MANUFACTURE AND EVALUATION OF A SIMPLIFIED MACHINE FOR PLANTING OKRA SEEDS

Moheb M. A. El-Sharabasy[*] **Mahmoud M. A. Ali[*]**

ABSTRACT

The object of this study was to manufacture and evaluate a simplified planter for planting okra seeds. The okra planter consists of four main parts of three cylindrical ellipsoid hoppers with bored metal strips, furrow openers and covering device. The planter was adjusted to plant okra seeds under the following parameters: three different numbers of holes on the hopper of 3, 4 and 5 holes; four different hole diameters of 6, 6.5, 7 and 7.5 mm; and three different planter forward speeds of 0.55, 0.78 and 1.15 km/h. From obtained laboratory and field tests, it could be concluded the followings: The maximum seed discharged from the hoppers of 8.16, 7.82 and 7.42 kg/fed were achieved at 5 holes number on the hopper and planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively. The maximum mean seed No. in the hill of 4.91, 4.63 and 4.36 seed/hill were achieved at 4 holes number on the hopper, 7.5 mm hole diameter and planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively. While these values were decreased to 3.71, 3,38 and 3.08 seed/hill and to 4.43, 4.05 and 3.72 seed/hill at 3 and 5 holes number, 7.5 mm hole diameter and planter forward speed of 0.55, 0.78 and 1.15 km/h, respectively. The minimum values of (C.V.) of 7.96, 9,14 and 14.81 % were occurred at 4 holes number on the hopper, 7 mm hole diameter and planter forward speed of 0.55, 0.78 and 1.15 km/h, respectively. The maximum okra yield of 5.12 Mg/fed was achieved at 4 holes number on the hopper, 7 mm hole diameter and planter forward speed of 0.78 km/h. While, the minimum okra yield of 2.91 Mg/fed was achieved at 5 holes number on the hopper, 6 mm hole diameter and planter forward speed of 0.55 km/h. The minimum energy consumed and planting cost of 0.186 and 41.60 kW.h/fed; 16.10 and 43.90 L.E/fed were obtained at high forward speed of 1.15 km/h for both worker with planter and tractor with planter, respectively.

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[*] **Assist. Prof. of Agric. Eng., Fac. of Agric., Zagazig Univ., Egypt.**

1. INTRODUCTION

Nowadays, some farmers are sowing special kinds of crops which give more benefits than other traditional crops. Some of these crops are okra, rosella, rosemary and all kinds of aromatic and medicine crops. These crops are sowing in a small scale of areas over wide Egypt, for this reason most farmers sowing these crops manually or using mechanical planters consumed more cost and not available in the right time. **Kumar et. al. (1986)** developed a manually operated seeding attachment for an animal drawn cultivator. The seed rate was 43.2 kg/h, while the field capacity was 0.282 ha/h. Tests showed minimal seed damage with good performance for wheat and barley. **Simalenga and Hatibu (1991)** tested a hand planter on the field and found the work rate of the planter to be between 18 man-hours per hectare and 27 man-hour per hectare when using conventional hand-hoe planting method. **Gupta and Herwanto (1992)** designed and developed a direct paddy seeder to match a two-wheel tractor. The machine had a field capacity of about 0.5 ha/h at a forward speed of 0.81m/s. Damage due to the metering mechanism was nil for soaked seeds and 3% for pre germinated seeds. **Molin and D'Agostini (1996)** developed a rolling punch planter for stony conditions, using 12 spades radially arranged with cam activated doors and a plate seed meter. Preliminary evaluation showed important improvement in the planting operation with reduction in human effort, more accurate stands and high field capacity. To attain optimum planting condition for productivity. **Pradhan et. al. (1997)** developed a power tiller-operated groundnut planter cumfertilizer drill with an actual field capacity of 0.16 ha/h. **Sivakumar et. Al. (2005)** developed a direct seeder based on the machine and operational parameters involved in direct sowing of rice. In the existing models of the direct rice seeder, the dry/wet seeds are drilled continuously at a higher seed rate than the recommended and without desired seed to seed spacing. They studied the influence of the operational parameters viz., drum shape, diameter of drum, diameter of seed metering hole, number of seed metering holes and forward speed of operation on seed rate of the rice drum seeder in the laboratory condition. The hyperboloid drum shape was optimized with 200 mm drum diameter, 9 numbers of seed metering holes having 10 mm diameter of seed metering hole and 1.0 km/h forward speed of operation. **Bamgboye and**

Mofolasayo (2006) evaluated a manually operated two-row okra planter. The laboratory investigation included the determination of the variation in weight of seeds discharged from hoppers, percentage damage of seeds, and average intra-row spacing of seeds. The field tests comprised the determination of effective field capacity, average depth of placement of seeds in the furrows, and mean spacing of seeds within each row. A percentage of difference between the weights of seeds discharged from the two hoppers of 4.97% was obtained during testing; while the seed rate was 0.36 kg/h. A reduction in damage percentage of 3.51 % was attained with spacing varying from 59 cm to 70 cm, and an average depth between 8 mm and 9 mm. The overall average efficiency of the planter was 71.75%. **Abo El-Naga (2010)** evaluated a developed direct seeding machine and compared with the common systems for direct seeding for rice. The developed direct machine with furrow opener at seed rate of 40 kg/ fed, the germination ratio was 78.4%, plant population was 208.69 plants /m^2, the values of C. V. were 9.37 and 13.73 % at lateral and longitudinal direction, respectively and grain yield was 3.225 tons/fed. The energy consumed and the costs were 0.514 kW.h /fed and 22.12 L. E. /fed, respectively. **El-Sharabasy (2011)** manufactured and evaluated a manually operated planter for planting different seeds. The constructed planter consists of four main parts namely: seed hopper, feed device, furrow opener and covering device. The planter was evaluated under three different types of seeds sugar beet, zucchini and ground nut; five different cell diameters of 1.0, 1.5, 2.0, 3.0 and 4.0 cm and three numbers of cells on the disk of 2, 3 and 4. He mentioned that the maximum seed weights discharged from the hoppers of 64.53, 168.27 and 720 g were achieved at cell diameters of 2.0, 3.0 and 4.0 cm and No. of cells on the disk of 4 for sugar beet, zucchini and ground nut, respectively. The minimum energy consumed and planting cost of 0.185 kW.h/fed and 10.41 L.E/fed were obtained at high forward speed of 2.3 km/h. Based on the available literature, this study was carried out to construct and evaluate a simplified machine suitable for direct okra sowing which will reduce the drudgery associated with the traditional methods of planting okra seed with zero damage of seeds, low coefficient of variation in addition to low required energy and cost.

2. MATERIALS AND METHOD

2.1. MATERIALS:

2.1.1. The used crop:

Okra seeds (Balady) variety were used in laboratory and field experiments with a rate of 3-4 kg per feddan, 60 cm row spacing and about 15 cm between hills in the same row.

2.1.2. The used tractor:

A Kubota tractor model (L 285) of 30 hp (22.37 kW) engine power at rated speed of 2800 rpm was used to draw the okra machine in field experiments.

2.1.3. The constructed planter:

The manually drawn planter shown in Fig.1 and Photo 1 was constructed at the work shop of Agricultural Engineering Department, faculty of agriculture, Zagazig University. This planter consists of three direct feed hoppers having different discharge holes, two ground wheels, three furrow opening, covering device, handles and the frame which support all previous planter parts.

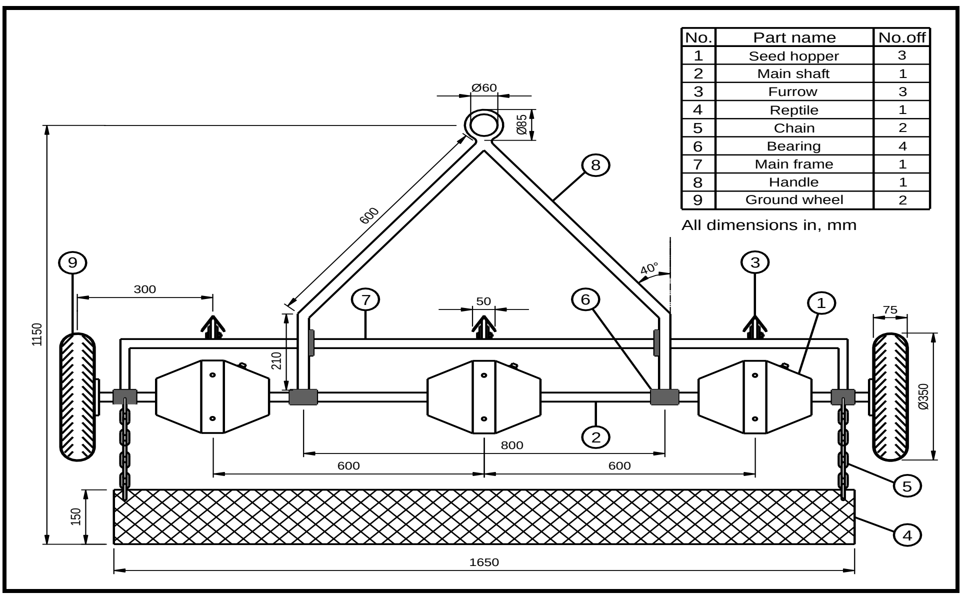

Fig. 1. The top view of the developed direct okra planter.

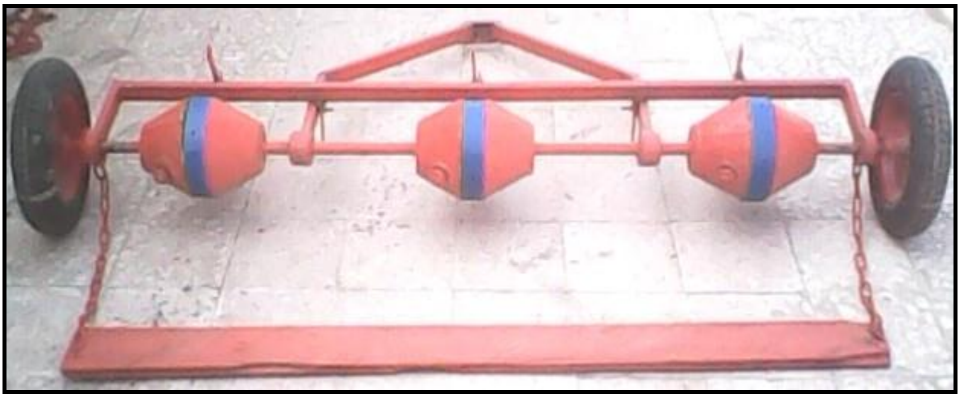

Photo 1. The developed okra planter.

1. Seed hopper: The planter has three seed hoppers made of mild steel; each one has drum ellipsoid cross section, and it has three diameters of 100 mm at both ends and 200 mm at the middle. The drum ellipsoid shape of the seed hopper and the mixer in the middle of the drum always turn up and down okra seeds and guide them into the ground through the metering holes. These seed hoppers were welded on the main shaft at 600 mm from each other to take the rotating motion from the ground wheels and to specify the distance between rows. The maximum capacity of each hopper was 3.00 kg. This capacity is based on the volume of seeds required to plant about one feddan of land continuously from the okra seeds. The lower part with trapezoidal shape ended with the housing. Fig.2.

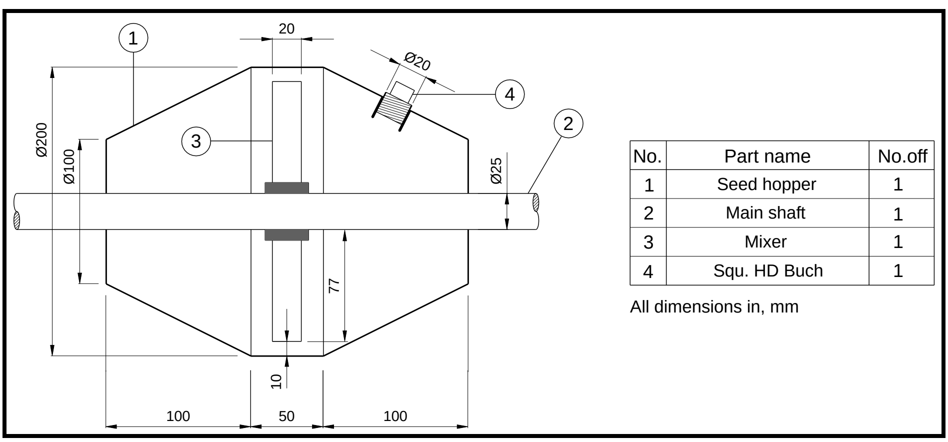

Fig. 2. A cross section in the drum ellipsoid unit of the okra planter.

2. Metering device: The metering device consists of different metal strips having different numbers of holes and different holes diameters. The metal strips were located in the middle of the drum hopper at the 200 mm diameter part. Each strip has 630 mm in length, 50 mm in width and 0.3 mm in thickness. Each strip was bored with different holes diameters and numbers, and then it was fixed in the middle of drum hopper making a circle with 200 mm in diameter (circumference of 630 mm). The dimensions of the strips and the holes diameter and numbers of holes on each strip are shown in Fig. 3. and Photo 2. These diameters and numbers of holes are such that the okra seeds can be accommodated to fall into the soil with the adequate numbers in the hill and suitable distance between hills. To change the metal strip with another on the drum hopper, a Hexagon HD. Bolt and Nut was used to fix it tightly.

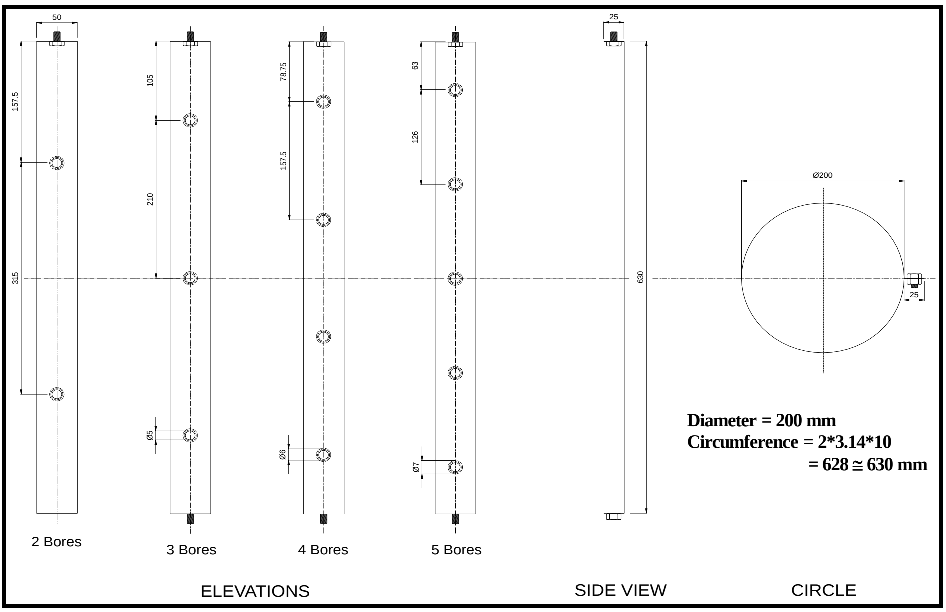

Fig. 3. Elevations and side view of strips with different metering bores.

3. Furrow opening device: The okra planter has three such furrow openers made from mild plate iron with a length of 150 mm, width of 40 mm and thickness of 5 mm. To facilitate the attachment of the furrow opening device to the main frame and control the furrow depth, it was drilled at the upper part with three bores to accommodate a 10 mm diameter bolt with the nut in other plate welded on the main frame.

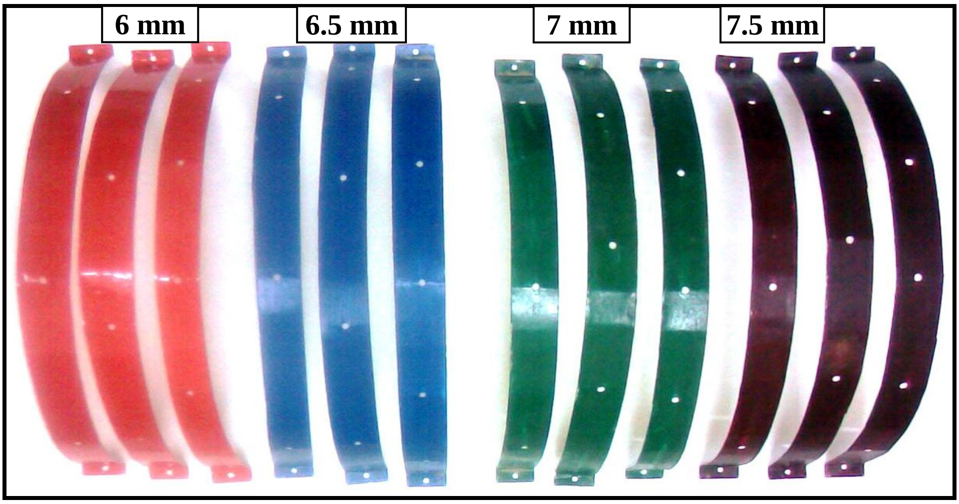

Photo 2. The strips with different metering bores.

4. Covering device: The covering device was made from a wooden plate with dimensions of (1650 × 150 × 50 mm). For attachment the wooden plate to the main frame, it was connected with two chains welded with the main frame at the external bearings on the main frame. The covering plate is slightly run above the soil after planning process for optimum covering the furrows.

5. Drive wheels: Two pneumatic drive wheels with diameter of 350 mm were constructed to carry the planter parts and also transmit the rotating motion to the seed hoppers. The diameter of drive wheels was adequate to introduce a vertical distance of 80 mm between the bottom of the seed hoppers and the soil surface to prevent the seed hopper touch with soil during planting operation and also reduce seed scattering, whereas the planter has no seed tubes.

6. Handle (Attachment): The handle consists of two mild steel bars having rectangular section of 40 mm × 20 mm, each bar length is 820 mm. The rear two ends of previous steel bars were welded on the bearings located on the main shaft and main frame in a horizontal position. While, the front two ends of steel bars were welded together with a steel circle for attachment with the tractor draw bar.

2.2. METHOD:

All tests carried out on the okra planter were done in the laboratory and on the field after that. The laboratory and field tests were carried out at the work shop of Agricultural Engineering Department, Faculty of Agriculture, Zagazig University and a private farm, El Rooda village, Sharkia province to evaluate the performance of the okra planter during the successful agricultural season of (2010/2011).

2.2.1. Laboratory tests:

The okra planter was calibrated in the laboratory to determine the rate of discharge, uniformity of seed spacing in the rows. Each hopper of the constructed planter was loaded with 2 kg of okra seeds. Then, the planter was held above a special stand to free the drive wheel to be rotated. A paint mark was made on the drive wheel to serve as reference point to count the number of revolutions when turned; and a polythene bag was placed under each hopper to collect the seeds discharged from the holes. The drive wheel was rotated 30 times at low speed as would be obtained on the field. A stop watch was used to measure the time taken to complete the revolutions. The seeds in each bag were weighed on an electrical balance and the procedure was repeated five times to calculate the mean of each treatment.

2.1.2. Field tests:

The experimented area was 9720 m^2 (about 2.32 feddans) in sandy loamy soil, divided into three main plots having dimensions of (50×64.8 m) planted with okra seeds. The plot areas were ploughed with chisel plow double face and harrowed to obtain a fairly flat ground. The constructed planter was operated at three different forward speeds of 0.55, 0.78 and 1.15 km/h, four different hole diameters of 6, 6.5, 7, and 7.5 mm and three hole numbers of 3, 4 and 5 holes and replicated three times to determine the actual field capacity and efficiency, coefficient of variation seeds in the field, energy consumed, total planting cost and crop yield.

1. Number of seeds in the hill: To determine the number of seeds in the hill, the covering device was removed from the planter and then it was observed the number of seeds in the hill after planting operation in each treatment.

2- Coefficient of variation (C.V.): Coefficient of variation is used as an indicator of seed scattering. The coefficients of variation under 10 % are considered excellent, with values under 20 % generally considered acceptable for most field applications as reported by **Coates (1992)**: The mean value (x_a), standard deviation (δ) and coefficient of variation (C.V.) is determined as follows:

$$\delta = \sqrt{\frac{\sum (x_i - x_a)^2}{n-1}} \quad (1)$$

Where: xi = The individual reading.

X_a = Mean reading = $\frac{\sum x_i}{n}$

n = Number of readings.

$$C.V. = \left(\frac{\delta}{x_a} \right) \times 100 \quad (2)$$

3. Crop yield: The okra pods were picking manually after reaching the suitable size by hands and weighted to calculate the weight of each treatment by kg and converted to kg/fed.

4. Field capacity: was the actual average time consumed during planting operation (lost time + effective time). It can be determined from the following equation, **(Keppner et al. 1982):**

$$(3)\ F.C_{act} = \frac{60}{Tu + Tl}\ , \quad (fed / h)$$

Where: $F.C_{act}$ = Actual field capacity of the planter.

T_u = Utilization time per feddan in minutes.

T_l = Summation of lost time per feddan in minutes.

5. Field efficiency: is calculated by using the values of the theoretical field capacity and effective field capacity rates as, **(Keppner et al. 1982):**

$$\eta_f = \frac{F.C_{act}}{F.C_{th}} \times 100 \quad (\%) \quad (4)$$

Where: η_f = Field efficiency, %.

6. *Energy for manual work:* Manual labor could be determined as mechanical power equal to (0.075 to 0.10 hp) at continuous work **(Lijedahl et al. 1951)**.

$$Worker\ power = 0.10\ hp\ (0.\ 075\ kW) \qquad (5)$$

So, the energy can be calculated as following:

$$Consumed\ energy = \frac{Worker\ power, (kW)}{Field\ capacity, (fed / h)},\ kW.h / fed \qquad (6)$$

7. Energy for tractor: To estimate the engine power during planting process, the decrease in fuel level in fuel tank accurately measuring immediately after each treatment. The following formula was used to estimate the engine power (**Hunt, 1983**):

$$EP = \left[F.C\left(1/3600\right)PE \times L.C.V \times 427 \times \eta_{thb} \times \eta_m \times 1/75 \times 1/1.36\right], kW \qquad (7)$$

Where:

f.c = Fuel consumption, (*l*/h).

ρE = Density of fuel, (kg/*l*), (for Gas oil = 0.85).

L.C.V = Calorific value of fuel, (11.000 k.cal/kg).

η_{thb} = Thermal efficiency of the engine, (35 % for Diesel engine).

427 = Thermo-mechanical equivalent, (kg.m/k.Cal).

η_m = Mechanical efficiency of the engine, (80 % for Diesel engines).

So, the energy can be calculated as following:

$$Energy\ requirements = \frac{Engine\ power, (kW)}{Actual\ field\ capacity, (fed / h)},\ kW.h / fed \qquad (8)$$

8. Planting cost: The planting cost was estimated using the following equation:

$$Planting\ cost = \frac{Machine\ cost\ (L.E / h)}{Actual\ field\ capacity\ (fed / h)}, (L.E / fed) \qquad (9)$$

Machine cost was determined by using the following equation **(Awady 1978)**:

$$C = \frac{P}{h}\left(\frac{1}{a} + \frac{i}{2} + t + r\right) + (0.9W.S.F) + \frac{m}{144} \quad (10)$$

Where:

C = Hourly cost, L.E/h.
P = Price of machine, L.E.
h = Yearly working hours, h/year.
A = Life expectancy of the machine, y.
i = Interest rate/year.
F = Fuel price, L.E/l.
t = Taxes, over heads ratio.
R = Repairs and maintenance ratio.
m = Monthly average wage, L.E
0.9 = Factor accounting for lubrications.
W = Engine power, hp.
S = Specific fuel consumption, l/hp.h.
144 = Reasonable estimation of monthly working hours.

3. RESULTS AND DISCUSSION

Data obtained from laboratory tests and field experiments aimed to evaluate a simplified machine for direct planting okra seeds. Results show that there are some operating parameters affecting the planting process with thus planter such as No. of bores on the strips, the diameter of these bores and the planter forward speed.

3.1. Seed discharge:

The laboratory tests were carried out to obtain the suitable seed discharge from seed hoppers to give adaquate plant density in the unit area according to the reccommended plant population. of. It was observed that this amount of (3-4 kg/fed) could be achieved at bore diameter of between (6 to 7.5 mm) and No. of bores of between (3 to 5 bores) on the circumference of the seed hopper. The field tests were carried out under the previous conditions and show that:

3.1.1. Effect of hole diameter on seed discharge:

Related to the effect of hole diameter on okra seed discharge. Fig. 4. show that increasing the hole diameter from 6 to 7.5 mm led to increase the seed discharge from 3.04 to 5.93 kg/fed at 4 No. of holes on the hopper and high planter forward speed of 1.15 km/h. Increasing seed discharge as the hole diameter increases was due to increase the effective space allow more seeds fallen down from hopper.

3.1.2. Effect of numbers of holes on seed discharge:

Regarding the effect of No. of holes on okra seed discharge. Fig. 4. show that increasing No. of holes from 3 to 5 holes increased seed discharge from 2.86 to 7.42 kg/fed at hole diameter of 7.5 mm and high planter forward speed of 1.15 km/h. Increasing seed discharge as the No. of holes increase may

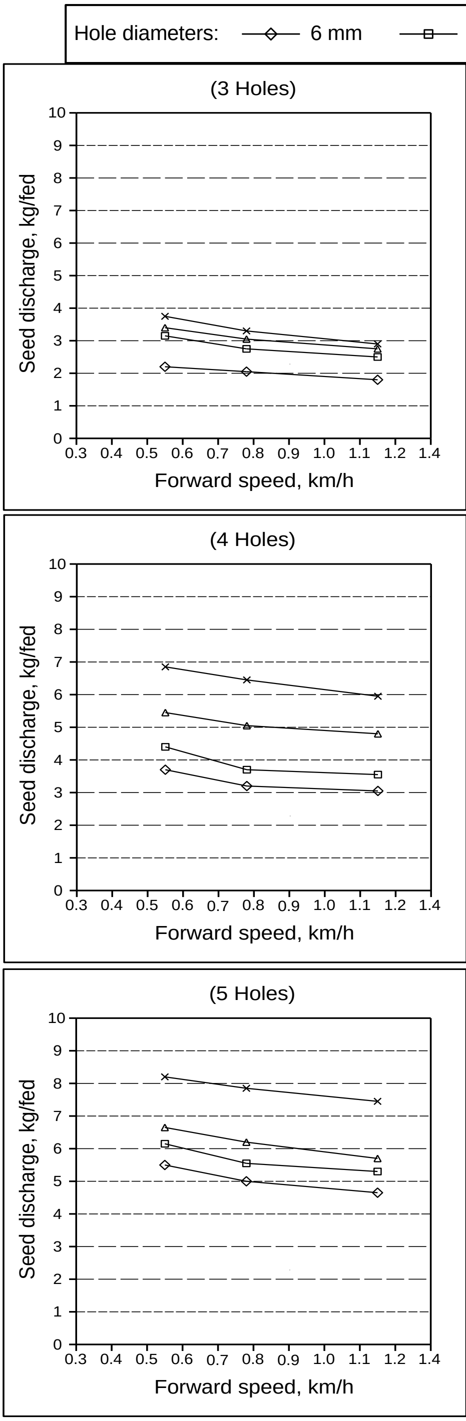

Fig.(4): Effect of machine forward speed on seed discharge at different hole diameters and different No. of holes on the hoppers.

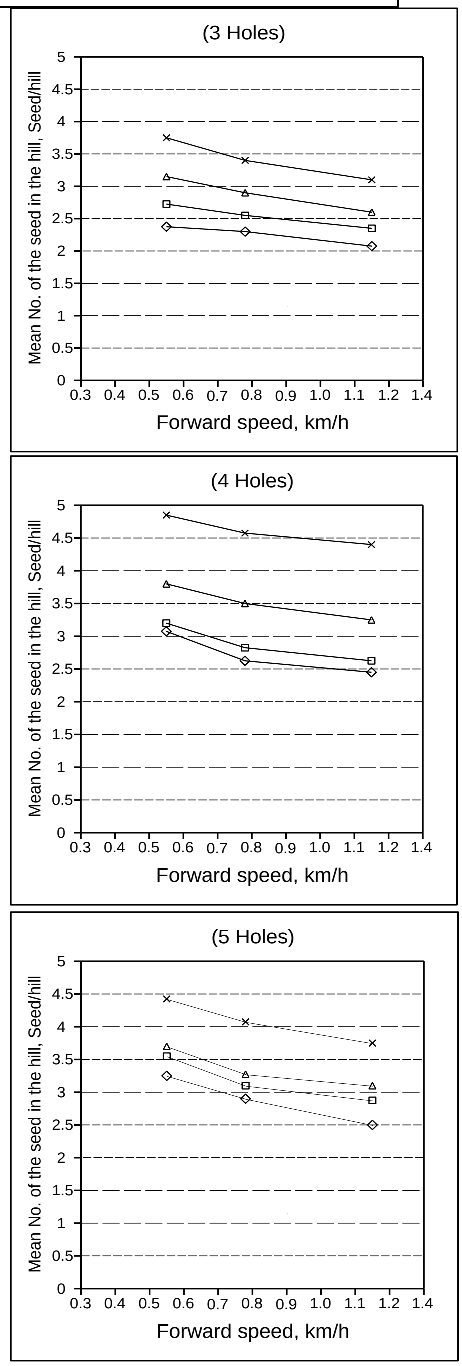

Fig.(5): Effect of machine forward speed on No. of seeds per hill at different hole diameters and different No. of holes on the hoppers.

attribute to increase the number of spaces in one revolution of ground wheel that allow more seeds fallen down from hopper.

3.1.3. Effect of planter forward speed on seed discharge:

As to the effect of planter forward speed on okra seed discharge. Results in Fig. 4. show that, increasing planter forward speed leads to decrease seed discharge in all test runs. Increasing planter forward speed from 0.55 to 1.15 km/h reducing seed discharge from 5.38 to 4.68 kg/fed at hole diameter of 7 mm and 4 No. of holes on the hopper. The high planter forward speed producing a high rotation motion for the seeds in the hopper making the seeds passing over the holes without fallen down due to increase shearing force by increasing rotating speed presenting insufficient time for seeds to fall down from the hopper holes.

3.2. Number of seeds in the hill:

Date in Fig. 5. show the effect of the number of holes, the hole diameter and planter forward speed on number of seeds fallen down from the hopper in the hill.

3.2.1. Effect of hole diameter on No. of seeds per hill:

As to the effect of hole diameter on the number of seeds in the hill. Fig. 5. show that increasing the hole diameter from 6 to 7.5 mm led to increase the number of seeds in the hill from 2.45 to 4.36 seed/hill at 4 No. of holes on the hopper and high planter forward speed of 1.15 km/h. Increasing No. of seeds per hill as the hole diameter increases was due to increase the seed discharge.

3.2.2. Effect of numbers of holes on No. of seeds per hill:

Concerning the effect of No. of holes on the number of seeds in the hill. Fig. 5. show that, generally, increasing the No. of holes on seed hoppers increased the No. of seeds per hill. Increasing the No. of holes from 3 to 4 holes increased the No. of seeds per hill from 3.71 to 4.91 seeds/hill at hole diameter of 7.5 mm and planter forward speed of 0.55 km/h. This result was attributed to increase the number of spaces in the unit time allowing okra seed fallen down from holes. The same trend was noticed when the No. of holes increased from 4 to 5 holes under hole diameter of 6 and 6.5 mm.

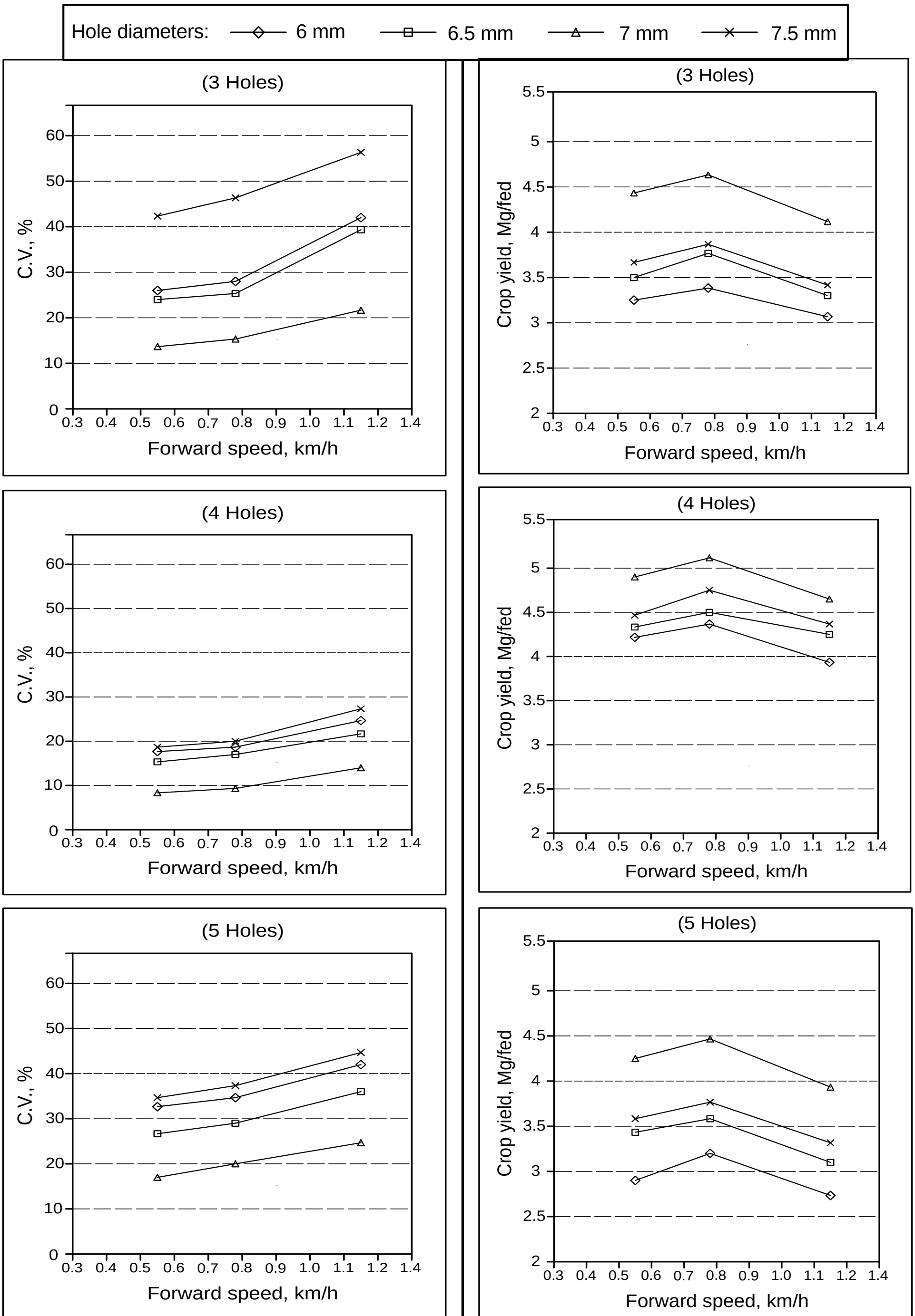

Fig.(6): Effect of machine forward speed on C.V. at different hole diameters and different No. of holes on the hoppers.

Fig.(7): Effect of machine forward speed on okra yield at different hole diameters and different No. of holes on the hoppers.

hopper. Increasing the No. of holes from 4 to 5 holes led to decrease the No. of seeds per hill from 4.91 to 4.43 seeds/hill at 7.5 mm hole diameter and planter forward speed of 0.55 km/h. This result may due to increase the fallen space causing seed clogging at the time of fallen down from the holes resulting less seeds in the hills.

3.2.3. Effect of planter forward speed on No. of seeds per hill:

Regarding the effect of planter forward speed on No. of seeds per hill. Fig. 5. illustrated that increasing planter forward speed from 0.55 to 1.15 km/h led to decrease the No. of seeds per hill from 3.71 to 3.08, from 4.91 to 4.36 and from 4.43 to 3.72 seeds/hill at constant hole diameter of 7.5 mm and No. of holes on the hopper of 3, 4 and 5 holes, respectively. Decreasing the No. of seeds in the hill by increasing the planter forward speed could be resulted as the seed discharge decreased because of increasing rotating speed of seed hoppers presenting insufficient time for seeds to fall down from the hopper.

3.3. Coefficient of variation, (C.V.):

Fig. 6. show the effect of the number of holes, the hole diameter and planter forward speed on coefficient of variation (C.V) during planting okra seeds.

3.3.1. Effect of hole diameter on the coefficient of variation, (C.V.):

As to the effect of hole diameter on the coefficient of variation, (C.V.). Fig. 6. show that the hole diameter of 7 mm gave the lowest (C.V.) values of 7.96, 9.14 and 14.81 % at No. of holes on the hopper of 4 holes and different planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively. Any further decrease or increase the hole diameter leads to increase the (C.V.) values, rapidly. Decreasing hole diameter from 7 to 6 mm increased the (C.V.) values from 7.96, 9.14 and 14.81 % to 16.51, 18.24 and 24.15 % at No. of holes on the hopper of 4 holes and different planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively. While increasing hole diameter from 7 to 7.5 mm increased also the (C.V.) values from 7.96, 9.14 and 14.81 % to 17.80, 19.60 and 26.50 % at No. of holes on the hopper of 4 holes and different planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively.

These results illustrated that the hole diameter of 7 mm was the suitable one which gave the lowest (C.V.) values because of there are adequate space to fall down okra seeds smoothly. While the okra seeds may clogged in the small hole diameter of 6 mm and not fallen down since the average okra seed diameter was 4.5 mm. Whereas, the large hole diameter of 7.5 mm could be included more than one seed causing unsuitable seed discharge and then high (C.V.) values.

3.3.2. Effect of number of holes on coefficient of variation, (C.V.):

Concerning the effect of No. of holes on the coefficient of variation, (C.V.). Fig. 6. show that the hole number of 4 holes was the suitable which gave the lowest (C.V.) values of 7.96, 9.14 and 14.81 % at hole diameter of 7 mm and different planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively. Any further decrease or increase in hole number less or more than 4 holes leads to increase the (C.V.) values rapidly. The 3 hole number increased the (C.V.) values from 7.96, 9.14 and 14.81 % to 14.31, 16.21 and 21.68 % at hole diameter of 7 mm and different planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively. While the 5 hole number increased the (C.V.) values also from 7.96, 9.14 and 14.81 % to 16.57, 19.71 and 25. 21 % at hole diameter of 7 mm and different planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively. These results illustrated that the 4 hole number was the suitable one which gave the lowest (C.V.) values because the 4 holes number presented adequate inner circumference distance which give the okra seeds the suitable time to move and fallen down from the holes. While the 3 hole number gave a long circumference distance causing more impact forces on okra seeds in the hopper resulting in unsteady fallen down. Whereas, the 5 hole number gave short circumference distance resulted short time for okra seeds to fall down from holes which making double planting space and also it could be fallen seeds from more than hole at the same time causing unsuitable seed discharge and then high (C.V.) values.

3.3.3. Effect of planter forward speed on coefficient of variation, (C.V.):

Fig. 6. show that, generally, increasing planter forward speed leads to increase the coefficient of variation, (C.V.) values. Increasing planter forward speed from 0.55 to 1.15 km/h increased the (C.V.) values from 14.31 to 21.68 %, from 7.96 to 14.81 and from 16.57 to 25.21 % at constant hole diameter of 7 mm and different numbers of holes of 3, 4 and 5 holes, respectively. Increasing the (C.V.) values as the planter forward speed

increased may be attributed to insufficient time and unsuitable conditions in the hopper causing unsteady fallen down of seeds from planter hoppers.

3.4. Okra yield:

3.4.1. Effect of hole diameter on okra yield:

Related to the effect of hole diameter on Okra yield. Fig. 7. show that the hole diameter of 7 mm gave the highest yield of 4.89, 5.12 and 4.66 Mg/fed at No. of holes on the hopper of 4 holes and different planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively. Any further decrease or increase the hole diameter leads to decrease the okra yield rapidly. Decreasing hole diameter from 7 to 6 mm decreased the okra yield from 4.89, 5.12 and 4.66 Mg/fed to 4.26, 4.41 and 3.95 Mg/fed at No. of holes on the hopper of 4 holes and different planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively. While increasing hole diameter from 7 to 7.5 mm decreased also the okra yield from 4.89, 5.12 and 4.66 Mg/fed to 4.48, 4.75 and 4.35 Mg/fed at No. of holes on the hopper of 4 holes and different planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively. These results illustrated that the hole diameter of 7 mm was the suitable one which gave the lowest (C.V.) values which gave the suitable uniformity distribution for okra seeds and then gave the suitable plant numbers and distribution in the field resulting in high okra yield.

3.4.2. Effect of number of holes on okra yield:

As to the effect of hole diameter on okra yield. Fig. 7. show that the hole number of 4 holes was the suitable which gave the highest okra yield values of 4.89, 5.12 and 4.66 Mg/fed at hole diameter of 7 mm and different planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively. Any further decrease or increase in hole number less or more than 4 holes leads to decrease the okra yield rapidly. The 3 hole number decreased okra yield values from of 4.89, 5.12 and 4.66 Mg/fed to 4.43, 4.62 and 4.13 Mg/fed at hole diameter of 7 mm and different planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively. While the 5 hole number decreased okra yield values from of 4.89, 5.12 and 4.66 Mg/fed to 4.26, 4.47 and 3.93 Mg/fed at hole diameter of 7 mm and different planter forward speeds of 0.55, 0.78 and 1.15 km/h, respectively. These results illustrated that the 4 hole number was the suitable one which gave the lowest (C.V.) values and the suitable uniformity distribution for okra seeds and then gave the suitable plant numbers and distribution in the field resulting in high okra yield.

3.4.3. Effect of planter forward speed on okra yield:

Concerning the effect of hole diameter on okra yield. Fig. 7. show that the planter forward speed of 0.78 km/h was the suitable which gave the highest okra yield values of 4.62, 5.12 and 4.47 Mg/fed at hole diameter of 7 mm and different hole numbers of 3, 4 and 5 holes, respectively. Any further decrease or increase in planter forward speed less or more than 0.78 km/h leads to decrease the okra yield rapidly. The planter forward speed of 0.55 km/h decreased okra yield values from 4.62 to 4.43, from 5.12 to 4.89 and from 4.47 to 4.26 Mg/fed at hole diameter of 7 mm and different hole numbers of 3, 4 and 5 holes, respectively. While the planter forward speed of 1.15 km/h decreased okra yield values from 4.62 to 4.13, from 5.12 to 4.66 and from 4.47 to 3.93 Mg/fed at hole diameter of 7 mm and different hole numbers of 3, 4 and 5 holes, respectively. These results illustrated that the planter forward speed of 0.78 km/h was the suitable one which gave the suitable uniformity distribution for okra seeds and then gave the suitable plant numbers and distribution in the field resulting high okra yield.

3.5. Planter field capacity and efficiency:

As shown in Table 1. The effective field capacity of the okra planter increased from 0.221 to 0.395 fed/h as planter forward speed increased from 0.55 to 1.15 km/h, while the field efficiency was decreased from 86.33 to 80.12 %. These values correspond to those of the literature cited and even have acceptable values as those of the manually-operated seeding attachment. The satisfactory results may be due to the high maneuverability of the direct planter, which saves time in turning or moving from place to another.

Table 1: Field capacity, field efficiency, energy consumed and planting cost for okra planter.

Forward speed, (km/h)	A.F.C. (fed/h)	F.Eff. (%)	Energy for worker (kW.h/fed)	Energy for tractor (kW.h/fed)	Cost of machine and worker (L.E./fed)	Cost of machine and tractor (L.E./fed)
0.55	0.221	86.33	0.333	74.35	28.78	78.46
0.78	0.281	83.98	0.262	58.58	22.63	61.71
1.15	0.395	80.12	0.186	41.60	16.10	43.90

3.6. Energy consumed and planting cost:

Concerning the effect of okra planter forward speed on energy consumed (kW.h/fed) and planting cost (L.E/fed), results in Table 1. indicated that at forward speeds of 0.55, 0.78 and 1.15 km/h the energy consumed were 0.333, 0.262, 0.186 kW.h/fed and 74.35 58.58 and 41.60 kW.h/fed for man worker with planter and for tractor with planter, respectively. While, the planting cost were 28.78, 22.63 and 16.10 L.E/fed and 78.46, 61,71 and 43.90 L.E/fed, at the same previous conditions. It is noticed that increasing planter forward speed leads to decrease both energy consumed and planting cost; these results were attributed to the increase in planter field capacity as the forward speed increased.

4. SUMMARY

A simplified okra planter was manufactured from locally available materials and evaluated under laboratory and field conditions. This planter could be drawn by a human, animal or small tractor. This planter was developed to be suitable for planting the most spherical seeds with different sizes. In this study, the new planter was adjusted to plant okra seeds under their own characteristics. The obtained laboratory and field tests reveal that the coefficient of variation values were minimum, while the okra yield was maximum under the following conditions:

- The use of the simplified manually or tractor drawn planter for sowing okra seeds.
- Operate the manufactured machine at a forward speed of about 0.78 km/h.
- Adjust the hopper holes diameter at 7 mm with 4 numbers of holes.

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الملخص العربي

تصنيع وتقييم آلة مبسطة لتناسب زراعة بذور الباميا

د. محب محمد أنيس الشرباصي* **د. محمود مصطفى علي علي***

يلجأ بعض المزارعون في هذه الأيام إلى بذر بعض أنواع المحاصيل الغير تقليدية وذات الربحية العالية مقارنة بالمحاصيل التقليدية الأخرى. هذه المحاصيل مثل الباميا، الكركديه، إكليل الجبل وغيرها من النباتات الطبية والعطرية ذات المردود الاقتصادي العالي. ولأن هذه المحاصيل تزرع على نطاق محدود في مصر فإن المزارعين يلجئون إلى بذر هذه المحاصيل يدوياً أو باستخدام آلات الزراعة التي غالباً ما تكون مكلفة أو غير متوافرة في جميع الأحيان أو أن بعض هذه الآلات له المقدرة على زراعة نوع من البذور دون آخر. لذا فإن هذا البحث تم إجراؤه لتصنيع وتقييم آلة للزراعة في جور بخامات محلية رخيصة الثمن وذلك لزراعة العديد من هذه المحاصيل بسهولة ويسر مع التوفير الكبير في تكاليف عملية الزراعة. وقد تم تطوير وتصنيع هذه الآلة في ورشة قسم الهندسة الزراعية - كلية الزراعة - جامعة الزقازيق لزراعة بذور الباميا على مسافات بين الخطوط ٦٠ سم وبين الجور تتراوح مابين ١٠-٢٠ سم حسب إرشادات وزارة الزراعة. تتركب هذه الآلة من أربع أجزاء رئيسية هي:-

١- **قادوس البذور:** حيث تحتوي الآلة على ثلاثٍ منها ذات شكل اسطواني غير كامل بكل منها فتحة لدخول البذور يمكن سدها بواسطة مسمار مسنن ذو رأس مربع وتستمد حركتها الدورانية من العمود الرئيسي المتصل بالعجلات الأرضية. السعة الكلية لكل قادوس حوالي ٣ كجم، وبالتالي فإن هذه الآلة يمكنها زراعة واحد فدان دون إعادة التزود بالبذور وهذا يقلل الزمن المفقود ويزيد من كفاءة الآلة.

٢- **الشرائط المثقبة:** هذه الشرائط ذات أبعاد (٢٠ مم عرض × ٦٣٠ مم طول) يتم تثقيبها بعدد (٣، ٤ و ٥ ثقوب) وهذه الثقوب تكون ذات أقطار مختلفة (٦، ٦.٥، ٧ و٧.٥ مم) لتناسب أقطار بذور الباميا.

٣- **الفجاجات:** حيث تحتوي آلة الزراعة على ثلاث فجاجات تقوم بفتح الخط بالعمق المطلوب قبل نزول البذور مباشرة. يمكن التحكم في ارتفاع الفجاجات من خلال ثقوب رأسية ومسمارين مسننين.

٤- **جهاز التغطية:** عبارة عن لوح من الخشب أبعاده (١٦٥٠ مم طول × ١٥٠ مم عرض × ٣٠ مم سمك) وهو يقوم بالتغطية بعد الزراعة مباشرةً.

تم إجراء الاختبارات المعملية والحقلية على الآلة المطورة في ورشة قسم الهندسة الزراعية – كلية الزراعة - جامعة الزقازيق وفي مزرعة خاصة بقرية الروضة - فاقوس – شرقية ، وذلك لمعايرة هذه الآلة، قياس كلاً من نسبة التشتت للبذور ومتوسط عدد البذور الساقطة في الجورة، كمية المحصول النهائي، السعة والكفاءة الحقلية،

* أستاذ مساعد – قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق – مصر.

وكذلك الطاقة المستهلكة والتكاليف الكلية لعملية الزراعة من خلال المتغيرات التالية: أربعة أقطار مختلفة للفتحات في الشرائط المثقبة هي (٦، ٦.٥ ،٧ و ٧.٥ مم) للتحكم في عدد البذور في الجورة الواحدة، أعداد مختلفة من الفتحات على محيط الشريط المثقب (٣ ، ٤ و ٥ فتحات) للتحكم في المسافات بين الجور و ثلاث سرعات أمامية لآلة الزراعة (٠.٥٥ ، ٠.٧٨ و ١.١٥ كم/س).

وقد خلصت النتائج إلى الآتي:

- أعلى كمية من البذور الساقطة من القواديس كانت ٨.١٦ كجم/ف عند عدد فتحات ٥ فتحة، قطر فتحات ٧.٥ مم و سرعة أمامية ٠.٥٥ كم/س.
- أكبر عدد لمتوسط البذور في الجورة الواحدة كان ٤.٩١ بذرة عند عدد فتحات ٤ فتحة، قطر فتحات ٧.٥ مم و سرعة أمامية ٠.٥٥ كم/س.
- القيم الصغرى لمعامل الاختلاف كانت ٧.٩٦، ٩.١٤ و ١٤.٨١ % عند عدد فتحات ٤ فتحة، قطر فتحات ٧ مم و سرعات أمامية ٠.٥٥، ٠.٧٨ و ١.١٥ كم/س، على الترتيب.
- أعلى كمية من محصول الباميا كانت ٥.١٢ ميجاجرام/ف تم الحصول عليها عند عدد فتحات ٤ فتحة، قطر فتحات ٧ مم و سرعة أمامية ٠.٧٨ كم/س.
- أقل طاقة مستهلكة وتكاليف كلية لعملية الزراعة باستخدام الآلة الجديدة كانت ٠.١٨٦ و ٤١.٦٠ كيلوات.س/ف و ١٦.١٠ و ٤٣.٩٠ جنيه/ف عند سرعة أمامية ١.١٥ كم/س لكل من العامل مع الآلة والجرار مع الآلة، على الترتيب.
- استخدام الآلة الجديدة لزراعة الباميا بعدد فتحات ٤ فتحة على قادوس البذور، قطر الفتحات ٧ مم وسرعة أمامية لآلة الزراعة ٠.٧٨ كم/س. أدى إلى زراعة الباميا على مسافات ٦٠ سم بين الصفوف، ١٥ سم بين الجور و متوسط عدد بذور في الجورة ٣ بذرة مما أعطى أعلى إنتاجية للفدان.