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DEVELOPING A COMBINE MACHINE FOR INCREASING SEPARATION EFFICIENCY OF ONION CROP

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ABSTRACT

The experiments were carried out at El-Maamoria village- El-Gamalia region, Dakhlia Governorate during onion harvesting season 2008-2009 to evaluate onion harvesting crop by a combine machine for harvesting and collecting onion crop and achieving the following factors: Decreasing separation losses, increasing soil pulverization and increasing cleaning efficiency of onion crop. All treatments were carried out on onion crop at two different moisture contents (M_1=24.5% and M_2= 20.5%) and four different of rear angle of ray separator (R_1=0, R_2=5, R_3=10 and R_4=15 degree) with different four vibrator speeds (V_1=170, V_2= 200, V_3=230 and V_4=260 rpm).The best results of separation losses and cleaning efficiency were at (M_2=20.5%, R_1=5 degree, V_4=230 rpm).

INTRODUCTION

Onion (*Allium cepa,* L.) is one of the crops of *Amaryllidaceae* family and is one of the most important vegetable and field crops in the world. It is one of major exportable vegetable and field crop in Egypt after potato crop, where Egypt takes fifth order or rank after U.S.A, Japan, Italy and France. Onion harvesting in Egypt still use traditional method. Collecting process of onion is also manually performed. Many of these traditional methods of harvesting and collecting onion crop have many problems such as increasing separation losses, decreasing soil pulverization and decreasing cleaning efficiency of onion crop with the separating problem of onion bulbs from the soil clods during harvesting. In this study, the developing combined machine was mainly used for harvesting and separating (cleaning) of onion crop.

Review of Literature

As there are many factors affecting harvesting and separation of onion crop such as speed ratio, tilt angle of share, depth of share, moisture content of soil, working width, rear angle of ray separator, vibrator speed ….etc; so in the coming study, some of the mentioned parameters were tested according to the most effective parameters i.e. rear angle of ray separator vibrator speed and moisture content of soil.

Singal and Thierstein (1979) reported that the optimum moisture content for peanut harvesting is between 35 and 40% to decrease damage nuts percentage.

White (1983) found that a high-moisture from 45 to 60% could result in a high quality product with minimal losses.

Misener *et al*. (1984) reported that the vibrating blade effectively broke up the soil with soil separation improved by increasing the vibration amplitude. Satisfactory soil separation was possible with little agitation of the

main digger chain. Using photography and determining soil to potato ratios. They estimated that 93 to 95% of the soil was removed before the main digging chain under the test conditions. They studied that three-harvester forward speed were considered in the test (1.6, 2.3 and 3 km/h) and the prototype harvester worked well in the silty loam soil with moisture content levels up to 29% (dry bases).

Hammad *et al*. (1991) reported that the soil moisture content is important factor which affects indirectly the potato yield and damaged. If the soil moisture content is lower than optimum, it affect potato production by increasing the rupture and clods which increase potato damage. If the soil moisture content is higher than the optimum it causes more clay coat on the potato surface and consequently low marketing grade and more blockages in the machine of harvest was conducted at soil moisture content of 15% (d.b) to avoid the previous problems.

Kang and Halderson (1991) designed and tested a two-row, vibrating blade and potato digger was designed and tested for the effects of amplitude of vibration. They found that the draft force decreased as vibration frequency increased and travel speed decreased.

Youssif (1995) recommended that the use of three-point share (TPS), at 17 degree cutting angle, 102 r.p.m spinner speed and 225 cycle/min. sieve frequency to have the lowest of total damage percentage of onion bulbs.

Abdel-Bary. (2001) found that the percentages of lifted tubers were decreased by increasing rotary speed of elevator chain from 100 to 160 r.p.m (2.14 to 3.85 m/s) for sponta variety. These were from 97.48 to 95.23%, while increasing rotary speed from 100 to 160 r.p.m (2.14 to 3.85 m/s) increased the damaged tubers percentage these were from 1.40 to 3.17%.

Abdel-Bary. (2001) found that the percentages of lifted tubers were increased by increasing riddle inclination from 5˚ to 7˚. While, these percentage were decreased by increasing riddle inclination more than 7˚. On the other hand increasing riddle inclination from 5˚ to 9˚ decreased the damaged tubers percent from 2.06 to 0.83%.

The objectives of this study are:

1- Decreasing separation losses of onion crop.

2- increasing cleaning efficiency of onion crop.

MATERIALS AND METHODS

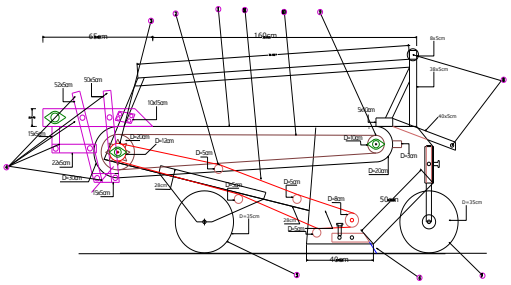
The experiments were carried out at El-Maamoria village- El-Gamalia region, Dakhlia Governorate during onion harvesting season 2008-2009 to evaluate onion harvesting crop. The main objective of the present study is to determine the following factors: Decreasing separation losses and increasing cleaning efficiency of onion crop.

Materials:

1. The tractor: To make suitable harvesting onion, a tractor of Kubota 55 hp Model KUBOTA L.2402-M manufactured in Japan, Engine Diesel, 3 cylinders and Power 55 hp (22.44 kW) at 2800 r.p.m

2 Specifications of the harvester before development:

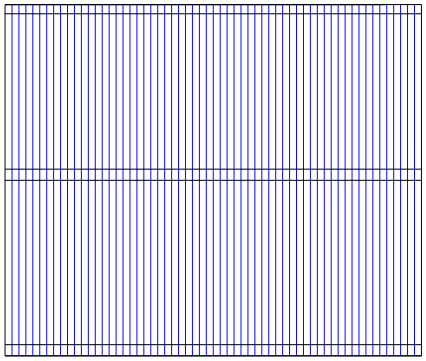
The harvester before development consists of a frame, a shear, 3 hitch points, a vibrator, two wheels, two discs, a group of pulleys, separating unit (elevator), gear box, group of links, came and transmission system. Overall dimensions of harvester before development length 180 cm, width 140 cm and height 80 cm



Harvester before development

No	part
1	frame
2	Pulley of elevator
3	gear
4	Vibrator
5	wheel
6	share
7	disc
8	Hitch points
9	pulley
10	belt
11	elevator

Fig (1): The harvester before development



Elevator before development

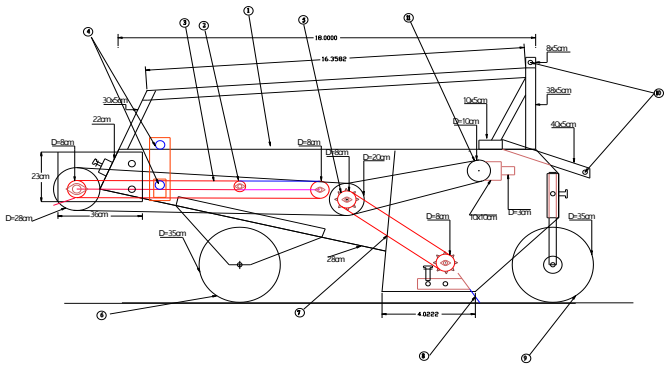
Fig (2): The elevator before development

a- The separation unit: The separation unit consists of a elevator. It is used to remove soil adhering to soil surface. It takes power from the tractor P.T.O. by transmission system. The elevator consists of a group of parallel steel stalks. Dimensions of elevator before modification were 150 cm length, 120 cm width and 2 cm space between stalks.

c- The vibrator: The vibrator unit in rear of harvester was insufficient to separate soil particles from onion bulbs.

Fig (3): The vibrator and elevator before development

3 Specifications of the harvester after development: The harvester after development consists of the frame, shear (digging unit), 3 hitch points, the vibrator, two wheels, two discs, group of pulleys, separating unit (front elevator and ray separator), gear box, group of links, came and the transmission system. Overall dimensions of the harvester after development were 205 cm length, 140 cm width and 80 cm height.



No	part
1	frame
2	bare
3	Ray separator
4	vibrator
5	gear
6	wheel
7	elevator
8	Share
9	disc
10	Hitch points
11	pulley

Fig (4): The combine harvester and elevator after development

a- **The separation unit**:

The separation unit consists of front elevator and ray separator. It is used to remove soil adhering to onion bulbs. It takes power from the tractor P.T.O. by a transmission system.

***Front elevator:**

Front elevator consists of group of parallel steel stalks, two bars, six gears. The length of each stalks 120 cm. Dimensions of front elevator are 60 cm length, 120 cm width and 4 cm Space between parallel iron stalks.

****Ray separator:** Ray separator consists of two bars, each bar consist of group of pulleys, traveled with group of parallel belts. Dimensions of ray separator are 110 cm length, 120 cm width and 3 cm Space between parallel iron stalks.

*****The vibrator:** The vibrator extended in the beginning of last of one-third of the rear elevator.

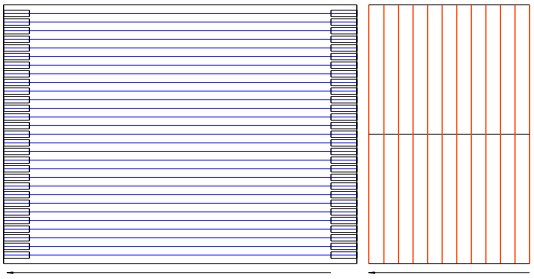


Fig (5): Front elevator and ray separator after development

Fig (6): The vibrator after development

4- Physical properties of onion bulbs:

Two hundred samples of onion bulbs were taken randomly to determine the mentioned specifications. Each value represents ten samples were taken randomly from the medium and asides of ridge. Means of the physical properties of onion bulbs were 4.8 cm depth, 5.7 cm height, 6.1cm diameter, 145 gram weight and 78.8 cm3 volume.

Methods of Experiment

1. Experimental procedure

All experiments were carried out at different combinations of rear angle of elevator, speed of vibrator at speed ratio (K3= 1.05), tilt angle of share (T4=25°) and depth of share (D3= 7 cm). These treatments were carried out to determine the losses of separation, soil pulverization and cleaning efficiency.

2. Experiment measurements:

A. Moisture content of soil:

The moisture content of soil (d.b.) was measured using the oven methods at 105^0 C for 24 hours. Thirty samples of soil were taken randomly to determine the moisture content of soil before harvesting. Thirty samples of soil were carried out at El-Serw Agricultural Research Station Lab, Soil Department. By (equation 1) according to (*ASAE Standard Methods 1997).*

$$Mc = \frac{Ww - Wd}{Wd} X100 \quad \text{..... (1)}$$

where, Mc =material moisture content, % W_w=wet shredded material mass, g. W_d = dry shredded material mass, g

B. Separation losses (Sl):

Separation losses were determined by using the following method:

1- Using a piece of cloth put under the chain.
2- Harvester starting work for ten maters.
3- Weighing the collecting bulbs over the a piece of cloth ($\mathbf{W_l}$), kg
4- Weighing the collecting bulbs over the soil at ten maters ($\mathbf{W_{nl}}$), kg
5- Calculating the total weight of bulbs ($\mathbf{W_t = W_l + W_{nl}}$), kg

Separation Losses were determined by using the following equation (2):

$$\mathbf{Sl = \frac{W_l}{W_t} x\ 100,\ \%} \quad \text{..... (2)}$$

Where:
Sl = separation Losses, %
$\mathbf{W_l}$ **=** weight the bulbs over the apiece of cloth**,** kg
$\mathbf{W_t}$ = total weight of bulbs ($\mathbf{W_l + W_{nl}}$), kg

C. Cleaning efficiency:

Cleaning efficiency was determined by using the following equation (3):

$$\mathbf{\dot{\eta}_{cl} = \frac{W_{cl}}{W_t} x\ 100,\ \%} \quad \text{..... (3)}$$

Where: $\dot{\eta}_{cl}$ = cleaning efficiency, %
W_{cl} = weight of cleaning bulbs in the sample after vibration, kg
W_t = weight of total sample before vibration, kg.

Fig (7): the cleaning efficiency

Test factors:

1- Moisture content: M_1 and M_2 are 24.5% and 20.5% respectively.
2- Rear angle of elevator: R_1, R_2, R_3 and R_4 are 0, 5, 10 and 15˚ respectively.
3- Speed of vibrator: (V_1, V_2, V_3 and V_4 are 170, 200, 230 and 260 rpm respectively).

RESULTS AND DISCUSSION

A. Separation losses:

1. Effect of rear angle of ray separator on separation losses:

Increasing rear angle of ray separator resulted in decreasing the separation losses from data shown in fig (1). As increasing rear angle of ray separator from 0 to 5 degree at speed of vibrator 170 rpm resulted in decreasing the separation losses from 3.05% to 2.82% under moisture content 24.5%. On the other hand, the increase of rear angle of ray separator from 5 to 10 degree showed a decrease in separation losses from 2.82% to 2.22% under the same conditions and the increase of rear angle of ray separator from 10 to 15 degree showed a decrease in separation losses from 2.22% to 1.61% under the same conditions. Similar trends were shown under different speeds of vibrator. From all curves, it was found that, under moisture content 20.5% at speed of vibrator 170 rpm showed an increase of rear angle of ray separator from 0 to 5 degree resulted in decreasing the separation losses from 3.65% to 3.20%. From all curves, it was found that, under moisture content 20.5% at speed of vibrator 170 rpm showed an increase of rear angle of ray separator from 0 to 5 degree resulted in decreasing the separation losses from 3.65% to 3.20%.

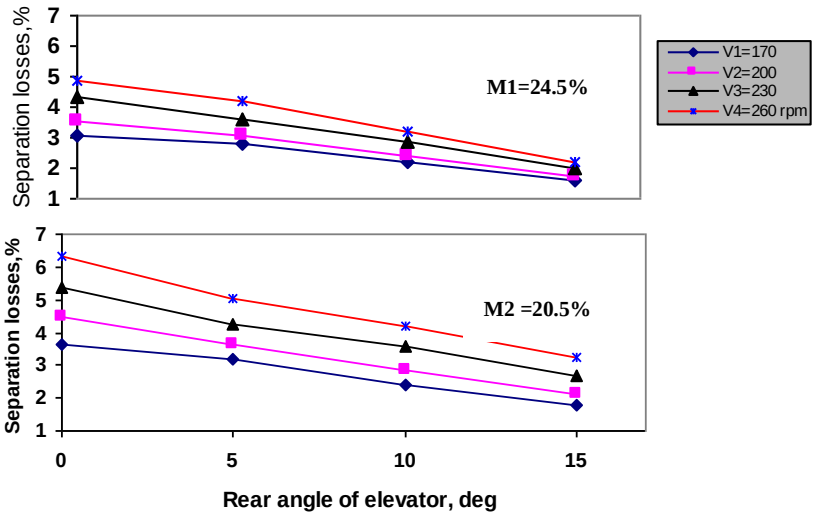


Fig. (1); Effect of rear angle of elevator and speed of vibrator on separation losses at different of moisture contents.

On the other hand, the increase of rear angle of ray separator from 5 to 10 degree showed a decrease in separation losses from 3.20% to 2.38% under the same conditions and the increase of rear angle of ray separator from 10 to 15 degree showed a decrease in separation losses from 2.38% to 1.76% under the same conditions. Similar trends were shown under different speeds of vibrator.

Increasing the rear tilt angle of the ray led to decreasing separation losses according to minimizing time of bulbs staying on the ray separator. The analysis of variance for data showed that the rear angle of ray separator had a significantly affect on the separation losses ($p < 0.01$).2. Effect of **Speed of vibrator on Separation losses:**

From data shown in fig (2) it is easy to notice that increasing speed of vibrator resulted in increasing the separation losses. As increasing speed of vibrator from 170 to 200 rpm at rear angle of ray separator 0 degree resulted in increasing the separation losses from 3.05% to 3.54% under moisture content 24.5%. Also, the increase of speed of vibrator from 200 to 230 rpm showed an increase in separation losses from 3.54% to 4.34% under the same conditions and the increase of speed of vibrator from 230 to 260 rpm showed an increase in separation losses from 4.34% to 4.85% under the same conditions. Similar trends were shown under different rear angles of ray separator.

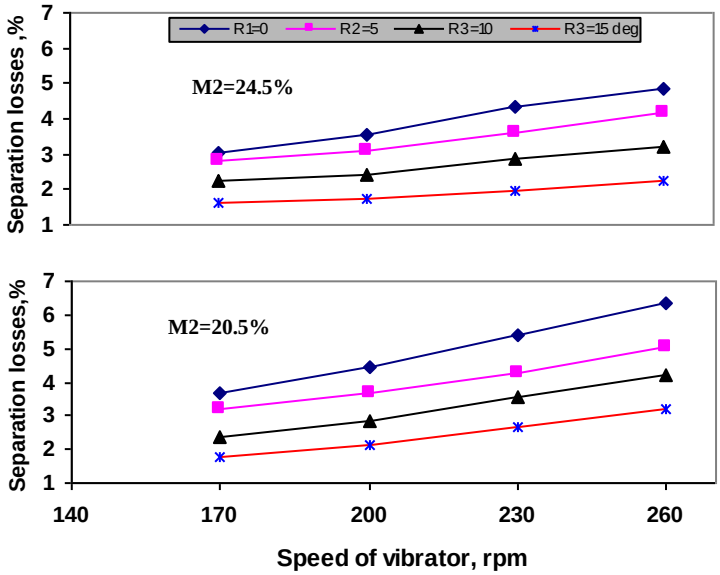


Fig. (2); Effect of speed of vibrator and rear angle of elevator on separation losses at different of moisture contents.

On the other hand, the increase of speed of vibrator from 170 to 200 rpm at rear angle of ray separator 0 degree resulted in increasing the separation losses from 3.65% to 4.45% under moisture content 20.5%. Increasing speed of vibrator from 200 to 230 rpm showed an increase in

separation losses from 4.45% to 5.37% under the same conditions. While increasing speed of vibrator from 230 to 260 rpm showed an increase in separation losses from 5.37% to 6.32% under the same conditions. Similar trends were shown under different rear angles of ray separator. Increasing vibrator velocity led to an increase of separation losses. This phase may be according to the excess of belts fluttering which resulted in expansion the distances among belts and consequently caused more separating losses. The analysis of variance for data showed that the speed of vibrator had a significantly affect on the separation losses ($p < 0.01$).

B. Cleaning Efficiency:

1. Effect of rear angle of ray separator on cleaning efficiency:

From data shown in fig (3) it was found that, increasing rear angle of ray separator resulted in decreasing the cleaning efficiency. As increasing rear angle of ray separator from 0 to 5 degree at speed of vibrator **170 rpm** resulted in decreasing the cleaning efficiency from 83.42 to 82.35% under moisture content 24.5%. On the other hand, the increase of rear angle of ray separator from 5 to 10 degree showed a decrease in cleaning efficiency from 82.35 to 81.22% under the same conditions. While increase of rear angle of ray separator from 10 to 15 degree showed a decrease in cleaning efficiency from 81.22 to 80.35% under the same conditions. Similar trends were shown under different speeds of vibrator. Consequently, performing the tretments under moisture content 20.5% and at speed of vibrator **170 rpm,** showed increasing rear angle of ray separator from 0 to 5 degree resulted in decreasing the cleaning efficiency from 88.92 to 86.75%. On the other hand, the increase of rear angle of ray separator from 5 to10 degree showed a decrease in cleaning efficiency from 86.75 to 85.22% under the same conditions.

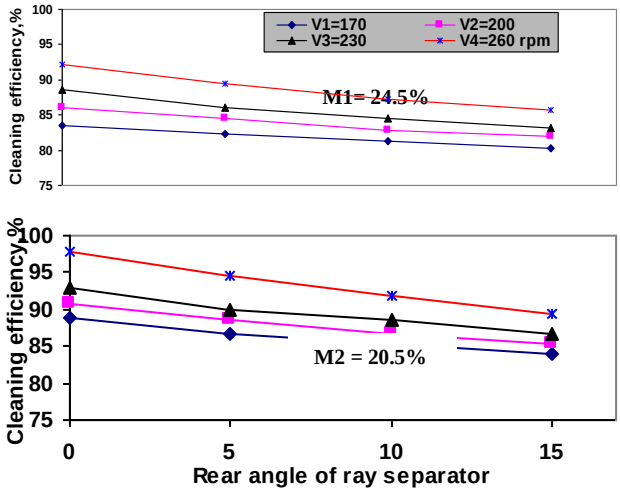


Fig. (3); Effect of rear angle of ray separator and speeds of vibrator on cleaning efficiency at different of moisture contents.

In the other way, the more increase of rear angle of ray separator from 10 to 15 degree showed a decrease in cleaning efficiency from 85.22 to 84.05% under the same conditions. Similar trends were shown under different speeds of vibrator. These achieved data may be according to increasing the rear angle of separator which decrease time remaining of bulbs with soil on the ray separator and consequently gave less cleaning efficiency because of the increase of cohesion force between bulbs and soil especially with higher moisture content. The analysis variance for data showed that the rear angle of ray separator had a significantly affect on the cleaning efficiency ($p < 0.01$).

2. Effect of speed of vibrator on cleaning efficiency:

From data shown in fig (4) it was concluded a directly proportional relationship between speed of vibrator and cleaning efficiency. As increasing speed of vibrator from 170 to 200 rpm at rear angle of ray separator 0 degree resulted in increasing the cleaning efficiency from 83.42 to 86.02% under moisture content 24.5%. On the other hand, the increase of speed of vibrator from 200 to 230 rpm showed an increase in cleaning efficiency from 86.02 to 88.55% under the same conditions. Increasing speed of vibrator from 230 to 260 rpm showed an increase in cleaning efficiency from 88.55 to 92.15% under the same conditions. Similar trends were shown under different rear angles of ray separator.

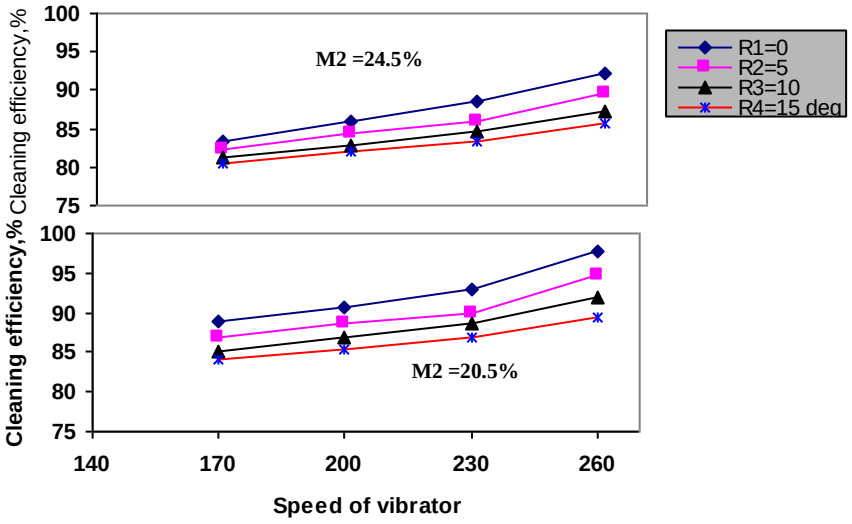


Fig. (4); Effect of speeds of vibrator and rear angle of elevator on cleaning efficiency at different of moisture contents.

In addition, at rear angle of ray separator 0 degree and under moisture content 20.5% increasing speed of vibrator from 170 to 200 rpm resulted in increasing the cleaning efficiency from 88.92 to 90.65%. On the other hand, the increase of speed of vibrator from 200 to 230 rpm showed an increase in cleaning efficiency from 90.65 to 93.02% under the same conditions. While

increasing speed of vibrator from 230 to 260 rpm showed an increase in cleaning efficiency from 93.02 to 97.75% under the same conditions. Similar trends were shown under different rear angles of ray separator. Generally, the least value of cleaning efficiency was 80.35%, and it was obtained under speed of vibrator of 170 rpm and rear angle of ray separator 15 degree with moisture content of 24.5% While the highest value was 97.75%, and it was achieved under speed of vibrator of 260 rpm and rear angle of ray separator zero degree with moisture content of 20.5%. These obtained data may be owing to increasing the vibrator speed that resulted in increasing cleaning efficiency. Increasing vibrator speed led to decreasing soil particles cohesion and adhesion for soil with bulbs especially with lower moisture content. The analysis of variance for data showed that the speed of vibrator had a significantly affect on the cleaning efficiency ($p < 0.01$).

Conclusion

The conclusion can be summarized as follows:

1- The results showed that decreasing moisture content resulted in increasing separation losses and cleaning efficiency.
2- Also, the obtained results showed that increasing rear angle of ray separator resulted in decreasing separation losses and cleaning efficiency.
3- On the other hand, the results showed that increasing vibrator speed resulted in increasing separation losses and cleaning efficiency.
4- the standard working factors of harvester are moisture content M2= 20.5%, rear angle of ray separator R2=5 deg and speed of vibrator 230 rpm.

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تطوير آلة مجمعة لزيادة كفاءة الفصل لمحصول البصل

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يعتبر البصل من أهم محاصيل الخضر فى مصر نظرا لزراعته على نطاق واسع بالمقارنة بمحاصيل الخضر الأخرى وهو يحتل المركز الثاني من الناحية التصديرية بعد البطاطس. وهو نبات عشبي ثنائي الحول، جذوره ليفية قليلة الانتشار رأسيا وأفقيا. ويزرع البصل فى مصر بطريقة الشتل ، ومن أهم أصنافه جيزة 6 محسن, جيزة 20, شندويل 1 والبحيرى الأحمر (الطنطاوي).

ويتم حصاد البصل في مصر يدوياً وهى طريقة لا تتناسب مع المساحات الكبيرة خاصة في الأراضي الجديدة ، كما أن استخدامها يؤدى إلى زيادة نسبة الفقد والتلف في المحصول وتحتاج إلى أيدي عاملة مدربة ووقتا أطول ، مما يؤدى إلى زيادة تكاليف الفدان الواحد وكذلك انخفاض كفاءة الفصل وزيادة نسبة فواقد الفصل وانخفاض درجة التحبب وكذلك كفاءة التنظيف وكل هذا يؤدى الى انخفاض جودة محصول البصل من الناحية التسويقية.

ومن الدراسة تم الحصول على النتائج الآتية

1- انخفاض المحتوى الرطوبى للتربة أدى إلى زيادة كلا من فواقد الفصل وكفاءة التنظيف وفى المقابل انخفاض المحتوى الرطوبى للتربة أدى إلى انخفاض درجة تحبب التربة
2- زيادة زاوية الميل الخلفية لحصيرة الفصل نتج عنها انخفاض كلا من فواقد الفصل ، كفاءة التنظيف ودرجة تحبب التربة.
3- زيادة سرعة الهزاز أدت إلى زيادة كلا من فواقد الفصل ، كفاءة التنظيف ودرجة تحبب التربة.
4- أفضل ظروف تشغيل للآلة كانت عند محتوى رطوبى للتربة 20.5% وزاوية ميل خلفية لحصيرة الفصل 5 درجة وسرعة هزاز 230 لفة/دقيقة.

قام بتحكيم البحث

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