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Fabrication and Performance Evaluation of a Potato Planter under Egyptian Conditions

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ABSTRACT

The field experiments were carried out to develop and construct of a local planting machine for the potato crop suitable for Egyptian conditions. The performance of the developed machine was studied under the following parameters: Four different machine speeds of (0.72, 1.08, 1.44 and 1.8 km/h). Three different ranges of diameter tuber about (2 : <4 cm), (4 : <6 cm) and (6 : <8 cm). Three different planting depth of (6, 8, and 10 cm). The performance of the manufactured machine was evaluated taking into consideration the following indicators: void tuber, double tuber, germination percentage, field capacity, field efficiency percentage, concumed energy and operating costs. The machine was designed to be mounted on the tractor's hydraulic device and carried on two ground wheels. The feed device of the machine consists of two gears and a chain with 16 feeding spoons to transfer potato tubers from the hopper to the soil at regular distances and depths. The experimental results reveal that the highest value of machine field efficiency was 87.2% and highest value of machine field capacity 0.245 fed/h, the lowest value of the energy consumed and the lowest value of the operating cost were 1.29 kW.h/fed and 213 LE/fed, respectively. The optimum operating parameters of the developed potato planter machine were found at 1.44 km/h machine speed, (6 : <8 cm) tuber diameter and 10 cm planting depth.

INTRODUCTION

Potato crop is considered one of the most important strategic crops in the world in general and in Egypt in particular, where the proportion of potato exports was estimated at 25% of the total Egyptian agricultural exports. Egypt occupies an advanced position among the potato producing countries as well as exporting them, as potato crop occupies the second place in export after cotton. Birch et al. (2012) stated that, the third-most strategic food crop in the world is the potato. In the past two decades, potato production in developing nations has grown significantly and has already surpassed that in the developed world, highlighting the growing significance of potatoes as a staple food crop to fulfill the demands of growing human populations. Another significant source of starch is the potato. **Ismail et al. (2011)** reported that, although output increased from 16.68 t/ha in 2004 to 21.5 t/ha in 2006, the production of potatoes in Egypt does not keep up with the sharp rise in exports and population. **Zaheer and Akhtar (2016)** stated that, potatoes are an economically significant staple crop that are grown all over the world due to their successful large-scale production, consumption, and accessibility on the open market. Basic elements including carbohydrates, dietary fiber (skin), a number of vitamins, and minerals like potassium, magnesium, and iron are all found in potatoes. Because they include vital food antioxidants including vitamins, carotenoids, polyphenols, and minerals, potatoes, especially those that are colored, play a significant part in the creation of the antioxidant defense system. **Morsy et al. (2006a)** designed and evaluated potato planting machine and mechanical aids to perform planting of sprouting tubers operation. The potato planter was made in a specialized workshop in the village of El-Shoaraa in the Damietta Governorate using materials that were readily available locally and suitable for the Egyptian environment and conditions. It had high field efficiency. **El-Maksoud et al. (2011)** mentioned that, planting depth and machine speed affect the actual field capacity common pattern for planting depths at all rates of pace. The actual field capacities were (1.3, 1.2 and 1.1), (1.37, 1.28 and 1.2), and (1.66, 1.54 and 1.43) fed./h after accounting for the impact of the planting speed of 5 km/h and the planting depths of 3, 5 and 7cm. **Boydaş (2017)** stated that, in this study, the seed metering mechanism in a fully autonomous potato planter was examined in relation to various cup sizes (C1–C2–C3), seed sizes (25–45 and 45–65 mm), forms (oblong and spherical), and angular speeds (0.9, 2.04 and 3.18 rad s^{-1}). **Wanzhi et al. (2020)** stated that, this study developed ahigh-efficiency, precise aspiration-spoon-belt mechanism for measuring potato seeds. The major components of the seed metering device's construction and characteristics were examined and computed. Its design was based on the central composite experimental design approach of Box-Behnken. The criteria for high-efficiency precision seeding was fulfilled when the seeding belt speed was 0.43 m/s1, the seeding spoon aperture was 15.72 mm, and the cleaning air pressure was 2.64 kPa. The qualified seed index was 91.38 percent at the time, which was higher than the agricultural industry average. At the time, the multiple seed index was 4.65 percent, the qualified seed index was 3.97 percent, and the missing seed index was 3.97 percent. **Aboegela et al. (2021)** developed a single-row automatic potato planter by modification the metering mechanism spoon size to well-matched with size and shape of tuber. This planter was locally fabricated to be operated by mini tractors to suit the small holdings. The modified planter performance was evaluated under three different spoon diameters of 25, 35 and 45mm, three forward speeds of 1.6, 2.4 and 3.2 km/h. So, the objectives of this study were: Manufacture and performance evaluation of a machine for planting potato crop with locally made raw materials, suitable for the Egyptian conditions. Determine the most appropriate operating factors affecting the performance of the manufactured machine and economic evaluation of the potato planter.

MATERIAL AND METHODS

This study was carried out through the year of 2020/2021 at Agricultural Engineering Department, Faculty of Agriculture, Damietta University to develop and construct a locally potato planter for planting potato crop under Egyptian conditions. The field experiments were carried out through the year of 2021/2022 at Halawa village in Kafr El-Batekh town, Damietta Governorate, to evaluate the constructed potato planter under Egyptian conditions.

MATERIALS:

Soil properties:

The experiments were carried out in sandy loam soil. Soil properties were shown in table (1).

Table (1): Some properties of experimental soil.

Item	Description
Soil	Sandy loam
Softness	medium softness
Soil structure	55% sand, 30% loam, 15% clay
Bulk density	1.5 kg/cm^3
Soil PH	6
Soil moisture content	14.7%
Organic matter	1.05%

The used crop: Potato tuber (Cara variety) was bought from a local market in Kafr Saad town, Damietta Government; some properties of the used potato tuber (Cara variety) under this study are shown in table (2).

Table (2): Some properties of the used potato tubers (Cara variety).

Item	Value	Unit
A. Length, L.	7	cm
A. Width, W.	5	cm
A. Thickness, Th.	4	cm
Volume, V.	586.43	cm^3
Area, A.	27.48	cm^2
Moisture content of tuber, M.C.	80	%
Static coefficient of friction, M_S	4.5	Degree

The manufactured potato planter:

The potato planter was manufactured, developed and evaluated technically at Agricultural Engineering Department, Faculty of Agriculture, Damietta University, Egypt. Some considerations were taken in consideration during construction the potato planter as follow: Using locally available materials for construction the developed local potato planter for planting potato crop under Egyptian conditions; selection the materials was based on availability, durability, ease of machining, and low cost. The main parts of the constructed potato planter are presented in the schematic diagram and machine picture in Fig. 1 as following:

Metering device:

The metering device has three main parts as following:

The movement gears:

It consists of two gears of iron metal, which take their movement from machine ground wheel. The first gear (Drive) has a diameter of 7 cm consists with 14 teeth, while the other gear, big one (Driven), has a diameter of 14 cm with of 32 teeth. It moves as a result of the movement of the driving gear through the use of the gear law, the gear ratio is therefore 2:1, through a 208 cm long iron chain, the distance between the feeding spoons was modified to be 13 cm along the chain in order to the distance between hills in the same row to be 26 cm.

Feeding tube:

It is a square metal tube with dimensions of (10 x 10 x 110 cm) length, width and height. It was designed to guide the tubers from metering device to the furrow in the soil.

Feeding spoons:

The feeding spoons on the conveyor chain were made of galvanized iron. The shape and dimensions of the feeding spoons are depended on the physical properties of the tested tubers. Each spoon has inner and outer diameters of (5 and 8 cm), respectively, and its depth is 1 cm. All spoons arranged on the chain circumference at an equal distance of 13 cm, it has been constructed as shown in Fig. (2 and (3).

Furrow opener:

The furrow opener consists of two parts of metal sheets and installed on a vertical steel bar in the form of a duck leg. There are four holes in the vertical steel bar to control planting depth through a pin, constructed with the following dimensions: 30cm for length, 26cm for width and 28cm for depth.

The covering device:

The covering device consists of two incomplete steel discs with 1cm for thick, 40 cm in diameter, and inclined at disc and tilt angles of 45 and 25 degree, respectively. The covering device connected with two vertical steel bars with four holes to control the level of coverage. The covering device constructed with the following dimensions: 60 cm for length and 48cm for height, and the diameter of the disc was 40cm, as shown in Fig.4

Metering movement mechanism:

The metering movement mechanism transmit the rotating motion from machine ground wheel to the lower and upper gears through two chains, the first one transmit the motion of ground wheel to the horizontal axe by two gears having diameters of 7 cm, and 14 cm. The second chain in vertical position transmit the rotating motion of the lower to the upper gear to guide the spoon chain into the tuber hopper with suitable speed for metering device, as shown in Fig. 5

Tractor:

The potato planter was constructed for operating in small and narrow areas; therefore it is used with small agricultural tractors with engine horse power of 25:35 hp. A small farm tractor with a horse power of 25 horses, Jinma Model, was used during the all test runs and trials of the constructed potato planter.

METHODS:

Field experiments were carried out to evaluate a local manufactured potato planter. The performance of the manufactured potato planter was experimentally measured under the following parameters:

- Four different machine forward speeds of (0.72, 1.08, 1.44 and 1.8 km/h).
- Three different tubers diameter ranges of (2 : <4, 4 : <6 and 6 : <8 cm).
- Three different planting depths of (6, 8 and 10 cm).

MEASUREMENTS AND DETERMINATIONS:

Evaluation of potato planter was performed taking into consideration the following indication:

Machine field capacity:

The field capacity of the potato planter is the rate at which it performs its primary function, i.e., the area that can be planting per hour. The field capacity is divided into theoretical field capacity and actual field capacity. (Morad et al, 2012):

a. Theoretical field capacity ($F.C_{\cdot th}$):

$$F.C_{\cdot th} = \frac{W \times S}{CONSTANT}, fed/h \dots\dots\dots\dots (1)$$

b. Actual field capacity ($F.C_{\cdot act}$):

$$F.C_{\cdot act} = \frac{1}{AT}, fed/h \dots\dots\dots\dots\dots (2)$$

Where:

$F.C_{\cdot th}$ =Theoretical field capacity, fed/h.
$F.C_{\cdot act}$ =Actual field capacity, fed/h.
W =Nominal working width (distance between planting rows), m.
S =Average machine forward speed, km/h.
AT =actual total time, h/fed.

Machine field efficiency:

The field efficiency is the ratio between the capacity of a machine under field conditions and the theoretical maximum capacity. The machine field efficiency can be calculated as follows, (Keppner et al. 1982)

$$\eta f = \frac{F.C_{\cdot act}}{F.C_{\cdot th}} \times 100, \% \dots\dots\dots\dots\dots (3)$$

Where:

ηf= Machine field efficiency, %.

$F.C_{\cdot th}$= Theoretical field capacity, fed/h.

$F.C_{\cdot act}$= Actual field capacity, fed/h.

Void tuber percentage:

The void tuber percentage 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, it can be calculated as follows, **(Ismail, 2007)**:

$$T_v = \frac{B_n}{M} \times 100, \% \dots\dots\dots\dots\dots (4)$$

Where:

T_v= The void tuber percentage, %.

B_n= The number of spoons that have no tubers.

M= The number of the used spoons.

Double tuber percentage:

The double tuber percentage 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, it can be calculated as follows, **(Ismail, 2007)**:

$$T_d = \frac{A_n}{M} \times 100, \% \dots\dots\dots\dots\dots (5)$$

Where:

T_d= The double tuber percentage, %.

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

M= The number of the used spoons.

Distribution uniformity:

The distribution uniformity of potato tubers in the row was estimated by calculating the tuber void index and the tuber double index. The uniformity of the tubers in the row can be calculated as follows **(Morsy et al. 2006b)**:

$$UH = 100 - (T_v, \% + T_d, \%), \% \dots\dots\dots (6)$$

Where:

UH= The distribution uniformity of potato tuber in row, %.

T_d= The double tuber percentage, %.

T_v= The void tuber percentage, %.

Spacing of planting adjustment:

Using the law of transmission ratio, for gears and chain in order to ensure the uniformity of the cultivation distances in the soil, where the ratio was 2:1. Each turn of the machine hopper corresponds to two turns of the feeder, it can be calculated as follows **(Kumar et al. 2017):**

Chain length: $L = 2C + 1.57(D + d) + (D - d)^2$ …..(7)

Pitch: $P = d.\ \sin(\frac{180}{Z_1})$ …………… (8)

$$\frac{N_1}{N_2} = \frac{Z_2}{Z_1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where:

C=The distance between gears.
D =Large gear diameter.
d =Small gear diameter.
N2 =Gear speed of the large gear, (rpm).
Z1 =Number of teeth of the small gear.
Z2 =Number of teeth of the large gear.
N1 =Gear speed of the small gear, (rpm).

Germination percentage:

The germination percentage is the number of tubers grown for every 10 meters that have been planted, the percentage of germination can be calculated as follows:

$$G = \frac{N}{S} \times 100.\% \ldots\ldots\ldots\ldots\ldots (10)$$

Where:

G =Germination percentage, %.
N =Number of plants per ten meters along the planting row.
S =Number of delivered tubers per ten meters along the row,

The value of (S) was calculated during the field calibration of the planter.

Power required:

The required engine power per meter width implement, which needed to draw the potato planter during through the hydraulic device of the tractor, can be calculated as follows **(Hunt, 1983)**:

$$P_O = F_c \times F_d \times \left(\frac{1}{3600}\right) \times c.v \times 427 \times \eta_{th} \times \eta_m \ldots. (11)$$

Where:

Po =Power requirements (kW).
F_c =Fuel consumption (l/h).
F_d =Density of fuel (kg/l).
C.V. =Calorific value (kcal/kg).
η_{th} =Thermal efficiency.
η_m =Mechanical efficiency.

Energy consumed:

The energy consumed by the tractor while using the potato planter during planting operation, can be calculated as follows:

$$E = \frac{P_o}{F.C._{act}}, kW.h/fed \ldots\ldots\ldots\ldots (12)$$

Where:

E =Energy consumed, kW.h/fed.
P_o =Power required, kW.

Operational cost:

The operation cost required for the potato planter machine was estimated using the following equation (Awady et al. 1982):

$$C_{op} = \frac{C}{F.C._{act}}, L.E/kg \ldots\ldots\ldots (13)$$

Where:

C_{op}= Operational cost, L.E/kg.
C= Hourly cost, L.E/h.
M_P= Machine productivity, kg/h.

The hourly cost of potato planter machine was determined using the following equation **(Awady, 1978)**:

$$C = \frac{P}{h}\left(\frac{1}{a} + \frac{i}{2} + t + r\right) + (1.2\,W.S.F) + \frac{m}{144} \quad \ldots\ldots\ldots(14)$$

Where:

C =Hourly cost, L.E/h.
P =Price of machine, L.E.
h =Yearly working hours, h/y.
a =Life expectancy of the machine, y.
i =Interest rate/y.
1.2 =Factor accounting for lubrications.
t =Taxes, over heads ratio.
W =Engine power, hp.
r =Repairs and maintenance ratio.
F =Fuel price, L.E/l.
m =Monthly average wage,L.E
S =Specific fuel consumption, l/hp.h.
144 =Reasonable estimation of monthly working hours.

RESULTS AND DISCUSSIONS

Data obtained from the field experiments aimed to evaluate the developed planting unit for potato planting. Results show that the suitable planting process is greatly affected by many parameters such as machine forward speed, tuber diameter and planting depth.

Influence of machine forward speed on void tuber percentage at different diameter of tubers at different planting depths.

Relating to the effect of machine speed on void tuber percentage using planting depth of 6 cm, results in Fig. 6 show that increasing machine speed from 0.72 to 1.44 km/h measured at different ranges of diameter tuber from ranges of (2 : <4 cm), (4 : <6 cm) and (6 : <8 cm) increased void tuber percentage from 31.75% to 41.5%, from 25% to 39.5%, and from 18,5% to 37,5%, respectively

Any further increase in machine speed more than 1.44 up to 1.8 km/h measured at the same tubers diameter increased void tuber percentage from 41.5% to 48.75%, from 39.75% to 46%, and from 37.5% to 43.25%, respectively. The same thing at planting depth of 8cm, results increased void tuber percentage from 29.25% to 39.75%, from 27.25% to 35.25%, and from 21.25% to 31.5%, respectively.

Any further increase in machine speed more than 1.44 up to 1.8 km/h measured at the same tubers diameter increased void tuber percentage from 39.75% to 43.75%, from 35.25% to 41%, and from 31.25% to 37.25%.

Also at planting depth of 8cm, increased void tuber percentage from 23.25% to 33.5% from 17% to 20.25% and from 11.25% to 12.5%, respectively. Any further increase in machine speed more than 1.44 up to 1.8 km/h measured at the same tubers diameter increased void tuber percentage from 33.5% to 37.75%, from 20.25% to 21.25%, and from 12.5% to 15.75%.

Influence of tubers diameter on double tuber percentage at different machine forward speeds and different planting depths.

Relating to the effect of tuber diameter on double tuber percentage using planting depth of 6 cm, results in Fig. 7 show that increasing tuber diameter from ranges of (2 : <4 cm), (4 : <6 cm) and (6 : <8 cm), decreased the double tuber percentage from 37.5% to 25%, at machine forward speed of 0.72 km/h, from 41.75% to 32.5% at machine forward speed of 1.08 km/h, from 43.75% to 32.5% at machine forward speed of 1.44 km/h, and from 45.25% to 37.5% at machine forward speed of 1.8 km/h, respectively. The same thing decreased the double tuber percentage at planting depth of 6 cm from 27.75% to 23.25%, at machine forward speed of 0.72 km/h, from 34.25% to 28% at machine forward speed of 1.08 km/h, from 41.75% to 33.75% at machine forward speed of 1.44 km/h, and from 45.25% to 37% at machine forward speed of 1.8 km/h, respectively.

Also at planting depth of 10 cm, decreased the double tuber percentage from 18.75% to 10%, at machine forward speed of 0.72 km/h, from 21.5% to 11.25% at machine forward speed of 1.08 km/h, from 25% to 12.5% from 25.25%to 12.5%, at machine forward speed of 1.44 km/h, and from 31.25% to 18.5% at machine forward speed of 1.8 km/h, respectively

Influence of machine forward speed on germination percentage at different diameter of tubers and different planting depths.

Relating to the effect of machine speed on Germination percentage using planting depth of 6 cm, results in Fig. 8 show that increasing machine speed from 0.72 to 1.44 km/h measured at different ranges of diameter tuber ranges of (2 :<4 cm), (4 : <6 cm) and (6 : <8 cm), decreased germination percentage from 68.25% to 58.5%, from 75% to 60.25%, and from 81.5% to 62.5%, respectively. Any further increase in machine speed more than 1.44 up to 1.8 km/h measured at the same tubers diameter decreased Germination percentage from 58.5% to 51.25%, from 60.25% to 54%, and from 62.5% to 56.75%, respectively. At planting depth of 6 cm, the same thing at planting depth of 8 cm, decreased germination percentage from 70.75% to 60.25%, from 72.75% to 64.75%, and from 78.75% to 68.5%, respectively. Any further increase in machine speed more than 1.44 up to 1.8 km/h measured at the same tubers diameter decreased germination percentage from 60.25% to 56.25%, from 64.75% to 59%, and from 68.5% to 62.75%, respectively. Also, at planting depth of 10 cm, the germination percentage decreased from 76.5% to 66.5%, from 83% to 79.75% and from 88.75% to 87.5%, respectively. Any further increase in machine speed more than 1.44 up to 1.8 km/h measured at the same tubers diameter decreased germination percentage from 66.5% to 63.5%, from 79.75% to 78.75%, and from 87.5% to 84.25%, respectively.

Influence of machine forward speed on field capacity at different diameter of tubers and different planting depths.

Relating to the effect of machine speed on field capacity using planting depth of 6 cm, results in Fig. 9 show that increasing machine speed from 0.72 to 1.44 km/h increased field capacity from 0.118 fed/h to 0.225 fed/h at tuber diameter (2 : <4 cm), from 0.112 fed/h to 0.215 fed/h at tuber diameter (4 : <6 cm)and from 0.106 fed/h to 0.209 fed/h, at tuber diameter (6 : <8 cm), respectively. Any further increase in machine speed more than 1.44 up to 1.8 km/h measured at the same tubers diameter increased field capacity from 0.225 fed/h to 0.245 fed/h, from 0.215 fed/h to 0.238 fed/h, and from 0.209 fed/h to 0.230 fed/h, respectively. The same thing at planting depth of 8 cm, increased field capacity from 0.110 fed/h to 0.214 fed/h at tuber diameter (2 : <4 cm), from 0.104 fed/h to 0.207 fed/h at tuber diameter (4 : <6 cm)and from 0.098 fed/h to 0.201 fed/h, at tuber diameter (6 : <8 cm), respectively. Any further increase in machine speed more than 1.44 up to 1.8 km/h increased field capacity from 0.214 fed/h to 0.237 fed/h, from 0.207 fed/h to 0.229 fed/h, and from 0.201 fed/h to

Also at planting depth of 10 cm, increased field capacity from 0.103 fed/h to 0.209 fed/h at tuber diameter (2 : <4 cm), from 0.095 fed/h to 0.202 fed/h at tuber diameter (4 : <6 cm)and from 0.087 fed/h to 0.194 fed/h, at tuber diameter (6 : <8 cm), respectively. Any further increase in machine speed more than 1.44 up to 1.8 km/h increased field capacity from 0.209 fed/h to 0.233 fed/h, from 0.202 fed/h to 0.224 fed/h, and from 0.194 fed/h to 0.215 fed/h, respectively.

Influence of machine forward speed on field efficiency percentage at different diameter of tubers and different planting depths.

Relating to the effect of machine speed on field efficiency percentage using planting depth of 6 cm, results in Fig. 10 show that increasing machine speed from 0.72 to 1.44 km/h measured at different ranges of diameter tuber about (2 : <4 cm), (4 : <6 cm) and (6 : <8 cm) decreased field efficiency percentage from 85.3% to 83.9%, from 85.8% to 84.1%, and from 86.2% to 84.6%, respectively. Any further increase in machine speed more than 1.44 up to 1.8 km/h measured at the same tubers diameter decreased field efficiency from 83.9% to 83.1%, from 84.1% to 83.6%, and from 84.6% to 83.2%, respectively. The same thing at planting depth of 8 cm, decreased field efficiency percentage from 85.8% to 84.8%, from 86.2% to 85.7%, and from 86.7% to 85.2%, respectively.

Any further increase in machine speed more than 1.44 up to 1.8 km/h measured at the same tubers diameter decreased field efficiency from 84.8% to 83.2%, from 85.7% to 83.5%, and from 85.2% to 84.1%, respectively. Also, at planting depth of 8 cm, decreased field efficiency percentage from

85.4% to 84.3%, from 86.6% to 85.5%, and from 87.2% to 85.8%, respectively. Any further increase in machine speed more than 1.44 up to 1.8 km/h measured at the same tubers diameter decreased field efficiency from 84.3% to 83.6%, from 85.5% to 84.1%, and from 85.8% to 84.5%, respectively.

Influence of planting depth on consumed energy at different machine speed and different ranges of tuber diameters.

Concerning the effect of planting depth on consumed energy at range of tuber diameter (2 : <4 cm), Fig. 11 show that increasing planting depth from 6 cm to 10 cm measured at different machine speeds about 0.72, 1.08, 1.44 and 1.8 km/h, increased consumed energy from 1.78 to 4.28 kW.h/fed, from 1.68 to 4.18 kW.h/fed, from 1.53 to 4.03 kW.h/fed, and from 1.33 to 3.83 kW.h/fed, respectively. The same thing at range of tuber diameter (4 : <6 cm), increased consumed energy from 1.76 to 4.26 kW.h/fed, from 1.66 to 4.16 kW.h/fed, from 1.51 to 4.01 kW.h/fed, and from 1.31 to 3.81 kW.h/fed, respectively. Also at range of tuber diameter (6 : <8 cm), increased consumed energy from 1.74 to 4.24 kW.h/fed, from 1.64 to 4.14 kW.h/fed, from 1.49 to 3.99 kW.h/fed, and from 1.29 to 3.79 kW.h/fed, respectively.

Influence of machine forward speed on operating costs at different planting depth and different diameter of tubers.

Concerning the effect of planting depth on operational cost at machine speed o.72 km/h, Fig. (12) show that increasing planting depth from 6 cm to 10 cm measured at different ranges of tuber diameter ranges of (2 : <4 cm), (4 : <6 cm) and (6 : <8 cm). Increased consumed energy from 235.5 to 264.5 L.E/fed, from 230.5 to 259.5 L.E/fed, and from 220.5 to 249.5 L.E/fed, respectively. Any further increase in planting depth measured at the same of machine speed will lead to increase the operational cost. The same thing at machine speed 1.08 km/h, increased consumed energy from 233 to 262 L.E/fed, from 228 to 257 L.E/fed, and from 218 to 247 L.E/fed, respectively.

Also at machine speed 1.44 km/h, Increased consumed energy from 230.5 to 259.5 L.E/fed, from 225.5 to 254.5 L.E/fed, and from 215.5 to 244.5 L.E/fed. Also at machine speed 1.8 km/h, increased consumed energy from 228 to 257 L.E/fed, from 223 to 252 L.E/fed, and from 213 to 242 L.E/fed.

CONCLUSION

This study was carried out through the year of 2020/2021 at Agricultural Engineering Department, Faculty of Agriculture, Damietta University to develop and construct a locally planter for planting potato crop under Egyptian conditions. The machine was fabricated in a local workshop in Damietta Governorate. The samples of potato tubers were bought from a local market in Kafr Saad town, Damietta Governorate. The field experiments were carried out in a sandy loam soil to evaluate the performance of the constructed potato planter under the following parameters:

1. Four different machine forward speeds of (0.72, 1.08, 1.44 and 1.8 km/h).
2. Three different ranges of tuber diameters (2 : <4 cm), (4 : <6 cm) and (6 : <8 cm).
3. Three different planting depths of (6, 8 and 10 cm).

The obtained results for the developed potato planter assisted to provide the following recommendations:

The constructed potato planter may be suggested to be produced on a large scale to be used in the small Egyptian fields, to solve partially some of the problems facing Egyptian farmers and potato producers.

The results of this study are highly recommended to use the locally manufactured planter for planting potato crop under Egyptian conditions, and getting the highest field efficiency with the lowest energy consumed and lowest operational cost under the following conditions: Machine forward speed of 1.44 km/h, planting depth of (10 cm) and potato tuber diameter ranges of (6 : <8 cm).

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHORS CONTRIBUTION

EL-Sharabasy, M. M. A and Saad, H. M, wrote the manuscript. All authors checked and confirmed the final revised manuscript.

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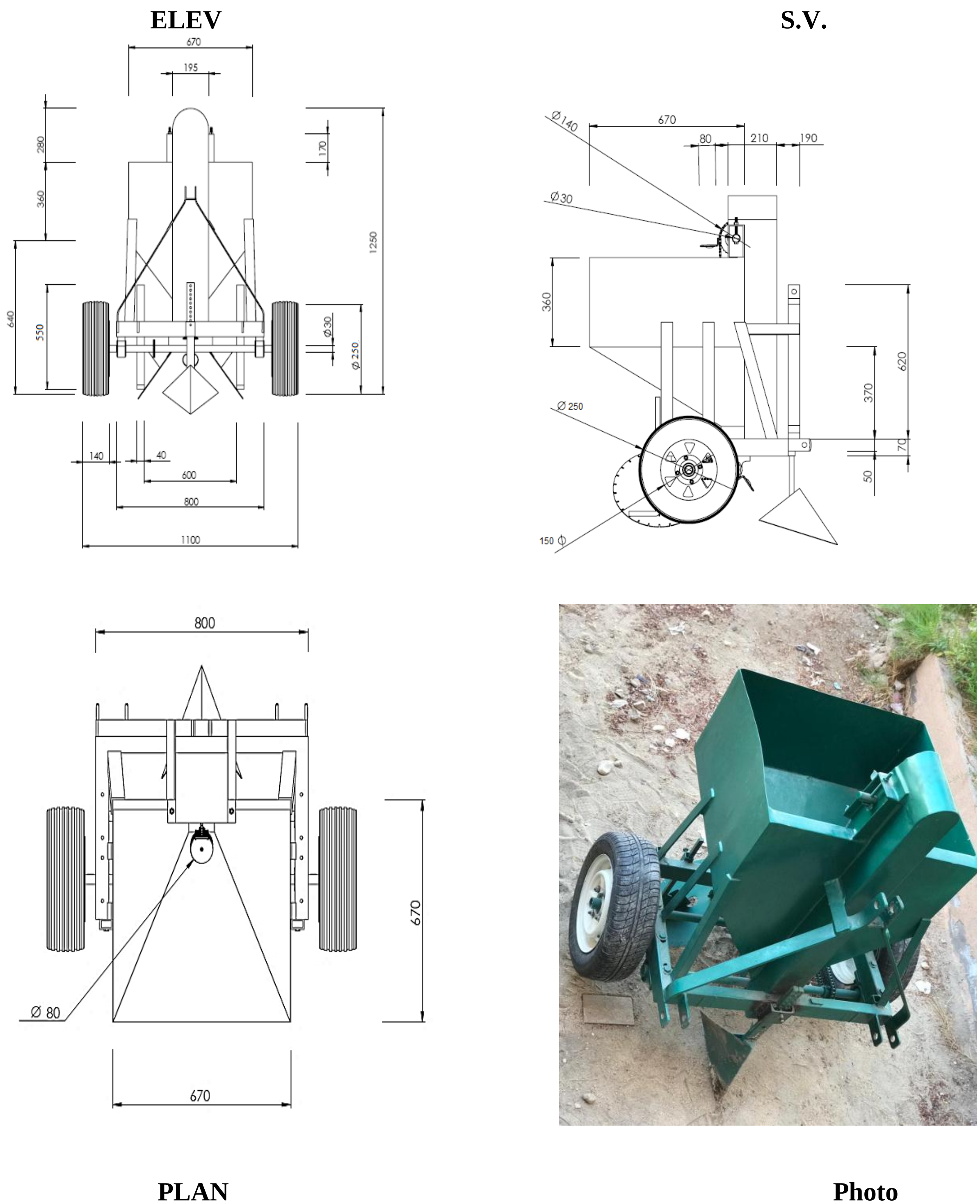


All dimensions in, mm

Fig. 1. The elevation, side view, plane and a photo of the developed potato planter.

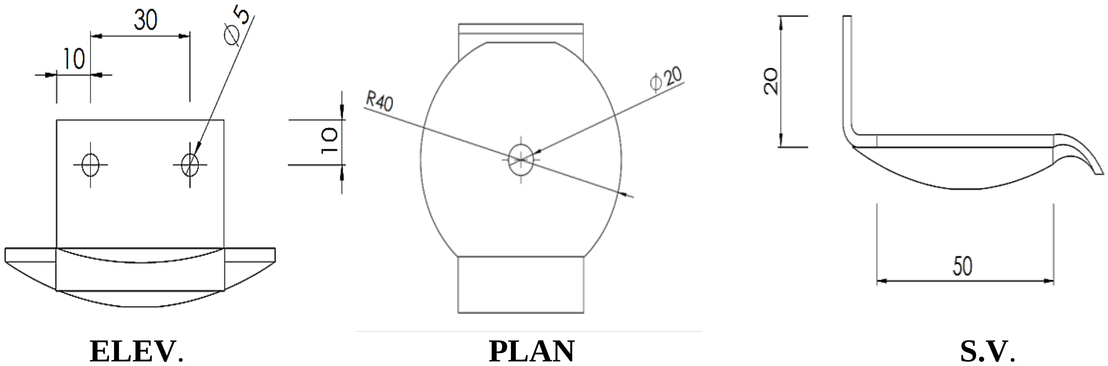
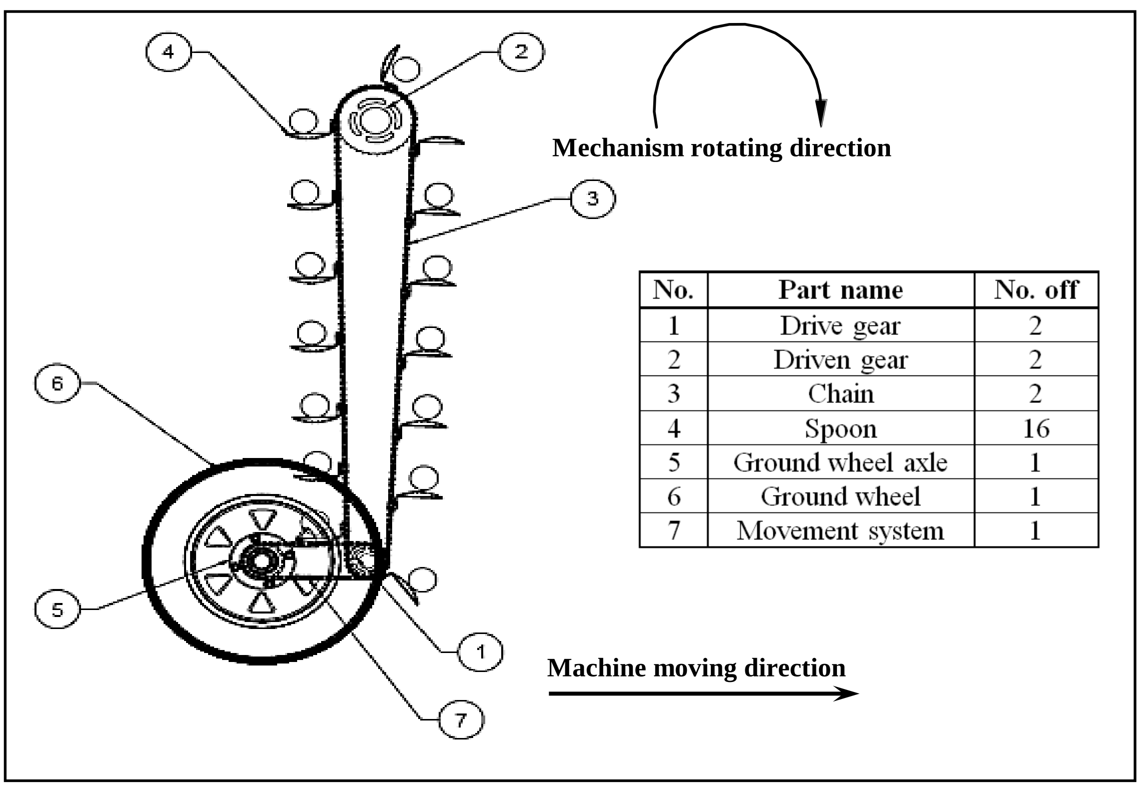


Fig. 2. The elevation, side view and plane for the feeding spoon.

Fig. 3. The feeding spoons.

(A) **(B)**

Fig. 4. The furrow opener (A), and the covering device (B).



No.	Part name	No. off
1	Drive gear	2
2	Driven gear	2
3	Chain	2
4	Spoon	16
5	Ground wheel axle	1
6	Ground wheel	1
7	Movement system	1

Fig. 5. The metering movement mechanism.

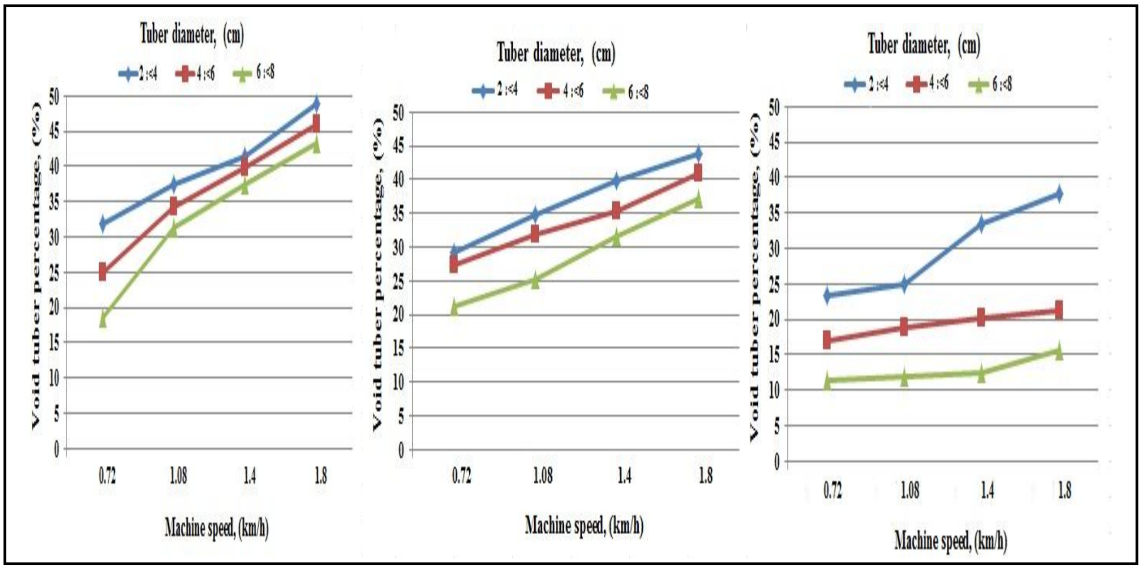


Fig. 6. Effect of machine forward speed on void tuber percentage at different planting depths.

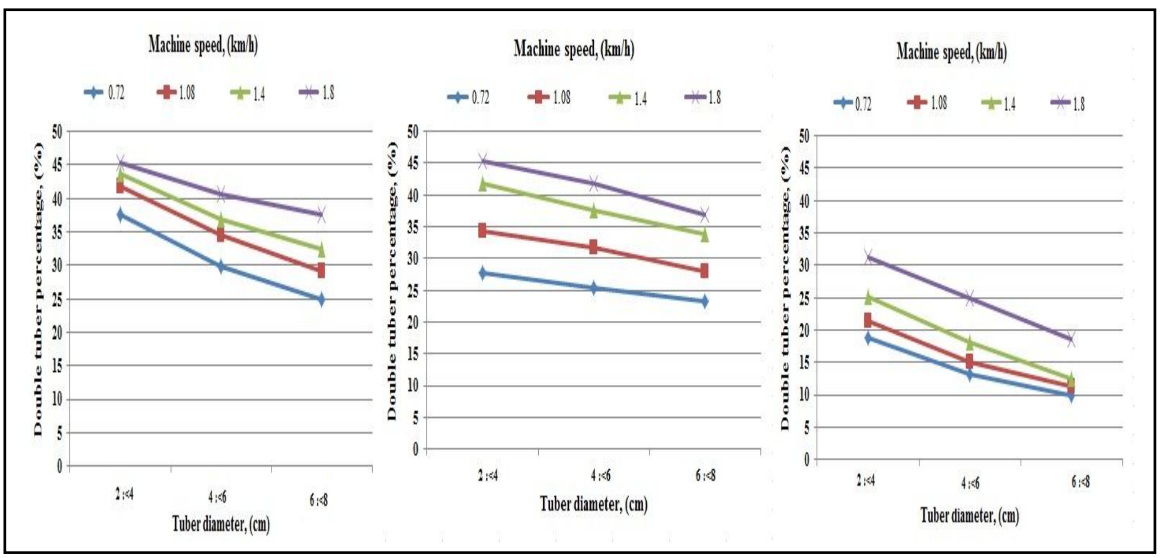


Fig. 7. Effect of tuber diameter on double tuber percentage at different machine forward speeds and different planting depths.

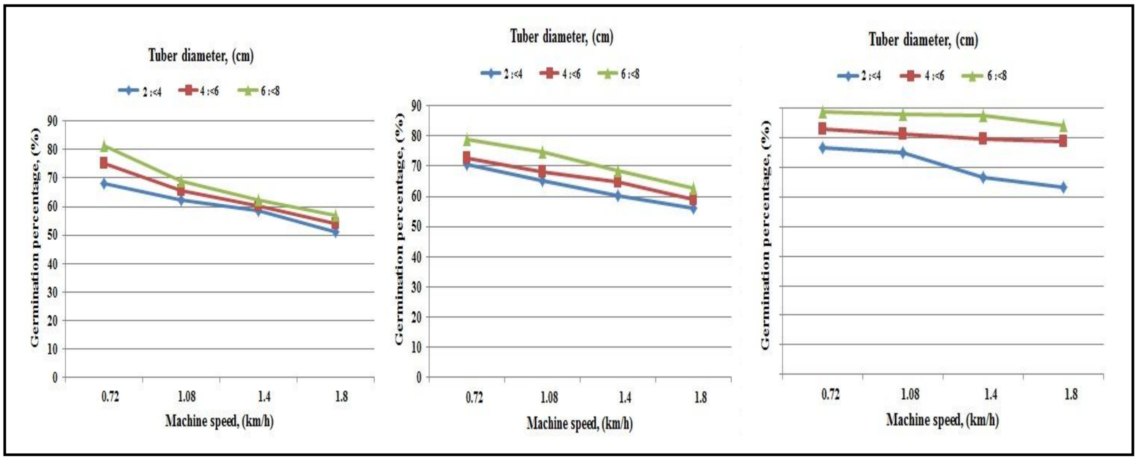


Fig. 8. Effect of machine forward speed on germination percentage at different planting depths.

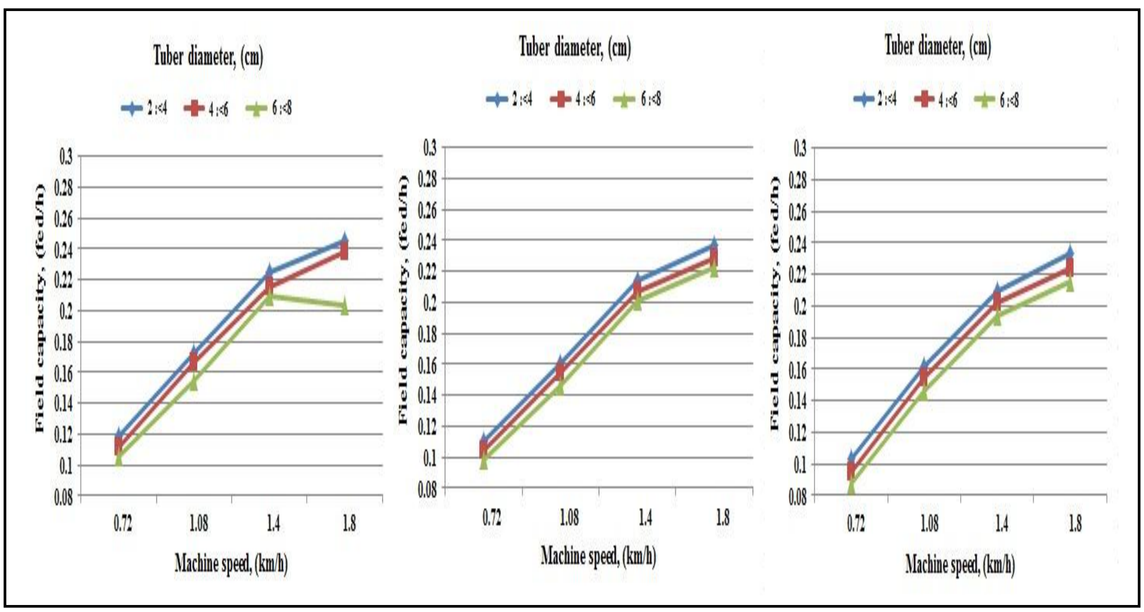


Fig. 9. Effect of machine forward speed on field capacity at different planting depths.

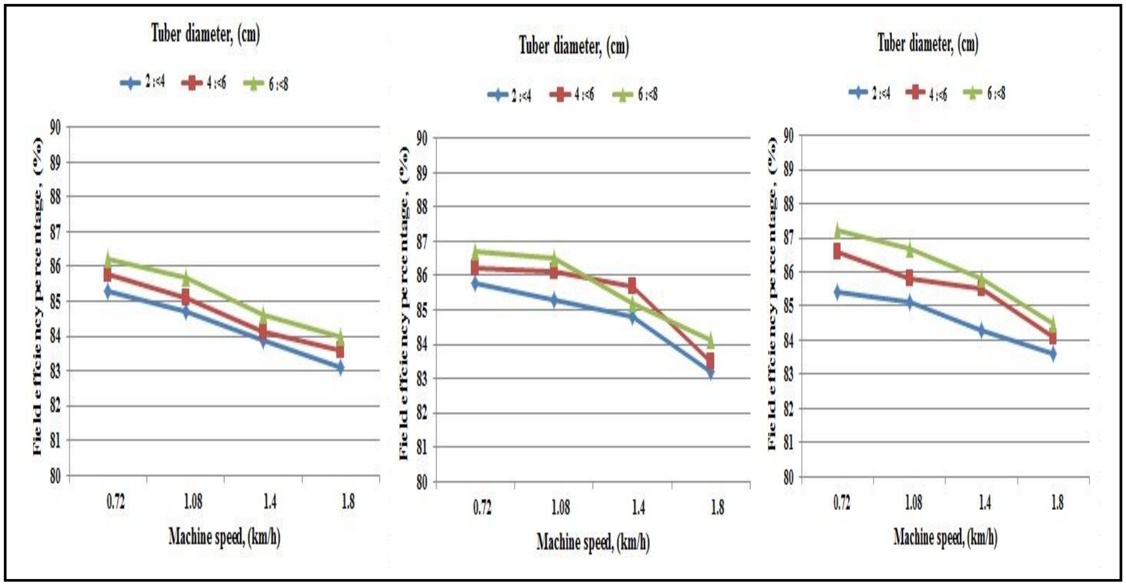


Fig. 10. Effect of machine forward speed on field efficiency at different planting depths.

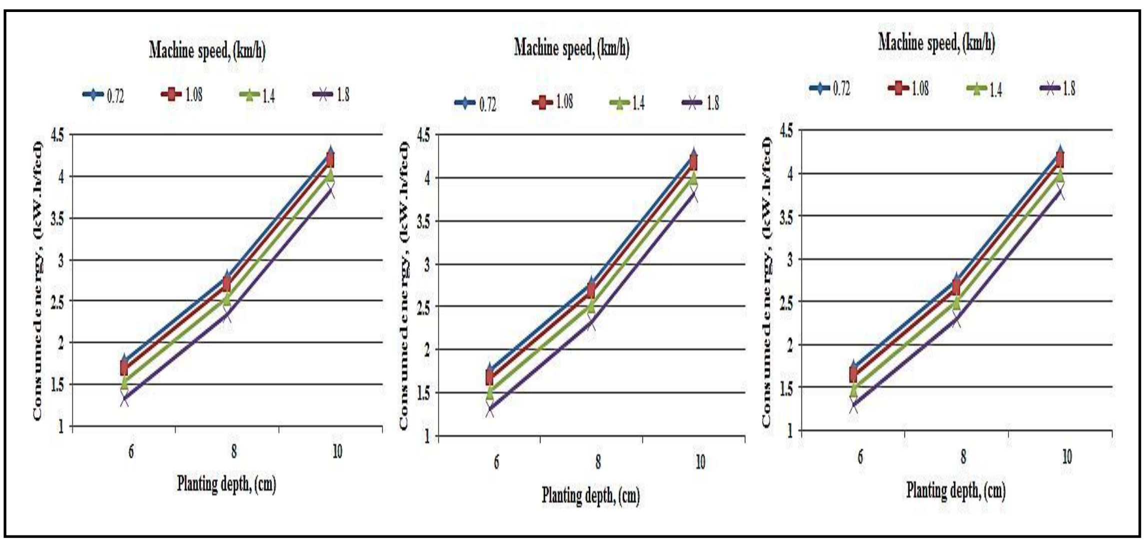


Fig. 11. Effect of planting depth on consumed energy at different ranges of tubers.

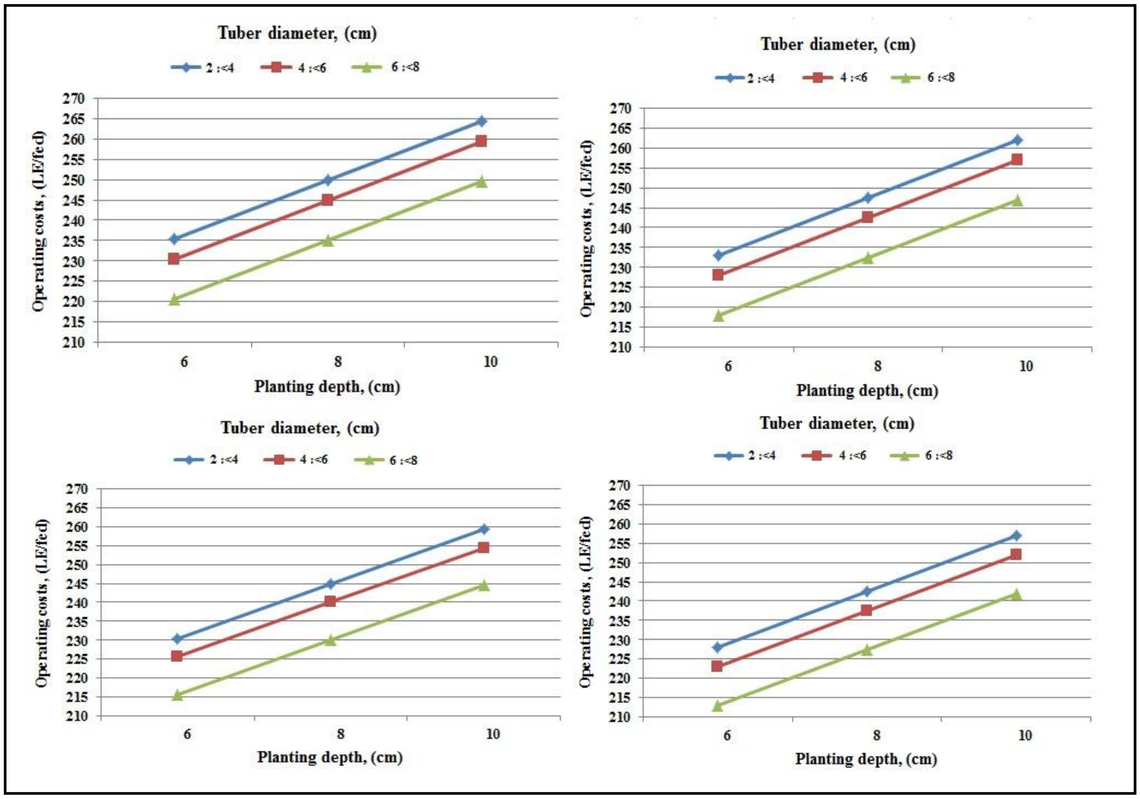


Fig. 12. Effect of planting depth on operating costs at different ranges of tuber diameters.

تصنيع وتقييم أداء آلة لزراعة محصول البطاطس تحت الظروف المصرية

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يعتبر محصول البطاطس من أهم المحاصيل الإستراتيجية على مستوى العالم بشكل عام وفي مصر بشكل خاص، كما يعتبر محصول البطاطس من أكثر محاصيل الخضر الغنية بالعناصر الغذائية فهو مصدر مهم للمواد الكربوهيدراتية وأيضاً يحتوي على كميات كبيرة من البروتين وبعض العناصر المعدنية مثل البوتاسيوم والفوسفور والحديد، كما أنه غني بفيتامين (أ). إلا أن إنتاجية محصول البطاطس في مصر تكاد تكون منخفضة أو متوسطة نتيجة لإستخدام طرق الزراعة التقليدية وذلك الأمر ناتج عن الظروف المصرية الزراعية الغالب عليها المساحات والحيازات الزراعية الصغيرة في الدلتا بوجه خاص وهذا يعيق إستخدام الآلات الكبيرة في الزراعة مما يجعل تكلفة زراعة محصول البطاطس باهظة الثمن وغير اقتصادية.

تم تطوير وتصنيع آلة لزراعة محصول البطاطس بخامات محلية في قسم الهندسة الزراعية، كلية الزراعة، جامعة دمياط. كما تم إجراء التجارب الحقلية في أرض رملية طميية في إحدى قري محافظة دمياط وذلك لتقييم أداء آلة زراعة البطاطس المحلية الصنع بهدف تحقيق معدلات أداء وكفاءة حقلية عالية وبتكاليف تشغيل مناسبة وبأقل طاقة مستهلكة.

مكونات آلة زراعة محصول البطاطس المحلية:

١. **الإطار:** عبارة عن إطار مربع الشكل من الصلب يحمل جميع مكونات الآلة ومثبت عليه نقاط شبك الآلة مع الجرار ومحاور عجلات الأرض للآلة.

٢. **صندوق الدرنات:** مصنوع من الحديد الصلب تنحدر جوانبه تدريجياً للحفاظ على التدفق المستمر لدرنات البطاطس إلى جهاز التلقيم.

٣. **جهاز التلقيم:** يتكون من ثلاثة أجزاء رئيسية وهي:

- منظومة نقل الحركة: حيث تقوم بنقل الحركة من العجلات الأرضية للآلة إلى ملاعق التلقيم.
- ملاعق التلقيم التي تحمل الدرنات إلى أنبوب التغذية ثم إلى التربة ووضعها على مسافات منتظمة.
- أنبوب التغذية: الذي بدوره يحافظ علي سلامة وصول الدرنات الي التربة.

٤. **الفجاج:** وهو يشبه محراث من نوع رجل البطة ويمكن التحكم في ارتفاعه وانخفاضه لضمان شق التربة على الاعماق المناسبة للزراعة.

٥. **جهاز التغطية:** يتكون من قرصين ثابتين غير مكتملين الأقطار ويمكن التحكم في ارتفاعه وانخفاضه لتحديد أفضل وضعية لتغطية الدرنات.

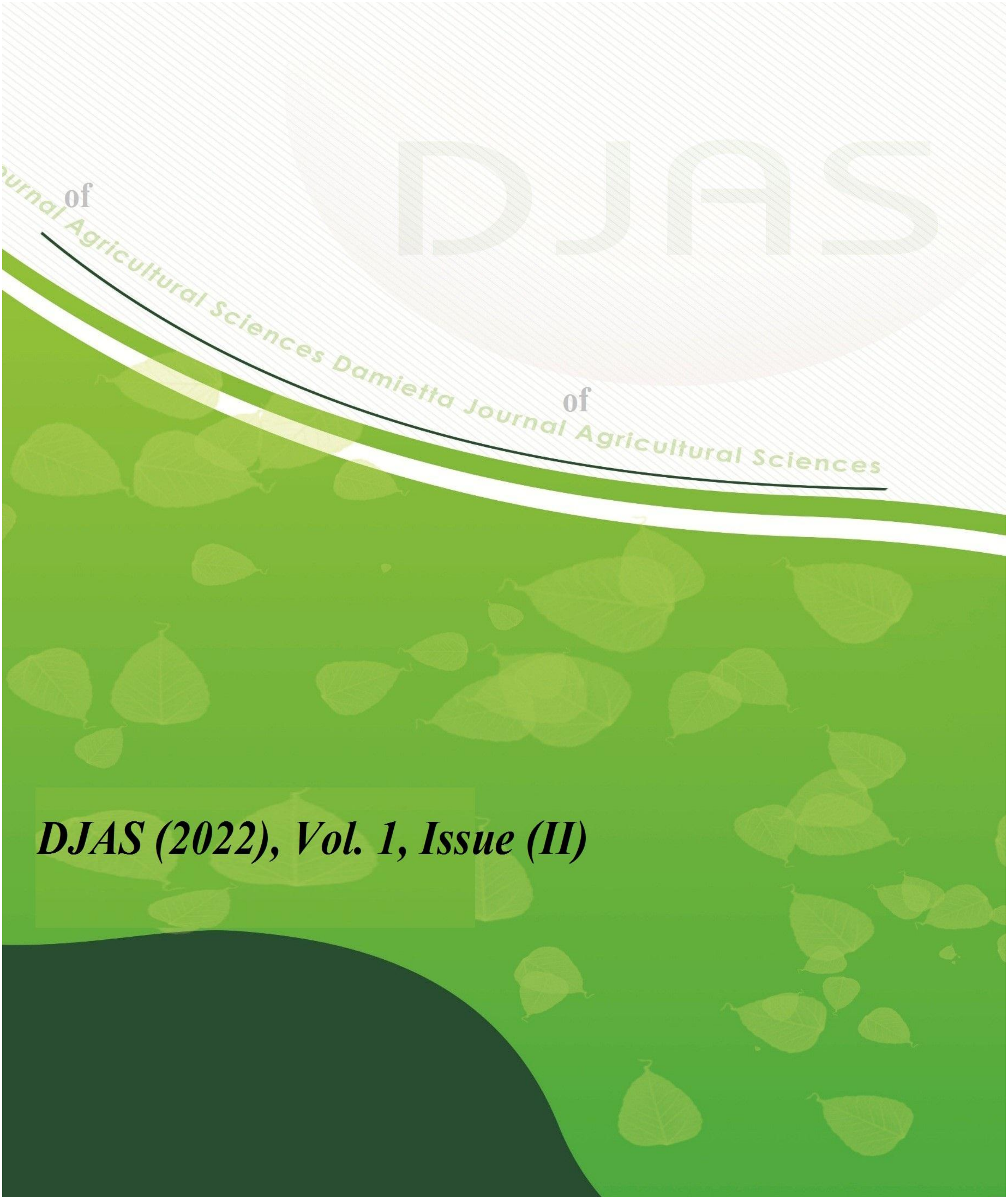
تم تقييم آلة زراعة البطاطس محلية الصنع بأخذ عوامل التشغيل التالية:

- أربع قيم مختلفة لسرعة الآلة الأمامية وهي: ٠,٧٢ ، ١,٠٨ ، ١,٤٤ ، ١,٨ كم/ساعة.
- ثلاث قيم مختلفة لعمق الزراعة وهي: ٦ ، ٨ ، ١٠ سم.
- ثلاث قيم مختلفة لقطر درنات البطاطس وهي: ٢:>٤ سم ، ٤:>٦ سم ، ٦:>٨ سم.

تم تقييم آداء آلة زراعة البطاطس المصنعة محليا من خلال القياسات التالية:

النسبة المئوية للفراغ الدرني، النسبة المئوية لإزدواج الدرنات، نسبة الإنبات، السعة الحقلية، الكفاءة الحقلية، الطاقة المستهلكة، تكاليف التشغيل. أظهرت النتائج التجريبية أن أعلى قيمة للكفاءة الحقلية كانت ٨٧,٢% والسعة الحقلية للآلة كانت ٠,٢٤٥ فدان/ساعة. بينما أقل قيمة للطاقة المستهلكة مع أقل قيمة لتكاليف تشغيل الآلة المصنعة محلياً كانت ١,٢٩ كيلووات.ساعة/فدان و٢١٣ جنية/فدان. تم الحصول على عوامل التشغيل المثلى لآلة زراعة البطاطس المصنعة محلياً عند سرعة أمامية للآلة ١,٤٤ كم/ساعة، عمق زراعة ١٠ سم وقطر درنات ٦:٨ سم.

الكلمات الرئيسية: الدرنات; الملاعق; جهاذ التلقيم; السرعة الأمامية للآلة.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