Misr J. Ag. Eng., 24(3): 492-503 FARM MACHINERY AND POWER

THE EFFECT OF HARVESTING OPRATION ON POTATO CROP HANDLING

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ABSTRACT

This study aimed to investigate the effect of some operational factors related to harvesting machine on damage and unlifted potato tubers. These factors included: Three different forward speed 3.02, 4.25 and 5.2 km/h, three different chain speeds 2.3,3.5 and 4.65 km/h, three different agitation throw-out zero, 1and 2 cm, three different chain inclinations 15, 20 and 25 degree, three different harvesting depths 10, 16 and 22 cm and soil moisture content 15, 20 and 25% and storage time after harvesting 0,1,2,3 and 4 week. The experiments were carried out in Nubaria location, el-Bheara Governorate in 2006. From the obtained results, it was cleared that the proper condition to operate the harvesting machine were 22 cm harvesting depths,5.2 km/h forward speed, 4.65 chain speed, zero agitation throw-out, 15% soil moisture content and primary chain inclination of 15 degree. The moisture content of potato tubers varied with storage time after harvesting.

INTRODUCTION

Potato is one of the most important crops in Egypt, is widely used as food stuff. Potatoes are one of the major vegetable crops in Egypt, whose cultivated area is about 200.000 fed. to produce about 2 million ton/year distributed on the summer, nile and winter seasons. **(The annual statistics book, 2005).**

Potato tubers damage and losses due to mechanical harvesting techniques are significant problems for growers nationwide. They can be minimized by studying the factors and improving harvesting methods and post harvest operations such as handling grading, storing and marketing.

Hyde et al. (1983) reported that 60 % of tubers damage occurs after the tubers leave the harvester, but this damage could be reduced if more soils were eliminated by the potato harvester so that potato conveying

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equipment would not be required to both move the tubers and eliminate soil.

They added that there are many factors that directly affect in the damage of potato tubers, such as: digger share, digger forward speed and chain speed, impact duration, soil load level in the primary chain, potato varieties, harvesting type, chain and soil conditions. **Smith (1983)** cleared reported that, incorporates the points that the seed grower requires, fast forward speed minimum damage rough sizing of seed and ware, minimum tuber damage and recovey from the haulm extractor, and the ability to tackle varying slopes. The design is provided with adjustable angle on primary web to maintain constant 18 inclinations. **Siepman (1983)** mentioned that harvesting by hand with a fork is very labour and time consuming depending on the conditions (climate, soil, yield etc. up to 300 man h/ha) and therefore only suitable on a small plot. **McRae (1980)** said that damage begins at the share and generally takes the form of shearing if share is set 25 mm too deep an increase in soil uptake of 210-240 t of soil/ha can result. It is important for the operator to try to minimise this error, but if the share is set too shallow damage can be unacceptable high. Spillage of tubers sideways from a share which is not scouring properly can lead to cutting by side discs. **Abdou (1985)** studied the effect of mechanical harvesting on mechanical potato damage under the condition of clay soil and found that the use of mechanical harvesting in mechanical planting area had higher percent of undamaged potato by comprise with mechanical harvesting in manual planting area. **Misener et. al. (1984)** reported that the harvester forward speed was limited by the capability of the vibrating blade to effectively separate the soil from the tubers. At operating speeds greater than 3.0 km/h., the blade appeared to overload and little separation was accomplished with the existing soil moisture conditions. The upper speed of 3.0 km/h., was equivalent to the maximum speed of commercial harvester under similar conditions. In general the prototype harvester worked well in silty clay loam soil with moisture level up to 29 % dry basis. The hydraulic system operating the chains, brushes and vibrating blade was satisfactory. **Abdou (1991)** found that the lowest percentage values of total damage tuber of 3.97 %, imbded tubers 1.63 % and black spot 4.20 % for clay

soil, total damage tuber 2.26 %, imbded tubers 1.06 % and black spot 4.66 % for silty loam soil, and total damage tubers 3.05 %, imbded tubers 1.13 % and black spot 4.20 % for sandy soil. **Mady (1991)** concluded the low tractor forward speed 2.1 km/h., is preferable for potato harvesting, the suitable gigging depth was 22 cm, Turnill hestair harvester gave the best performance according to the following reasons: 1- Great separation area. 2- Separation chain bars were covered by polyethylene. 3- low drop hight from the separation chain.

Vibrating the share and separating table leads directly to reduce the required draft and increases the performance efficiency.

MATERIALS AND METHODS

A) Materials:

All the experiments tests were carried out at Nubaria location,El-bheara Governorate in 2006 and to conduct them the following were used:

1-Harvester:

Turnill harvester was used and the specifications of it was shown in fig.(1) and table (1).

Fig.(1): The harvester used for the experimental work.

Table (1): turnill hestair harvester specifications:

Manufacture in:	England
No. of rows	Two
Share shape	Trapezium
Share width	40 cm

Separation chain: Front chain Length Width Height Rear chain Length Width Height	 165 cm 68 cm 70 cm Single covered 75 cm 136 cm 30 cm
Cutting disc	Adjustable
Hitching	3 points

2-Tractor:

The source of power for the field experiments was Fiat tractor (2-WD). Engine power of 120 hp (51 kW).

3- Soil moisture content:

A random sample of soil was taken from soil up to 20 cm depth to determine the moisture content before harvesting. The moisture content were 15, 20 and 25%. The soil moisture content determined in the soil laboratory of agriculture land research institute, ministry of agriculture.

4- Procedures:

The harvesting operation were evaluated and The following:

1-Tractor Forward speeds: Three forward speeds named: 3.02, 4.25 and 5.2 km/h.

2- Chain speeds of 2.3, 3.5 and 4.65 km/h.

3- Three different agitation throw-out by using plain roller of (zero agitation), 1 and 2 cm sprockets.

4-Three chain inclinations of 15, 20 and 25 degree.

5- Harvesting depths of 10,16 and 22 c m.

6-Storage times after harvesting were 0,1,2,3and 4 week.

B) Methods:

1-Physical properties of potatoes tuber:

Dimensions like length (L), Width (W), and thickness (T) mm, mass of potatoes tubers g, volume (V) cm^3, sphericity (S) %. Bulk density g/cm^3, geometric diameter (Gd) mm, and arithmetic diameter (Ad) mm, for potatoes tubers are according to **El-Raie et al. (1996)** as follows:-

$V = \pi/6 (L\ W\ T), mm^3$ ---------- (1)

$S = 100*(L\ W\ T)^{1/3} /L, \%$ ---------- (2)

$Gd = (L\ W\ T)^{1/3}, mm$ ---------- (3)

$Ad = (L+W+T) /3, mm$ ---------- (4)

2- lifted tubers

The lifted tubers "L" ton/ feddan was evaluated by weighing the tubers "W " kg, lifted by the digger over the soil surface, collected from the area equal to 10 m and using the following equation:

$$L = \frac{W * 4200}{10 * 1000} = W * 0.42 = 0.42\ W \text{ ton /feddan} \quad \text{----------(5)}$$

3- Unlifted tubers (U):

The unharvested potato tubers were manually harvested by hand digging for the same area. The tubers was weighted and unlifted tubers " U"was determined according to :

$$U = 0.42W \text{ ton/fed.} \quad \text{---------- (6)}$$

Where: W : the weight of unlifted tubers from 10 m^2 area.

The percentage of unlifted tubers were calculated also using the following equation:

$$U = \frac{\overline{W}}{W_t} \% \quad \text{----------(7)}$$

Where: W_t = The weight of total tubers yield

$$= W + \overline{W}$$

4-Total tubers yield "Y" ton /fed.

The total tubers yield was measured from 10 m area as follow:

$$Y = L + U \quad \text{----------(8)}$$

5- Damage index:

Random samples of tubers were collected from each treatment and classified as follows:

Undamaged: tubers have no bruise and cut,

Scuffed: only skin broken, no flesh damage,

Peel damage: which can be removed by a stroke 3 mm deep of hand potato peeler,

Severe damage: which cannot removed by a 3 mm deep stroke of a hand peeler.

The total damage index (TDI) was calculated as indicated by **Mady (1991).**

TDI = Scuffed x 1 + Peeler x 3 + Severe x 7. ---------- (9)

RESULTS AND DISCUSSION

1- Physical properties of Diamant potatoes tubers under study:

Average dimensions of potato tubers used in the experiments are as follows:

Length (L)= 82.81 mm, Width (W)= 51.75 mm and Thickness (T)= 44.35 mm

Also sphericity, mass, volume, bulk density geometric diameter and arithmetic diameter of potato tubers are shown in table 2. These data were measured of 100 fruit sample, according to **(El-Raie 1996).**

Table 2: Physical properties of Diamant potatoes tubers variety.

Physical properties	**Max.**	**Min.**	**Average**
Length, mm	130	36.1	82.81
Width, mm	74.34	30.27	51.75
Thickness, mm	65.19	25.44	44.35
Sphericity, %	89.21	55.12	74.02
Mass, g	345	19	113.13
Volume, cm^3	282.78	14.99	97.95
Bulk density, g/ cm^3	1.38	1.01	1.17
Geometric diameter, mm	39.17	29.52	36.67
Arithmetic diameter, mm	41.10	30.70	38.63

2-Effect of some operational factors on different damage percentages.

a- Harvesting depth.

Fig.(2) illustrate the relation between the harvesting depth (cm) and damage percentage(%) on potato tubers. It's noticed that, the increase of harvesting depth was followed with an increase in undamaged tubers percentage and a decrease in scuffed damage tubers, peeler damage tubers, severe damage tubers, total damage index, imbedded tubers and total damage tubers under forward speed of (5.2 km/h), agitation throw out of (zero), chain inclination of (15^o), chain speed of (4.65 km/h) and soil moisture content of (15%).

b-Forward speed.

Fig.(3) show the relation between tractor forward speed (km/h) and damage percentage(%) on potato tubers .

The results indicated that, the increase of tractor forward speed from 3.02 to 5.2 km/h was accompanied with decreased in each of scuffed damage tubers, peeler damage tubers, severe damage tubers, total damage index and total damage tubers of potato tubers for the experimented potato harvesters. And an increase in undamaged tubers, imbedded tubers increasing by increase tractor forward speed under(22 cm) the harvesting depth, (zero) agitation throw out, (15^{o}) chain inclination, (4.65 km/h) chain speed and soil moisture content of (15%).

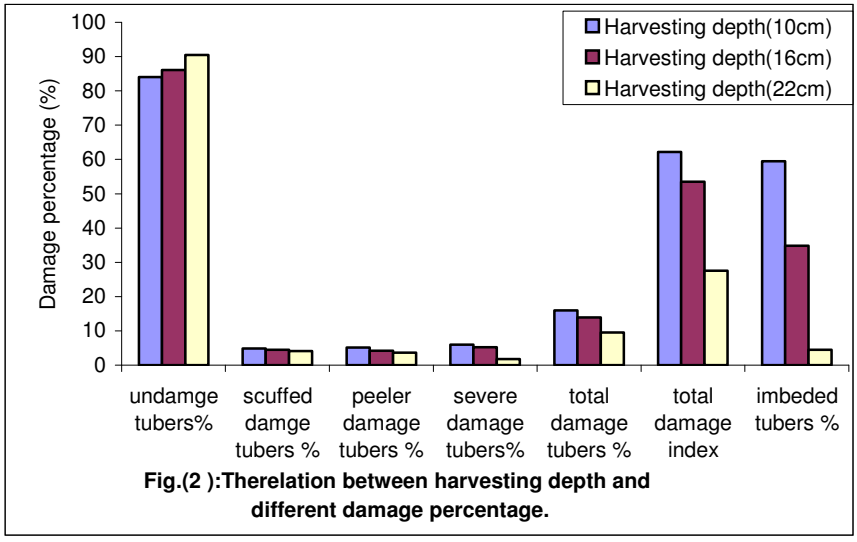

Fig.(2):Therelation between harvesting depth and different damage percentage.

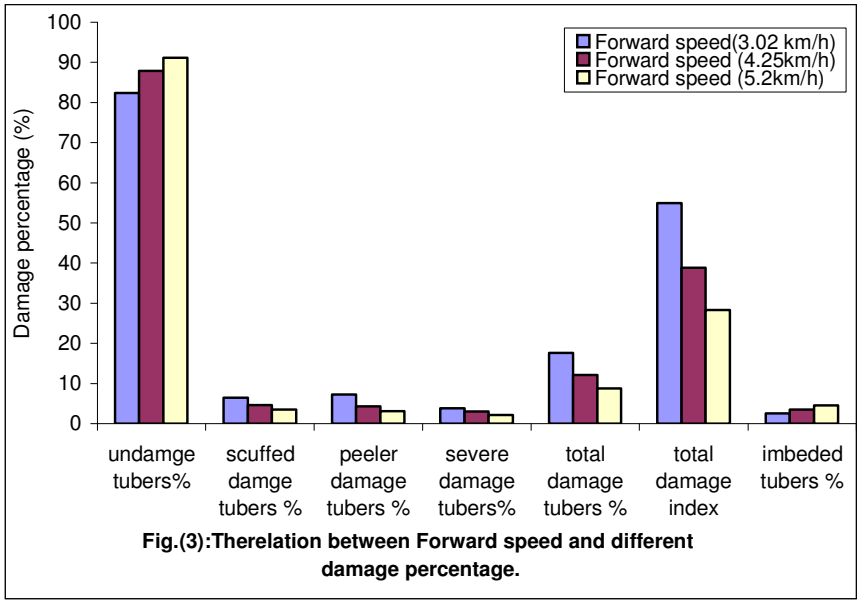

Fig.(3):Therelation between Forward speed and different damage percentage.

c-Agitation throw out.

The relation between agitation throw out(cm) and damage percentage(%) on potato tubers was representing fig.(4).

he results indicated that, the undamaged tubers, imbedded tubers decreased by increase of agitation throw out from zero to 2 cm ,this due to the increase of scuffed damage tubers, peeler damage tubers, severe damage tubers, total damage index by increasing agitation throw out at tractor forward speed (5.2km/h) the harvesting depth(22 cm), chain inclination (15^{o}), chain speed (4.65 km/h) and soil moisture content (15%).

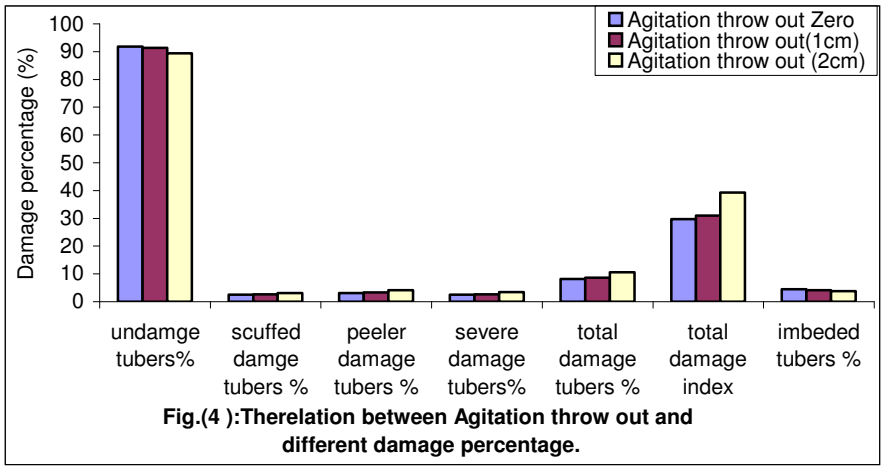

Fig.(4):Therelation between Agitation throw out and different damage percentage.

d-Chain inclination.

Fig.(5) show the relation between chain inclination(degree) and damage percentage(%) on potato tubers

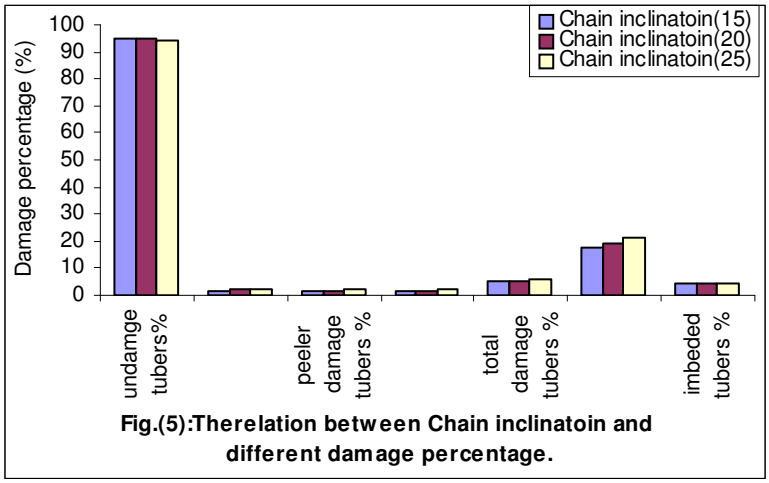

Fig.(5):Therelation between Chain inclinatoin and different damage percentage.

The results indicated that, scuffed damage tubers, peeler damage tubers, severe damage tubers, total damage index and total damage tubers increased While the undamaged tubers, imbedded tubers decreased by increasing chain inclination from 15° to 25° under agitation throw out (zero), tractor forward speed (5.2km/h) the harvesting depth(22 cm), chain speed (4.65 km/h) and soil moisture content (15%).

e-chain speed.

Fig.(6): show the relation between chain speed(km/h) and damage percentage(%) on potato tubers. its effect on damage percentage(%) of potato tubers was illustrated in fig.(6) which

indicated that, increasing chain speed (from 2.3 to 4.65 km/h) increased undamaged tubers and decreased each of scuffed damage tubers, peeler damage tubers, severe damage tubers, total damage index, imbedded tubers and total damage tubers under chain speed at chain inclination (15°), agitation throw out (zero), tractor forward speed (5.2 km/h), the harvesting depth(22 cm), chain speed (4.65 km/h) and soil moisture content (15%).

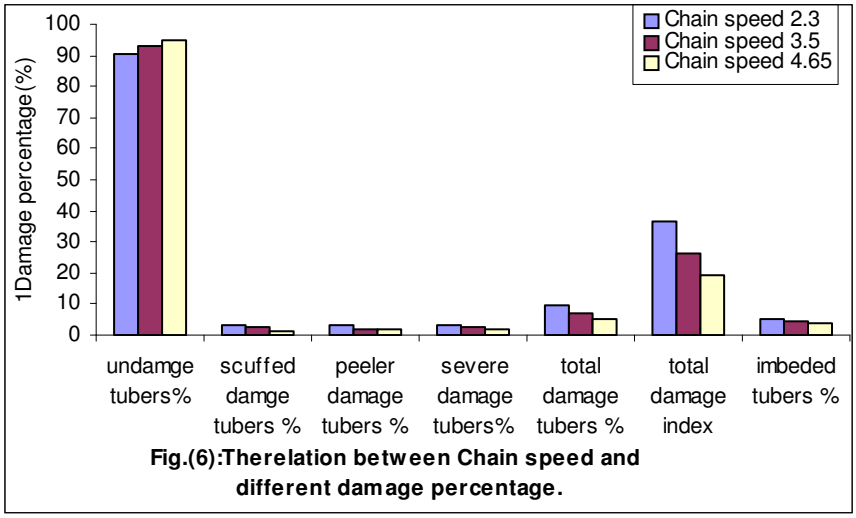

Fig.(6):Therelation between Chain speed and different damage percentage.

f- soil moisture content.

Fig.(7) show the relation between soil moisture content(%) and damage percentage(%) of potato tubers

The results indicated that, increasing soil moisture content from 15% to 25% caused a decrease in each of scuffed damage tubers, peeler damage tubers, severe damage tubers, total damage index and total damage tubers

of potato tubers for the experimented potato harvesters and an increase in undamaged tubers, and imbedded tubers under tractor forward speed(5.2km/h) the harvesting depth(22 cm), agitation throw out (zero), chain inclination (15^{o}), chain speed (4.65 km/h)

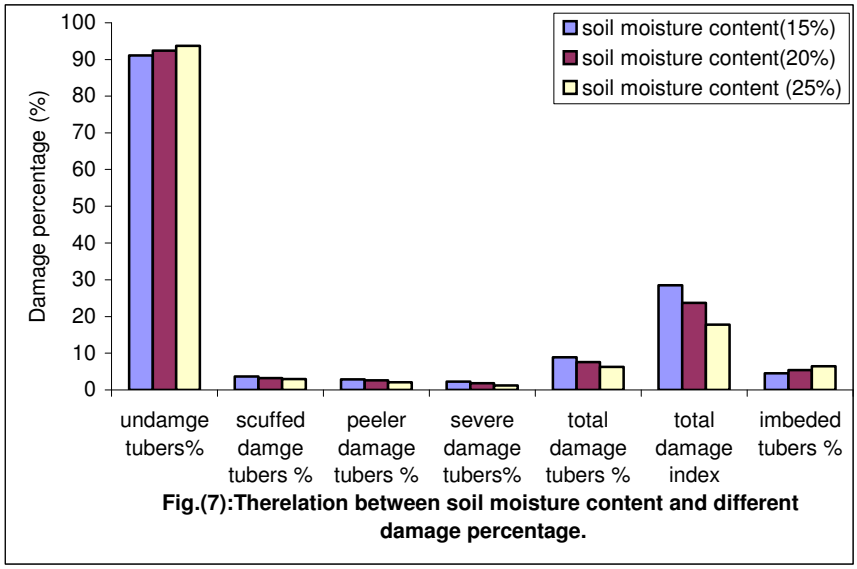

Fig.(7):Therelation between soil moisture content and different damage percentage.

3-Effect of storage time after harvesting .

Fig.(8) show the effect of storage time after harvesting and moisture content(%) of potato tubers. It cleared in the moisture content of potato decreased from 100% to 89.1% when storage time after harvesting increased from 0 to 4 week.

The moisture content varied with storage time after harvesting.

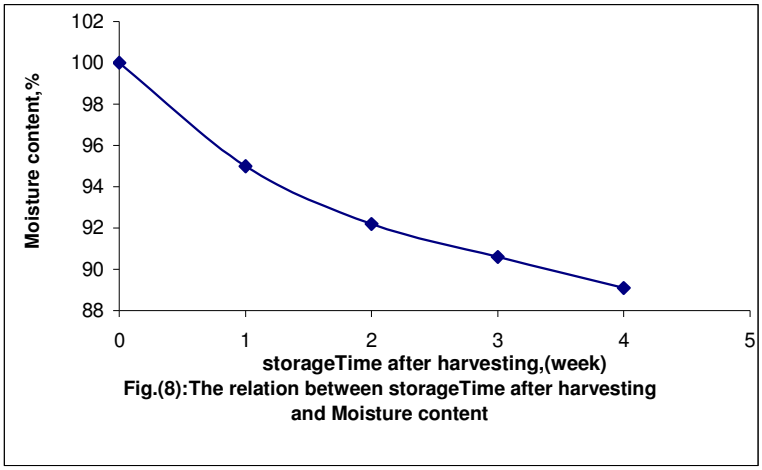

Fig.(8):The relation between storageTime after harvesting and Moisture content

COUNCLUSION

From the obvious results, it can be concluded that the potato can be harvested efficiently under the following condition : (22 cm) the harvesting depth , (5.2 km/h) forward speed , (zero) agitation throw out, (15^{o}) chain inclination, (4.65 km/h) chain speed and (15%) soil moisture content for sandy soil.

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الملخص العربى

تأثير عملية الحصاد على تداول محصول البطاطس

د/جمال كمال عرفة

يعتبر محصول البطاطس من أهم المحاصيل الزراعية فى مصر لما له من أهمية تصديرية واستخدمات عديدة فى كثير من الصناعات الغذائية. حيث تبلغ المساحة المنزرعة من محصول البطاطس حوالى 200.000 فدان بأنتاجية 2 مليون طن/سنة.

ويهدف هذا البحث دراسة أهم العوامل المؤثرة فى عملة حصاد محصول البطاطس والتىتؤثر على تداوله ، حيث أن من المشاكل التى تواجة المزارع اثناء الحصاد الالى للبطاطس هى مشكلة تلف الدرنات والتى تؤثر علىعملية التصدير وعلى جودة المحصول ومدة تخزينه وسعره والدخل الناتج عنه, والدرنات المفقودة تحت سطح التربة والتى تؤثر كذلك على الأنتاجية والدخل.

ونفذت هذه التجارب فى مزرعة خاصة بمدينة النوبارية – محافظة البحيرة عام 2006م .

والعوامل التى تم دراستها هىالسرعة الامامية للجرارفي المدى 3.02 – 5.2 كم/ساعة، سرعة الحصيرة 2.3 – 4.65 كم/الساعة، وواهتزاز الحصيرة على المحور الرأسى صفر-2 سم، وزاوية ميل الحصيرة 15 – 25 درجة ، وعمق الحصاد 10-22 سم، والمحتوى الرطوبى للتربة 15 – 25 % وكذلك دراسة الخواص الطبيعية لمحصول البطاطس (صنف ديامونت).

وخرجت النتائج بالتوصيات التالية: للحصول على اقل درنات مفقودة تحت سطح التربة واقل درنات تالفة (تحت ظروف هذا البحث) يكون عمق الحصاد 22 سم ، السرعة الامامية للجرار5.2 كم/ساعة، سرعة الحصيرة 4.65 كم/ساعة، وواهتزاز الحصيرة صفر-1 سم، وزاوية ميل الحصيرة 15 درجة، ومحتوى الرطوبة للتربة 15 %. المحتوى الرطوبى لدرنات البطاطس يقل بزيادة فترة التخزين.

باحث بمعهد بحوث الهندسة الزراعية- مركز البحوث الزراعية