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DEVELOPMENT OF A COMBINATION UNIT FOR HARVESTING AND GATHERING POTATO CROP.

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ABSTRACT: Potato digger was developed to be used for harvesting potato, separating them from soil and transporting tubers on a trailer outside the harvested area.

Potato digger consists of a digging blade, soil sieving and transport conveyors, while the developed potato digger consists of a digging blade, soil sieving, transport conveyors, elevator and trailer.

The performance of both potato diggers before and after development was investigated in terms of Field capacity, Field efficiency, potato losses, harvesting and cleaning efficiencies, power, energy and cost as a function of change in digger forward speed and penetration angle.

The experimental results reveal that the use of the developed potato digger maximize both of harvesting and cleaning efficiencies and minimize both of losses and cost comparing with the same digger before development under the following conditions:

-Operating the digger at forward speed of about 2.4-km/h and penetration angle of 14°.

-Adjusting the separating sieve at slope angle of 8^0 and at operational speed of 12 m/s.

INTRODUCTION

Potato is considered one of the major vegetable crops that widely used as food-stuff all over the world. It is usually planted three times a year .The cultivated area in Egypt is about 189,764 feddan yearly producing about 1.903134 tons with an average yield of 10.3 ton/ feddan according to Ministry of Agric. (2001).

Potato crop is an expensive labor consuming under traditional method. The two main labor-intensive operations of potato production are planting and harvesting.

Harvesting is one of the most critical operations for potato production. Potato tubers are grown below the surface of the ground. Therefore, it requires specially developed machines to dig and separate them from the soil.

In recent years some progress towards fully mechanized of potato harvesting has been occurred.

Verma et al (1977) developed and tested an experimental potato digger equipped with an oscillating blade. The machine was tested at frequencies up to 9 cps and amplitude of 30 mm. The results indicated that, with their soil type, a reduction in draft requirements of up to 76 % and a decrease in percentage of skinned tubers occurred.

Al Jubori and. Nulty (1980) stated that the use of vibrating blades for harvesting potatoes caused a reduction in the power requirement to pull the harvester, reduce potato damage and losses and improving the separation efficiency of potatoes from the soil

Desa-Ahmed and Shamsudden (1987) described the development and fabrication of a prototype groundnut digger lifter based on a potato digging machine .The design consists of two digging blades that penetrate under the plant row to loosen the soil and cut the top root. There are lifting rods on the blades which help lift the plants from the soil and elevate them to the conveyor The conveyor performs the tasks of separating, shaking and elevating the plants to a discharge unit. From preliminary tests carried out at a speed of 0.9 Km/h. the machine has a working capacity of 0.5h /fed with an efficiency of 63 %..

Younis (1987) tested one row potato digger mounted on 51.5 kW tractors in sandy soil at different digging depth and speed. Losses such as skinned potato and that were measured. The total loss was about 3% of the total yield compared with 8-14% for conventional harvesting (Baladi plow).

Kang, et al (1989) designed and constructed an oscillating potato digger from power tillers to evaluate the effects of vibration on potato digging. Changing the levels of amplitude, frequency, and travel speed, combinations of such parameters were tested in the potato field .the measured variables were harvesting loss and damage, and storing loss of the mechanically harvested potatoes. It was observed that the operation of the digger blade was good with amplitude of 12 mm, frequency of 9.67 HZ, and travel speed of 0.87 Km/hr. Under these conditions the harvesting loss and damage were 3.18 % and 0.67 % that are very low than those of 6.83 % and 9.83 % of traditional harvesting method.

Abdel-Aal et al (2002) modified a potato harvester to be suited for Egyptian farms .The modified harvester is one-row harvester, trailed behind the tractor and P.T.O. operated, to be fitted on the tractor s two hitch system. The machine consists of digging blade, frame, gearbox, hitching system, and riddle system .The optimum engineering parameters for the modified harvester which achieved the highest undamaged, lowest damaged and losses were forward speed of 2.3 km/h, digger tilt angle of 14°, distance between the blade and elevator chain of 5 cm., chain speed of 2.41 m. /s., riddle speed of 4.63 V and riddle inclination of 7°.

As mentioned in the previous review, potato is easily bruised or skinned during the separation process; therefore the separation of potato from soil, similar size stones and clods is a major problem. A great attention must be paid to solve this problem by developing a successful separating mechanism that should based on cleaning potato with minimum damage. Therefore, the objectives of this study are: -

1-Developing potato digger to use for harvesting potatoes, separating tubers from soil and transporting them by a trailer outside the harvested area.

2-Selecting the optimum operation conditions (forward speed and penetration angle) for operating the developed harvester.

3-Comparing the developed harvester with the same harvester before development from the economic point of view.

MATERIALS AND METHODS

Field experiments were carried out at talat mostafa farm Alexandria Governorate to develop and evaluate the potato digger during the harvesting operation of potato crop (Nikola-variety) comparing with the same digger before development under Egyptian conditions.

The mechanical analysis of the soil (at a depth of 0-45) was conducted in the land and soil research institute by using the hydrometer method. The results of mechanical analysis are listed in table (1)

Table (1): Mechanical analysis of the experimental soil.

Soil components			Soil Type
Clay %	Silt %	Sand %	
12	16	72	Sandy Loam

Soil moisture content was determined at depth of 20 cm (tubers zone). The soil moisture content was with an average value of 18 %. Soil moisture content was determined on dry basis with the oven method at 105°c for 24 hours.

A 4-wheel tractor (M. T. Z. model) of the standard type 90 hp (66.2 kW) was used for operating both potato diggers before and after development, A one –row potato digger (PDIS – model)-trailed with 2 points linkage with a share width of 70 cm was used for harvesting potato (Fig 1)

A developed Potato digger

Such development had been introduced to overcome the problems noticed under the harvesting operation using the ordinary digger .The digger is unsuitable for harvesting potato successfully, high percentage of losses as well as damage are resulted during the harvesting operation. The development was done at the local workshop in Noubaria. The schematic diagram of the developed potato harvester is shown in Fig (2).

The developed potato digger consists of a frame, digging blade, separating unit (front chain, separating sieve, elevator), transmission system and transporting trailer.

The frame

The frame is made of rectangular iron sheet steel. The frame is of 200 cm length, 66 cm width and 86 cm height. The frame include elements to fix a gear box, parts of power transmission, hitching system, digging blade, parts of separating system. The two tires wheel (45 cm diameter and 12 cm thickness) carry the harvester frame. The two wheels were adjusted to be suited for the distance between the furrows

The digging blade

The blade is made of steel

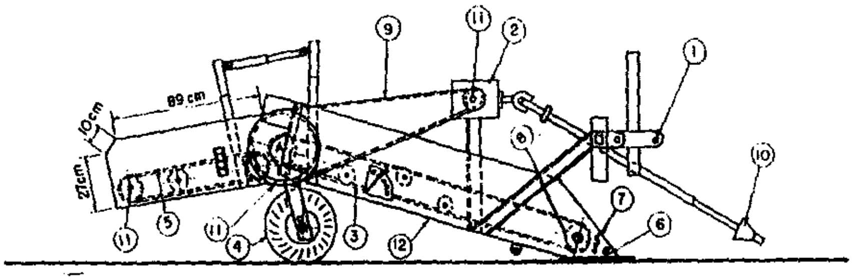

Fig (1) Potato digger before development

(1) Linkage attachment point 2) Gear box (3) Front chain (4) Transport wheel (5) Rear chain (6) Digging blade (7) Penetration angle control (8) Roller (9) Transmission system (10) Universal joint (11) Sprocket (12) Frame

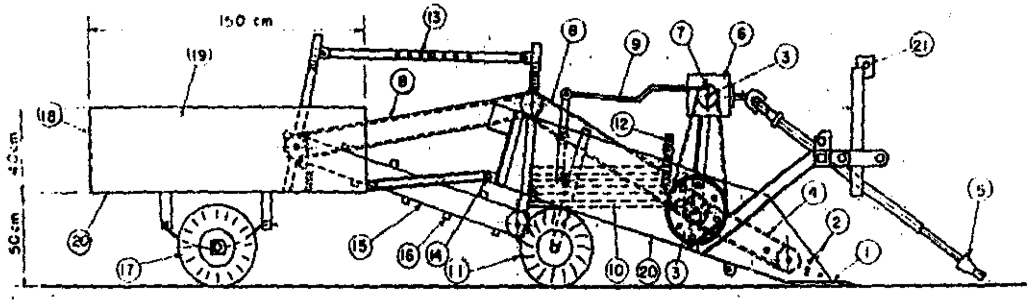

Fig (2) Potato digger after development

(1) Digging blade (2) Penetration angle control (3) sprocket (4) Front chain (5) Universal joint (6) Gearbox (7) Crank-haft (8) Transmission system (9) Connecting rod (10) Separating sieve (11) Transport wheel (12) Sieve inclination control (13) Elevator control lever (14) Trailer attachment (15) Elevator (16) Obstacles (17) Trailer wheel (18) Trailer gate (19) Trailer (20) frame

iron (14.3 mm) thickness (700 mm) length, (250 mm) width with curved shape to be able for penetrating soil and lifting tubers from the ridge to the front chain.

The separating unit

The separating unit consists of front chain, separating sieve, and elevator.

The-separating unit is used to remove soil adhering to potato tubers. The front chain is (84 cm) length and (66 cm) width, the chain webs are strait bars of steel (1.13 cm) thick and (63 cm) length of steel linked together to form a chain and the bars are far enough apart (30 mm) the distance between bars to allow soil to pass through back on the field. The front chain is operated by means of sprocket and chain powered from the tractor P.T.O at an average speed of 100 r.p.m. (2.5 m / s as recommended).

The separating sieve was made of parallel links (0.85 cm) thickness. The sieve frame was made of steel with (85 cm) length, (58 cm) width at the front and (46 cm) width at the rear .The sieve is carried on 4 links of (20cm) length. The links are fixed in the frame in such a way to permit the sieve to move easily. The multiple linkages system agitate the sieve

The sieve crankshaft is powered from the tractor P.T.O. through the machine gearbox.

The elevator frame was made of rectangular iron with (136 cm) length and 60 cm width. The elevator also contains parallel wooden links (3cm) thickness. It is used for lifting potato tubers from the separating sieve to the transporting trailer .The elevator is operated by means of sprocket and chain powered from the tractor P.T.O. at an average speed of 2.5 m/s.

The transmission system

The harvester is operated by means of gear box powered from the tractor P.T.O. through a universal joint .The power is transmitted from the gear box to the front chain, separating sieve, and the elevator with different reduction speed ratios.

The transporting trailer

The transporting trailer was built from sheet steel with full capacity of (400 kg) of potatoes .The trailer is rectangular with (150 cm) length and (90 cm) width having a depth of (40 cm).

The trailer frame was carried by two rubber wheels at the two sides (45cm diameter and 12 cm thickness). The trailer was attached to the digger frame by means of drawbar.

Sieve speed adjustment

A vibrated sieve is used to remove soil adhering to potato tubers. Agitation of the separating sieve results in displacement of the potato tubers over its surface. The potato tubers should be so agitated that separation is optimal.

The potato tubers should be uniformly distributed over the sieve surface and moved towards the delivery end of the sieve. The sieve is agitated by multiple system linkage kinematics characteristics of linear motion of the driving link and the crank –connecting rod mechanism for small values of r/L (crank shaft length / connecting rod length) are given by the following (Klenin et al 1970):

$$X = r(1 - \cos\omega t)$$

$$\dot{X} = \omega r \sin \omega t$$

$$\ddot{X} = \omega^2 r \cos\omega t$$

Where: -

X :Instantaneous displacement, cm.

$\dot{X}$: Motion velocity, cm/s

$\ddot{X}$: Acceleration of motion, cm/s^2.

ω : Angular velocity, rad./s

r : crank shaft length , cm.

The following forces acting tuber lying on a sieve: -

1- W: Force due to the weight of the potato tuber directed downward.

2- F_i: Inertia force acting in a direction opposite to that of the mass acceleration force. The magnitude of the force F_i is obtained from the expression:

$$F_i = m\ddot{x} = m\,\varpi^2 r \cos \varpi t$$

Where:

m : is the mass of potato tuber, kg.

3- F_f: Friction force between the potato tuber and the sieve surface acting in a direction opposite to that of the direction of relative motion.

4- R: Reaction force of the working surface on the potato tuber acting in a direction normal to the surface.

The sieve is set horizontal or inclined to the horizontal plane, the angle of inclination selected from the condition.

$$\alpha \le \varepsilon$$

Where:

α : Angle of sieve with the horizontal

ε : The friction angle between the potato tubers and the sieve surface

$(\varepsilon = 15^{\circ})$

According to the condition given above, the material will not slide over the sieve when it is stationary. When the sieve is agitated at a particular frequency and amplitude, a motion is imported to the tubers relative to the sieve surface.

The possible types of motion of the tubers are only sliding motion over the sieve towards the delivery end, and in the reverse direction or loss of all contact between the tubers and the sieve surface.

Motion of potato tubers over the sieve surface at the delivery end From A to B.

Motion at the delivery end is possible when the resultant of all forces acting the tuber is greater than the friction force (Fig 3) that is:

$$W\sin\alpha + F_i\cos(\varepsilon-\alpha) \geq F_f$$

$$F_f = R\tan\varepsilon = \mu R$$

Where:

F_f : The friction force

ε : Friction angle

μ Coefficient of friction

R: Normal force

To determine force (R) projecting all the force in a direction normal to the sieve

$$R = W\cos\alpha + F_i\sin(\varepsilon-\alpha)$$

Then Motion of the potato tuber at the exit may be expressed by the following inequality:

$$W\sin\alpha + F_i\cos(\varepsilon-\alpha) \geq$$

$$\mu W\cos\alpha + \mu F_i\sin(\varepsilon-\alpha)$$

Or

$$mg\sin\alpha + m\omega^2 r\cos\omega t\cos(\varepsilon-\alpha) \geq$$

$$\mu\, mg\cos\alpha + \mu m\,\omega^2 r\cos\omega t\sin(\varepsilon-\alpha)$$

$$\omega_1 = \sqrt{\frac{g(\mu\cos\alpha - \sin\alpha)}{r\cos\omega t\,[\cos(\varepsilon-\alpha) - \mu\sin(\varepsilon-\alpha)]}}$$

Or

$$N_1 = \frac{60}{2\pi}\sqrt{\frac{g(\mu\cos\alpha - \sin\alpha)}{r\cos\omega t\,[\cos(\varepsilon-\alpha) - \mu\sin(\varepsilon-\alpha}}$$

Sliding motion of the potato tuber up and down the surface From B to A (Fig 4)

The movement of tubers from B to A is possible when

$$F_i\cos(\varepsilon-\alpha) - W\sin\alpha \geq F_f$$

Where:

$$R = W\cos\alpha - F_i\sin(\varepsilon-\alpha)$$

Then the motion of the potato tuber in this case may be expressed by the following inequality:

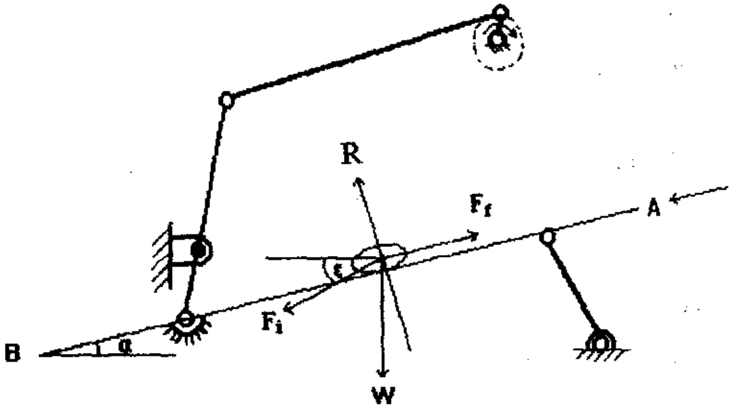

Fig: (3) Motion of potato tuber over the sieve at the delivery end (from A to B).

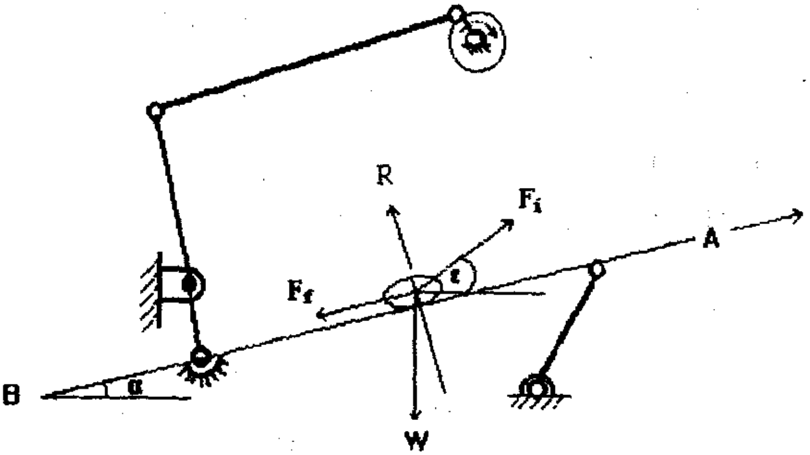

Fig: (4) Motion of potato tuber over the sieve at the delivery end (from B to A).

$$F_i \cos(\varepsilon - \alpha) - W \sin\alpha \geq$$
$$\mu\, W \cos\alpha - \mu\, F_i \sin(\varepsilon - \alpha)$$

$$m\omega^2 r \cos\omega t \cos(\varepsilon - \alpha) - mg\sin\alpha \geq$$
$$\mu\, mg\cos\alpha - \cos\omega t \sin(\varepsilon - \alpha)$$

$$\omega_2 = \sqrt{\frac{g(\mu\cos\alpha + \sin\alpha)}{r\cos\omega t\left[\cos(\varepsilon - \alpha) + \mu\sin(\varepsilon - \alpha)\right]}}$$

$$N_2 = \frac{60}{2\pi}\sqrt{\frac{g(\mu\cos\alpha + \sin\alpha)}{r\cos\omega t\left[\cos(\varepsilon - \alpha) + \mu\sin(\varepsilon - \alpha)\right]}}$$

Riding of potato tubers on the sieve surface

The motion of tubers in this case may be expressed by the following in equality:

$$W \sin\alpha + F_i \cos(\varepsilon - \alpha) \geq F_f$$

But in this case

$N = 0 \quad \therefore F_f = 0$

$$\therefore F_i \cos(\varepsilon - \alpha) \geq -W\sin\alpha$$

$$m\,\omega^2 r\cos\omega t\cos(\varepsilon - \alpha) \geq -mg\sin\alpha$$

$$\omega_3 = \sqrt{\frac{-g\sin\alpha}{r\cos\omega t\cos(\varepsilon - \alpha)}}$$

$$N_3 = \frac{60}{2\pi}\sqrt{\frac{-g\sin\alpha}{r\cos\omega t\cos(\varepsilon - \alpha)}}$$

It follows from these equations that the mass of potato tubers and soil moves along the sieve both toward the exit ($N > N1$) and to the opposite direction ($N > N2$) and at the same time some of the tubers thrown off the surface of the sieve ($N > N3$).

Sieving and separating soil from potato tubers are more successful under the following conditions:

$N_3 > N > N_1$ and $N_1 > N_2$

Where:

N: the optimum sieve speed

In this investigation, the developed machine was adjusted as follows:

$\frac{r}{L} = \frac{1}{50}$ (As recommended)

$\alpha = 8^\circ$ (to be less than the friction angle between the potato tubers and the sieve surface). Under the above conditions and by using the previous equations, optimum sieve speed was calculated to be as follows:

N= 465 rpm corresponding to an angular sieve speed of 12 m. /s.

Experiments

The experimental area was about (12 Feddans) divided into two equal plots (6 Feddans each.). One of the two plots was harvested with potato digger before development and the other with potato digger after development.

Each plot divided into three subplots (2 Feddans each) for three replicates in completely randomized block design. The potato diggers before and after development were operated in each subplot at four different forward speeds of 1.6, 2, 2.4 and 3 km / h and three different penetration angles of 8, 14 and 20 degree. The row width was adjusted at 75 cm; the spaces were adjusted at 25 cm and the depth at 20 cm for potato planting .The vines of the potato were removed ten days before harvesting.

Measurements

Evaluation of potato harvesting machines performance was done taking into consideration the following indicators: -

Field capacity and efficiency

Field efficiency (η_f) is the ratio of actual field capacity to theoretical field capacity expressed as percent

$$\eta_f = \frac{\text{Effective field capacity}}{\text{Theortical field capacity}} \times 100$$

Where-Effective field capacity is the actual average working rate of area and theoretical field capacity is calculated by multiplying machine forward speed by the effective working width of the machine.

Buried tubers (losses)(Bt)

The buried potatoes tubers percentage were calculated also by using the following equation:

$$B_t\% = \frac{M}{W_T} \times 100\,\%$$

Where : M –mass of buried tubers in the sample,

Wt - mass of the total sample.

Damaged and undamaged tubers

Random samples of tubers were collected and weighed for each treatment. Each sample was divided into two portions are damaged (D_t) and undamaged tubers ($U.D_t$) .The weight of damaged tubers (m_1) and the weight of undamaged tubers (m_2). The percentage of each portion was calculated as follows:

$$D_t\% = \frac{m_1}{W_t} \times 100\,\%$$

$$U.D_t\% = \frac{m_2}{W_t} \times 100\,\%$$

Harvesting efficiency (η_H)

Harvesting efficiency is the mass ratio of undamaged tubers raised over the soil surface by the digger and can be calculated by using the following equation:

$$\eta_H = \frac{R_t - D_t}{W_t} \times 100$$

Where

R_t : Raised tubers

Cleaning efficiency : (η_{cl})

It was determined by using the following formula:

$$\eta_{cl} = \frac{Wcl}{Wt} \times 100$$

Where: -

W_{cl}: Weight of cleaning tubers in the sample kg

Harvesting power

Harvesting power was estimated from the fuel consumed during the harvesting operation using the following formula Barger et al .(1963)

$$Bhp = \frac{f_c \times \rho_f \times L.C.V \times 427 \times \eta_{th} \times \eta_m}{60 \times 60 \times 75}$$

Where:

fc :fuel consumption L/h

ρ_f : Density of fuel kg/l (for diesel fuel = 0.85 kg/l).

ηth : thermal efficiency considered to be 40% for diesel engine

ηm Mechanical efficiency of the engine considered to be 80 % for diesel engine

L.C.V Calorific value of fuel about 10000 k cal/kg

427 Joules constant (thermo mechanical equivalent) J/Kcal

Harvesting energy

Estimation of the energy required for operating harvesting machines was carried out using the following formula

Energy requirements ((kW-h/ fed.)

$$= \frac{\text{Engine power(kW)}}{\text{Efefctive field capacity(fed/h)}}$$

Criterion cost

The machine cost was determined using the following equation (Awady 1978).

C = P/h (I/a+i/2+t+r) +(1.2 W.S.F.) + m/144

Where:

C: hourly cost (L.E./ h)

P: price of machine L.E.

h: yearly working hours (h/yr)

a: life expectancy of the machine in year.

i : annual interest rate (%/yr)

t :-Taxes over head ratios(%/yr)

r: annual repairs and maintenance rate (%/yr)

W: power (k. W)

S: specific fuel consumption (kg / k W.h)

F: fuel price (L.E./L.)

m: Operator monthly salary L.E/ mo.

1.2:a factors accounting for lubrication

144:monthly average hours (h/mo)

The operating cost was determined using the following equation

$$\text{Operatingcost/fed} = \frac{\text{Machinecost/h}}{\text{Effectivefieldcapacityfed/h}}$$

Criterion cost/fed. =

Operating cost/fed.+ Transporting cost/fed. + Product losses cost/fed .

It should be pointed out that for the harvesting method using potato diggers before development another cost must be added. This cost is required to transmit the potato outside the harvested area.

RESULTS AND DISCUSSIONS

The discussion will cover the results obtained under the following headings: -

Effect of different harvesting methods on potato losses

It was found that the highest damage percentages of 4.4 % and 3.7 % were obtained at forward speed of 3 km/h and penetration angle of 8° for both potato digger before and after development respectively. While the lowest percentages of damaged tubers of 2.3 and 2.2 % were recorded at forward speed of 1.6-km/h and penetration angle of 20° under the same conditions. The highest damage ratio at high forward speed may be due to the floating action of the blade and increasing the circulating motion of the soil on the blade as a result, high friction will be expected.

Regarding the effect of harvesting method on buried tubers, the highest buried tubers percentage according to the obtained data were 16.2 and 6.8 % at forward speed of 1.6 km/h and penetration angle of 80 for both potato diggers before and after development respectively. While the least buried tubers percentages of 12.5 % and 3.7 % were obtained at forward speed of 2.4-km/h and penetration angle of 14° under the same previous conditions.

As the effect of harvesting method on total losses,. Results show that increasing forward speed from 1.6 to 2.4 km/h, was followed with a reduction in the percentage of total losses by 7.39, 7.06, and 7.3 % for potato digger before development and by 10.11, 18.29, and 15.12 % for potato digger after development at penetration angles of 8°, 14°.and 20° respectively. Any further increase in the forward speed from 2.4 up to 3 km/h, total losses will increase. The obtained data also show that the highest percentages of total losses of 19.7 and 9.9 % were recorded at forward speed of 3 km/h and penetration angle of 8° for both potato digger before and after development respectively. While the lowest percentages of total losses of 15.8 and 6.7 % were obtained at forward speed of 2.4 km/h and penetration angle of 14°

under the same conditions The increase in total losses at high forward speeds is due to the increase in both of buried and damaged tubers. So, it is recommended to use the developed potato digger to harvest potato with minimum losses. Concerning the effect of harvesting method on damaged tubers. The represented data in Fig (5 ، 6) show that the percentage of the raised potatoes as will as potato losses were affected greatly by the digger forward speed and penetration angle

Effect of harvesting methods on harvesting and cleaning efficiency

It is noticed that The increase of forward speed from 1.6 to 2.4 km/h, was followed with an increase in harvesting efficiency by 1.7, 1.43, and 1.56 % for digger before development and by 1.09, 1.61, and 1.4 % for digger after development at penetration angles of 8, 14, and 20 degree respectively .Any further increase in forward speed from 2.4 up to 3 km/h, caused a decrease in harvesting efficiency by 2.67, 2.02 and 2.28 for digger before development and by 1.64, 1.7 and 1.83 for digger after development.

The increase in harvesting efficiency by increasing forward speed up to 2.4 km/h may be attributed to the increase in the raised potatoes at that range of speeds. While the decrease in harvesting efficiency at speeds higher than 2.4 up to 3 km/h may be attributed to the decrease of the raised potatoes comparing with the increase in buried potatoes.

The same trend was noticed with the cleaning efficiency for potato digger after development

Increasing forward speed from 1.6 to 2.4 km/h caused an increase in the cleaning efficiency by 1.92, 2.4, and 2.01 % at penetration angles of 8°, 14°, and 20°. Respectively. The increase of forward speed from 2.4 up to 3 km/h was followed with a decrease in cleaning efficiency by1.19, 1.25, and 1.17 %.

The increase in cleaning efficiency by increasing forward speed from 1.6-2.4 km/h is attributed to the increase of sieve speed to be able to clean potato from soil and stones while the decrease in cleaning efficiency at speeds more than 2.4 km/h is due to the more amount of soil with potatoes on the sieve.

As to the potato digger before development, it is noticed that increasing forward speed from 1.6 to 3 *km/h* decreased cleaning efficiency by 3.8, 3.12, and 3.23 % at penetration angles of 8, 14, and 20 degree respectively. This is because there are not any sieves in the digger before development.

Harvesting efficiency as well as cleaning efficiency is greatly affected by the harvesting method under all operating conditions. Fig (7,8) illustrated the effect of penetration angle and forward speed on harvesting efficiency.

From the previous analysis, it is recommended to use the digger after development to increase cleaning efficiency as the developed machine keeps potatoes clean by means of the vibrating sieve and the transporting trailer

Effect of harvesting methods on power and energy requirements

Fuel consumption as well as power and energy requirements are highly affected by both forward speed and penetration angle. Fig (9) show a remarkable drop in the energy requirements as the forward speed increased at any penetration angle while the vice versa was noticed with the required power.

The obtained data show that increasing forward speed from 1.6 to 3 km/h, increased the required power by 6.16, 6.07, and 6.44 %, while decreased energy requirements by 39.42, 38.21, and 36.88 % for potato digger before development .at penetration angles of 8, 14, and 20 degree respectively. Also increasing forward speed from 1.6 to 3 km/h was followed with an increase in power by 4.65, 5.45, and 6.43 % and a decrease of energy by 36.59, 36.54, and 34.72 % for potato digger after development under the same previous conditions.

The increase in power required by increasing forward speed is due to the increase in fuel consumption. While the decrease in energy requirements by increasing forward speed could be due to the high increase in field capacity comparing with the increase in the required power

Effect of different harvesting methods on harvesting cost

Cost of field machinery is depended on many factors due to the machines and the power unit used.

A complete cost analysis was made at different operating conditions and related with the actual field capacity for the machines used.

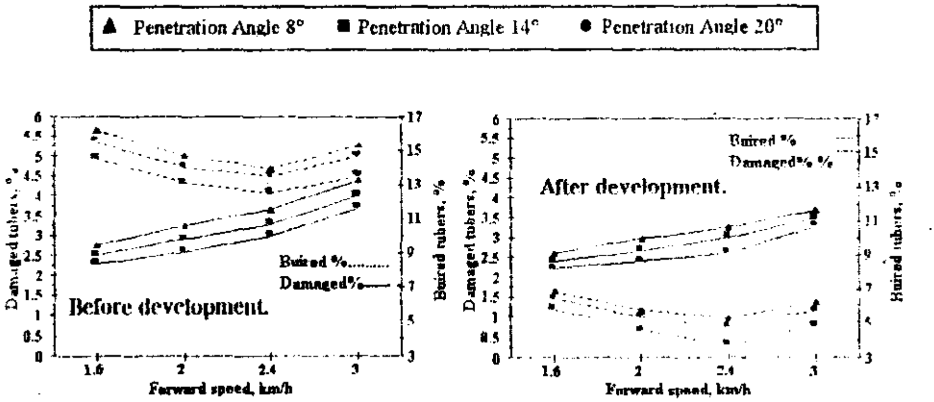

Fig (5) the effect of forward speed and penetration angle on damaged and buried tubers percentage

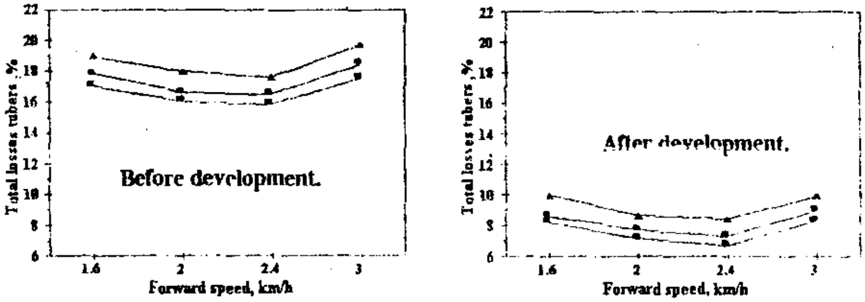

Fig. (6): The effect of forward speed and penetration angle on total losses percentage.

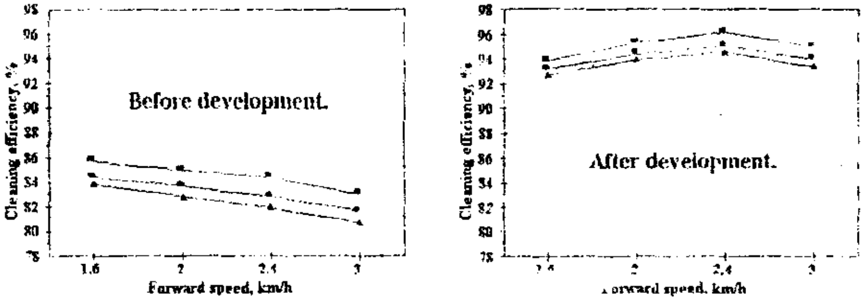

Fig:. (7) Effect of harvesting methods on harvesting efficiency

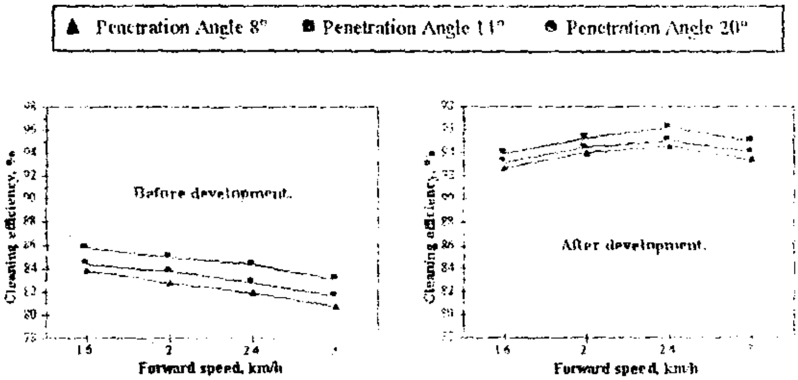

Fig (8) Effect of harvesting methods on cleaning efficiency

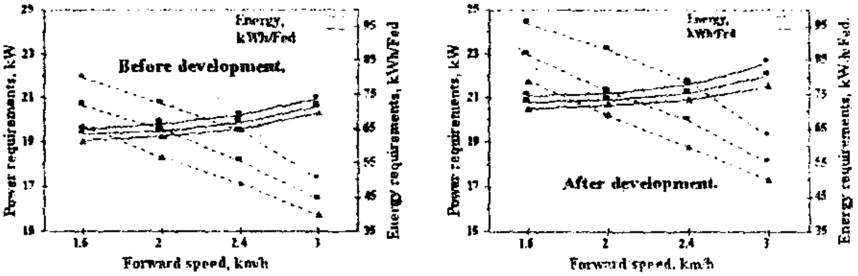

Fig.(9) Effect of harvesting methods on power and energy requirements

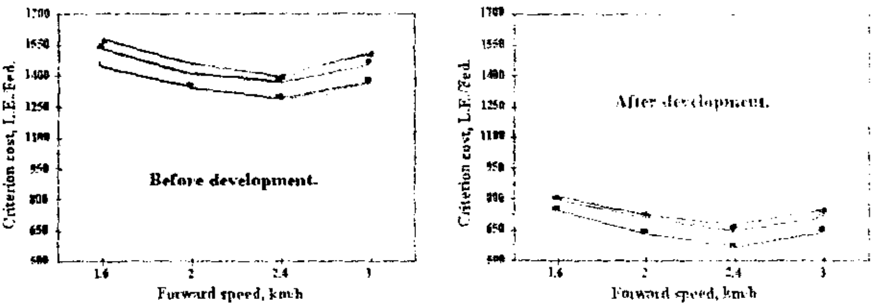

Fig.(10) Effect of different harvesting methods on harvesting cost

The relation between forward speeds, penetration angle on criterion costs for harvesting potatoes using potato diggers before and after development is illustrated in Fig (10).

Results show that increasing forward speed from 1.6 to 2.4 km/h decreased criterion cost by 11.25, 10.89, and 10.51 % for potato digger before development and by 16.87, 23.786, and 18.95 % for potato digger after development at penetration angles of 8, 14, 20 deg. respectively. Any further increase in forward speed from 2.4 up to 3-km/h. -criterion cost will increase

The decrease in criterion cost in the speed range from 1.6 to 2.4 km/h is attributed to the increase in field capacity, while the increase in criterion cost by increasingforward speed up to 3 *km/h* is due to the increase in total losses cost.

It was noticed that the use of potato digger after development costs less than the digger before development under all operation conditions. This attributed to the high decrease in both transport cost and total losses cost.

CONCLUSION

The recommendations of this work can be summarized as follows:

1-The developed potato digger is recommended to be used for harvesting potatoes because of its higher cleaning efficiency and less of both losses and cost comparing with the same digger before development.

2-The proper operational conditions for the developed potato digger are forward speed of 2.4 km/h, penetration angle of 14 degree and sieve slope of 8 degree and operating speed of 12 m/s

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تطوير آله مجمعة لحصاد وجمع محصول البطاطس

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تم تنفيذ التجربة فى مزرعة طلعت مصطفى بالإسكندرية لتطوير وتقييم آلة حصاد البطاطس المطورة ومقارنتها بالآلة قبل التطوير.لاستخدامها فى حصاد وفصل البطاطس من التربة و نقلها إلى خارج الأرض التى تم حصادها.وتم اختيار الظروف المثلى(السرعة الأمامية وزاوية الاختراق) لتشغيل الآلة المطورة.مع مقارنتها بالآلة قبل التطوير من الناحية الاقتصادية و المساحة التى تم عليها التجربة (١٢) فدان.وقد تم دراسة (السعة الحقلية و الكفاءة الحقلية – الفقد و التلف فى الدرنات - إستهلاك الوقود و القدرة و الطاقة المطلوبة و التكاليف .و تتكون الآلة قبل التطوير من إطار وسلاح تقليع

البطاطس ووحدة فصل (حصيرة أمامية -حصيرة خلفية) - مجموعة نقل الحركة حيث يتم رفع البطاطس وسقوطها على الارض خلف الآلة مباشرة .أما الآلة بعد التطورفتتكون من إطار وسلاح تقليع البطاطس ووحدة فصل(حصيرة أمامية -غربال فصل - سير رافع) - مجموعة نقل الحركة - حيث يتم رفع البطاطس وسقوطها على مقطورة ملحقة بالآلة و نقل البطاطس خارج الأرض.

من النتائج المتحصل عليها يمكن التوصية بإستخدام آلة الحصاد المطورة لأنها ذات كفاءة حصاد وتنظيف أعلى وكذلك لتقليل الفقد فى الدرنات وتحقيق تكلفة اقل من آلة الحصاد قبل التطوير و تشغيل آلة الحصاد عند سرعة ٢,٤ كم/ساعة وزاوية اختراق ١٤ درجة مع ضبط غربال الفصل بميل ٨ درجات وتشغيل الغربال على سرعة ١٢ متر/ ثانية.