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Development of a simple machine suit planting maize in hills

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Abstract: Field experiments carried to develop a simple machine for using in planting maize seeds. , The use of the developed machine for planting both Triple (Hybrid 310, Hybrid 352) and Single Hybrid 168 maize. The evaluation of developed machine is carried out through the terms of three forward speed (1.8, 2.7, and 3.5 km/h). The evaluation of the developed machine was investigated through the plant characteristics as follows; germination period, germination ratio, plant population per square meter, and total grain yield for each treatment. The field capacity, field efficiency, power, energy, and production cost were taken into consideration. The experiments yielded the following results: The most suitable number of cells in the feeding device is (20) cells to ensure that the disc does not move at high speed, leading to the breakage of the grains or the cells not being filled with grains and the speed of the disc is proportional to the follow of the grains from the hopper resulting in a distance of approximately (25 cm) between hills in the same row, The use of the developed machine for planting both Triple (Hybrid 310, Hybrid 352) and Single Hybrid 168 maize. Statistical analysis of the results showed that different letters under the same factor are significantly different at $p \leq 0.05$ as determined through the LSD test.

Keywords: Maize; Hybrid 168; Hybrid 310; Hybrid 352, mechanical, machine.

Introduction:

Maize (Zea mays, L.) is an important cereal crop in the worldwide. It contains about 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 17% ash. Due to higher yield potential, short growing period, high value for food, forage and feed for livestock, poultry and a cheaper source of raw material for agro- based industry, it is increasingly gaining an important position in the cropping system **Saif et al. 2003.** So this machine was designed for several reasons, including the lack of a small- space machine in particular, the area is less than an acre, and thus the farmer can use it. The seed emergence percentage decreased by increasing planting forward speeds from 2.2 to 6.4 km/h with all mechanical planting methods which used **El-Awady *et al.* (2004)**. The maize is a plant with single productivity; therefore plant density determines yield significantly. Optimal plant density can be affected by the genetic properties and vegetation time of the given hybrid, just as by the conditions of the production area, by the crop yield and the extent of water and nutrient supply **Pepo and Sarvari (2013)**. The knowledge of some physical and mechanical properties of these seeds is an important tool for designing agricultural machines and equipment for planting, harvesting, processing, packaging and storage. Some of the properties determined include size, geometric mean diameter, surface area, bulk volume, bulk density, true density, porosity, sphericity, angle of repose, coefficient of friction, rupture force and rupture energy **Soyoye et al.,(2018).**Seed metering mechanism is the core functional component of any planter. A new seed metering mechanism was developed for round seeds with the cell design termed 'Anjul' aimed to eliminate seed damage and obtain better seed singulation of seeds while metering. There was no visible damage to the seed by the planter. A comparison of X-Ray photographs of metered seeds with normal seeds was done for assessing seed damage. No crack or breakage in the metered seed was **Vinod et al., (2018)**. Due to the lack of systematic research on seedling conditions, transplanting conditions and effects, the efficiency of dry land semi-automatic transplanting machines was still low. The quality of transplanting operations needs to be improved. The planting mechanism is the core component of the semi-automatic transplanting machine, which directly affects many key indexes of the transplanting effect **Jin et al.,(2020).** With the development of precision farming technology, precision farming has become one of the most important means in the cultivation of certain crops such as corn, cotton and sugar beet, as precision farming enables to save a large amount of seeds, reduce labor and increase productivity **Wang et al.,(2020).** Mechanical properties of corn grains are of key importance in a design of processing machines whose energy demand depends on these properties. The aim of study is to determine the selected mechanical properties of corn grains and the rupture energy. The selected physical properties (size, volume) of corn grains have been distinguished and a static compression test has been carried out on an Instron 5966 testing machine **Kruszelnicka (2021)**.

MATERIALS AND METHODS

Field experiments were carried out to develop a simple machine to accommodate the planting of maize in hills under study and other grain in physical characteristics. The Hybrids of maize grains were cultivated in the field where the land was cultivated at Shobra Sora village, Diarb Negm Center, Sharkia governorate in the season 2020 – 2021.

MATERIALS:

Developed machine: A machine of dimensions 85 L × 106 W × 67 H cm planted in row provided with two tubes transfer the grain from the hopper across a feeding device to the ground. Distance between tubes rows is about 70 cm.

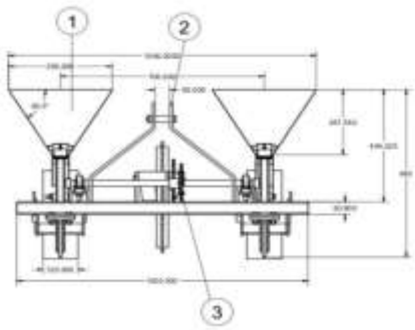
The used tractor: Kubota model with water cooled, Four stroke diesel engine, and power of 22.07 kW.

Tested crop: Three varieties of maize were used (one type of white maize (Triple Hybrid 310) and two types of yellow maize (Triple Hybrid 352, Single Hybrid 168). Characteristics of the maize hybrids are provided in Table 1.

Table 1. Characteristics of the maize hybrids .

Characteristics	**Hybrid 310 (white)**		**Hybrid 352 (yellow)**		**Hybrid 168 (yellow)**	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Length, mm	9.25	13.03	10.65	13.62	9.14	11.58
Width, mm	7.87	11.3	6.42	9.43	6.8	9.29
Thickness, mm	3.67	5.8	3.7	6.68	3.52	7.25
Mass, g	0.24	0.26	0.2	0.22	0.18	0.28
Bulk density, g/cm^3	0.77	1	0.75	1.06	0.667	0.900
Repose angle, degree	20.96	29.49	20.38	29.19	20.65	32.62

The developed machine: A maize planting machine was manufactured from low cost, local material to overcome the problems of high power and high cost requirements under the use of imported machines and to design local machines suitable for small holdings. The side view, elevation and plan of the machine is shown in **Figure(1, 2 and 3).**



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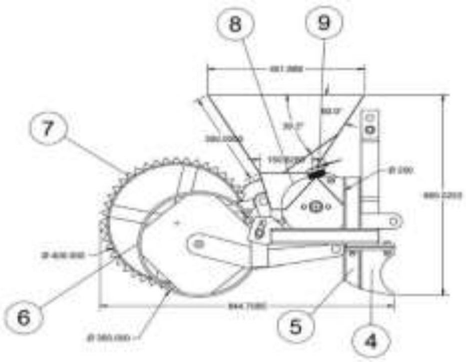

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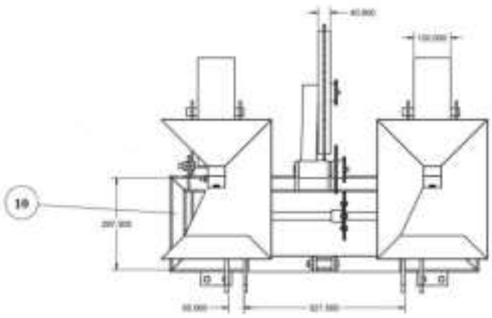
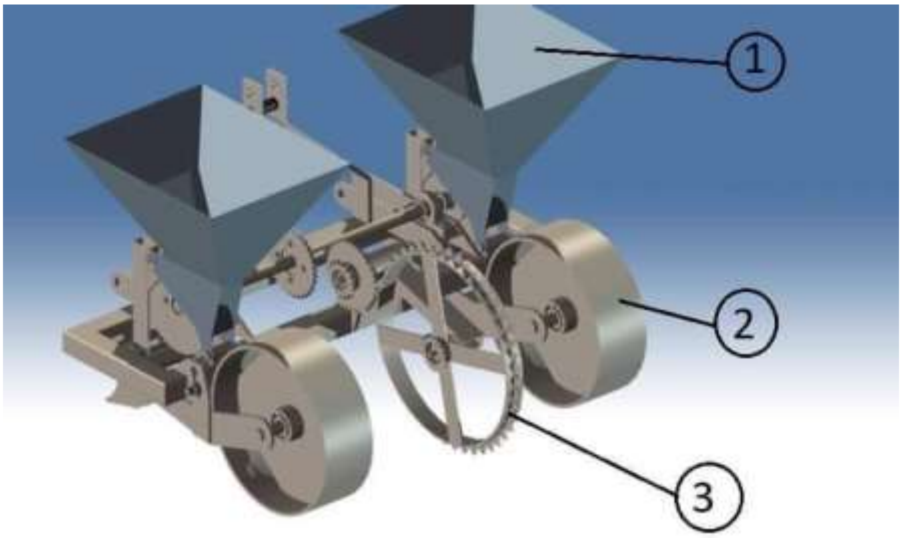


Plan

No.	**Part name**	**No.**	**Part name**	**No.**	**Part name**
1	Grain hopper	5	Grain tube	8	Grain metering device
2	Hitching points	6	Covering wheel	9	Brush
3	Transmission system	7	Metering wheel	10	Frame
4	Furrow opener				

Overall dimensions in mm.

Figure 1. Three views of the developed maize machine.



No.	Part name
1	Grain hopper
2	Covering wheel
3	Metering wheel

Figure 2. Isometric for the developed maize machine.

The developed machine:

Grain hopper:

The grain hopper was made from metal with a trapezoidal shape. The overall dimensions of the grain hopper are 36 cm length, 45 cm width and 26 cm height. The bottom of the hopperhad an inclination angle of (32°) with the horizontal plan.

Brush:

Brush is a piece of plastic in the grain hopper, which helpsnot more than a grain in the cells on the grain disk, where brush is directly above the grain disk, and a tendency with a nail of the grain hopper makes it easy to jaw and install.

Figure 3. The developed maize planter mounted on the tractor.

Grain metering device:

The grain metering device takes a feed from the bottom of the grain hopper to fall behind furrow opener. When the wheel of the metering turn, it transmits the motion to the grain metering devices, then fill cells with grain s to fall behind the furrow opener. The grain metering device made from Teflon. There is one grain disk inclined with circular shape is shown in Figure 4. Inclined with circular shape the depth of the cell is 8 mm, 13 mm length and diameter is 9 mm. The inclined with circular grain disk contains 20 hollow cells in the outer surround. Three speeds were used for grain metering device (5.5, 9, 11.5 rpm).

Figure 4. Inclined with circular shape

Transmission system:

Sprockets and chains were used as a transmission system. The transmission system of the machine is used to transmit power from a large metering wheel mounted in the middle of planter frame. Transmission system consisted of chain and sprockets. The sprocket of 18 teeth on metering wheel was connected with sprocket of 36 teeth on the frame. The other sprocket is on the frame with 18 teeth was connected with sprocket of 36 teeth on the metering-device shaft. So, the transmission ratio between metering wheel and metering device shaft was 4:1. The metering device has 20 cells and the diameter of metering wheel is 40 cm. So, the grain spacing in the same row is about 25 cm.

Frame:

The dimensions of the frame are 97 cm length, 30 cm width and 35 cm thickness. The planter units are mounted on a main frame which is attached to three-point hitch of the tractor. The frame is mounted on one metering wheel, which is used to drive the grain metering device at a speed in proportion to the forward travel of the planter.

Metering wheel:

The motion was transmitted to the metering device from metering wheel by chain and sprockets. Metering wheel with diameter of 40 cm and width of 4 cm was set in the center of the manufactured machine and also after 35cm from the grain disk center.

Furrow openers:

Shoe-type openers are intended for work on leveled well tilled soils. In terms of construction, these shoes are distinguished by the angle of entrance into the soil. The openers consist of a narrow casing opener tip, with a sharp knife set at an obtuse angle to the horizontal for formation of furrow.

Covering device:

The covering device should press the soil firmly around the grain s, cover them to the proper depth and yet leave the soil directly above the row loose enough to promote easy emergence.So, a press-wheel with diameter of 35 cm and width of 12 cm was set in the manufactured machine as a covering device

Instruments

Electric Balance: The grain s were weighed using a sensitive electronic balance with an accuracy of 0.1 gram. The balance JL – Jewelry Light is characterized by the accuracy and quality with small sizes.

Stop watch: A stop watch was used to estimate the time requirements of different operations. The accuracy of stop watch 0.01 sec.

Graduated cylinder: Graduated cylinder was used to measure the fuel consumption for each operation.

Digital caliper with Vernier: Dimensions of crop were determined considering the three axes xx, yy, and zz. A digital caliper reading is up to 15cm. Its accuracy is 0.05 mm. A digital caliper manufactured from hardened stainless steel. It made in China.

METHODS:

The performance of the developed machine was studied under the following parameters:

1. Three forward speeds: 1.8, 2.7 and 3.5 km/h,
2. Three speeds for grain metering device: 5.5, 9, 11.5 rpm equivalent 27.5, 42.5, 55 m/min
3. Three of maize varieties of maize were used (one type of white maize (Triple Hybrid 310) and two types of yellow maize (Triple Hybrid 352, Single Hybrid 168).

Measurements

The grain mechanical properties were measured using the following equations **:**

Volume: It is determined as the procedure of **Vursavus and Ozguven, (2004)** as follows:

$$V = \frac{\pi}{6}\ L . W . T \qquad (1)$$

Where: L,W and T are length , width and thickness in mm, respectively.

The arithmetic diameter and geometric diameter: The arithmetic diameter (D_a) and geometric diameter (D_g) are calculated according to **Fadavi et al. (2013)** as follows:

$$D_a = \frac{L+W+T}{3} \qquad (2)$$

$$D_g = (L . W . T)^{1/3} \qquad (3)$$

Where D_g is the geometric diameter, mm, S_a is the surface area, mm^2 by assuming that the kernels were ellipsoid, L is the length of the kernel, mm, W is the width of the kernel, mm, T is the thickness of the kernel, mm.

Sphericity : Sphericity (S) is calculated as cited by **Perez et al. (2007)** as follows:

$$S = \frac{D_g}{L} \times 100 \qquad (4)$$

Surface area and projected area: Surface area (S_a), and the projected area (A_p) are calculated according to **Goyal et al. (2007) and Yildirim and Tarhan, (2016)** as follows:

$$S_a = \pi . (D_g)^2 \qquad (5)$$

Emergency: The emergency ratio was counted after three weeks from planting in a one-meter square by the following equation:
E = ((Number of plants/m^2) / (Theoretical number of plants /m^2)) ×100 (6)

Uniformity of plant distribution: It was measured after 16 days at two directions from lateral to longitudinal by using a wooden frame (80 x 80 cm) divided in two directions at equal distance (5x5cm).The deviation of plant from average number of plant at standard area was estimated according to Steel and Torrie (1980);

$$C.V= [\sigma n] / [\ x^{-}\ ] \times 100 \qquad (7)$$

Where:

C.V : coefficient of variation in the longitudinal and lateral direction

from average number of plants at a standard unit area

x^{-}: average number of plant at standard unit area.

σn : Standard deviation.

$$\sigma n = \sqrt{\frac{\Sigma (x - x^{-})^2}{n-1}} \quad (8)$$

Where:

Σx : Summation of the number of plants on the longitudinal or lateral direction.

Σx^{-2} : Summation of the square number of plants on the longitudinal or lateral direction.

n : Number of readings.

The coefficient of variation under 10% is considered excellent and with value under 20 % is generally considered acceptable for most field applications as reported by **Coates (1992).**

Missing hills percentage:
The theoretical adjusted hill numbers in 5 m long distance in the same row were estimated and the actual were accounted and the missing hill numbers were found in the same distance. The percentage of the missing hills was given by Helmy et al., (2005) using the following equation:
Missing hills, % = (No. of missing hills / No. of theoretical hills) × 100 (9)

Transverse scattering:

The transverse scattering was calculated by the same method mentioned with longitudinal scattering but around the centerline of row (Metwalli et al., 1998).

Percentage of hills have double plants:
The percentages of hills have double plants were calculated according to Helmy et al. (2005) by using the following equation;
Percentage of hills have double plants = ((No. of hills have double plants/m)/ (No of theoretical hills/m)) ×100 (10)

Theoretical field capacity: It was determined using the following formula:

$$Pth = S \times W / 4200 \text{ (ha/h)} \quad (11)$$

Where:

Pth : Theoretical productivity of the machine, fed/h.

S : travel speed, m/h. W :Rated width, m.

Effective field capacity: It was determined by using the following formula:

$$Pact = 60 / Tu + Ti \text{ ha/h} \quad (12)$$

Where:

Pact : The actual capacity of the machine, ha/h

Tu : the utilized time per ha, min.

Ti the summation of time lost per ha, min.

Field efficiency: It was calculated using the following formula:

$$\zeta = Pact / Pth \times 100 \quad (13)$$

Fuel consumption : Volumetric fuel consumption per unit time was determined by measuring the volume of the consumed fuel. It was calculated as the following:

$$VFC = V/t \quad (14)$$

Where: VFC = The volumetric fuel consumption rate, l/h;
V = The volume of consumed fuel, l; t = The duration of the experiment, h.

Power: The following formula was used to estimate Power (P) as provided by Hunt (1983):

$$P = (FC/c) \times (\eta_{th}/100) \times HV \quad (15)$$

where P = Required power, kW FC = Fuel consumption, kg/h

ηth = The thermal efficiency, % c = Constant, 3600.

HV = The fuel heating value, kJ/kg

Energy requirements: It was calculated using the following formula (Kepner *et al*. 1982):

$$EP = [\text{ f.c. } (\tfrac{1}{3600})\, \rho E \times L.C.V. \times 412 \times \eta thb \times \tfrac{1}{75} \times \tfrac{1}{1.359}], kW \quad (16)$$

Where:

f.c. : The fuel consumption, (*l*/h).

ρE : The density of fuel, (kg/*l*), (for Diesel = 0.85).

L.C.V. : The lower calorific value of fuel, (9850 k.cal/kg).

η*thb* : Thermal efficiency of the engine (0.325 for Diesel).

412 : Thermo-mechanical equivalent, (Kg.m/k.cal).

Hence, the energy requirements can be calculated as follows:-

Energy requirements = $\frac{\text{Required power (kW)}}{\text{Grain yield (ton / fed)}}$, kW. ha / ton (17)

Cost analysis: It was determined using the following equation (El-Awady *et al.* 1982):

$$C = \frac{p}{h}\left(\frac{1}{a} + \frac{i}{2} + t + r\right) + (\ 1.2\ W.S.F\ ) + \frac{m}{144} \qquad (18)$$

Where:-

C = Hourly cost, \$/h. *P* = Price of machine, \$.

h = Yearly working hours, h/year. *a* = Life expectancy of the machine, h.

i = Interest rate/year. *F* = Fuel price, \$/*l*.

t = Taxes, over heads ratio. *r* = Repairs and maintenance ratio.

m = Monthly average wage, \$ *1.2* = Factor accounting for lubrications.

W = Engine power, hp. *S* = Specific fuel consumption, *l*/hp.h.

144 = Reasonable estimation of monthly working hours.

The operational cost was determined using the following equation:

Operating cost = $\frac{\text{Machine cost (L.E/h)}}{\text{Eff.field capacity (fed/h)}}$, \$ /ha (19)

Production cost = $\frac{\text{Operating cost (L.E/fed)}}{\text{Grain yield (ton/fed)}}$, \$ /ha (20)

TESTING AND EVALUATION:

The soil was plowed twice by chisel plough and leveled by land lever. The experiments was made in an 4200 m^2 in the village of shobra sora and the number of experimental pieces was 27 pieces of three varieties of maize (Triple Hybrid 310, Triple Hybrid 352 and Single Hybrid 168) with three forward speed (1.8, 2.7, and 3.5 km / h) with grain disk inclined with circular shape which is suitable for all hybrids. Tests were conducted on the machine to as certain its performance. The maize grains (Zea mays L.) were cultivated at distance between rows of 70 cm under three tested forward speed.

RESULTS AND DISCUSSIONS

The performance of developed machine was discussed through the following criteria

1- Germination ratio:

The three types of maize grains Hybrids (Triple 310 (White), Triple 352 (Yellow), Single 168 (Yellow)) are characterized by high germination ratio where (98.8, 98, and 97.7 %) respectively, as shown in **Figure 1**.

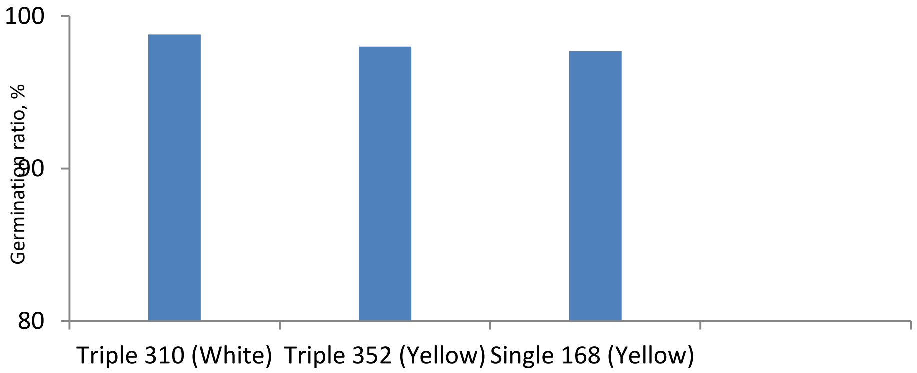


Figure 1. Germination ratio before its passage on the metering device.

2- Theoretical and actual field-capacity:

The effect of forward speed on theoretical, actual field-capacity and field-efficiency as shown in **Figure 2**. The minimum theoretical field capacity of 0.24 ha/h. was obtained with forward speed of 1.8 km/h. While the maximum theoretical field capacity of 0.47 ha/h. was obtained with forward speed of 3.5 km/h. The minimum actual field capacity of 0.17 h/ha was obtained with forward speed of 1.8 km/h. While the maximum actual field capacity of 0.26 h/ha was obtained with forward speed of 3.5 km/h. The minimum field efficiency of 56.41 % was obtained with forward speed of 3.5 km/h. While the maximum actual field capacity of 71.67 % was obtained with forward speed of 1.8 km/h.

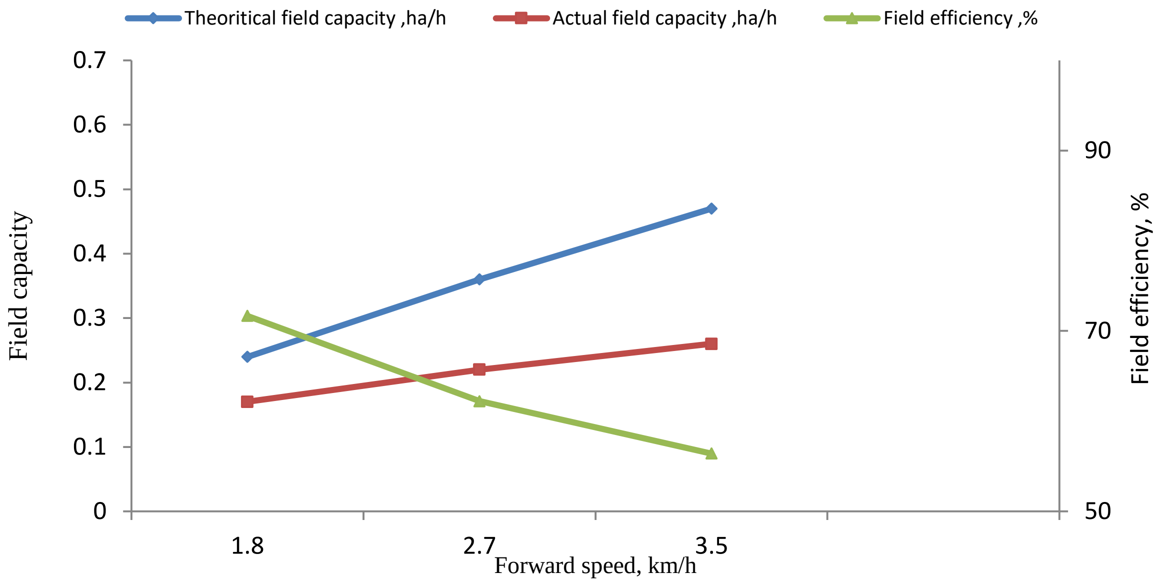


Figure 2. Effect of forward speed on theoretical, actual field-capacity and field-efficiency.

3- Grains emergence:

The effect of forward speed on maize grains emergence as shown in **Figure 3**. These results agree with Afify (2009), reported that the maize grains emergence decreased with increasing forward speed. Data obtained show that increasing forward speed from1.8 to 3.5 km/h, measured for three types of maize grain s Hybrids (Triple 310 (White), Triple 352 (Yellow), Single 168 (Yellow)) at inclined with circular shape, decreased Hybrid 310 grain s emergence from 90.82 to 81.27 %. And decreased Hybrid 352 grain s discharge for inclined with circular shape from 95 to 90.25 %. And decreased Hybrid 168 grain s discharge for inclined with circular shape from 95 to 89.06 %.

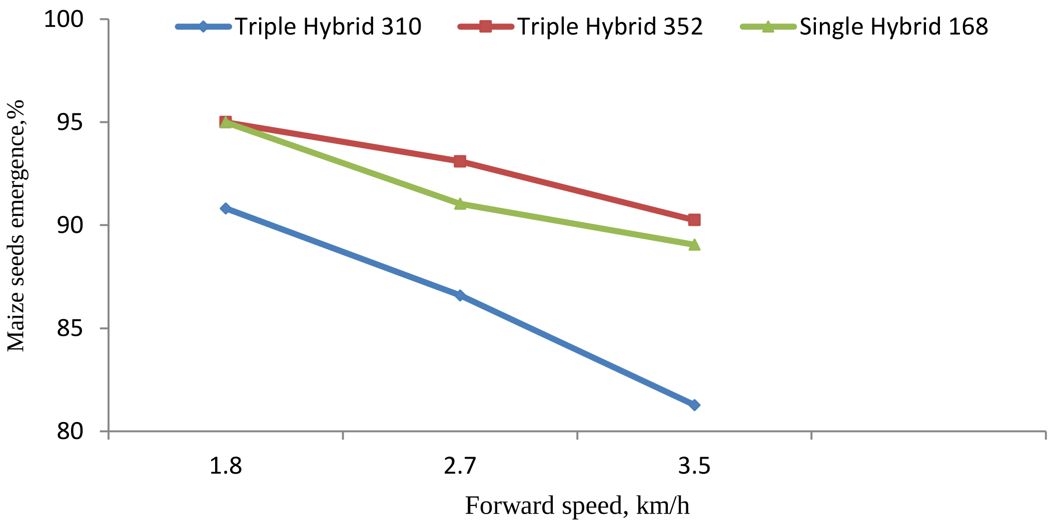


Figure 3. Effect of forward speed on maize grains emergence.

4- Longitudinal scattering and transverse scattering : :

The vise versa of uniformity distribution was done with grain scattering as shown in **Figure 4.** These results agree with Liu et al. (2017), who stated that the coefficient of variation of seed spacing increased with the increase of travel speed. It noticed that increasing the forward speed of developed machine from 1.8 to 3.5 km/h increased the grain scattering for three types of maize grain s Hybrids (Triple 310 (White), Triple 352 (Yellow), Single 168 (Yellow)) at inclined with circular shape, increased Hybrid 310 from 25.14 to 30.49 cm. And increased Hybrid 352 for inclined with circular shape from 24 to 29.1 cm. And increased Hybrid for inclined with circular shape from 21 to 26 cm. There is no scattering in the transverse.

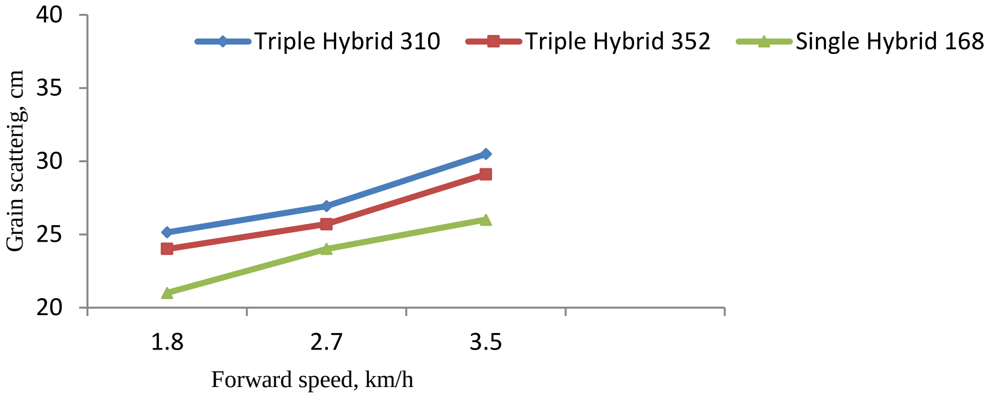


Figure 4. Effect of forward speed on grain scattering.

5- Power and energy requirements:

It is noticed that increasing the forward speed of developed machine from1.8 to 3.5 km/h increased the required power from 9.776 to 13.748 kw. On the other hand, The energy requirements decreased from 56.83 to 51.83 kw.h/ha. As increasing the forward speed of the developed machine from 1.8 to 2.7 km/h, and increased from 51.83 to 52.08 kw.h/ha. as increasing the forward speed from 2.7 to 3.5km/h.That is due to the decrease in crop yield, as shown in **Figure 5**.

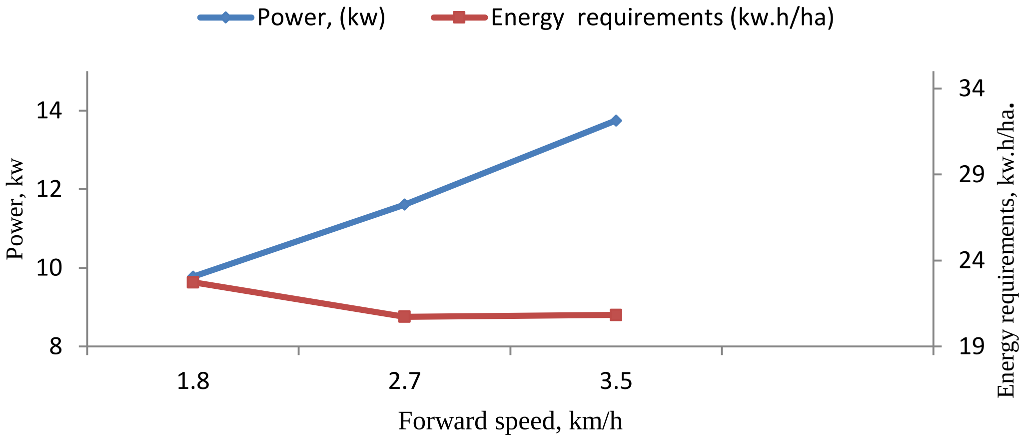


Figure 5. Effect of forward speed on power and energy requirements.

6- Missing hills and double plants index:

The effect of forward speed on missing hills for three types of maize grain s Hybrids (Triple 310 (White), Triple 352 (Yellow), Single 168 (Yellow)), as shown in **Figure 6.** Data showed that increasing forward speed from 1.8 to 3.5 km/h., the missing hills percent increased from 9.18 to 18.73 and from 5 to 9.75 and from 5 to 10.94 % for maize grains Hybrids (Triple 310 (White), Triple 352 (Yellow), Single 168 (Yellow)), respectively. . These results agree with Yang et al. (2015), found that missing-seeding index and precision index become worse with the increase of forward speed. **Figure 7.** show by increasing forward speed from 1.8 to 3.5 km/h., the double plants percent decreased from (7.21 to 1.92), (10.09 to 4.33) and (15.38 to 6.25)% for maize grain s Hybrids (Triple 310 (White), Triple 352 (Yellow), Single 168 (Yellow)), respectively.

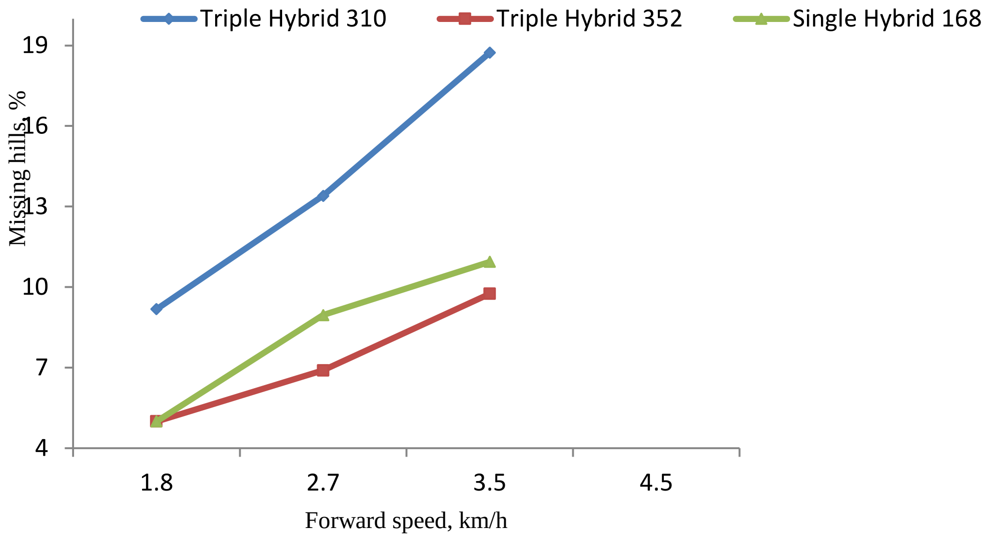


Figure 6. Effect of forward speed on missing hills.

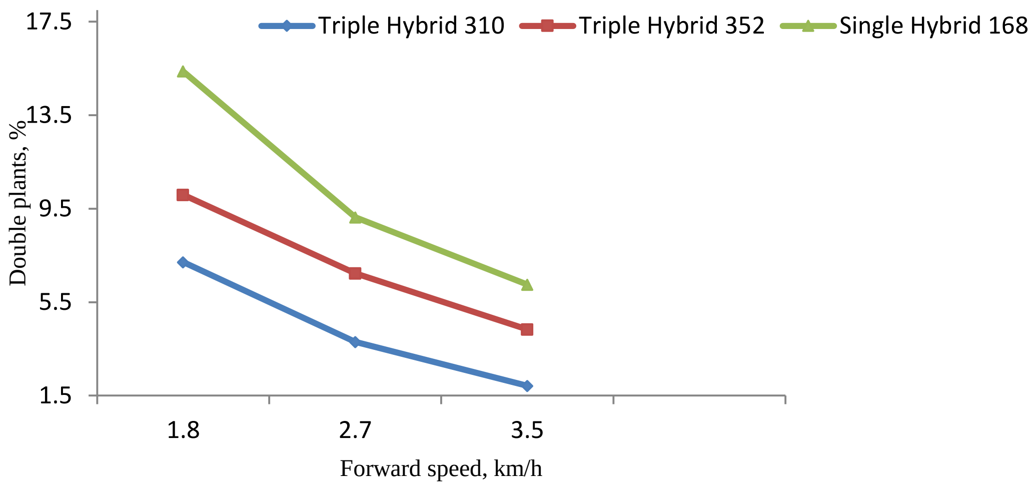


Figure 7. Effect of forward speed on double plants.

7- Crop yield:

The effect of forward speed on crop yield. The maize yield decreased with increasing forward speed. Data obtained show that increasing forward speed from 1.8 to 3.5 km/h, measured for three types of maize grains hybrids (Triple 310 (White), Triple 352 (Yellow), Single 168 (Yellow)) at inclined with circular shape, decreased Hybrid 310 maize yield for inclined with circular shape from 10.21 to 7.93 ton/ha. And decreased Hybrid 352 grain s discharge for inclined with circular shape from 13.24 to 10.38 ton/ha. And decreased Hybrid 168 maize yield for inclined with circular shape from 18.24 to 13.71 ton/ha as shown in **Figure 8**.

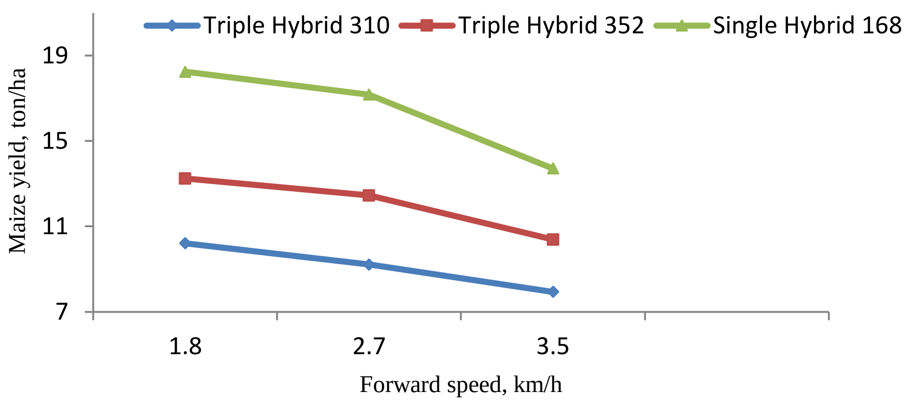


Figure 8. Effect of forward speed on crop yield.

8- Operating and production cost:

It is remarked that increasing the forward speed of developed machine from 1.8 to 3.5 km/h decreased the operating cost from 37.32 to 26.72 $/ha. That is due to the increase in effective field capacity as increasing the forward speed as shown in **Figure 9**. The obtained data in **Figure 10.** viewed that increasing the forward speed of developed machine from 1.8 to 2.7 km/h decreased the production cost from (3.65 to 3.25), (2.82 to 2.41) and (2.05 to 1.75) $/ton ., while the production cost increased as increasing forward speed from (3.25 to 3.37),(2.41 to 2.57) and (1.75 to 1.95) $/ton for maize grains Hybrids (Triple 310 (White), Triple 352 (Yellow), Single 168 (Yellow)), respectively.

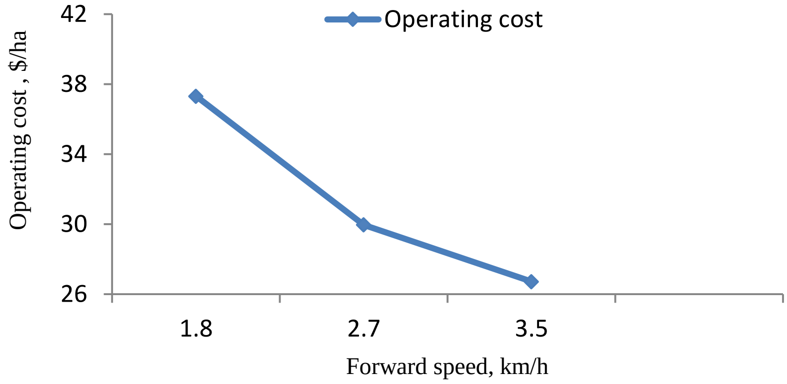


Figure 9. Effect of forward speed on operating cost.

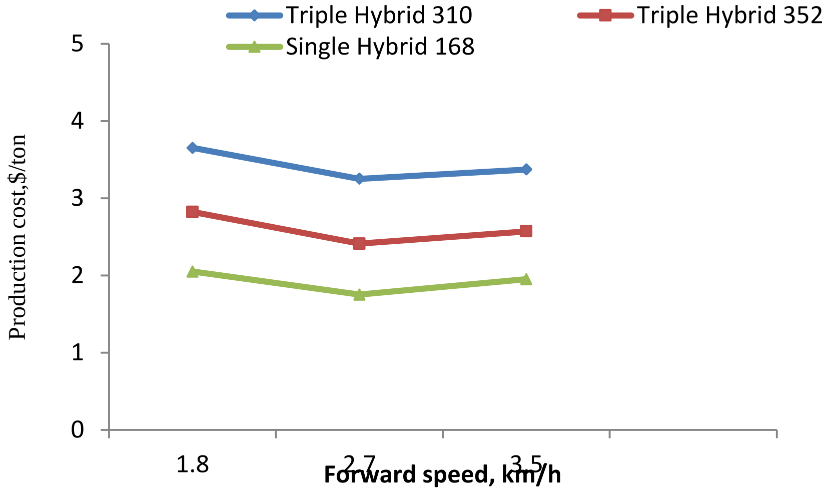


Figure 10. Effect of forward speed on production cost.

Test results

LSD All-Pairwise Comparisons Test are presented in (Tables 2 to 4) for some variables in the field.

Table 2 LSD All-Pairwise Comparisons Test of Triple 310 (White) for Varities

Forward speed	**1.8 km/h**	**2.7 km/h**	**3.5 km/h**
Parameter	**Triple 310 (White)**	**Triple 310 (White)**	**Triple 310 (White)**
Emergence ratio	90.8 b	85.8b	92.8 b
Missing hills(%)	9 a	13.4 a	18.7 a
Plant spacing (cm)	25.1 a	26.9 a	30.4 a
Double plants(%)	7.2 b	3.8 b	4.7 a
Production cost ($/ton)	3.65 a	3.25c	3.37 b
Crop yield(ton/ha)	10.22g	9.23h	7.94i

From Table 2 found that the speeds (1.8, 2.7, 3.5 km/h) are suitable with emergence ratio, missing hills and plant spacing, while the speed of 3.5km/h is greater speed with double plants then a close result with other speeds (1.8 and 2.7km/h), the most appropriate is 1.8 km/h with crop yield then 2.7 and 3.5km/h and the most appropriate is 1.8 km/h with production cost then 3.5 and 2.7 km/h

Table 3 LSD All-Pairwise Comparisons Test of Triple 352 (Yellow) for Varities

Forward speed	**1.8km/h**	**2.7 km/h**	**3.5 km/h**
Parameter	**Triple 352 (Yellow)**	**Triple 352 (Yellow)**	**Triple 352 (Yellow)**
Emergence ratio	95.0a	93.1 a	90.2 a
Missing hills(%)	5 b	6.9 c	9.7 c
Plant spacing (cm)	24.0 b	25.6 b	29.1 b
Double plants(%)	8.9 b	5.9 b	3.5 a
Production cost ($/ton)	2.82d	2.41f	2.57e
Crop yield(ton/ha)	13.25d	12.47e	10.37f

From Table 3 found that the speeds (1.8, 2.7, 3.5 km/h) are suitable with emergence ratio and plant spacing, while the speed of 1.8km/h is greater speed with missing hills then a close result with other speeds (2.7 and 3.5km/h) and the most appropriate is 3.5 km/h with double plants then a close result with other speeds (1.8 and 2.7km/h) , the most appropriate speed is 1.8km/h with production cost then the speeds 3.5 and 2.7km/h and the most appropriate speed is 1.8km/h with crop yield then the speeds 2.7 and 3.5 km/h.

Table 4 LSD All-Pairwise Comparisons Test of Single 168 (Yellow) for Varities

Forward speed	**1.8km/h**	**2.7km/h**	**3.5 km/h**
Parameter	**Single 168 (Yellow)**	**Single 168 (Yellow)**	**Single 168 (Yellow)**
Emergence ratio	95.0 a	91.0 a	89.0 a
Missing hills (%)	5 b	8.9 b	10.9 b
Plant spacing (cm)	21.0 c	24.0 c	26.0 c
Double plants (%)	15.3 a	9.1 a	8.4 a
Production cost ($/ton)	2.05g	1.75h	1.95g
Crop yield(ton/ha)	18.23 a	17.18 b	13.72 c

From Table 4 found that the speeds (1.8, 2.7, 3.5 km/h) are suitable with emergence ratio, missing hills, plant spacing and double plants, while the speed of 1.8 km/h is greater speed with crop yield then the speeds 2.7 and 2.5km/h and the speeds (1.8, 3.5 km/h) are suitable with production cost then the speed 2.7km/h.

CONCLUSION

This study aimed to develop a simple machine to accommodate the planting of maize in hills. This developed machine is one of the main reasons for its design, the lack of a machine for planting maize in small areas, so this machine is used in areas less than an acre and is highly efficient. The results concluded that the optimum distance between hills was 25 cm to achieve higher grain yield, lower energy, lower production cost and higher germination ratio with higher field efficiency at forward speed of 2.7 km/h .so the results recommended using the distance between hills of 25 cm.

REFERENCES

Afify M K. (2007). Development of a seed drill feeding device to suit planting in hills. Misr J. Ag. Eng., 26(1): 561-579.

Coates W. (1992). Performance evaluation of a pendulum spreader. Trans. ASAE, 8 (3): 285 – 288.

El-Awady M N, Ghoniem EY, Hashish A I. (1982). Agriculture comparison between wheat combine harvesters under Egyptian conditions. Res.Bul.Ain-Shams Univ.13p.

El-Awady M N, Yehia I, Badr S E , Hassan M A. (2004). Effect of some planting systems on coriander-cropproductivity. Misr J. Agric. Eng., 21(1):45-54.

El Shal A M, Awny A. (2019). Fabricating and Evaluating Performance of a Planter Prototype for planting chinese garlic cloves. J. of Soil Sciences and Agricultural Engineering, Mansoura Univ.Vol 10 (10): 605 – 612.

Fadavi A, Hassan-Beygi S R, Karimi F. (2013). Moisture dependent physical and mechanical properties of Syrjan region wild pistachio nut. Agric. Eng. Int.: CIGR J., 15(2):221-230. http://www.cigrjournal.org/index...

Goyal R K, Kingsly A R P, Kumar P, Walia H. (2007).Physical and mechanical properties of aonla fruits. J. of Food Eng.82:595-599. https://doi.org/10.1016/j.jfoodeng.2007.03.019.

Helmy M A , Goma S M , Badawy M E. (2005). Modification and evaluation of garlic planter. Misr J. Agric. Eng.,22 (2): 663-687.

Hunt D. (1983). Farm power and machinery management. 8th Ed., Iowa State University, Press Ames, U.S.A, PP.29.

Jin X, Cheng Q, Zhao B, Ji J T, Li M Y. (2020). Design and test of 2ZYM-2 potted vegetable seedlings transplanting machine. Int J Agric & Biol Eng,13(1): 101–110.

Kepner R A , Bainer R, Barger E L. (1982). Principles of farm machinery. Willey and Sons Inc.New York..

Kruszelnicka W. (2021). Study of Selected Physical-Mechanical Properties of Corn Grains Important from the Point of View of Mechanical Processing Systems Designing. Materials ,14, 1467. https:// doi.org/10.3390/ma14061467.

Liu Q W, He X T, Yang L, Zhang D X, Cui T, Qu Z, et al. (2017). Effect of travel speed on seed spacing uniformity of corn seed meter. Int J Agric & Biol Eng, 10(4): 98–106.

Metwalli, M.M.; M.A.K. El Said and S.I. Yousef (1998). Performance evaluation of some planting machinery sugar beet. Misr J. Agric. Eng., 15(1):57-68.

Pepo P, Sarvari M. (2013). Agrotechnikai valtozasok. Magyar Mezogazdasag. 24-31.

Perez E E, Crapiste G H , Carelli A A . (2007). Some physical and morphological properties of wild sunflower seeds. Biosystems Eng. 96(1): 41-45.

Saif U, Maqsood M, Farooq M, Hussain S, Habib A. (2003). Effect of planting patterns and different irrigation levels on yield and yield components of maize (Zea mays L.). Int. J. Agric. Biol., 1: 64-66

Soyoye B O, Ademosun O C, Agbetoye L A S. (2018). Determination of some physical and mechanical properties of soybean and maize in relation to planter design. Agricultural Engineering International: CIGR Journal, 20(1): 81–89.

Steel R G D , Torrie J H. (1980). Principles and procedures of statistics. McGraw-Hill Textbook, First Edition.

Vinod Kumar, Vijaya Rani, Mukesh Jain, Anil Kumar, Sushil Kumar , Naresh D. (2018). Design of 'Anjul' Seed Metering Mechanism for Round Seeds and its Seed Pattern Characteristics. Int.J.Curr.Microbiol.App.Sci.7(03): 1536-1543. doi: https://doi.org/10.20546/ijcmas.2018.703.183 .

Vursavus K, Ozguven F. (2004). Mechanical behaviour of apricot pit under compression loading. J. of Food Eng. 65:255-261. https://doi.org/10.1016/j.jfoodeng.2004.01.022.

Wang W J, Diao P S, Jia H L, Chen Y L. (2020). Design and experiment evaluation of furrow compaction device with opener for maize. Int J Agric & Biol Eng, 13(2): 123–131.

Yang L, He X T, Cui T, Zhang D X, Shi S, Zhang R, et al. (2015). Development of mechatronic driving system for seed meters equipped on conventional precision corn planter. Int J Agric & Biol Eng, 8(4): 1－9.

Yildirim S, Tarhan S. (2016). Aerodynamic properties of apricot pits. J. Agric. Fac. of Gaziosmanpasa Univ. 33 (1): 47-55.