A SUITABLE POTATO PLANTER TO PLANT TUBER PIECES WITH PREVIOUSLY GROWN SPROUTS
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ABSTRACT
Small developed potato planter was constructed and tested to plant potato tubers with previously grown sprouts. Measurements on sprout pulling-force were conducted. They depend primarily upon the mass of tuber, the germination period and the shape of tuber sprout. Pulling sprout force, shatter bruises, and the percentage of sprout damage (sprout separation %) were correlated with the mass of the tuber pieces. The speed of feeding system and the free fall height were also examined. The tuber spacing in row, tuber void, doubles and tuber intensity were evaluated as dependent variables. The correlation between the tuber mass and the sprout resistance to pulling was found to be moderate \( r = 0.77 \) and variable with the germination period. The lowest percentage of sprout removal (0.7%) was at 20 rpm and 4 mm of sprout length. The void ratio were largely valid within the range of 0.6 up to 0.8 m/s of planting speed, moreover, the results revealed that the tubers double decreases with increasing planting speed.

Key words: planter, potato device, tuber pieces planter and sprouts systems analysis of potato feeding.

INTRODUCTION
Potato is ranked as one of the most important vegetable crops in Egypt. Despite the increase of the yield from 8.34 ton/field. in 1986 to 10.50 ton/field. in 1991 (Ag. St. year Book), the production does not meet the dramatic increase of population and exportation, at the same time. Special attention must be given to establish a new suitable technique for potato planting as an important operation influencing the yield. There is a trend towards planting tuber pieces of potato with previously grown sprouts. Increasing productivity of potato in a shorter period is the main goal, which can be achieved by using suitable technology. The suggested technique is divided into two main steps. The first includes the method of tuber cutting. While the second is investigating the methods of sprout growing. Mechanical tuber cutting results in different sized tuber pieces. To improve tuber size uniformity, tubers should be presided and the tuber cutter knives should be adjusted. Accordingly (Liritani et al.-1972). Tuber pieces less than 28g should be discarded due to its low productivity. Small pieces will also result in undesirable stands in the field by causing multiple tuber pieces in a hill or missing hills (Young et al.-1984).

While Alojzy et al. (1989) indicated that the small tuber pieces is more desirable for use under conditions of a long growing season, because plants from small tuber tends to stay green longer and mature. He also added that the size of the tuber surface of the impact head was correlated with the tuber mass and size. A study in New Brunswick showed that 25% missing plants at emergence caused an 8 % yield reduction (James et al., 1973). However, Votoupal (1984) indicated no reduction in yield for up to 37% missing plants primarily because largest tuber were conformed. Spacing was shown to affect yield when the coefficient of variation reaches 37 %. While, Liritani's study (1972) on spacing interacts with tuber size, indicated that when considering
total yield effect on the spacing variability of 25, 50 and 75% did not reduce yields when the means spacing was 45.7 cm for cut tuber of 68g. Haderlie et al. (1989) indicated that the yield sometimes tended to decrease as tuber piece spacing increased. Ismail (1992) showed that only 10% of the variation in tuber mass per hill was attributable to tuber size when spacing was 30 cm. The resultants also showed that the most suitable tuber piece size must be in range of 30-50 grams per hill when spacing was 25 ± 5 cm.

The life-period of potato plant takes usually about 120 days. This period can be divided into three stages as follows:

**First Stage**: Starts from first day of planting till the appearance of the tubers. It takes about 6 to 8 weeks.

**Second Stage**: Takes about two week from the appearance of potato tubers.

**Third Stage**: Starts from tuber formation till harvesting time.

The first stage is considered the longest one. Therefore, it is important to try to reduce this stage by using previously grown sprouts in planting. Applying this technique needs modification of the potato planter. Various types of potato planters are available in the world market (Smith and Wilker-1984). They added that these planters may be varied within the row in row width, plant spacing and within its mechanisms which have to be fed by hand or fully automatic types. These machines may not be able to plant potato tubers by previously grown sprouts. the damage of the tuber pieces which have grown sprouts will increase as a function of the friction between the tuber and the guide surface of feeding system. Nevertheless, this phenomenon affects the quality of planting.

The purpose of this study is to develop and modify a small potato planter having a feeding system with a chain-spoons to plant potato tuber pieces with previously grown sprouts.

**DESIGN CONSIDERATION**

A widely design of chain-spoons feeding system is set vertically, and the buckets are provided with indented spoons. A single tuber is manually fed to every spoon, which will be lifted upward. Then, the tuber is dropped down on the next back of spoon in conveyor (Fig. 1-A). Under this condition the tuber piece is exposed to friction force between its surface and the conveyor guide, until it leaves the feeding unit. The tuber pieces will be exposed to damage every revolution of feeding system. Mainly, there are three zones of damage namely:

1- The zone at which the tuber is dropped on the next spoon.
2- The zone at which the tuber is exposed to friction between its surface and the conveyor guide.
3- The zone at which the tuber piece leaves the feeding unit and impact to the bottom surface of the ridge.

To meet the aim of this paper a theoretical analysis was conducted to deal with the machine design parameters.
Fig. 1-A: The first damage zone
1- Chain-feed device.
4- Spoon.

Fig. 1-B: The second damage zone
2- Driven gear.
5- Driver gear.

Fig. 1-C: The third damage zone
3- Guide surface.
6- Soil surface

Fig. 1: The damage zones in chain-feed device potato planter.
First Damage Zone:

Primary observation during one revolution of the chain-fed system indicated that the tuber piece conveyed to the maximum point on the chain-fed and then it came to drop at fraction of a second. Then, the conveying velocity of chain-spoon will cause a force to push the tuber towards the next back of spoon. The direction analysis of falling of tuber pieces, as shown in Fig. (1-A), consider that the direction of motion, with neglected air resistance, is subjected to the following factors:

1- The conveying velocity of chain-spoon, m/s
2- Mass of tuber piece, kg
3- Gravitational of soil, m/s

Theoretically, the initial speed of tuber falling (V0) at the moment of leaving the spoon and take its way to the next back of spoon may be calculated by the following Eq. (V0 = ω R). Referring to Fig. (1 -A) and resolve “V0” into components “Vx” and “Vy” relative to the two coordinates “X” and “Y”, the motion of the tuber is considered a linear motion with a uniform acceleration in direction of “Y” axis.

Then,

\[ V^2 = V_Y^2 + 2 g S \]  \hspace{1cm} (1)

where;
\[ V = \text{Impact speed of tuber on the next back of spoon, m/s} \]
\[ V_Y = \text{Tuber speed in the spoon} = V_0 \cos \alpha = \omega R \cos \alpha \]
\[ \omega = \text{Angular speed of driven gear, rad/s} \]
\[ S = \text{The vertical displacement of tuber, m} \]

Substituting the values of “Vy” in Eq. 1, then

\[ V^2 = 0.01 n^2 R^2 \cos^2 \alpha + 2 g S \]  \hspace{1cm} (2)

Where:
\[ n = \text{Revolution number of the feeding unit, rpm} \]
\[ R = \text{Radius of feeding gear (r1) + tuber radius (r2), m} \]
\[ \alpha = \text{Tuber falling angle, degree} \]

The kinetic energy relative to the impact of the tuber piece on the next back spoon \( I_1 \) may equal “1/2 m \( V^2 \)”. Substituting the value of “\( V \)” from Eq. 2. Then,

\[ I_1 = 0.005 n^2 m R^2 \cos^2 \alpha + S g m \]  \hspace{1cm} (3)

The maximum impact of the tuber will occur at the maximum of “n”, “S”, “R” and “m”. The value of “\( I_1 \)” is found to be 0.051 J at \( n = 25 \) rpm, \( R = 0.14 \) m; \( g = 9.81 \) m/s; \( \alpha = 30^\circ \); \( S = 0.1 \) m and \( m = 0.05 \) kg. Then the damage force upon the tuber is about 0.51N.

Second Damage Zone: Logically, the tuber on the spoon back, (Fig. 1-B) will exposes during conveying to;

a) Friction force between the feeding guide and the tuber surface.
b) The mass of tuber pieces.

By taking the force vectors in the direction of “OY” axis as shown in Fig. 1-B the equation of Newton dynamic may be rewritten in the following pattern:

\[ ma = mg - F \]
\[
m \frac{dv}{dt} = mg - F
\]

Multiplying equation "4" by "\(\frac{dt}{dt}\)" and integrating from initial speed of tuber "\(V_1 = 0\)" at initial time "\(t_0 = 0\)" to the maximum speed \(V_2\) at maximum time of conveying the tuber until exiting from the feeding guide "\(t\)". Then,

\[
\int_{V_1}^{V_2} dv = \int_{t_0}^{t} g \, dt - \int_{t_0}^{t} \frac{F}{m} \, dt
\]

\[
V_2 = gt - \frac{F}{m} t
\]

Tuber falling height "\(h\)" (Fig. 1-B) may be obtained by integrating the Eq. 6 relative to the dropping time "\(t\)". Then,

\[
\int_{t_0}^{h} dh = \int_{t_0}^{t} \left[g \, t - \frac{F}{m} \, t\right] \, dt
\]

\[
h = \frac{g}{2} \frac{t^2}{2} - \frac{F}{2m} \frac{t^2}{2}
\]

Then the "\(F\)" values is equal

\[
F = m \left[g \frac{2h}{t^2}\right]
\]

Eq. 9 may be used to determine the friction force (\(F\)), if data are available for "\(m\)", "\(g\)" , "\(h\)" , and "\(t\)". For sake of an example, let us assume that \(m = 0.05\) kg, \(g = 9.81\) m/s\(^2\), \(h = 90\) cm and \(t = 0.25\) s. Then \(F = 0.949\) N and the negative sign means that the direction of "\(F\)" force in the opposite direction of tuber motion.

**Third Damage Zone:**

The geometrical analysis of falling from the feeding device until the furrow bottom play an important role to determine the values of tuber damage. Logically, the motion of the exiting tuber chain-fed is relative to the two velocity vectors namely peripheral speed of this unit \((V_L)\) and the forward speed of the planter \((V_m)\). Theoretically, the tuber exiting speed \(V_x\) [the tuber speed at the moment of leaving the feeding unit] may be calculated according to Gosensieve and Ismail (1985) and Ismail (1986) by the following Eq.

\[
V_x = \sqrt{V_m^2 + V_L^2 + 2 \, V_m \times V_L \times \cos \gamma}
\]

Where:
- \(\gamma\) = The deposition tuber angle in feeding mechanism,
- = arc cos \([1 - ((d/2)/(R_L + L))]\), degree
- \(d\) = Tuber diameter, cm
- \(R_L\) = Driver gear radius, cm
- \(L\) = Spoon length, cm
- \(V_m\) = Forward speed, m/s
- \(V_L\) = Peripheral speed for spoon, m/s

To determine the free falling height "\(h\)" displacement relative to the Y-Y coordinate. It is necessary to resolve "\(V_x\)" into the two components "\(V_h\)" in x-axis direction and "\(V_v\)" in Y-axis direction (Fig. 1-C). The falling tuber in "O-Y" direction is donate as the following form:
\[
\text{d} V_H = a_H \text{ dt} \\
\int_{V_e \sin \beta}^{V_H} \text{d}V = \int_{0}^{t_2} g \text{ dt}
\]

Where:
- \( V_e \sin \beta \) = Donate as initial tuber falling speed, m/s
- \( V_H \) = Final tuber speed at moment contact with the soil surface, m/s

\[
\therefore V_H = V_e \sin \beta + g t_2 
\]

(11)

But
\[
V_H = \frac{dH}{dt} 
\]

(12)

Substituting the Eq. 12 in Eq. 11, then
\[
H = \int_{0}^{t_2} (V_0 \sin \beta + g t) \text{ dt} 
\]

\[
H = V_e \ t_2 \sin \beta + g t_2^2 
\]

(13)

Where:
- \( H \) = Free falling height, cm
- \( t_2 \) = Dropping time of tuber, s
- \( g = a_e \) = Gravitational constant, 981 cm/s
- \( \beta \) = Tuber exiting angle from feeding disc, degree

Finally, the drop time "\( t_2 \)" and the contact tuber velocity "\( V_H \)" can be obtained from Eq. 13 and Eq. 11 respectively. The kinetic energy of the tuber impact "\( I_s \)" between the tuber and ridge bottom may be equal to "\( 1/2 \ m \ V^2 \)". Substituting the "\( V \)" as "\( V_H \)" from Eq. 11. Then:
\[
I_s = \frac{1}{2} m [V_e \sin \beta + g t_2^2]^2 
\]

(14)

Substituting the value of "\( t_2 \)" from Eq. 13 in Eq. 14,
\[
I_s = \frac{1}{2} m [V_e^2 \sin^2 \beta + 2 g H] 
\]

(15)

Eq. 15 represents the relationship between the kinetic energy of tuber impact and the parameters that affect it's values. The maximum kinetic energy upon the tuber pieces will occur at the maximum of \( V_e \), \( H \) and \( m \). The value "\( I_s \)" is found to be 0.151 J at \( n = 25 \) rpm; \( R_1 = 8 \) cm; \( L = 6 \) cm; \( \gamma = 22^\circ \); \( V_m = 0.6 \) m/s; \( \beta = 30^\circ \); \( m = 0.05 \) kg and \( H = 30 \) cm. Then the damage force upon the tuber is about 0.503 N. From the above analysis, the total damage forces are considered as the sum of the three types of damage "\( F_T = 1.962 \) N".

To avoid these disadvantages, the structure of chain feeder has been developed. The spoons were replaced with a simple cups (Fig.2-A). They are designed to convey the tuber and to keep it from movement until exiting from the feeding system. Consequently, the tuber did not:

a) Dropped down on the next spoon in conveyor (first zone of tuber damage).

b) Act upon on the friction force between it's surface and the guide of feeding system (second zone of tuber damage).

To overcome the damage of tuber in the third zone, as noticed from Eq. 15, the exiting tuber angle "\( \theta \)" and the free fall height may be minimized. Then the following attempts were carried out:
1) In the new design, the tuber exiting angle (Fig. 2-B) makes the tuber be dropped in vertical direction. Consequently, the "P angle = 0" and the Eq.15 become:

\[ I_c = m \cdot g \cdot H \]

2) Reducing the free fall height "H" from 30 to 10 cm.

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**Fig. 2-A**
1- Driver gear  
2- Driven gear  
3- Cups  
4- Chain

**Fig. 2-B**

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**MATERIALS AND METHODS**

Potato Planter:
The new constructed chain-fed of the potato planter was developed to plant tuber pieces having grown sprouts. The planter was constructed at local workshop. Its consists of the following parts:

1) A steel frame consists of different parts which can be easily assembled and modified (Figs. 3 and 4) as follows:
   a. Two main square beams with cross-section of 100*100 mm. The first, at the front end (800 mm) and the second, at the back end (1500 mm).
   b. The main beams were connected to each other by two iron units (1300 × 300 mm). The two feeding systems were fixed in each of these units.

2) Two furrow openers (shoe shape type) were fixed in the front beam (Fig. 3). Each of them can be adjusted to control the depth of furrow.

3) Feeding system consists of two units, each unit contains ten cups.

4) Furrow closing system consists of three furrow closing units located at the back end.

5) Transmission system.

6) Tuber box.
Planter preparation
The planter was calibrated and adjusted to achieve 25 cm distance between tubers in row, 71 cm distance between two rows and 6 cm planting depth referring to (Ismail-1988; Nassar-1977 and Omar-1977).
Tuber Preparation

The sprouts were left to grow on the tuber. After that the tubers were cut into pieces. Each pieces has one or more sprout. A glass room was constructed at the roof of Ag. Mech. Dept. Six plant benches were installed inside the glass room to be used for germination tests. Each has surface area of 1 m² (2 m long x 0.5 m wide). The surface of plant benches were provided with straw bed.

The tuber pieces were distributed on them with rows distance of 10 cm and tuber distance in row of 5 cm. A tank of water was connected with the plant benches using a 12 mm diameter plastic tube to keep straw bed wet.

Experimental study

The experimental study consisted of two parts as follows:

1- Conducting laboratory tests to study the effect of germination period, mass of tuber pieces and the sprout length on the sprout resistance to damage.

2- To carry out the field tests on the new potato planter.

Laboratory tests

1- Tensile (pull) force tests were carried out to determine the proper age, as an index of sprout length, of potato tuber having sprouts. A force gauge device (Fig. 5) with maximum capacity of 2200 g, resolution 1 g and capacity of 0.2% was used to evaluate the sprout pulling force.

2- The providing tuber damage of the investigated planter is considered the first indicator of the feeding mechanism performance. It was evaluated by measuring the percentage of sprout removing (Br %) and the shatter index (SI).

3- The shatter bruise was determined by visual examination. The length of each bruise in the skin was measured using a handheld caliper. The bruise depth was located by slicing the potato tuber perpendicularly and along the depth of the cut. The depth was then measured using a handheld caliper. The shatter index (SI) was estimated by Grant et al., 1985:

\[ SI = \sum_{n=1}^{N} \frac{d_n \times h_n}{N} \]

Where:
- \( d \) = Length of shatter, mm
- \( h \) = Depth of shatter, mm
- \( N \) = Number of observation per tuber

4- The percentage of sprout removing (8 %) can be calculated after 5 evaluation of chain-cub feeding system as follow:

\[ B_r \% = \frac{B \times R}{T \times B} \times 100 \]

Where,
- \( B \times R \) = Removed sprout number after 5 revolutions of feeding system
- \( T \times B \) = Total number of sprout before tuber fed
Field tests

The field was divided into plots (22.5×50m) each and sub plots (7.5× 50m) each. The experiments were carried out in El-Tawella, Dakahilia Governorate private sector farm. The mechanical analysis of the experimental soil was 21.05% sand, 30.0% silt, 47.2% clay and 1.75% coarse sand. At depth from zero to 20 cm. The plots were selected at random from each treatment after plowing, harrowing and soil leveling were done traditionally.

1- Tuber spacing of the investigated planter is considered the first indicator of feeding mechanism performance. It was evaluated by measuring the space between tubers in row for each treatment. The frequency of tuber spacing was computed according to analysis of single-variable method (Robert-1976).

2-Tuber void (%) is considered the second indicator for feeding mechanism performance. Tuber is void when the distance between planted tubers in row (Sc) > 2 (the pre-adjusted distance) St , Bernacki et al. (1972). Tuber void was estimated for each treatments by estimating the number of "Sc" in each experimental plot. The percentage of voids can be calculated as follows:

\[ V_t = \frac{m_n}{M} \times 100 \]

Where:

- \( V_t \) = The percentage of tuber void, %.
- \( M \) = The theoretical number of cups at limited time of working feeding mechanisms.
- \( m_n \) = Number of spacing (Sc) ≥ 2 Si ≥ 50 cm at the same limited time.
3. The tuber doubles (%) could be considered as the third indicator for feeding mechanism. It could be calculated when the distance between tuber in row \( (S_t) \) is half or less than the pre-adjusted space in row \( (S_r) \) i.e., \( S_c \leq (S_r/2) \leq 12.5 \) cm. The percentage of double was calculated using the method of calculating void (%).

RESULTS AND DISCUSSION

1. Sprout Resistance to Pulling: To study the tuber sprout resistance to pulling, three parameters were investigated; the sprout length, tuber size, and the sprout age. Fig. (6) shows the best fitted curves for the relationship between the pulling force "N" and the sprout length at different mass of tuber pieces "30 and 40 g". The general trend of this relationship is that as the sprout length increases the pulling force increases to average values of 19.4 and 22.4 N at maximum and peak pulling resistance respectively for tuber pieces of 30 g. Then the curve slides down. The fact that the maximum pulling force was achieved at the top side (29 mm of sprout length) may be explained by that the sprout more than 29 mm length takes the shape of un-aerial tube. Then the pulling force become un-equilibrium with internal cohesion force of the sprout.

For tuber pieces with 40 g., the relationship between the sprout length ,mm, and sprout resistance to pulling take the same trend of tuber pieces with 30 g. At sprout length of 28 mm the maximum and peak reading recorded the highest values (24.2 and 28.7 N respectively). The analysis of variation of between the mass of tuber pieces and with sprout resistance to pulling indicated that there is no significant effect \( (Pr > 0.01) \) and the correlation between predicted and measured values of pulling forces \( (N) \) as affected by sprout length (mm) were very close. The relationships between the tuber pieces mass and the sprout resistance to pulling as a reference of sprout growing age were illustrated in Fig. 7 (A and B). In general, increasing the tuber mass increases the resistance of sprout pulling. Also the sprout resistance was greater after 3 weeks from germination than it after 2 weeks. The moderate correlation \( (r^2 = 0.77) \) was depicted between tuber mass and the sprout resistance to pulling and varied with period of germination.

2. Sprout Resistance to Removal: The relationship between the sprout length, mm, as a function of germination period and sprout resistance to removal in percentage for the developed potato planter is illustrated in Fig. 8. The general tested variables indicated that as the sprout length increases, the sprout resistance to removal is increases. Also, the percentage of sprout removal is directly proportional with the feeding system speed.

The lowest amount of sprout removal was obtained at 20 rpm and 4 mm of sprout length. The relationship between the percentage of sprout removal and the mass of tuber pieces was tabulated in table 1. Generally, increasing both of feeding system speed and mass of tuber pieces increases the percentage of sprout removal.
Fig. 6: The relationship between the sprout length and the pulling force.

Fig. 7: The relationship between the tuber mass and the pulling force.
Table 1: The percentage of sprout removal.

<table>
<thead>
<tr>
<th>RPM</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>X'</th>
<th>CV</th>
<th>σn-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.7</td>
<td>0.73</td>
<td>0.84</td>
<td>0.756</td>
<td>7.94</td>
<td>0.600</td>
</tr>
<tr>
<td>23</td>
<td>0.82</td>
<td>0.84</td>
<td>0.94</td>
<td>0.870</td>
<td>5.63</td>
<td>0.049</td>
</tr>
<tr>
<td>25</td>
<td>0.93</td>
<td>0.93</td>
<td>1.11</td>
<td>0.990</td>
<td>8.58</td>
<td>0.850</td>
</tr>
<tr>
<td>28</td>
<td>1.21</td>
<td>1.31</td>
<td>1.32</td>
<td>1.280</td>
<td>3.87</td>
<td>0.050</td>
</tr>
<tr>
<td>30</td>
<td>1.20</td>
<td>1.21</td>
<td>1.42</td>
<td>1.270</td>
<td>7.95</td>
<td>0.101</td>
</tr>
<tr>
<td>X'</td>
<td>0.972</td>
<td>1.004</td>
<td>1.126</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV. %</td>
<td>23.4</td>
<td>24.57</td>
<td>19.48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>σn-1</td>
<td>0.227</td>
<td>0.246</td>
<td>0.219</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RPM = the feeding system speed.

3. Tuber resistance to damage: The shatter bruise was measured as a dependent variable to evaluate the new develop of potato planter. The shatter bruise was improved by using the developed feeding system as shown in table 2. Significant differences (P < 0.05) were found in the shatter bruise when comparing new and old designs.

Table 2: Shatter bruise occurrences on both the new and old design of potato planter.

<table>
<thead>
<tr>
<th>RPM</th>
<th>The developed potato planter</th>
<th>The old design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length of shatter</td>
<td>Depth</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>20</td>
<td>18</td>
<td>4</td>
</tr>
</tbody>
</table>

4-Field Tests:
4.1-Tuber spacing in row:

The space between tuber pieces after planting using the feeding devices before and after modifications are shown in table 3. The result indicated that 43% of tuber pieces of 40g were distributed in spaces between 20-30cm (the pre-adjusted space). The remainder 57% was distributed either more or less than this range. The corresponding remainder percentage was about 68% for feeding device before modification. It may be due to the free fall height in old design is higher than in developed one. From the above result and with respect to the theoretical trend, the suggested feeding mechanism is suitable under Egyptian condition (tuber pieces 40 g).

Table 3: Tubers deviation frequency.

<table>
<thead>
<tr>
<th>Distance Sc (cm)</th>
<th>Before modification</th>
<th>Tuber mass, g</th>
<th>After modification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>&lt; 15</td>
<td>10.2</td>
<td>21.8</td>
<td>06.7</td>
</tr>
<tr>
<td>15-20</td>
<td>12.3</td>
<td>22.3</td>
<td>08.2</td>
</tr>
<tr>
<td>20-25</td>
<td>16.4</td>
<td>19.8</td>
<td>26.7</td>
</tr>
<tr>
<td>25-30</td>
<td>24.2</td>
<td>12.4</td>
<td>22.3</td>
</tr>
<tr>
<td>30-35</td>
<td>22.2</td>
<td>08.4</td>
<td>10.3</td>
</tr>
<tr>
<td>35-40</td>
<td>14.7</td>
<td>15.3</td>
<td>25.8</td>
</tr>
</tbody>
</table>
4.2-Tuber voids

The results of tuber void ratio (V%) versus planting speed (m/s) are shown in Fig. 9. The general trend of this relationship was that the percentage of tuber void increases with the increase of planting speed. It could be noticed that the increasing rates of "V,%" of tuber pieces with 50g were more than those of tuber pieces with 40 and 30g. These differences may be due to the low ability of the worker for catching larger size of tubers. Also Fig. 9 shows that the voids ratio were largely valid within the range of 0.6 up to 0.8 m/s of planting speed, more than those from 0.4 to 0.6m/s for all tuber mass. These variation was due to the relatively higher peripheral speed of feeding mechanism, than which were estimated theoretically. The average of "V,%" which accomplished tuber mass of 50g was high (10.76%±5.95%), followed by tuber pieces of 40g (8.2%±3.54%), and came at the end tuber pieces of 30g (5.2%±2.05%).

![Graph 1: Tuber Mass vs. Forward Speed](image)

Fig. 8: Percentage of sprout removal versus sprout length

![Graph 2: Bud Length vs. RPM](image)

Fig. 9: Tuber void ratio versus planting speed.

4.3-Tuber doubles:

Fig. (10) illustrates the tubers double"%" versus planting speed with different mass of tuber pieces (30, 40 and 50 g). The tuber double percentages were higher when planting tuber mass of 30 g comparing with those of both 40 and 50 g. This behavior may be attributed to the fact that worker can handle large pieces more correctly than small ones. Moreover, the results revealed that the tubers double decreases with increasing planting speed.
REFERENCES

Fig. 10: Tuber double versus planting speed.

More than one piece in one run of feeding.

The lowest tuber yield (2%) and the maximum tuber double (picking)
was obtained in the feeders caused to the pre-adapted space of 25
percentages of tubers spreading (according to the feeders the highest
percentages of mechanical feeding. The 30 g ultra pieces gave the highest
percentages of sprout removal. Comparing the effects of the mass of ultra
percentages of sprout removal. Comparing the effects of the mass of ultra
increases the

2. Increasing feeding system speed and tuber mass, increases the
maximum and peak pulling resistance respectively with upper pieces of 30

An obvious relationship between both sprout length and the sprout
pulling force increases to an average value of 19.4 and 22.4 N for
pulling force and plant growth. The sprout length increases the
resistance to pulling was obtained. As the sprout length increases the

Consequently, the percentage of potato production. The theoretical
concentration factors in designing and determining the potato planter

1. The mass of upper pieces with previously grown sprouts was a major

CONCLUSIONS

الملخص العربي

آلة زراعة البطاطس المناسبة لزراعة قطع من الدرنات ذات برعم سابقة النمو

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الإنجاز العلمي السائد الآن هو زراعة قطع من الدرنات البطاطس ذات البرعم النامي وذلك بهدف زيادة الإنتاج بما توفر كمية الطفولي وفي نفس الوقت تخفض الفترة الزمنية لنمو المحصول في الأرض مما يسمح للمرة الأولى أو زراعتها باستمرار أخرى تحقيق ذلك يتطلب تأثيث كل من طرق تطعُّم الدرنات آليًا وطرق نمو قطع الدرنات واختيار طول البرعم المناسب لإجراء الميكرمة الآلية. هذا بالإضافة إلى توفير الآلات ذات التقنية العالمية حتى تحفظ البرعم النامي من التلف مع ضمان تعطيل بكمية من التربة المناسبة والتي تتضمن استمرار نموه. لذلك كان هدف هذه الدراسة هو تطوير آلة إعداد نمو البرعم.

الآلهة السابقة مع تصنيع آلة زراعية ذات وحدتين للاستلام زراعة درنات البطاطس المتقدمة - عملية نمو البرعم.
عند إعداد الألة للتصنيع أخذ في الاعتبار مناطق التلف الأصلية التي يمكن أن تؤثر على استمرار نمو البراعم التي سبق تطبيتها. تم تقسيم هذه المناطق داخل الألة إلى ثلاثة مناطق أساسية وتم تقسيم العوامل المؤثر على نسبة التلف رياضياً وعلى هذا الأساس تم تجربة تلك عقد تنقيح الألة الجديدة. اعتمدت الدراسة على شتى:
الشقة الأولى: تناول بعض التجارب العملية لدراسة تأثير فترة النمو ووزن الدرنات المقطعة وطول البرعم النامي على مقارنة البرعم لإزالة (القطع) وتحديد أقصى قوى لقطع.
الشقة الثانية: أجراء بعض التجارب الحقلية لتقييم كفاءة الألة الجديدة من حيث انتظام توزيع قطع الدرنات في الحلق - نسبة العيبات - نسبة نسب للإرذ من درنة.

جاءت النتائج لتؤكد أن:
- وزن الدرنات المقطعة وفترة النمو وطول البرعم نامي عامل أساسي يتوقف عليها قوى الأداء اللازمة لقطع البرعم. أما الارتباط بين تلك العوامل وطول البرعم كانت متوسطة (0.77 = 0.77)
- استخدام الألة الجديدة أدى إلى انخفاض التلف بنسبة محسوسة عن الألة ذات الملاعق والجذر الناقل حيث كان المعامل 1.5 (S1) في الألة المعدلة مقابل 1.5 في الألة الشائعة الاستخدام.
- كانت كفاءة انتظام توزيع المسافة بين قطع الدرنات المزرعة حيث سجلت 93% من الدرنات المزرعة على مسافة 20 - 30 م. كما تحسنت نسبة العيبات وكذلك نسبة قطع أكثر من درنة.