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THE UTILIZATION OF HORIZANTAL METERING DEVICE TO PLANT TUBER WITH PREVIOUSLY PREBARING

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ABSTRACT

The aim of this paper is to utilize the horizontal metering disc device to perform planting of sprouting tubers operation with minimum sprout damage, minimum tubers void, minimum tubers double and in proper time. The Horizontal metering mechanism was investigated as a new system to fulfill planting potato tuber with previously grown buds (Sprouts). The construction features of the developed potato planter (Horizontal Metering Mechanism) prototype are mainly: tuber hopper; chamber room; circle tray with feeding cups; the vibration mechanism and power transmission system from the land wheel to the rod of metering device. The theoretical investigation of the developed mechanisms was investigated. The relation between horizontal disc and tuber diameters was theoretically found. The diagram among engineering of feeding disc device parameters and tuber diameters were illustrated. The result of tuber void ratio versus land wheel speed (rpm) was 0% for time equal to four cycle time of land wheel. The tuber out percentage was evaluated at two categories of tuber samples 30-50, 50-80g. The general trend of this relationship is the percentage of tuber out decreased with the increase of land wheel speed and decrease of feeding cups diameter. The maximum value of the sprout damage percentage (Ts,%) is 26.1% at land wheel speed of 14rpm. and feeding cups diameter of 8cm recorded for category 50-80g, and the minimum value of (Ts,%) was 11.5% at Land wheel speed of 10 rpm. and feeding cups diameter of 6cm recorded for category 30-50g. From above results, May be recommend that the disc metering mechanism need more improve.

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

INTRODUCTION

Potatoes are generally grown from seed pieces cut from the whole tubers. While, small tubers of potatoes are sometimes planted without cutting. In fact, the methods of planting potato tubers in Egypt may be divided into the manual (traditional), and mechanical methods. But, unfortunately, the manual method of potato planting still representing more than 85% from all the potato-cultivated area (Statistics of Ministry of Agriculture – in Arabic Ref., 1999).

Ismail (in Arabic Ref., 1991) offered another classification for the potato planters according to the metering mechanism type. His classification includes four categories. Those are picker power wheels, chain-cup, belt cup, and belt-spoons. He added that any metering mechanism of the above mentioned categories could be occupied into any trailed, or semi-mounted, or even mounted planter types. Srivastava et al. (1995) showed that many potato planting mechanisms and machines have been developed to permit and carry out any of the previous mentioned planting methods. They showed that different metering mechanism types are located past the feeding chamber. The tuber seeds then fall by gravity to a furrow, which has been opened by a furrow opener. Arsenault et al (1966) constructed 2-row planter for planting small potato research plots. They showed that the planter performance was good compared to commercial and other small plot planters. They cleared that labor requirements for planting with that planter was 40-60% less than that for hand planting.

Siepman (1983) cleared that the manual traditional method often resulted in irregular planting depth, consequently, resulted in high tuber loss during harvesting. Abdel-Galil (1992) described the Egyptian traditional planting method in a similar way of Abdou (1985), except in using a tractor-ridge share combination instead of the animal-Balady plow combination. Since, tractor-ridge share combination has to deform 2 ridges at lateral distances between them of about 70-78cm. Then about 22 workers per feddan have to dig the deformed ridges and put the tubers at sequence longitudinal distances of about 20-25cm. Those workers have also to restore the deformation of the ride walls.

Kidokoro and Yoneyama (1990) indicated that the accuracy of the mechanical potato planter is satisfactory for both planting depth and spacing. They showed that, there was no difference between mechanical planting and manual planting for days to emergence. However, yields were higher with mechanical planting. Also, they added that, mechanical planting reduced the working time by approximately 35.50 % in potatoes compared to hand planting. While, Bishop and Maunder (1980) indicated that potato planters are available in six basic types according to their metering mechanism design feature. Those types are arranged from the simple hand-feed machine, to the more complex automatic types. They mentioned that, those types could be refereed as follows hand-feed, cup-feed, flat-belt feed, molded-belt-feed, multi-belt feed, and finger-feed. Also, they added that those types are with various alternative specifications to suit the requirements. EL-Haddad and Ahmed (1983) designed and constructed a mounted two row semi-automatic machine for potato planting. They reported that the average number of tuber per Kasaba, planting depth, distance between two adjacent rows and distance between tubers in row were 16.2 tuber, 15.6 cm, 65.5 cm and 22 cm respectively. The field capacity, field efficiency, cost per feddan and the total time per feddan were 0.36 fed/h, 83%, 13.75 L.E/fed and 2.76 h/fed respectively.

In order to increase potato production quantity and quality, the may be realize the need to develop and use modern and improved potato machinery technology, specially sprouting tubers planters because the sprout tubers planting achieve early germination so, early harvesting, help of making strong roots and dispose of un-sprouted tubers. Thus, the aim of present paper is to design and evaluate the horizontal metering device to perform planting of sprouting tubers with minimum sprout damage, minimum tubers void, minimum tubers double and in proper time.

THEORETICA APPROCH

Transporting tuber mechanism conveys the seed to furrow, which get out with angle "β". This angle depended not only on engineering parameters for transporting disc device but also shape and on the size of tubers. The potato tubers differ considerably one from another in diameters and their surface is highly irregular, then let us consider the tuber with spherical shape which having diameter (d_t). Angle of tuber out "β" for the disc device can be determined by referring to Fig. (1):

$$\cos\beta = \frac{ob}{oo_1} = \frac{oA - Ab}{oA}$$

$$\cos\beta = \frac{R_{dis} - d_t/2}{R_{dis}}$$

$$\beta = \arccos \frac{R_{dis} - d_t/2}{R_{dis}}$$

$$\beta = \arccos\ 1 - \frac{d_t/2}{R_{dis}}$$

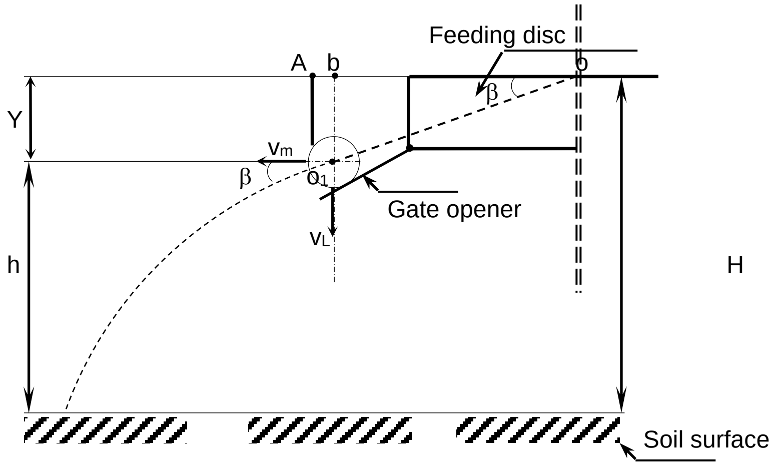

Fig. (1): The moment of the tuber get out from disc device.

Ismail (1989) found that, the relation between high of free of tuber (h) and planting speed (V_m) may be:

$$h = v_m \cos\beta \times t + (1/2) \times g\,t^2$$

where:

d_t	: diameter of tuber, mm
V_m	: planting speed, m/s
T	: times of tuber drop, s
g	: gravitational constant, m/sand
β	: angle of tuber out from device surface, degree
R_{dis}	: feeding device radius, mm

Then, the time of tuber drop is express as the following form:-

$$t = \frac{v_m \cos\beta \pm \sqrt{v_m^2\ \cos^2\beta\ + 2\,g\,h}}{g}\ \text{, sec}$$

From Fig. (1), the tuber drop high (h) may be equal:

$$h = H - y$$

But,

$$y = ob \,.\, \tan\beta$$

$$y = (R_{disc} - d_t/2) \times \tan\beta$$

$$= (R_{disc} - d_t/2) \times \tan(\arc\cos(1 - \frac{d_t}{2R_{disc}}))$$

Then,

$$h = H - \left[R_{disc} - d_t/2) \times \tan(\arc\cos(1 - \frac{d_t}{2R_{disc}}) \right]$$

where:

H : the total height of tuber dropping. mm

h :the free height of tuber

Theoretical relation between engineering parameter (β, h, t) and tuber diameter for the feeding disc device is illustrated in diagram Fig. (2). From diagram, angle of tuber out increased with increasing tuber diameter. The maximum of tuber out angle is found at 54° while the operational angle of disc device is 22° 33'. On the other hand, increasing tuber out angle decrease the time of tuber drop. While, the times of tuber drop increased exponentially with increasing height of free fall of tubers.

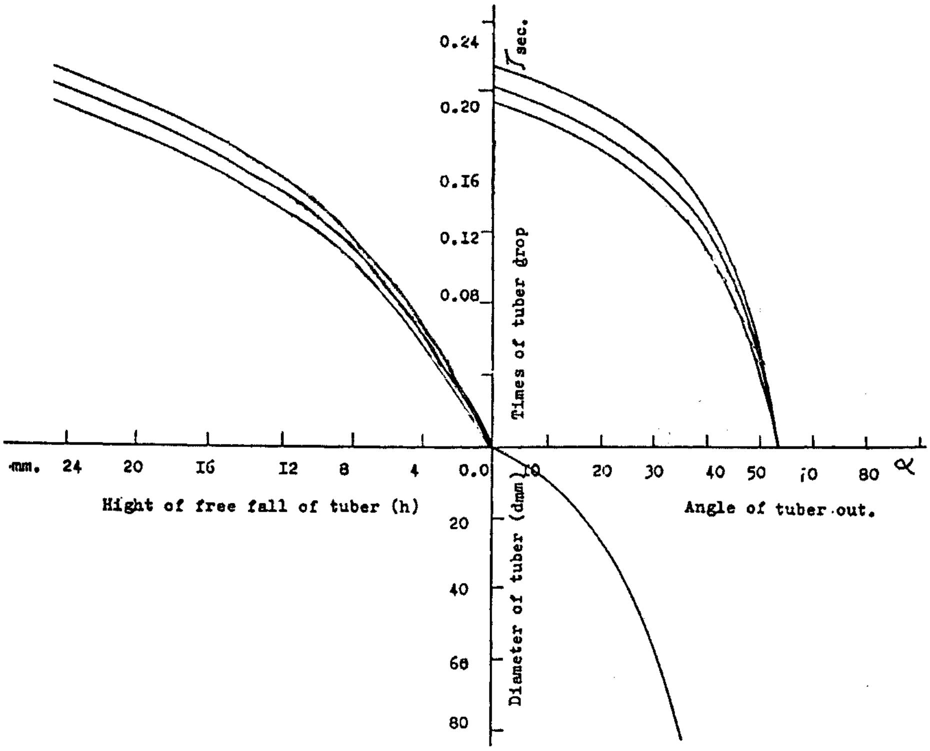

Fig. (2): The theoretical diagram of disc device engineering parameters.

MATERIAL AND METHODS

This study was carried out at the Agriculture Engineering Department of Agriculture Faculty, Mansoura University on the basis of the prototypes that investigated and tested to fulfillment of the requirements for the degree of master of science that was the supervised by Ismail (2001-2005). The main components of the Horizontal Metering device are as follows:

1-Tuber hopper

A rectangular hopper made of iron sheet (2 mm thick.), was fabricated to facilitate the tuber flow through vertical tube (100mm diameter) to a receiving chamber. The hopper sides are sloped gradually with an angle greater than the angle of repose of the tuber bulk. That was done to keep continues flow rate of tubers. The main dimensions of that tuber hopper are 700 × 600 × 750 mm.

2-Receiving chamber

A half cylinder chamber room, made of iron sheet (1.5 mm thick.), was made to receive potato tubers that come from feeding hopper through vertical tube. The main dimensions of that chamber room are 320 mm diameter and 150 mm height (Fig.-3).

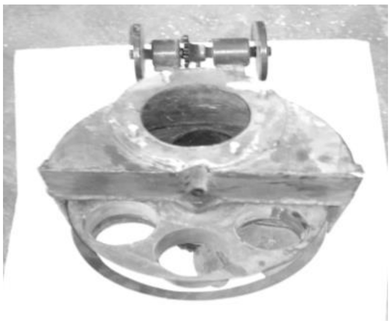

Fig. (3): Feeding chamber (Ismail-2005)

Fig. (4): Circle tray with feeding cups (Ismail-2005)

3-Circle tray with feeding cups

A rotation circle tray 300 mm, diameter and 8 mm thick, was equipped with the receiving chamber and provided with six cubs. Each cub has a gate in the bottom. The circle tray rotations are in the horizontal level. Under the cubs, another fixed tray divided into two parts was equipped; each of half circle shape. As the fixed tray is opened, it permits the potato tubers to fall in the ridge. And as it is closed, it prevents the tubers to fall in the ridge. The main dimension of each cub is 80 mm, diameter and 100 mm, height (Fig. -4).

4- The Vibration Mechanism

A vibration mechanism was designed and arranged as shown in Fig. (5). That mechanism is equipped down the feeding hopper to help in pushing an individual tuber into the cup. It consists mainly of a centric pulley, a connecting rod, a pushing rod (ended with small fiberglass ball), a vertical guide and a controlling system for the pushing rod displacement. The centric pulley has numerous un-centric holes to get multi pushing distances of 60, 70, and 80 mm.

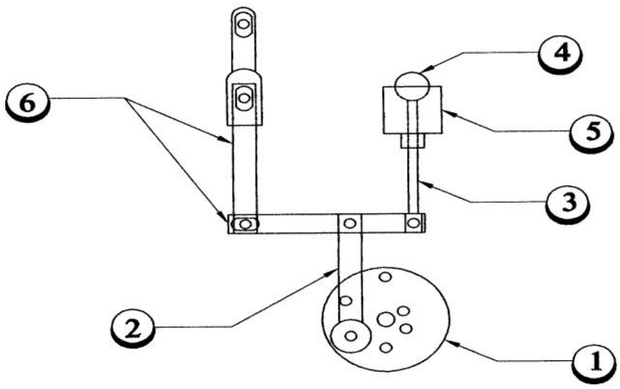

Fig. (5): The main Components of the developed vibration mechanism (Ismail-2005)

1- Description 2- Centric pulley 3- Connecting rod 4- pushing rod 5-small fiberglass ball 6- Guide 7- Distance controlling system

5- Power transmission system

The transmission system is designed to get a tuber space in row of about 23 cm. For avoiding the slip, a chain-sprocket transmission system is used to transmit the motion from the planter wheel (D = 440 mm), to both the rotation circle tray, and the vibration mechanism (Fig. 6 and 7).

The main parts of that transmission system design are as shown in Fig (7). It consists of land wheel, wheel shaft, main gear, gears with dog clutch system, sprocket, main shaft, gear cluster, shafts cluster, cone gear cluster and multi conveying chains (table-1).

Tubers Planting Methods

Evaluating the performance of any developed planting machines requires studying its functions. In this study, the tuber depositing processes are concerned to evaluate the two developed prototypes. The tuber deposing performance has been evaluated in terms of the uniformity of the tuber void ratio, tuber double ratio, distribution uniformity of the tuber in row, tuber sprouts damage % and tuber metering out ratio. The digital video camera ***(Benq 1300)*** with high resolution was used to follow and measure the tuber seed deposing performance.

The tuber double ratio (Td %)

The tuber double ratio could be considered as the first indicator for the tuber seed disposing performance. It was estimated for each treatment by counting the number of spoons that have more than one tuber and counting the number of the used spoons in each treatment. Then the percentage of tuber doubles ratio can be calculated as follows:

$$Td,\% = \frac{A_n}{M} * 100 \qquad (1)$$

where:

Td, % = The percentage of tuber double ratio %

M = The number of the used spoons.

A_n = the number of spoons that have more than one tuber.

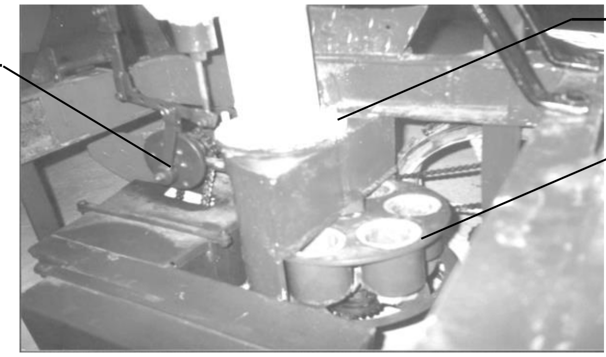

Fig. (6): The general view of horizontal feeding device (Ismail-2005).
1- receiving chamber 2- circle tray with feeding cups
3- the vibration mechanism

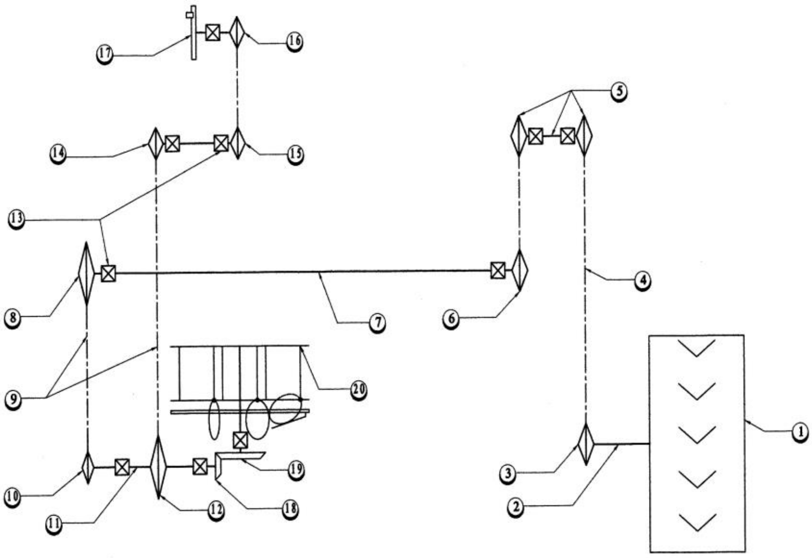

Fig. (7): Layout of the main parts of the power transmission system (Ismail-2005)

1- Land wheel **2- Land wheel shaft** **3- Sprocket (20 teeth)**
4- Chain **5- Two sprockets (20 teeth)** **6- Sprocket (20 teeth)**
7- Main shaft **8- Sprocket (30 teeth)** **9- Chains**
10- Gear (15 teeth) **11- Shaft** **12- Sprocket (30 teeth)**
13- Ball bearings **14- Sprocket (15 teeth)** **15- Sprocket (15 teeth)**
16- Sprocket (15 teeth) **17- Centric pulley** **18- Conical gear (10 teeth)**
19- Conical gear (10 teeth) **20- Rotation circle tray**

Tuber void ratio (Tv, %)

The tuber void ratio could be considered as the best indicator for the tuber seed disposing performance. It was estimated for each treatment by counting the number of spoons that have no tubers and counting the number of the used spoons in each treatment. Then the percentage of voids can be calculated as follows:

$$Tv,\% = \frac{B_n}{M} * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where:

Tv,= The percentage of tuber void %

M = The number of the used spoons.

B_n = The number of spoons that have no tubers.

The distribution uniformity of tuber seed in row (UH, %)

The theoretical uniformity of the tuber seed in row could be considered as the third indicator for the seed disposing performance. It was estimated by calculating the tuber void ratio and the tuber double ratio. Then the percentage of the uniformity of the tuber seed in row can be calculated as follows:

$$UH,\% = 100 - (Tv,\% + Td,\%) \ldots\ldots\ldots\ldots(3)$$

where:

UH = The percentage of the tuber seed uniformity in row %.

Tv = The tuber void ratio %.

Td = The tuber double ratio %.

The tuber sprouts damage ratio (Ts, %)

The tuber sprouts damage ratio could be considered as the fourth indicator for the seed disposing performance. It was estimated for each treatment by counting the number of tubers that have damaged sprouts and counting the number of all falling tubers in each treatment. Then the percentage of sprout damage sprouts can be calculated as follows:

$$Ts,\% = \frac{S_D}{S_A} * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

where:

Ts = The percentage of damage sprouts, %

S_D = The number of tubers that have damaged sprouts.

S_A = The number of all falling tubers.

The tuber metering out ratio (To, %)

The tuber out ratio could be considered as the fifth indicator for the seed disposing performance. It was estimated for each treatment by counting the number of all falling tubers and counting the number of all spoons or cups in each treatment. Then the percentage of out ratio can be calculated as follows:

$$To,\% = \frac{T_F}{S} * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

where:

To, % = The percentage of out tubers %

T_F = The number of all falling tubers.

S = The number of all spoons or cups in each treatment.

Statistical Analysis

The obtained data for horizontal metering mechanism of potato tubers were analyzed using program of Microsoft Excel to determine the significant factors affecting the performance of metering device in Department of Agriculture Engineering, Faculty of Agriculture, Mansoura University.

RESULTS AND DISCUSSION

Experiments was proceeded to test and evaluate the performance and efficiency (tuber void, %, tuber out, % and sprout damage, %) of the tuber sprout potato planting machine (horizontal metering device) in laboratory under the following different operational conditions:

1. Two speeds of land wheel, 0.23 and 0.32 m/s (10 and 14 rpm respectively).
2. Two tuber mass categories, (30-50 and 50-80g).
3. Two diameters of horizontal feeding cells, (6 and 8 cm).
4. Two distances of pusher stroke, (6 and 8 cm).

Tubers void, (V_t, %)

The result of tuber void ratio (V_t,%) versus land wheel speed (m/s) was 0 % per four revolution of land wheel, after that the tuber void ratio become rabidly increases (Fig-8).

The previous results were happened because of the pusher has not any effect on passing tubers from hopper to chamber room, so the potato tubers are crowding at the tube orifice in the tubers hopper bottom, and so the tubers has not passing from hopper to the chamber room and feeding cups.

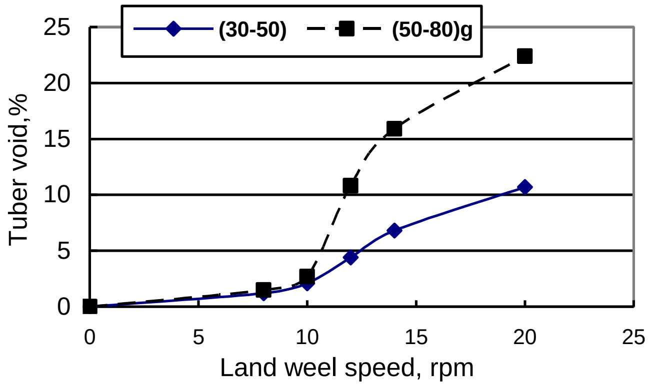

Fig. (8): The tuber void versus land wheel speed

Tubers metering out ratio, (O_t, %)

The tuber out percentages were evaluated at two categories of tuber samples 30-50 and 50-80 gram during four cycle time of land wheel, after that time, the tuber out, (O_t,%) become 0 % because of the previous reasons. The result of tuber out ratio (O_t,%) versus land wheel speed (rpm) and feeding cups diameter are shown in Fig. (9).

The general trend of this relationship was the percentage of tuber out decreased with the increases of land wheel speed and decreases of feeding cells diameter. It was clear that the decreasing rates of (O_t,%) for tuber category 50-80 g were more than those of tuber category 30-50 g.

For category 30-50 g, the maximum value of (O_t, %) was 280 % at Land wheel speed 10 rpm and feeding cells diameter 8 cm, and the minimum value of (O_t %) was 218.3 % at Land wheel speed 14 rpm and feeding cups diameter 6 cm. The maximum value of (O_t %) for category 50-80 g, was 213.3 % at Land wheel speed 10 rpm and feeding cups diameter 8 cm, and the minimum value of (O_t %) was 165 % at Land wheel speed 14 rpm and feeding cups diameter 6 cm.

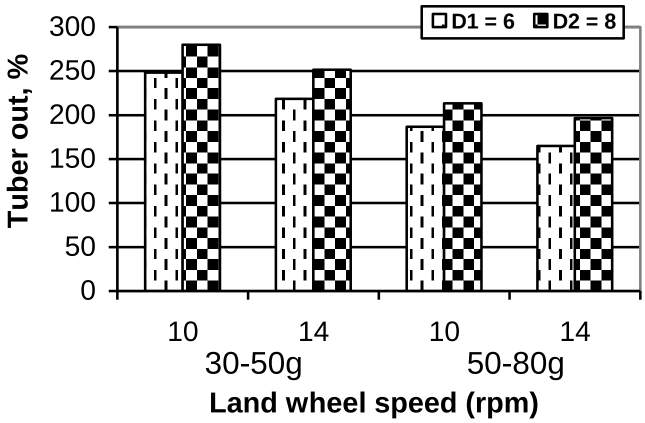

Fig (9): The Tubers out as affected by land wheel speeds tuber.

Sprout damage (Ts, %)

The result of sprout damage ratio (Ts,%) versus land wheel speed (rpm) and feeding cells diameters are shown in Fig. (10). The general trend of this relationship is the percentage of sprout damage increases with the increase of land wheel speed and feeding cells diameter.

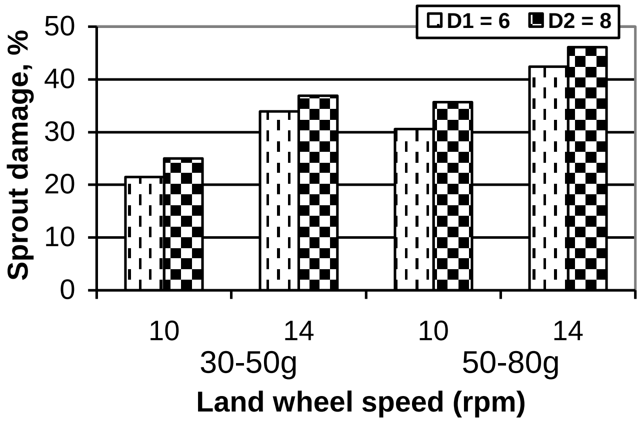

Fig. (10): The sprout damage as affected by Land wheel speeds and feeding cups diameter.

The increasing rates of (Ts, %) for tuber category 50-80 g were more than that of the tuber category 30-50g. The maximum value of (Ts,%) for category

30-50 g, is 36.9 % recorded at land wheel speed of 14 rpm and feeding cells diameter of 8 cm, while, the minimum value of (Ts,%) was 21.5 % at land wheel speed of 10 rpm and feeding cells diameter 6 cm. And for category 50-80 g, the maximum value of (Ts, %) was 46.1 % at land wheel speed of 14 rpm and feeding cells diameter of 8 cm. The minimum value of (Ts, %) was 30.6 % at land wheel speed of 10 rpm and feeding cells diameter of 6 cm. From the above results, it is clear that the designed of this prototype of feeding device need to be redesigned.

The distribution uniformity of tuber seed in row (UH, %)

The tuber space uniformity (UH %) versus planting speed (rpm) and Vibration System Ratios are as shown in Fig. (13) and Fig. (14). The general trend of this relationship was the percentage of tuber space uniformity decreased with the increase of planting speed, and increases the vibration system ratios. The previous relationship is correct at range from 0 to 4 (rpm.) of land wheel speeds. However, at case of the land wheel speed is exceed 4 (r.p.m.), the relationship between the percentage of tuber space uniformity and the planting speed become reversing.

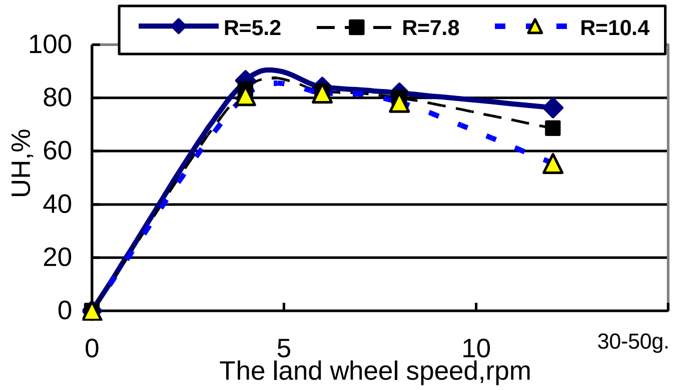

Fig. (13): The tuber space uniformity (UH %) versus land wheel speed

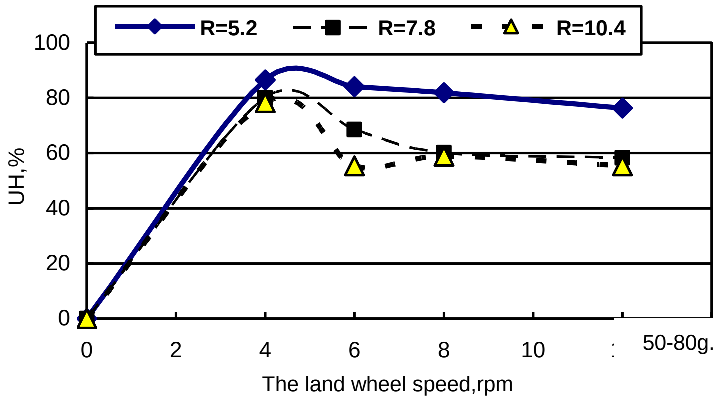

Fig. (14): The tuber space uniformity (UH %) versus land wheel speed

For category 30-50 g, the maximum value of (UH %) was 85.4 % at Land wheel speed 4 rpm. and vibration system ratio 5.2, and the minimum value of (UH %) was 73.86 % at land wheel speed 8 rpm and vibration system ratio 10.4. And for category 50-80 g, the maximum value of (UH %) was 86.04 % at Land wheel speed 4 rpm and vibration system ratio 5.2, and the minimum value of (UH %) was 78.33 % at Land wheel speed 8 rpm and vibration system ratio 10.4.

CONCLUSIONS

The result of tuber void ratio (v_t %) versus land wheel speed (rpm) was 0% during the first four cycles of land wheel, after that the tuber void ratio become 100%.

1- The general trend of this relationship is the percentage of tuber metering out decreases with the increase of land wheel speed and the decrease of feeding cups diameter.

2- The maximum value of (O_t,%) was 280 % at land wheel speed of 10 rpm and feeding cups diameter of 8 cm recorded for category 30-50 g, and the minimum value of (O_t,%) was 165% at land wheel speed of 14 rpm and feeding cups diameter of 6 cm recorded for category 50-80 g.

3- The maximum value of (Ts, %) was 46.1 % at land wheel speed of 14 rpm. and feeding cups diameter of 8 cm recorded for category 50-80 g, and the minimum value of (Ts, %) was 21.5 % at Land wheel speed of 10 rpm. and feeding cups diameter of 6 cm recorded for category 30-50g.

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إمكانية إستخدام قرص التلقيم الأفقي لزراعة درنات سابقة الإعداد

زكريا إبراهيم إسماعيل

جامعة المنصورة- قسم الهندسة الزراعية

لتطوير آلة تلائم زراعة درنات البطاطس سابقة النمو تم تصنيع وحدة التغذية الأفقية في الورش التابعة لكلية الهندسة و كذلك فى الورش التابعة لكلية الزراعة بجامعة المنصورة تحت إشراف قسم الهندسة الزراعية. حيث تقوم بزراعة البطاطس على مسافات 23سم داخل الخط الواحد و على مسافة 70سم بين كل خطين متجاورين- الوحدة مزودة بجهاز تلقيم أفقى دائرى الشكل بحيث يمكن الوصول بنقطة خروج التقاوي إلي أقل ارتفاع سقوط ممكن بالنسبة لسطح الأرض (10سم)- جهاز التلقيم مزود بخلايا تلقيم على شكل أكواب ذات بوابات تفتح تلقائيا عند نزول الدرنة إلى الأرض- صندوق الدرنات مزود بنظام اهتزازي يعمل على تحريك الدرنات داخل الصندوق وبالتالي سهولة مرور الدرنات إلى جهاز التلقيم- صندوق التروس مزود بقابض كلابى لتجنب تلف بوابات الأكواب بجهاز التلقيم وبالتالي الحفاظ على الآلة لأطول فترة ممكنة.

خطة التجارب بالنسبة لوحدة التلقيم الأفقي:-

تم إ اختبار أداء الآلة المطورة تحت ظروف تشغيلية مختلفة من خلال إجراء مجموعة من التجارب المعملية. في هذه المجموعة تم تقييم أداء هذه الآلة المطورة لوظائفها الهامة من حيث دقة وانتظامية توزيع التقاوي مع استخدام صنف بطاطس (كارا). تناولت عوامل الدراسة للمتغيرات التالية: سرعتان أماميتان للآلة (0.23 و 0.32 م/ث)- مجموعتان وزنيتين من درنات لبطاطس (30-50 جرام و 50-80 جرام)- قطران مختلفان للأكواب و هما 6 و 8 سم.- طولان لمشوار الدافع الاهتزازي و هما 6 و 8 سم. سجلت التجارب أهم النقاط التالية:-

- نسبة الدرنات الغائبة: وجد أنها كانت صفر% في الفترة من بداية عمل الآلة و حتى إتمامها أربع لفات من عجلة الأرض، و بعد ذلك يزيد نسبة الغياب زيادة عاليه كما ان المعدة توقف الآلة عن العمل لتراكم درنات البطاطس في قاع الخزان و بالتالي عدم مرورها إلى جهاز التلقيم.
- نسبة خروج الدرنات: وجد أن نسبة خروج الدرنات تكون مرتفعة جدا فى بداية عمل الآلة وبعد ذلك تصبح النسبة صفر %.
- نسبة التلف فى البراعم: كانت أعلى نسبة لتلف البرعم 16.1 % و اقل نسبة لها 1.5 %.

من النتائج السابقة يتضح لنا أن الآلة السابقة ذات جهاز التلقيم الافقى لا تصلح للزراعة وتحتاج إلى إعادة التصميم من جديد