Misr J. Ag. Eng., 28(2): 282 - 301 FARM MACHINERY AND POWER

DEVELOPMENT AND EVALUATION OF THE METERING DEVICE OF PLANTER TO BE SUITABLE FOR GARLIC GLOVES PLANTING

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ABSTRACT

The object of this study was to develop and evaluate the metering device of planter (Gaspardo) to be suitable for garlic gloves planting. The developed planting unit consists of gloves hopper, moving disc, fixed disc and mixer. This machine was evaluated to find out the optimum operating parameters for planting garlic cloves using versus nine different moving discs (12 cells) having three different cell diameters of 20, 2.5 and 30 mm and three different disc thicknesses of 20, 25 and 30 0m and four machine forward speeds of 1.17, 1.83, 2.61 and 3.65 km/h. The obtained results revealed that the maximum plant emergency ratio of 97.10 % for garlic gloves, the minimum missing hills of 5.1 % and the minimum longitudinal shattering of 0.48 cm were recorded at lower machine forward speed of 1.17 km/h, cell diameter of 30 mm and disc thickness of 30 mm. The minimum missing hills of 5.10 % was recorded at lower machine forward speed of 1.17 km/h, cell diameter of 30 mm and disc thickness of 30 mm. The maximum field capacity and minimum field efficiency of 0.176 fed/h and 67.43 % were recorded at higher machine forward speed of 3.65 km/h. The minimum power required and maximum energy consumed of 9.07 kW and 127.75 kW.h/fed were recorded at lower machine forward speed of 1.17 km/h. The minimum planting cost of 91.08 L.E/fed was recorded at higher machine forward speed of 3.65 km/h compared with manual planting which recorded 438.75 L.E/fed.

INTRODUCTION

Garlic is considered one of the most important vegetables crops in the world as well as in Egypt. Garlic also contains relatively low levels of the trace minerals copper, iron, zinc, calcium, manganese, and aluminum, although they may vary with soil conditions where the garlic was grown. Garlic lowers blood pressure, cholesterol and lowers or helps to regulate blood sugar. It helps to prevent cancer, remove heavy metals such as lead and mercury from the body. Raw Garlic is a potent natural antibiotic,

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while far less strong than modern antibiotics. There are about 300 varieties of garlic cultivated worldwide, particularly in hot, dry places. Today, garlic is one of the twenty most important vegetables in the world planting in total area of about one million hectares, with an annual production of about ten million metric tons of garlic globally. Major growing areas are USA, China, Egypt, Korea, Russia and India **(FAO, 2009)**. The prevailing planting of garlic in Egypt is manually in total area of 31680 feddans producing about 255000 tons **(Egyptian Ministry of Agriculture, 2008)**. **Hassan (1991)** described two methods of garlic planting in Egypt. In the first method, the garlic cloves are planted manually on both sides of the furrow (furrow width 50 – 60 cm). The clover seed is placed 5 to 7 cm where to thirds of the cloves is burred in the soil and the field is then irrigated. In the second method the garlic cloves is planted in rows spacing 30cm on the flat soil divided into 3×3 m plot. The first method is the prevailing garlic planting in practice Egypt. **Harb and Abdel Mawla (1997)** developed a metering belt system garlic planter to plat seeds at 10 cm distance between cloves along the rows. The machine opens a furrow for irrigation and plants two row of garlic on both sides the furrow top. Field experiments showed that the machine plants garlic cloves more uniformity at low forward speeds. At high forward speeds (above 3 km/h) the percentage of unsuccessful fed increased to more than 20 % and accordingly the mean number of seeds dropped per meter along the furrow decreased. This is mainly due to the centrifugal force action. Moreover, 90 % of the mechanically planted garlic germinated at the third week. **Mossa (1999)** found that the percentage of seeds dropped per meter along the furrow decreased about 20 % for the different crops by increasing speed. Also he indicated that lateral and longitudinal deviation of seeds along the row increased by increasing operating speed and decreasing seed size. **Jiaporn (2002)** stated that the major problem in planting garlic was a very expensive payment for employment of man power to plant by hand. The capacity of man power is very low about 0.05 ha./man/day and payment for planting is 11.9 % of total cost of production. According to the problems above, the development of garlic planter has been started by Jiaporn et al. in 1999. After the gathering of data about traditional garlic planting method, the studies of effect of planting method to yield were tested in the farmer field. The results shown that the drilling method was appropriated for fabricate the garlic planter. Hence, the design and development of garlic planter was started with the concept of the drilling planter attached to 5 hp power tiller. **El-Ashry (2004)** modified a potato planting machine to suit garlic crop by replacing the original metering tray by adjustable one which has diameter of 40 cm and 14 cells, each cell cone have diameter of 7.0 cm at upper hole and 5.0 cm at lower hole. The experiments were carried out to study the effect of machine forward speeds of (0.78, 1.2, 1.82 and 2.34 km/h) and planting spaces of (8.0, 12.0 and 16.0 cm) on planting density, planting uniformity, field efficiency, required energy and total yield. The results showed that, it is possible to use the potato planting machine, with some modifications on the feeding device to be used for planting garlic crop. Optimum values for the operation conditions were obtained at operating forward speed of 0.78 km/h and planting space of 8.0 cm where as given the best results of plant density, field efficiency, required energy and total yield. **Helmy et al. (2005)** modified and evaluated the feeding mechanism of the mechanical (Gaspardo) planter to plant garlic cloves under four levels of planting forward speeds of 1.5, 2.5, 4.0 and 6.0 km/h and two speeds of planter speed ratio of 0.6 and 0.8 with three levels of seed hopper capacity of 4.5, 2.25 and 1.125 kg. In addition to, they compared between manual planting and mechanical planting by planter**.** They found that the best limit of planting forward speeds of 1.5 to 2.5 km/h, planter speed ratio of 0.6 and seed hopper capacity is more than 50% of its capacity. **Yenpayub et al. (2006)** stated that the main concept of design and development of garlic planter is fabrication of the drilling planter and its metering device to be simple in their structure and easy to manufacture. This study followed research after the three types of garlic planters which included (inclined metering plate garlic planter), (vertical metering plate garlic planter) and (spring plate garlic planter). They compared between two models were constructed which included the vertical metering plate with triangular grooves and the bucket type garlic planter. The uniformity of metering system test for the two models, the bucket type garlic planter presented the most impressive results. The new prototype garlic planter had 12 rows and was attached to 5 hp power tiller. The result indicated that the optimum width of garlic planter was 0.8 meter or 8 rows. The suitable soil condition was dry soil. Farmer should apply water after planting. The maximum forward speed was 2.63 km/hr and wheel skid was high about 23.32%. The average depth and width of planting were 2.62 cm. and 4.66 cm. Time for turning at head land was 37 seconds. The field capacity was 0.31 ha/h and there were three operators.

Hence, the capacity of planter was 0.83 ha./man/day. So, the objectives of this study are to develop the metering device of planter (Gaspardo) to be suitable for planting garlic gloves and also to optimize some different operating parameters (the suitable diameter of disc cells, disc thickness and machine forward speed).

MATERIALS AND METHOD

The main experiments were carried out during the agricultural season 2009/2010 at a private farm, Hajer village, Sharkia Governorate to develop and evaluate the mechanical planter) to be suitable for planting garlic gloves.

MATERIALS:

1-Garlic variety: The garlic variety used in this study was (Baladi). It has different glove sizes causing a big problem during mechanical planting. So, the medium size of garlic gloves is the best category for mechanical planting. The properties of this category were determined from 100 gloves taken randomly as shown in table (1**).**

Table (1): The geometric and mechanical properties of garlic gloves.

Geometric and mechanical properties	Value	Unit
Av. Length	2.26	cm
Av. Width	1.05	cm
Av. Thickness	0.80	cm
Av. Volume	0.99	cm^3
Av. Geometric diameter	1.24	cm
Av. Arithmetic diameter	1.37	cm
Av. Flat surface area	1.86	cm^2
Av. Transverse surface area	1.47	cm^2
Av. Sphericity	54.75	%
Av. Weight of 100 gloves	84.38	g

2- Mechanical planter: The mechanical planter used in this study was type (Gaspardo) planter and its technical specifications were shown in table (2).

Table (2): The technical specifications of mechanical planter.

Made	Italy
Model	Gaspardo 1834
No. of units	4
Distance between units, mm	600
Total width, mm	2800
Total mass, kg	210
Seed hopper capacity, kg	4.5

3- Mechanical planter after modification: The mechanical planter was modified to be suitable for garlic planting as follows:

***(A) Metering discs*:** The main modification was occurred in metering moving discs to receive garlic gloves in their holes for reducing gloves damage to the minimum value, increasing germination ratio to the maximum value and economy to make the machine suitable for planting different crops to increase its use efficiency. Nine metering discs were made from hard wood with three different thicknesses of 20, 25 and 30 mm. Each disc was bored with 12 holes having different diameters of 20, 25 and 30 mm. The shape of metering discs before and after modification is shown in fig. (1).

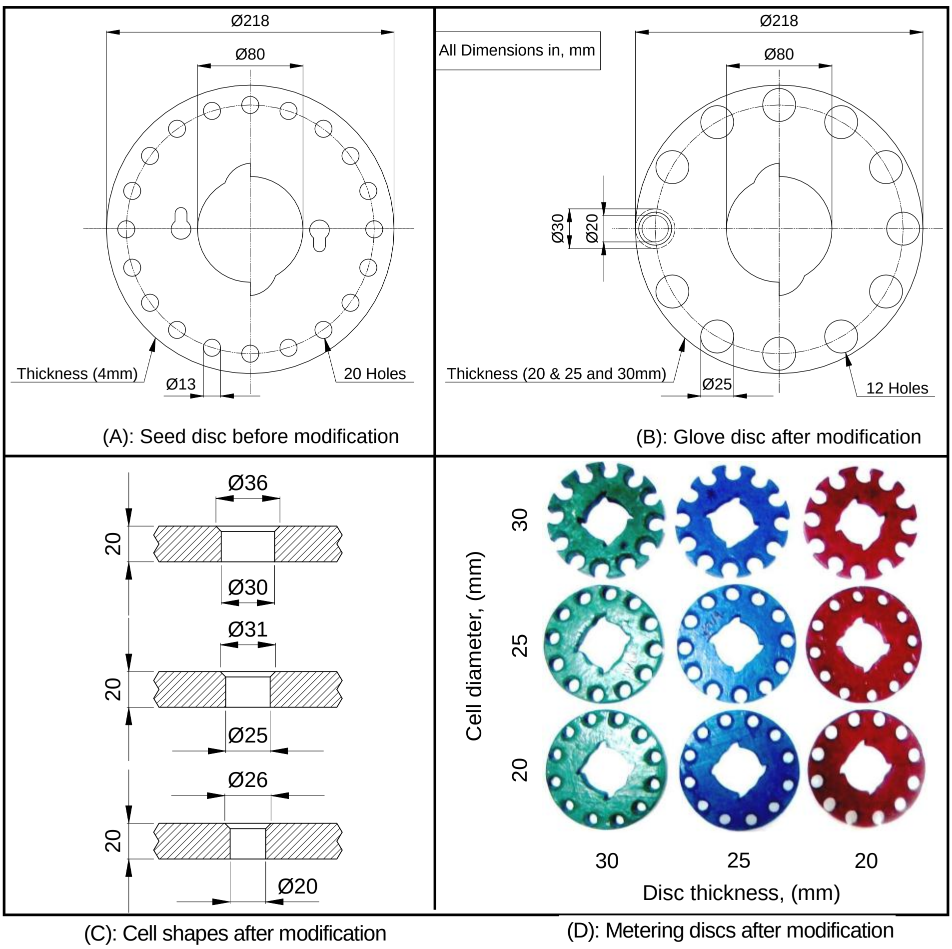


Fig.(1): Metering disc before and after modification.

***(B):Mixer*:** The original hummer and scraper in the seed hopper were removed and replaced with a new mixer made from mild steel and constructed directly over the slide part and metering disc to guide garlic gloves into the cells and also minimize gloves clogging in the cell. Mixer dimensions are shown in fig. (2). While the whole modified unit is shown in fig. (3).

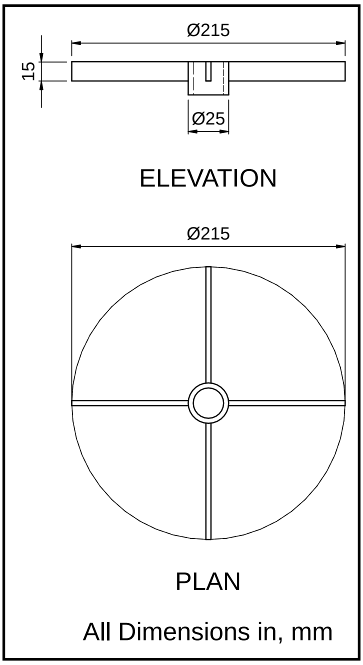


Fig.(2): Gloves mixer.

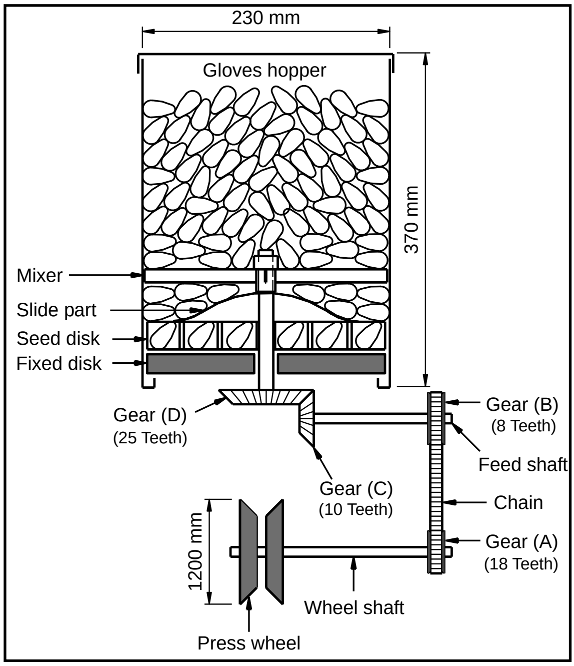


Fig.(3): Modified unit.

METHOD:

The modified unit of (Gaspardo) planter was evaluated under three disc thicknesses of 20, 25 and 30 mm, three cell holes of 20, 25 and 30 mm and four machine forward speeds of 1.17, 1.83, 2.61 and 3.65 km/h. The speed ratio between the ground wheel and the metering disc was 0.90 with adjusting the gears (A and B) shown in fig. (3). The planter was adjusted to plant garlic gloves with 70-80 kg/fed (about 150 kg/fed of bulbs) at 30 cm spacing between rows and about 11 cm between hills in the same row. A Kubota tractor model (L-285) with (30 hp - 22.05 kW) was used to operate the planter during all test runs in sandy loam soil. The garlic crop was fertilized and irrigated as recommendations of Egyptian ministry of agriculture. The modified planter was evaluated taking into considerations the following indicators:

1. Field capacity: was the actual average time consumed during planting operation (lost time + effective time). It can be determined from the following equation, (**Keppner et al. 1982)**:

$$F.C_{act} = \frac{60}{Tu + Tl}\ , \quad (fed/h) ....(1)$$

Where: $F.C_{act}$ = Actual field capacity of the planter.

T_u = Utilization time per feddan in minutes.

T_l = Summation of lost time per feddan in minutes.

2. Field efficiency: is calculated by using the values of the theoretical field capacity and effective field capacity rates as, **(Keppner et al. 1982)**:

$$\eta_f = \frac{F.C_{act}}{F.C_{th}} \times 100 \quad (\%),\ ....(2)$$

Where: η_f = Field efficiency.

3. Plant emergency: was calculated by the following formula after four weeks from planting date.

$$Em. = \frac{P}{d} \times 100, \quad (\%) \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Where: P = Average number of plant per 1 m^2.

d = Average number of gloves delivered from metering device per 1 m^2.

4. Missing hills: The percentage of missing hills was calculated using the following formula.

$$M_H = \frac{N_M}{N_T} \times 100, \quad (\%) \ldots\ldots\ldots\ldots\ldots..(4)$$

Where: N_M = Number of missed hills per 1 m^2.

N_T = Number of theoretical hills per 1 m^2.

5. Longitudinal scattering: The distance between 20 hills in the row for all treatments was measured. The longitudinal scattering of seed placements was determined statistically by standard deviation of the measured distances, according to **(Steel and Torrie, 1980)**.

6. Crop yield: The garlic bulbs were gathered manually after maturity by hand hoes and left on the soil until the moisture content reached to about

66.25 % in the bulbs. The garlic bulbs were collected and weighted to calculate the weight of each treatment by kg and converted to kg/fed.

Classification of garlic bulbs was carried out using a hard sheet of wood having different hole diameters of (35, 45 and 55 mm) to classify garlic bulbs into four classes as following:

Class (1) = (> 55 mm), Class (2) = (45 – 55mm), Class (3) = (35 – 45 mm) and Class (4) = (< 35 mm)

7. Consumed energy: To estimate the engine power during planting process, the decrease in fuel level was accurately measured immediately after each treatment. The following formula was used to estimate the engine power. **(Hunt, 1983).**

$$EP = \left[f.c\left(1/3600\right)PE \times L.C.V \times 427 \times \eta_{thb} \times \eta_m \times 1/75 \times 1/1.36\right],\ kW......(5)$$

Solving equation (5), the consumed energy can be calculated as following:

$$\text{Engine power (Diesel)} = 3.16\, f.c.\ \ , kW\ ....(6)$$

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

PE = The density of fuel, (kg/l), (for Diesel = 0.85).

L.C.V = The lower calorific value of fuel, (11.000 k.cal/kg).

η_{thb} = Thermal efficiency of the engine (35 % for Diesel).

427 = Thermo-mechanical equivalent, (kg.m/k.cal).

η_m = Mechanical efficiency of the engine (80 % for Diesel).

Hence, the specific energy consumed can be calculated as follows:

$$\text{Consumed energy} = \frac{\text{Engine power,(kW)}}{\text{Field capacity,(fed/h)}},\ \ kW.h/fed............(7)$$

8. Planting cost: The operating cost of planting operation was estimated using the following equation **(Awady et al. 1982)**:

$$\text{Operating cost} = \frac{\text{Machine cost (L.E/h)}}{\text{Actual field capacity (fed/h)}},\ (L.E/fed)........(8)$$

Machine cost was determined by using the following equation (**Awady, 1978)**:

$$C = \frac{P}{h}\left(\frac{1}{a} + \frac{i}{2} + t + r\right) + \left(0.9\, W.S.F\right) + \frac{m}{144}\ ....(9)$$

Where:

C = Hourly cost, L.E/h. P = Price of machine, L.E.

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

i = Interest rate/year. F = Fuel price, L.E/l.
t = Taxes, over heads ratio. r = Repairs and maintenance ratio.
m = Monthly average wage, L.E 0.9 = Factor accounting for lubrications.
W = Engine power, hp. S = Specific fuel consumption, l/hp.h.
144 = Reasonable estimation of monthly working hours.

RESULTS AND DISCUSSION

Data obtained from the field experiments aimed to evaluate the developed planting unit for garlic gloves planting. Results show that the suitable planting process is greatly affected by many parameters such as machine forward speed, gloves size, number of holes on the disc, disc thickness and holes diameter.

1- Plant emergency:

Plant emergency ratio was measured after four weeks from planting day. Fig. (4) show the effect of machine forward speed on plant emergency ratio. Generally, the machine forward speed has a great effect on plant emergency ratio. Increasing machine forward speed from 1.17 to 3.65 km/h decreased plant emergency ratio rabidly from 94.7 to 76.4 %, from 96.4 to 80.2 % and from 97.1 to 82.4 %, at constant cell diameter of 30 mm and different disc thicknesses of 20, 25 and 30 mm, respectively. This result may attribute to increase disc speed resulting in more scratching gloves in metering unit leads to rot gloves in the soil. Relating to the effect of cell diameter on the plant emergency ratio, results in fig. (4) show that increasing cell diameter leads to increase the plant emergency ratio under all experimental conditions. Increasing cell diameter from 20 to 30 mm under constant machine forward speed of 1.17 km/h increased the plant emergency ratio from 86.4, 88.7 and 91.1 % to 94.7, 96.4 and 97.1 % at various disc thicknesses of 20, 25 and 30 mm, respectively. Concerning the effect of disc metering thickness on the plant emergency ratio, results in fig. (4) show also that increasing disc metering thickness from 20 to 30 mm under constant machine forward speed of 1.17 km/h increased the plant emergency ratio from 86.4, 92.5 and 94.7 % to 91.1, 95.8 and 97.1 % at different cell diameters of 20, 25 and 30 mm, respectively. Increasing both cell diameter and disc thickness led to increase plant emergency ratio due to increasing the cell space containing garlic gloves with minimum scratching.

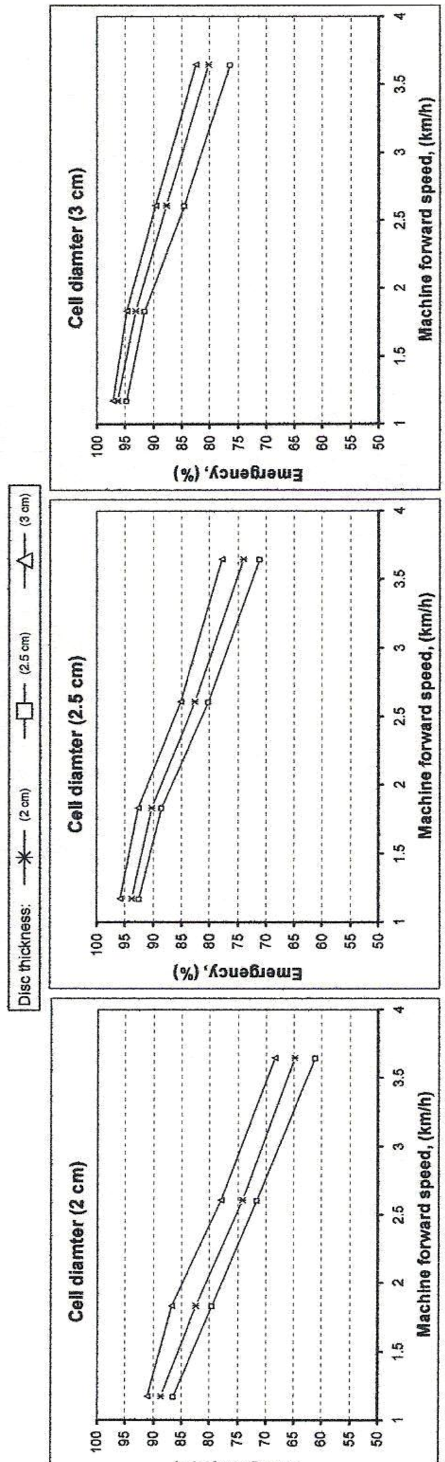


Fig. (4): Effect of machine forward speed on plant emergency at different cell diameters and different disc thicknesses.

2- Missing hills:

Data in fig. (5) reveal the effect of machine forward speed on missing hills percentage. Generally, the machine forward speed has a great effect on missing hills percentage. Increasing machine forward speed from 1.17 to 3.65 km/h increased missing hills percentage from 6.8 to 18.5 %, from 5.7 to 17.4 % and from 5.1 to 16.3 %, at constant cell diameter of 30 mm and different disc thicknesses of 20, 25 and 30 mm, respectively. This result may attribute to increase slippage of ground wheels resulting in more hills without garlic gloves.

Regarding to the effect of cell diameter on missing hills percentage, results in fig. (5) show that increasing cell diameter leads to decrease the missing hills percentage under all experimental conditions. Increasing cell diameter from 20 to 30 mm under constant machine forward speed of 1.17 km/h decreased the missing hills percentage from 8.4, 7.3 and 6.5 % to 6.8, 5.7 and 5.1 % at different disc thicknesses of 20, 25 and 30 mm, respectively. Relating to the effect of disc metering thickness on the missing hills percentage, results in fig. (5) show also that increasing disc metering thickness from 20 to 30 mm under constant machine forward speed of 1.17 km/h decreased the missing hills percentage from 8.4, 7.2 and 6.8 % to 6.5, 5.5 and 5.1 % at different cell diameters of 20, 25 and 30 mm, respectively. Increasing both cell diameter and disc thickness led to decrease missing hills percentage due to increasing the cell space containing garlic gloves resulting more gloves coming out from the metering device in the unit time.

3- Longitudinal scattering:

Fig. (6) show the effect of machine forward speed on longitudinal scattering. Data indicates that, increasing machine forward speed from 1.17 to 3.65 km/h increase the longitudinal scattering values from 0.71 to 3.18 cm, from 0.58 to 3.04 cm and from 0.48 to 2.87 cm, at constant cell diameter of 30 mm and different disc thicknesses of 20, 25 and 30 mm, respectively. This result may be due to increase the skidding of ground wheels as increasing the machine forward speed. Relating to the effect of cell diameter on longitudinal scattering, results in fig. (6) show that increasing cell diameter leads to decrease the longitudinal scattering under all experimental conditions.

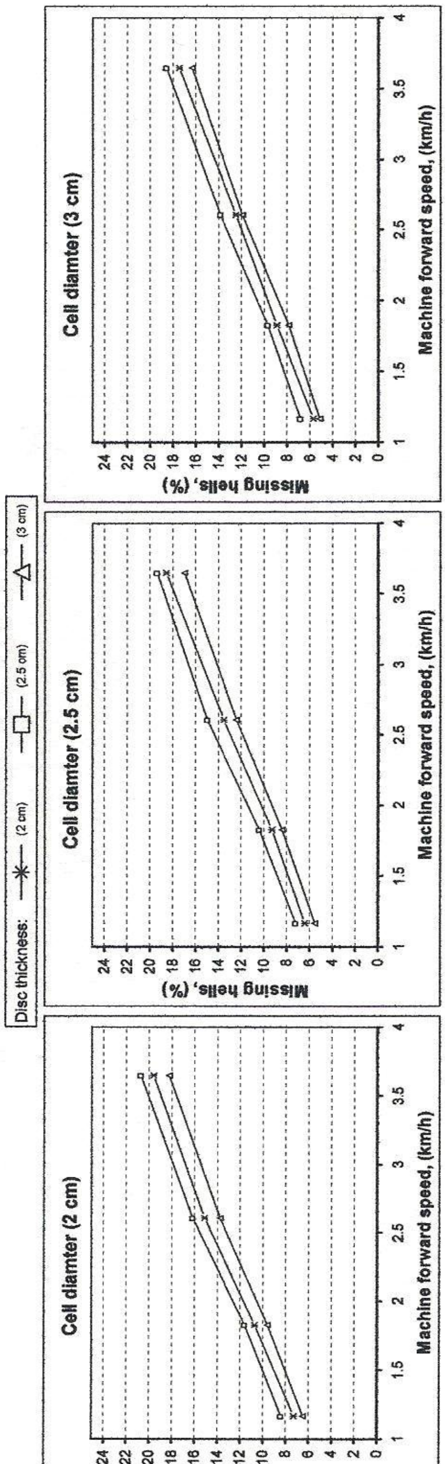


Fig. (5): Effect of machine forward speed on missing hills at different cell diameters and different disc thicknesses.

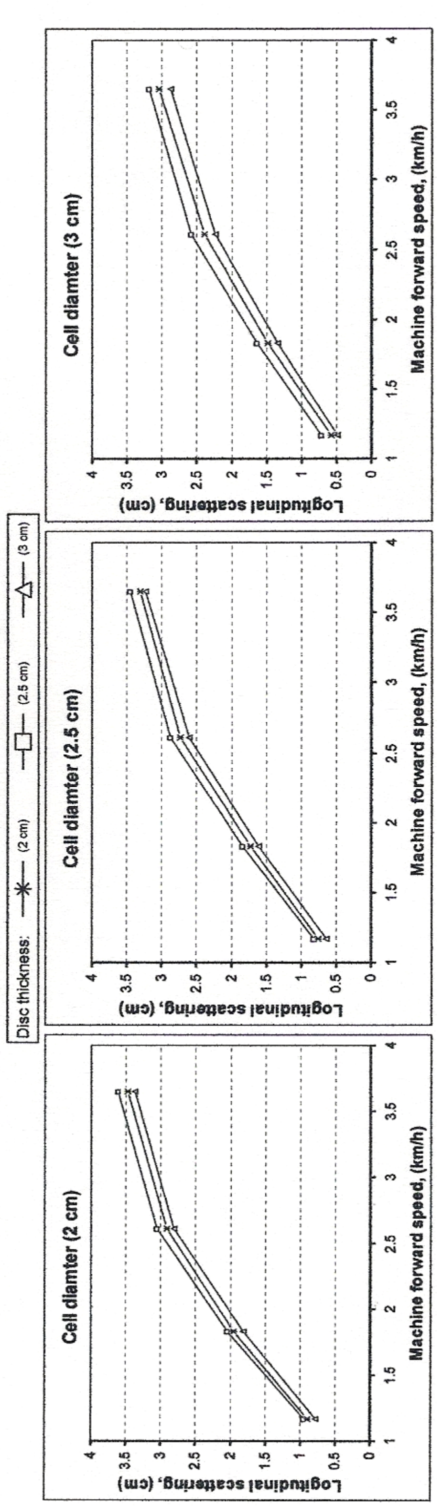


Fig. (6): Effect of machine forward speed on longitudinal scattering at different cell diameters and different disc thicknesses.

Increasing cell diameter from 20 to 30 mm under constant machine forward speed of 1.17 km/h decreased the longitudinal scattering from 0.95, 0.89 and 0.78 cm to 0.71, 0.58 and 0.48 cm at various disc thicknesses of 20, 25 and 30 mm, respectively. Concerning to the effect of disc metering thickness on the longitudinal scattering, results in fig. (6) show that increasing disc metering thickness from 20 to 30 mm under constant machine forward speed of 1.17 km/h decreased the longitudinal scattering from 0.95, 0.82 and 0.71 cm to 0.78, 0.64 and 0.48 cm at different cell diameters of 20, 25 and 30 mm, respectively. Increasing both cell diameter and disc thickness led to decrease longitudinal scattering due to increasing the cell space containing garlic gloves with out clogging resulting more gloves coming out from the metering device in the unit time.

<u>4- Total garlic yield:</u>

Data obtained in table (3) show the effect of machine forward speed on total crop yield. It is clear that the big amount of garlic yield was recorded at the lower forward speed of 1.17 km/h, while the small amount was recorded at the higher forward speed of 3.65 km/h; this may attribute to decrease both missing hills and longitudinal scattering during all treatments. However, increasing machine forward speed from 1.17 to 3.65 km/h, the total crop yield were decreased from 8384 to 6972, 8442 to 7072 and 8506 to 7122 kg/fed at constant disc thickness of 30 mm and different cell diameters of 20, 25 and 30 mm, respectively. This result may be due to increase the skidding of ground wheels increasing both missing hills and longitudinal scattering presenting low yield. On the other side, increasing cell diameter from 20 to 30 mm under constant machine forward speed of 1.17 km/h increased the total garlic yield from 8236, 8324 and 8384 kg/fed to 8361, 8440 and 8506 kg/fed at different disc thicknesses of 20, 25 and 30 mm, respectively. Concerning the effect of disc metering thickness on the total yield, results in table (3) show that increasing disc metering thickness from 20 to 30 mm under constant machine forward speed of 1.17 km/h increased the total garlic yield from 8236 to 8384, 8331 to 8442 and 8361 to 8506 kg/fed at different cell diameters of 20, 25 and 30 mm, respectively. Increasing both cell diameter and disc thickness led to increase total garlic yield due to increasing the cell space containing garlic gloves during planting operation resulting less missing hills and good longitudinal distribution for plants, which gave good yield.

Table (3): Effect of machine forward speed on total garlic yield and its classifications at different cell diameters and different disc thicknesses.

Cell diameter (mm)	Disc thickness (mm)	Machine forward speed, (km/h) 1.17 Class (1)	Class (2)	Class (3)	Class (4)	Total yield (kg/fed)	1.83 Class (1)	Class (2)	Class (3)	Class (4)	Total yield (kg/fed)	2.61 Class (1)	Class (2)	Class (3)	Class (4)	Total yield (kg/fed)	3.65 Class (1)	Class (2)	Class (3)	Class (4)	Total yield (kg/fed)
20	20	1894	3128	2553	661	**8236**	1684	2672	2775	706	**7837**	1516	2423	2716	772	**7427**	1132	2057	2768	802	**6779**
	25	2097	3247	2372	608	**8324**	1738	2624	2861	684	**7907**	1538	2452	2767	751	**7508**	1180	2093	2829	765	**6867**
	30	2154	3341	2515	374	**8384**	1772	2663	2971	593	**7999**	1581	2512	2835	686	**7614**	1241	2169	2874	688	**6972**
25	20	2041	3321	2491	485	**8338**	1756	2643	2904	629	**7932**	1547	2456	2787	731	**7521**	1191	2104	2839	749	**6883**
	25	2148	3346	2484	410	**8388**	1776	2677	2919	575	**8019**	1593	2527	2873	639	**7632**	1245	2181	2891	664	**6981**
	30	2231	3374	2516	321	**8442**	1795	2703	3039	551	**8088**	1643	2584	2936	552	**7715**	1271	2207	3017	577	**7072**
30	20	2094	3211	2574	382	**8361**	1767	2658	2963	598	**7986**	1578	2496	2819	713	**7606**	1228	2146	2851	726	**6951**
	25	2230	3369	2515	326	**8440**	1784	2694	3006	564	**8048**	1638	2571	2913	585	**7707**	1263	2203	2928	644	**7038**
	30	2245	3398	2539	316	**8498**	1827	2741	3082	484	**8134**	1696	2624	3007	427	**7752**	1288	2235	3043	556	**7122**

(Class-1) = (Bulb diameter > 55 mm)
(Class-2) = (Bulb diameter 45 - 55 mm)
(Class-3) = (Bulb diameter 35 - 45 mm)
(Class-4) = (Bulb diameter < 35 mm)

5- Classifications of garlic yield:

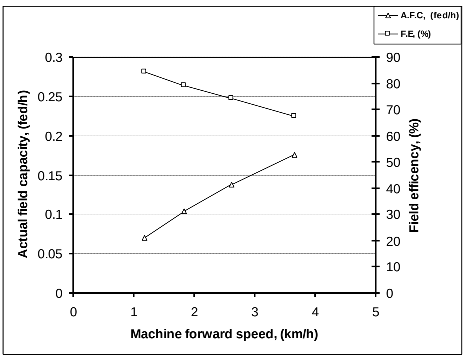
Classification of garlic bulbs is very important especially when we want to export garlic yield. Class (1) and Class (2) are the exported categories which have bulb diameter large than 45 mm. From obtained data in table (3), Class (1) and Class (2) are generally increased at lower machine forward speed of 1.17 km/h compared with the higher forward speeds. Increasing machine forward speed from 1.17 to 3.65 km/h decreased garlic bulbs in Class (1) from 2154 to 1241, from 2231 to 1271 and from 2245 to 1288 kg/fed at constant disc thickness of 30 mm and different cell diameters of 20, 25 and 30 mm, respectively. Also, decreasing garlic bulbs in Class (2) from 3341 to 2169, from 3374 to 2207 and from 3398 to 2235 kg/fed at the same previous conditions. Decreasing bulb diameter in Classes (1 and 2) by increasing machine forward speed may attribute to more skidding of ground wheels leads to increase longitudinal scattering and also decreasing planting depth. Relating to the effect of cell diameter on garlic bulbs in Class (1) and Class (2), table (3) show that increasing cell diameter of planting disc from 20 to 30 mm increasing the garlic bulbs in Class (1) from 2154 to 2245, from 1772 to 1827, from 1581 to 1696 and from 1241 to 1288 kg/fed at constant disc thickness of 30 mm and different machine forward speeds of 1.17, 1.83, 2.61 and 3.65 km/h. Also, increasing the garlic bulbs in Class (2) from 3341 to 3398, from 2663 to 2741, from 2512 to 2624 and from 2169 to 2235 kg/fed at the same previous conditions. Relating to the effect of planting disc thickness on garlic bulbs in Class (1) and Class (2), table (3) show that increasing disc thickness from 20 to 30 mm increasing the garlic bulbs in Class (1) from 2094 to 2245, from 1767 to 1827, from 1578 to 1696 and from 1228 to 1288 at constant cell diameter of 30 mm and different machine forward speeds of 1.17, 1.83, 2.61 and 3.65 km/h. Also, increasing the garlic bulbs in Class (2) from 3211 to 3398, from 2658 to 2741, from 2496 to 2624 and from 2146 to 2235 kg/fed at the same previous conditions. Increasing bulb diameters in Classes (1 and 2) by increasing both cell diameter and disc thickness was attributed to suitable area of holes on metering device to receive garlic gloves which decreasing both mechanical damage and missing hills.

6- Field capacity and field efficiency:

Fig. (7) show the effect of machine forward speed on field capacity and field efficiency. Data indicates that, increasing machine forward speed from 1.17 to 3.65 km/h led to increase field capacity from 0.071 to 0.176 fed/h, while the field efficiency was decreased from 84.52 to 67.43 % at the same previous conditions.

7- Consumed energy:

Fig. (7) show the effect of machine forward speed on the energy consumed. Data indicates that, increasing machine forward speed from 1.17 to 3.65 km/h led to increase power required from 9.07 to 15.10 kW, while the trend of consumed energy was against, since it was decreased from 127.75 to 85.80 kW.h/fed as the machine forward speed increased from 1.17 to 3.65 km/h, because of increasing in field capacity.



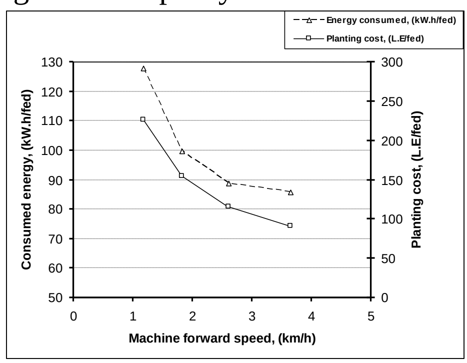


Fig. (7): Effect of machine forward speed on machine field capacity and efficiency, consumed energy and planting cost.

8- Planting cost:

The cost of garlic planting using the developed planting unit was decreased as the machine forward speed increased. Fig. (7) show that increasing forward speed from 1.17 to 3.65 km/h led to decrease planting cost from 225.77 to 91.08 L.E/fed. Compared with manual planting which was required about 117 man.h/fed with total planting cost of 438.75 L.E/fed. Since the wage of one labor was 30 L.E during 8 working hour.

CONCLUSION

From the obtained data it could be concluded the followings:

- The maximum plant emergency ratio of 97.10 %, the minimum missing hills of 5.10 % and the minimum longitudinal scattering of 0.48 cm were recorded at lower machine forward speed of 1.17 km/h, cell diameter of 30 mm and disc thickness of 30 mm.

- The maximum garlic yield of 8498 kg/fed and the maximum garlic yield in Class (1 and 2) suitable for exporting were 2245 and 3398 kg/fed were obtained at lower machine forward speed of 1.17 km/h, cell diameter of 30 mm and disc thickness of 30 mm.
- The maximum field capacity and minimum field efficiency of 0.176 fed/h and 67.43 % were recorded at higher machine forward speed of 3.65 km/h.
- The minimum power required and maximum energy consumed of 9.07 kW and 127.75 kW.h/fed were recorded at lower machine forward speed of 1.17 km/h.
- The minimum planting cost of 91.08 L.E/fed was recorded at higher machine forward speed of 3.65 km/h. compared with manual planting which recorded 438.75 L.E/fed.

REFERENCES

Awady, M. N. (1978): Tractor and farm machinery. Text book, Faculty of Agriculture, Ain-Shams University. Pp: 164-167.

Awady, M. N; E. Y. Ghoneim and A. I. Hashish (1982): A critical comparison between wheat combine harvester under Egyptian conditions. R. S. No. 1920, Ain-Shams University. (FAO) J.

El-Ashry, A. S. (2004). Modification of a potato planting machine to suit garlic crop. Misr J. Agric. Eng., 21(3): 657-668.

Harb, S. K. and H. M. Abdel- Mawla (1997). Development of a two-row garlic planter. Misr J. Agric. Eng., 14 (1): 144-155.

Hassan, A. A. (1991): Production of vegetable crops. First edition, Arab publ. and Dist., Cairo: 570-578.

Helmey, M. A; S. M. Gomaa and M. E. Badawy (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 Univ., Press Ames, USA. Ames, Iowa, USA: 364-368. inpho/content/compend/ae622e/ae622e14.htm.

Jiaporn, B. (2002): Final report "Design and Development of Garlic Planter attached to 5 HP power tiller." Project. Department of Agricultural Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Thailand. (Mimeographed).

Kepner, R. A; K. Bainer and E. L. Barger (1982): Principles of farm machinery. 3rd Ed., AVI Pub. Com. Inc., Westport. 527pp.

Mossa, A. I. (1999): Mechanical planting performance unites for three different crops. Misr J. Agric. Eng., 16(4): 84-92.

Steel and Torrie (1980): Principles and procedures of statistics. McGraw-Hill Company N.Y.

United Nations Food and Agriculture Organization (FAO), (2009): Garlic post harvest operations manual. CHAPTER XXXIIIII. www.fao. org/

Yenpayub, J; S. Kingthong and J. Benjaphragairat (2006): design and development of a garlic planter in Thailand**. M. Sc.** Agricultural Engineering Department, Faculty of Engineering, King Mongkut's Institute of Technology Lardkabang, Bangkok, Thailand 10520.

الملخص العربي

تطوير وتقييم جهاز التلقيم لآلة الزراعة في جور لتناسب زراعة فصوص الثوم البلدي

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تلقى زراعة الثوم في مصر اهتماماً كبيراً من المزارعين في الآونة الأخيرة لعدة أسباب منها: أنه تجود زراعته في مختلف الأجواء ومختلف أنواع الأراضي مثل الأراضي الطينية والأراضي حديثة الاستصلاح، كما أنه من محاصيل التصدير المهمة التي ترفع دخول المزارعين.

تزداد أهمية ميكنة زراعة محصول الثوم نظراً للتوسع في زراعته لسد الاحتياجات المحلية والتصديرية، وبذلك يمكن زراعته في المساحات المطلوبة في الوقت المحدد. إلا أن زراعة فصوص الثوم آلياً تلاقي العديد من المشاكل أهمها التلف الميكانيكي الناتج عن حركة جهاز التلقيم مما يؤثر بالسلب على نسبة الإنبات وبالتالي خفض كمية المحصول الناتج.

تم إجراء هذا البحث بقرية الحاجر- محافظة الشرقية في الموسم الزراعي ٢٠٠٩/٢٠١٠ م بغرض تطوير وتقييم آلة الزراعة في جور (جسباردو) لتناسب زراعة فصوص الثوم،

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وكانت أهم محاور التطوير هي تغيير سمك القرص الأفقي المتحرك، عدد الخلايا على القرص، شكل الخلية على القرص وكذلك تم إضافة قلاب أفقي داخل صندوق التقاوي لتلافي حشر الفصوص داخل الخلايا. وقد اشتملت الدراسة علي المتغيرات التالية:

- سمك القرص الأفقي المتحرك: (٢٠ ، ٢٥ و ٣٠ مم).
- قطر الخلية على القرص المتحرك: (٢٠ ، ٢٥ و ٣٠ مم).
- السرعة الأمامية لآلة الزراعة: (١.١٧ ، ١.٨٣ ، ٢.٦١ و ٣.٦٥ كم/س).

وقد أظهرت النتائج المتحصل عليها ما يلي:

- أعلى نسبة إنبات، أقل نسبة جور غائبة وأقل تشتت طولي للفصوص كانت ٩٧.١٠ %، ٥.١٠ % و٠.٤٨ سم، على الترتيب. تم الحصول عليها عند سمك أقراص ٣٠ مم، أقطار خلايا ٣٠ مم وسرعة أمامية منخفضة لآلة الزراعة ١.١٧ كم/س.
- أعلى كمية محصول للثوم، أعلى كمية محصول ثوم في الفئة (١ و ٢) القابلة للتصدير كانت ٨٤٩٨ كجم/ف و(٢٢٤٥ و ٣٣٩٨) كجم/ف، على الترتيب. تم الحصول عليها عند سمك أقراص ٣٠ مم، أقطار خلايا ٣٠ مم وسرعة أمامية منخفضة لآلة الزراعة ١.١٧ كم/س.
- أعلى سعة حقلية، أقل كفاءة حقلية، أقل طاقة مستهلكة وكذلك أقل تكاليف كلية لعملية الزراعة الآلية كانت ٠.١٧٦ ف/س، ٦٧.٤٣ %، ٨٥.٨٠ كيلووات.س/ف و ٩١.٠٨ جنيه/ف، على الترتيب. تم الحصول عليها عند السرعة الأمامية العالية لآلة الزراعة ٣.٦٥ كم/س.