤٢٠٠,٨٣ مترا مربعا.

لجنة الإشراف

الأستاذ الدكتور/متولى محمد
أستاذ ورئيس قسم الميكنة الزراعية
بكلية الزراعة بكفرالشيخ
جامعة طنطا

دكتور
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مدرس الهندسة الزراعية بقسم
الميكنة الزراعة بكلية الزراعة
بكفرالشيخ - جامعة طنطا

دكتور
إبراهيم صلاح الدين محمد
باحث بمعهد بحوث الهندسة الزراعية
مركز البحوث الزراعية

جامعة طنطا
كلية الزراعة بكفرالشيخ
قسم الميكنة الزراعية

دراسة على آلات الشتل تحت الظروف المحلية
تطوير أداء شتالة الخضر تحت الظروف المحلية

رسالة مقدمة من

إبراهيم عبدالمنعم قاسم عبدالكريم

للحصول على درجة الماجستير

فى العلوم الزراعية (الميكنة الزراعية)

لجنة المناقشة والحكم على الرسالة

أ٠د٠/ متولى متولى محمد

أستاذ ورئيس قسم الميكنة الزراعية بكلية الزراعة بكفرالشيخ- جامعة طنطا

....

أ٠د٠/ محمد أحمد الشيخة

أستاذ الهندسة الزراعية بقسم الميكنة الزراعية بكلية الزراعة- جامعة المنصورة

....

أ٠د٠/ ممدوح عباس حلمى

أستاذ الهندسة الزراعية بقسم الميكنة الزراعية بكلية الزراعة بكفرالشيخ- جامعة طنطا

....

التاريخ   /   / ١٩٩٩م

١١٣٢

جامعة طنطا
كلية الزراعة بكفر الشيخ
قسم الميكنة الزراعية

موضوع الرسالة

دراسة على آلات الشتل تحت الظروف المحلية

عنوان الرسالة

تطوير أداء شتالة الخضر تحت الظروف المحلية

رسالة مقدمة من

إبراهيم عبدالمنعم قاسم عبدالكريم

بكالوريوس علوم زراعية (ميكنة زراعية)
كلية الزراعة بكفرالشيخ
جامعة طنطا
١٩٩٥

للحصول على درجة الماجستير
فى العلوم الزراعية (ميكنة زراعية)
كلية الزراعة – بكفرالشيخ
جامعة طنطا

١٩٩٩ م