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DEVELOPMENT OF A LOCAL MACHINE FOR GARLIC CLOVES PLANTING

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ABSTRACT

The aim of this investigation is to design, develop and test a two rows garlic-cloves planter. The developed garlic-cloves planter consists of the tool bar, three hitching-points, frame, transmission system, furrow opener, covering device and two planting units. Each planting-unit consists of gloves hopper, agitator, cutoff, metering device, housing and metering device shaft. Laboratory experiments were carried out as a function of change in metering device speed, agitator speed, cutoff clearance and cloves size. The field experiments were conducted to optimize machine forward speed. The machine performance was studied in terms of cloves damage, plant scattering, emergency, crop yield, specific energy and planting cost. The experimental results reveal that the garlic-cloves planter is recommended to be used under the following conditions: Metering-device speed of 20 rpm (0.21 m/s) for all sizes of Chinese garlic-cloves. Agitator speed of 50 rpm (0.22 m/s) for all sizes of Chinese garlic-cloves. Cutoff clearance of 15 mm for all sizes of Chinese garlic-cloves. Planter forward speed of 3.44 km/h for the medium cloves.

Keywords: Garlic cloves, planting, planting machine, mechanization of garlic.

INTRODUCTION

Garlic (*Allium sativum* L.) is a crop with a long history of plantation in Egypt. The cultivated area of garlic crop in Egypt was 20.256 thousand faddans in 2009. The total annual production of garlic crop in Egypt was about 175.743 thousand tons in 2009 (Agric. Statistics Economic Affair Sector, 2009). Because of the high costs of the traditional methods of garlic planting, cultivation and harvesting which are high time consuming and labor intensive, its large scale production is not economical and is therefore very limited. The academic and applied researches indicated that the drop in garlic yield, occurring through different stages of garlic production, is a vital problem to be solved. As known, garlic crop is too sensitive to planting operation, due to the high percentage of non germinated cloves and non uniformity of seeds distribution affecting on the total yield. For this reason, such care had to be taken to design, develop and operate garlic planting machines with an accurate scientific guidance taking into consideration machine efficiency, seed uniformity, energy and cost requirements.

Rocha *et al.* (1991) designed a manually operated planter for garlic bulbs mounted on two bicycle wheels and equipped with a toothed belt distribution mechanism. In field tests with prototype equipment bulb were spaced at 5 bulbs/m.

Harb and Abdel-Mawla (1997) developed a metering belt system garlic-planter to plant cloves at 10 cm spacings. Field experiments showed that machine planted cloves grew more uniformity at low forward speeds. At high speed (above 3 km/h) the percentage of unsuccessful fed increased to more than 20 %, and accordingly, the mean number of cloves dropped per meter along the furrow decreased.

Yehia (1997) and Awady *et al.* (2000) designed a garlic clove metering vertical wheel with groove device. They studied the effect of

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feeder speeds, groove shapes (rectangle, trapezoidal, and triangle), and groove widths on cloves discharge, damage and longitudinal cloves-distribution. It was found that the groove width of "24 mm", of a triangular shape and feeder speed of "20 rpm" had the best longitudinal cloves distribution.

Jarudchai *et al.* (2002) designed and developed a garlic planter. They constructed and tested two models with different metering devices which included (1) a vertical metering plate with triangular grooves and (2) a bucket type device. The bucket type metering device presented the most impressive results regarding uniformity of the metering system and low garlic clove damage (0.23%). The planter was attached to a 5 hp power tiller and was tested actual field conditions. The maximum forward speed was 2.63 $km.h^{-1}$ and planter wheel skid was high at about 23%. The planter field capacity was 0.73 fed/h.

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 under machine forward speeds and planting spaces 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.

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 and two speeds of planter speed ratio with three levels of seed hopper capacity. In addition to, they compared between manual planting and mechanical planting by planter. They found that the best limits of planting forward speeds are 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.

Bakhtiari1 and Loghavi (2009) developed and evaluated an innovative garlic clove 3-row precision planter tractor-mounted. Seed metering-drum has three rows of 40 elliptical seed holes (30×20 mm) for accommodating garlic clove. The performance parameters measured/calculated during the field tests included planting depth, seeding rate, seed spacing, miss index, multiple index and clove damage. The results of the field evaluation showed that the new machine was capable of planting 92400 plants/fed at the average clove placement depth and spacing of 12.3 and 22.7 cm, respectively. Other performance parameters included miss and multiple indices of 12.3 and 2.43 %, respectively.

El-Sharabasy and Ali (2011) developed and evaluated the planting unit of planter (Gaspardo) to be suitable for planting garlic gloves. That machine was evaluated to find out the optimum operating parameters for planting garlic cloves using versus nine different moving discs having three different cell diameters and three different disc thickness and four machine forward speeds. The obtained results revealed that the maximum plant emergency ratio of 97.10 %, the minimum missing hills of 5.1 %, the minimum longitudinal scattering of 0.48 cm and the maximum garlic yield of 8498 kg/fad., were recorded at lower machine forward speed of 1.17 km/h, cell diameter of 30 mm and disc thickness of 30 mm.

The objectives of this research were:

- Designing and developing a tractor mounted precision planter capable of singulating and planting garlic cloves at predetermined depth, row and plant spacing.
- Optimize some different operating parameters (metering device speed, agitator speed and cutoff clearance) affecting the performance of the developed machine, through laboratory tests.
- Optimize the machine forward speed, through field experiments.
- Evaluation of the developed garlic planter from the economic point of view.

MATERIALS AND METHODS

The *main* experiments were carried out on sandy soil through successive agricultural seasons of 2010 and 2011 at El-Kassassin Research. Station, Ismailia Governorate, Agricultural Research Center, Egypt, to test the developed garlic-cloves planter. The mechanical analysis of the experimental soil was 4.0 % clay, 6.08 % silt and 89.92 % sand.

Materials

The Used Crop

Garlic cloves Chinese variety was used in laboratory and field experiments. Table 1 shows dimensions, mass, volume, geometric mean diameter, bulk and real density of Chinese garlic-cloves. These data were measured on 100 cloves sample, according to the standards set in (Mohsenin, 1986). Planting requires about 150 kg/fad., of cloves under rows spacing of about 60 cm with distance between cloves in the same row of about 10 cm.

The Designed Test-Rig

The test-rig was designed specifically for this work and was constructed at a Research Institute, Agric. Res. Center. The view of the test-rig is shown in Fig. 1. The main parts of the test-rig were as follows:

Frame

The frame was made of steel L-sections of "25 x 2.5 mm" with "207 mm" length and "86 mm" width. The frame was carried on four legs of "523 mm" height. Planting unit was hinged to the frame by two bolts.

Manual hand

The manual hand was connected with feeding shaft by a bolt to rotate feeding shaft manually.

The Developed Garlic-Cloves Planter

The developed garlic-cloves planter (Fig. 2) consists of the tool bar, three hitching-points frame, transmission system, furrow opener, covering device and two planting units. The overall dimensions of the developed garlic-cloves machine were 150 cm length, 90 cm width and 110 cm height. The total mass of the machine was about 205 kg.

Cloves box

The cloves hopper was built from sheet steel "2 mm" thick, with dimensions of 188 x 150 x 235 mm and "62^{o}" sloping bottom.

The agitator

The crank agitator with 3-wings which designed by Yehia (1997) was constructed. The delivery of garlic-cloves was activated by the agitator. The agitators were fixed inside the cloves hoppers. The agitators were operated by means of sprockets and chains powered from the ground wheel.

Cutoff

Cutoff was made of rubber with "19 mm" thickness, 122 mm length and 100 mm width. The cutoff had a rectangular gate. The cutoff was fixed on the top of metering device and the bottom of hopper by two long bolts passed across the two sides of the hopper. Three gates were tested for three garlic cloves grades as shown in Table 2.

Housing of metering device

Housing of metering device was made of sheet steel "2 mm" thick, with dimensions of 96 mm width, 200 mm rear diameter and 213 mm front diameter. Two flanges (sides) with diameter of 200 mm and thickness of 8 mm were bolted with two sides of the housing to support metering device shaft by two bearings. A funnel was welded in the bottom of the housing and bolted upper the clove tube (on frame of planting unit) which exists between two discs of furrow opener.

Metering-devices

A vertical-axis metering-wheel with triangles grooves (designed by Yehia, 1997) was developed according to seed physical and mechanical properties (Fig. 3). Grooves on wheel were located at the periphery. Cloves were picked up by each groove from the hopper and dropped into the seed tube. The designed and tested grooves dimensions for three sizes (classes or grades) of Chinese garlic cloves were shown in Table 3.

Metering-device shaft

A shaft of "300 mm" length and "20 mm" diameter was connected to the metering-device housing by two ball bearings which bolted with two flanges. The metering device was interference with the feed shaft.

Planting unit frame

The frame of planting unit, made of antimony material with total dimensions of 1040 mm length, 194 mm width 330 mm height which was taken from scrapped John Deere planter set in the developed garlic-clove planter.

Table 1. Physical properties of garlic cloves of Chinese variety

Cloves Size	Physical properties	Max.	Min.	Average	S. D.[1]	C. V.[2]
Large	L, mm	40	35	36.8	1.67	4.54
	W, mm	30	21	25.2	2.16	8.56
	T, mm	21	9	15.2	3.30	21.69
Medium	L, mm	34	30	31.9	1.27	4.00
	W, mm	27	21	24	1.65	6.87
	T, mm	17	8	13.0	2.29	17.55
Small	L, mm	29	25	27	1.14	4.21
	W, mm	25	19	22	1.38	6.34
	T, mm	14	9	12	1.43	11.92
Large	Mass, g	7	2.6	4.68	1.08	23.10
Medium		4	1.4	3.95	0.72	18.30
Small		2	0.8	1.52	0.31	20.14
Large	Volume, cm^3	6.65	2.54	4.36	0.98	22.53
Medium		3.49	1.20	3.82	0.70	18.29
Small		2.22	0.76	1.36	0.32	23.16
Large	D_g, mm	29	21	42.03	2.33	9.70
Medium		23	18	21.46	1.44	6.71
Small		21	16	19.18	1.23	6.39
Large	Bulk density, g/cm^3		0.52		-	-
Medium			0.54		-	-
Small			0.55		-	-
Large	Real density, g/cm^3	1.15	0.99	1.22	0.07	5.39
Medium		1.17	0.92	1.61	0.11	6.53
Small		1.40	0.9	1.11	0.15	13.38

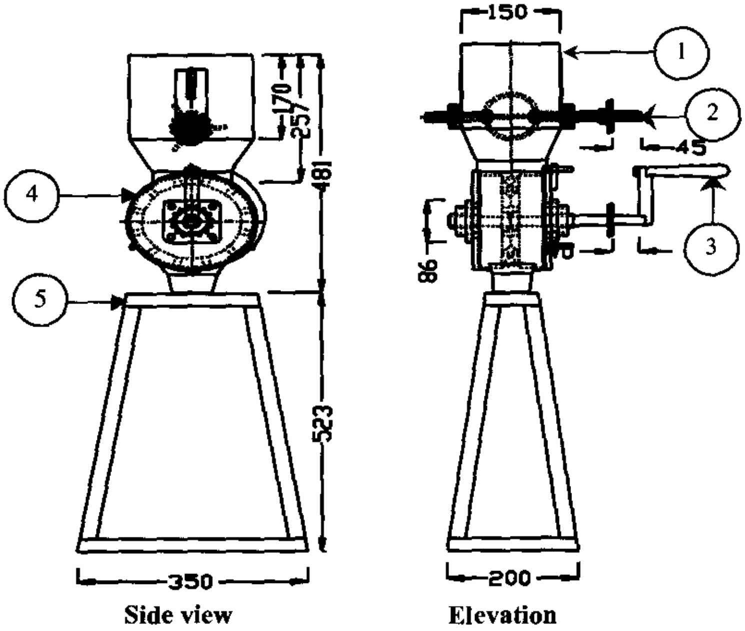
(1) S. D. is standard deviation. (2) C. V. is coefficient of variation.
L, W, T are length, width and thickness, respectively and D_g is geometric mean diameter.

Table 2. Tested gates for three garlic cloves grades

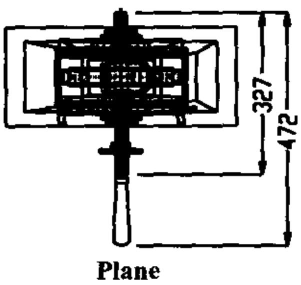
Cutoff dimension	Cloves grade.		
	Small	Medium	Large
Length, mm	37	39.5	44
Width, mm	31	33	35

Table 3. The designed and tested grooves dimensions for three sizes of Chinese garlic cloves

Cloves size	Groove Number	Groove dimensions, cm.		
		Length	Width	Depth
Small	13	3.0	2.0	2.0
Medium	12	3.5	2.5	2.5
Large	11	4.5	3.3	3.0

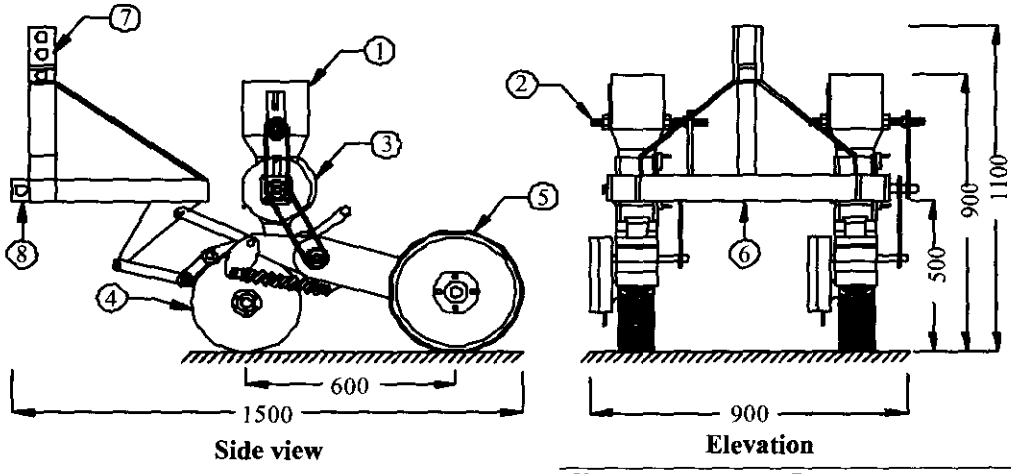


No.	Part name
1	Cloves box,
2	Agitator,
3	Manual hand,
4	Metering device,
5	Frame.



Dims. in mm.

Fig. 1. The three views of the test rig



No.	Part name
1	Cloves box,
2	Agitator,
3	Metering device,
4	Double disc furrow opener,
5	Ground wheel,
6	Tool bar,
7	Upper hitching point,
8	Two lower hitching points.

Dims. in mm.

Fig. 2. Elevation and side views of the developed garlic-cloves planter

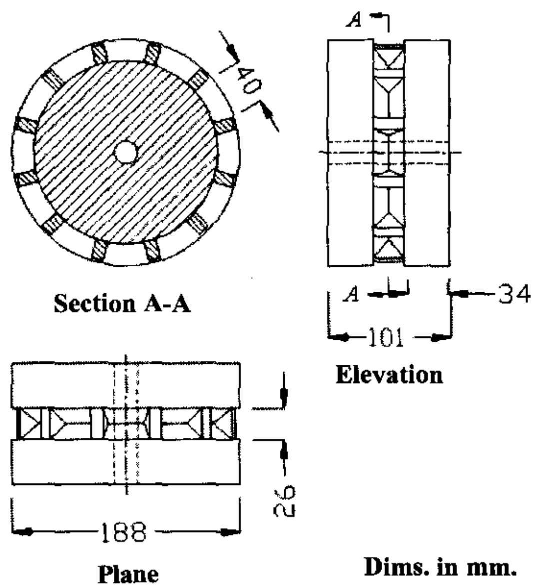


Fig. 3. Metering device of garlic-cloves

Furrow opener

A V-double discs furrow opener made of steel, had 310 mm diameter, 6 mm thickness and angle between discs of 9 degree which were taken from scraped John Deere planter were set in the developed garlic-clove planter.

Covering device

Zero pressure ribbed rubber soft center press-wheel with diameter of 400 mm and width of 100 mm which was taken from scraped John Deere planter set in the developed garlic-clove planter. The motion was transmitted to the metering device from press wheel by chains and sprockets.

Transmission system

Transmission system consists of chains and sprockets. The transmission ratio between drive wheel (covering wheel) and metering-device shaft was 1 : 1.16.

Tractor

Nasr tractor of 50 kW (65 hp) was used for operating the planter.

Methods

Laboratory as well as field tests were carried out to study the effect of operating parameters on garlic-cloves planter performance.

Laboratory tests

Laboratory experiments were conducted to optimize the following parameters:

Metering-device speed

Six metering-device speeds of 10, 20, 30, 40, 50 and 60 r.p.m (0.10, 0.21, 0.31, 0.42, 0.52 and 0.63 m/s) corresponding to ground-wheel speeds of 9, 17, 26, 34, 43 and 52 r.p.m (0.21, 0.36, 0.54, 0.71, 0.90 and 1.26 m/s).

Agitator speed

Six agitator speeds of 10, 20, 30, 40, 50 and 60 r.p.m (0.04, 0.09, 0.13, 0.18, 0.22 and 0.27 m/s).

Cutoff clearance

Four cutoff clearances of zero, 10, 15 and 20 mm.

Cloves size

Three clove-size (categories) of 25 – 29, 30 - 34 and 35 - 40 mm.

To optimize the laboratory parameters, the following indicators were taken into consideration.

Cloves discharge

Cloves were collected in plastic bag during a certain number of feeding-shaft revolutions to estimate cloves discharge under the previously mentioned factors.

Cloves damage

For the previously-mentioned factors, the visible damage of cloves after passing through the metering device was calculated by the following equations (Yehia, 1993):

$$\text{Visible cloves damage, \%} = \frac{N_d}{N_T} \times 100$$

Where: N_d = Namber of damaged cloves.

N_T = Total No. of cloves.

Field experiments

Field experiments were carried out to optimize the following parameters:

(1) Four forward speeds of 1.40, 2.38, 3.44 and 4.73 km/h (metering-device speeds of 22, 43, 53 and 73 r.p.m and ground-wheel speeds of 25, 50, 62 and 85 rpm).

(2) Cutoff clearance of zero and 15 mm.

Medium clove-size of 30 – 34 mm was used during the field experiments.

To optimize the field parameters, the following indicators were taken into consideration.

Plant scattering

Plant scattering represents the overall difference between the actual and nominal cloves spacing in a percentage along a randomly selected 5 m length of each planted row. That is:

$$C.V, \% = \frac{\Sigma[(D-L_1)+(D-L_2)+(D-L_n)]}{n \times D} \times 100$$

Where: CV = Coefficient of Variation, D = Nominal cloves spacing (cm), L = Actual cloves spacing (cm) and n = Total number of cloves spacing measured.

Missing hills and double plants

Missing hills and double plants were calculated according to the following equations:

$$\text{Missing hills} = \frac{N_m}{N_a} \times 100$$

Where: N_m=Number of missing cloves in meter.

N_a = Number of adjusted cloves in meter.

$$\text{Double plants} = \frac{N_b}{N_a} \times 100$$

Where: N_b = Number of double cloves in meter.

Emergence ratio

The number of plantings per meter of the row was counted to determine emergence ratio according to the following formula:

$$\text{Emergence ratio} = \frac{A_p}{A_d} \times 100$$

Where: A_p = Average plant No. per meter.

A_d = Average No. of delivered cloves per meter.

Final garlic-yield

Two rows of garlic crop with 3-m length for each forward speed were harvested by manual tool and weighed by analog balance to determine total yield, cloves yield and bulbs yield.

Actual field capacity ($F.C_{act}$)

The actual field capacity was calculated using the following equation:

$$F.C._{act} = \frac{1}{T_t} \text{ fed./h}$$

Where: T_t = Actual time consumed for planting one faddan, h/fad.

Field efficiency (η_f)

Field efficiency was calculated using the following equation:

$$\eta_f = \frac{F.C._{act.}}{F.C._{th.}} \times 100 \quad \%$$

Where:- η_f = Filed efficiency, %.

$F.C._{act}$ = Effective field capacity, fed./h.

$F.C._{th}$ = Theoretical field capacity, fed./h.

Slip of ground (press) wheel

Slippage percentage was calculated by using the following equation (Awady, 1992).

$$\text{Slippage, \%} = \frac{d_{act} - d_{th}}{d_{th}} \times 100$$

Where: d_{act} = Actual distance.

d_{th} = Theoretical distance.

$$d_{th} = \text{No. of wheel revolutions} \times \pi \times \text{wheel diam.}$$

Fuel consumption

Fuel consumption was recorded by accurately measuring the decrease in fuel level in the fuel tank immediately after executing each operation.

Required power

Required power was calculated by using the following formula (Hunt, 1983):

$$P = F_c \times F_d \times \left(\frac{1}{3600}\right) \times C.V. \times 4270 \times \eta_{th} \times \eta_m$$

Where: P = Requirements power (kW), F_c = The fuel consumption (L/h.). F_d = Density of fuel (kg/L), C.V. = Calorific value of fuel (kcal/kg), η_{th} = Thermal efficiency of fuel and η_m = Mechanical efficiency of fuel.

Specific energy

Specific energy can be calculated by using the following equation:

$$\text{Specific energy (kW.h/fed.)} = \frac{P\ (kW)}{F.C_{act}\ (fed./h)}$$

Cost analysis

The hourly cost was calculated according to equation of (Awady, 1978) in the following form:

C = P/h [1/a + i/2+ t+r] + (1.2 w×f ×s) + m/144

Where:

C: Hourly cost, LE/h

P: Capital investment, LE

h: yearly operating hour, h

a: life expectancy of equipment in year.

i: Interest rate,%

t: Taxes and over heads,%

r: Repairs ratio of total investment ,%

1.2: A Factor including reasonable estimation of the oil consumption in addition to fuel.

w: Horse power of engine.

f: Brake specific fuel consumption in l/hp.h.

s: Price of fuel par liter, L.E/l

m: Labor wage rate par month in L.E.

144: Reasonable estimation of monthly working hours

Operational cost can be determined using the following equation:

$$\text{Operational cost} = \frac{\text{Hourly cost}}{\text{Effective field capacity}}$$

Cost per unit of production can be determined using the following equation:

$$\text{Cost per unit of production} = \frac{\text{Operational cost}}{\text{Crop yield}}$$

Results of Field Experiments

The discussion will cover the obtained results under the following heads:

Results of Laboratory Experiments

Effect of some different metering-device parameters on garlic cloves discharge

Representative discharge values versus metering device speed are given for the three sizes of garlic cloves through various agitator speeds in Fig. 4.

Data obtained show that increasing metering device speed from 10 to 60 rpm, measured for various agitator speeds of 10, 20, 30, 40, 50 and 60 rpm, decreased cloves discharge from 79.2 to 47.7, from 111.8 to 76.6, from 115.5 to 78.8, from 121.4 to 82.1, from 124.1 to 85.6 and from 125.3 to 85.8 kg/fed for small cloves size; from 187.8 to 134.6, from 220.6 to 165.2, from 227.9 to 168.5, from 235.5 to 171.3, from 244.8 to 173.8 and from 245.6 to 174.3 kg/fed for medium cloves size and from 163.4 to 127.8, from 193.0 to 162.6, from 212.6 to 167.2, from 246.7 to 171.4, from 256.5 to 173.8 and from 257.1 to 175.2 kg/fed for large cloves size at constant cutoff clearance of 15 mm.

The same trend was noticed under the other cutoff clearances of zero, 10 and 20 mm.

The decrease in garlic cloves discharge by increasing metering device speed is because the increase in speed means not enough time to fill all metering device grooves by garlic cloves resulting in low cloves discharge.

The increase in cloves discharge by increasing agitator speed may be due the increase in cloves numbers which are pushed by crank wings of agitator to the metering device grooves.

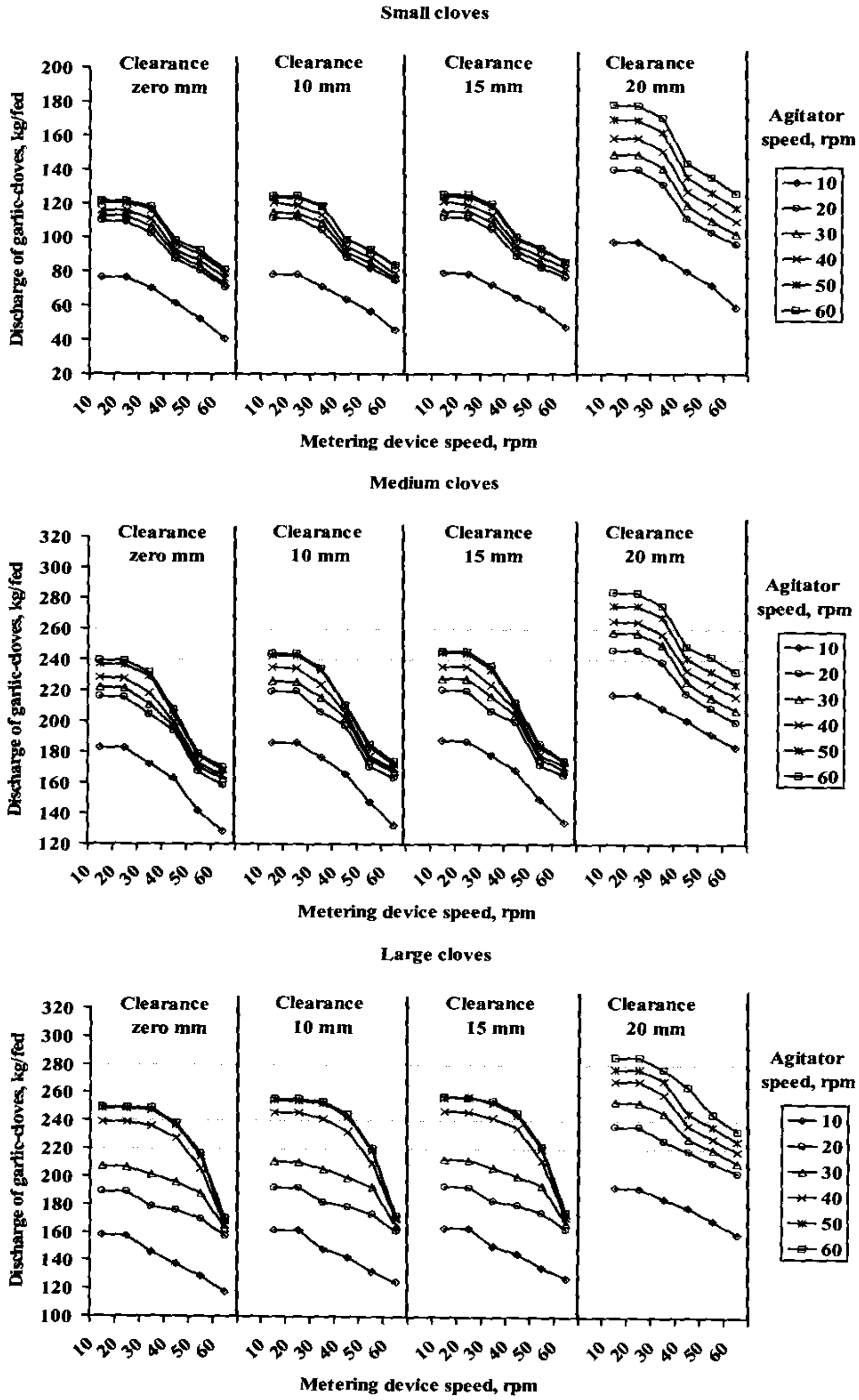


Fig. 4. Effect of metering-device speed, agitator speed and cutoff clearance on discharge of garlic-cloves

The increase in cloves discharge by increasing cutoff clearance is attributed to the high flow and the good dropping of cloves in the metering device grooves.

Effect of some different metering-device parameters on garlic cloves damage

Representative damage values versus metering device speed are given for the three sizes of garlic cloves through various agitator speeds in Fig. 5.

Data obtained show that increasing metering device speed from 10 to 20 rpm, measured for various agitator speeds of 10, 20, 30, 40, 50 and 60 rpm, decreased cloves damage from 4.8 to 4.3, from 4.2 to 4.0, from 3.8 to 3.5, from 3.6 to 3.1, from 3.1 to 2.5 and from 3.5 to 3.1% for small cloves size; from 2.9 to 2.5, from 2.6 to 1.9, from 2.3 to 1.7, from 1.7 to 1.3, from 1.5 to 0.8 and from 1.9 to 1.5% for medium cloves size and from 4.3 to 3.8, from 4.1 to 3.6, from 3.8 to 3.2, from 3.4 to 2.8, from 3.0 to 2.1 and from 3.5 to 2.8 % for large cloves size at constant cutoff clearance of 15 mm.

The same trend was noticed under the other cutoff clearances of zero, 10 and 20 mm.

The increase in garlic cloves damage at metering device speed of 10 rpm is due to increasing cloves jamming between metering device surface and the edges of agitator wings.

The increase in garlic cloves damage by increasing metering device speed from 20 to 60 rpm is due to increasing momentum of cloves.

The decrease in cloves damage by increasing agitator speed from 10 to 50 rpm may be due to decreasing the clove jamming and accumulation between agitator wings and metering-device surface.

The increase of cloves damage at agitator speed of 60 rpm may be due to entering of two cloves (in vertical location) in the same groove of metering device.

The decrease in cloves damage by increasing cutoff clearance from zero to 15 mm is due to decreasing the impact between clove dropped in metering device groove and the wall of cutoff hole in direction of cloves dropping from metering device (above double disc furrow opener).

The increase in cloves damage at cutoff clearance of 20 mm is due to increasing cloves jamming between metering-device surface and the bottom surface of cutoff.

Results of Field Experiments

Effect of forward speed and cutoff clearance on cloves emergence

Fig. 6 shows the effect of forward speed on garlic-plant emergence. The garlic-plant emergence decreased with increasing forward speed from 1.40 to 4.73 km/h and increased by increasing cutoff clearance from zero to 15 mm.

The maximum garlic-plant emergence of 99.81% was obtained with forward speed of 1.40 km/h and cutoff clearance of 15 mm. Meanwhile the minimum garlic-plant emergence of 98.05% was obtained with forward speed of 4.73 km/h and cutoff clearance of zero mm.

The decrease of garlic-plant emergence by increasing forward speed is due to the increase of metering device speed and the momentum of cloves which causes cloves damage accordingly. Added to that, the depth of planting could not be thoroughly adjusted at high speed that tends to decrease plant emergence. Meanwhile, the increase of garlic-plant emergence by increasing cutoff clearance is due to decreasing the clogging of cloves under the metering device.

Effect of forward speed and cutoff clearance on plant scattering

The plants distribution was analyzed in order to determine the coefficient of variation (CV) of garlic-plant spacing.

A low CV represents a row with more uniform seed spacing, while the vice versa was noticed with high values of CV. The plant scattering for different cutoff clearances and forward speeds were illustrated in Fig. 7.

The optimum conditions clarify that the forward speed of 3.44 km and cutoff clearance of 15 mm had the best longitudinal cloves distribution (CV of 19.6%).

The increase of plant scattering by increasing forward speed may be due to increasing ground-wheel slip. Whereas, the decrease of plant scattering by increasing cutoff clearance may be due to increasing cloves discharge.

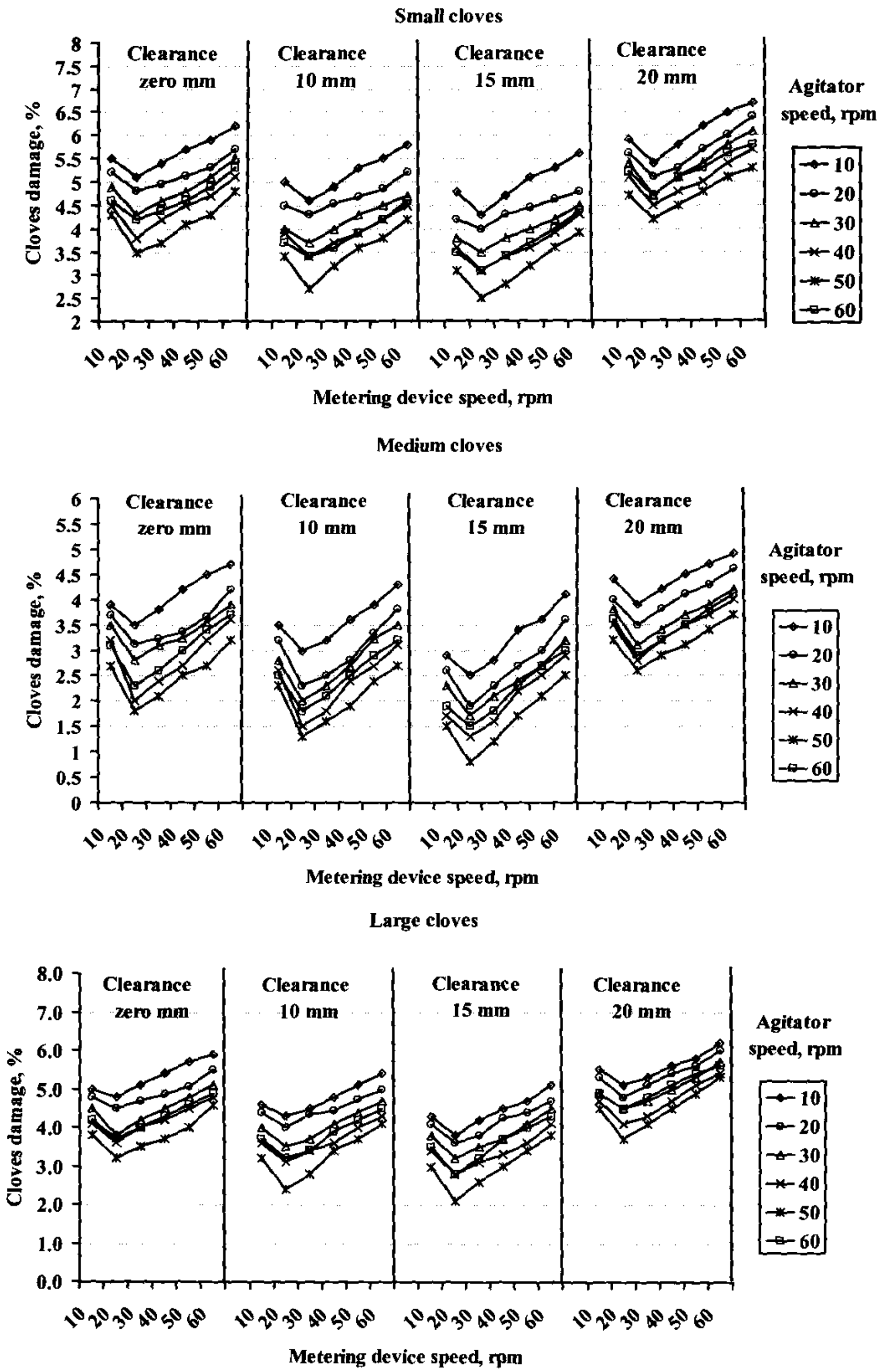


Fig. 5. Effect of metering-device speed, agitator speed and cutoff clearance on damage garlic-cloves

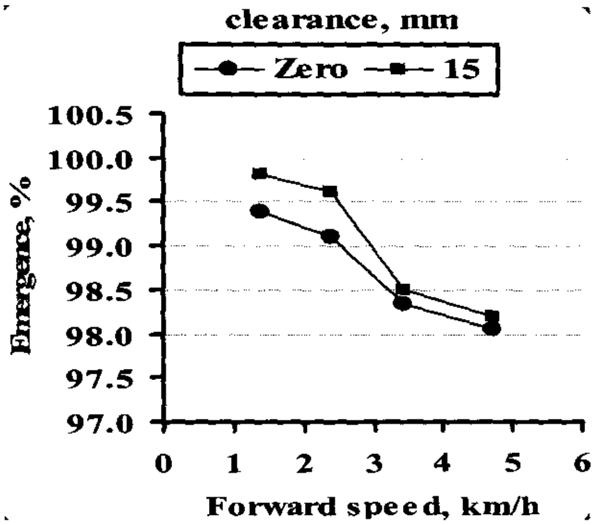


Fig. 6. Effect of forward speed and cutoff clearance on garlic-plant emergence

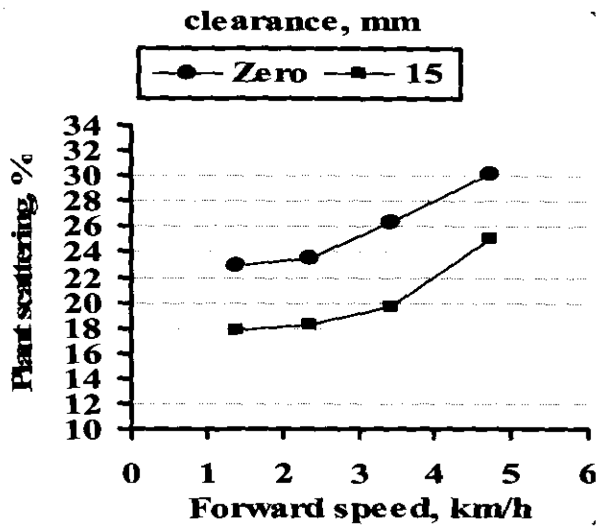


Fig. 7. Effect of forward speed and cutoff clearance on garlic-plant scattering

Effect of forward speed and cutoff clearance on missing hills and double plants

Figs. 8 and 9 show the effect of forward speed on missing hills and double plants.

Missing hills increased with increasing forward speed and decreased by increasing cutoff clearance.

Results show that increasing forward speed from 1.40 to 4.73 km/h, increased missing hills from 0.2 to 1.8% at constant cutoff clearance of 15 mm.

Double plants decreased with increasing forward speed and increased by increasing cutoff clearance from zero to 15 mm.

Results show that increasing forward speed from 1.40 to 4.73 km/h, decreased double plants from 20.6 to 6.6% at constant cutoff clearance of 15 mm.

The increase of missing hills by increasing forward speed may be due to increasing ground wheel slip.

Whereas, increasing double-cloves percent by increasing cutoff clearance may be due to increasing cloves discharge.

Effect of forward speed on final garlic yield

Fig. 10 shows the effect of forward speed and cutoff clearance on total yield, cloves yield and bulbs yield.

Total yield decreased with increasing forward speed and increased by increasing cutoff clearance. Cloves yield and bulb yield increased with increasing forward speed and increased by increasing cutoff clearance.

The maximum total yield of 7.2 tons/fad. was obtained with forward speed of 1.40 km/h and cutoff clearance of 15 mm. Meanwhile the minimum total yield of 4.07 tons/fad. was obtained with forward speed of 4.73 km/h and cutoff clearance of zero mm.

The decrease in total yield by increasing forward speed is due to the low plant emergence resulting from ground wheel slip at high speed. Also due to cloves damage occurred by the effect of the planting device.

The maximum cloves yield and bulbs yield of 2.42 tons/fad and 2.50 tons/fad. was obtained with forward speed of 3.44 km/h and cutoff clearance of 15 mm. Meanwhile the minimum cloves yield and bulbs yield of 1.44 tons/fad. and 1.52 tons/fad. was obtained with forward speed of 1.40 km/h and cutoff clearance of zero mm.

Effect of forward speed on machine field-capacity, efficiency and wheel slip

Fig. 11 shows the effect of forward speed on actual field-capacity, field efficiency and slip percent.

The maximum actual field capacity of 1.03 fed/h was obtained with forward speed of 4.73 km/h. Meanwhile, the minimum actual field

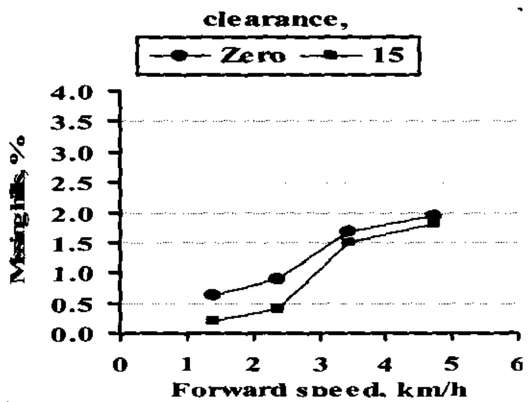


Fig. 8. Effect of forward speed and cutoff clearance on missing hills

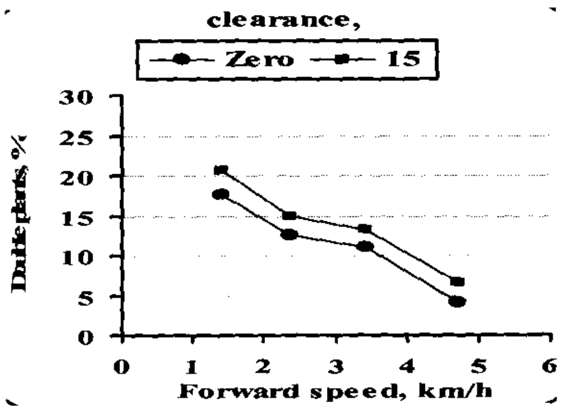


Fig. 9. Effect of forward speed and cutoff clearance on double plants

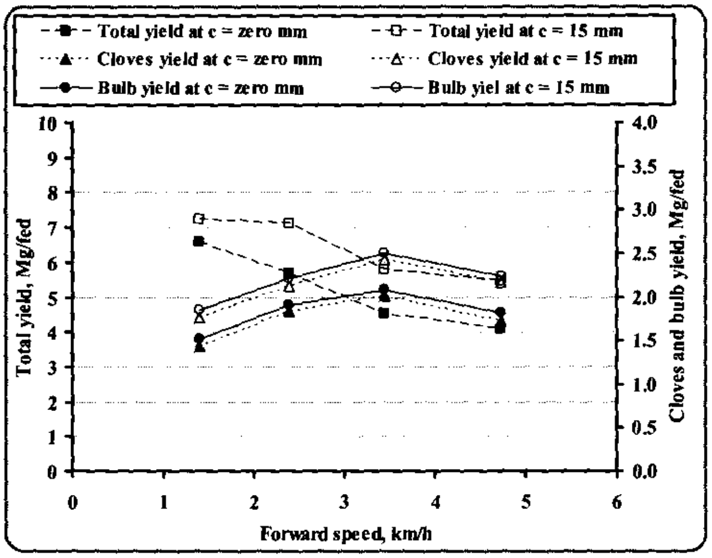


Fig. 10. Effect of forward speed and cutoff clearance on total yield, cloves yield and bulbs yield

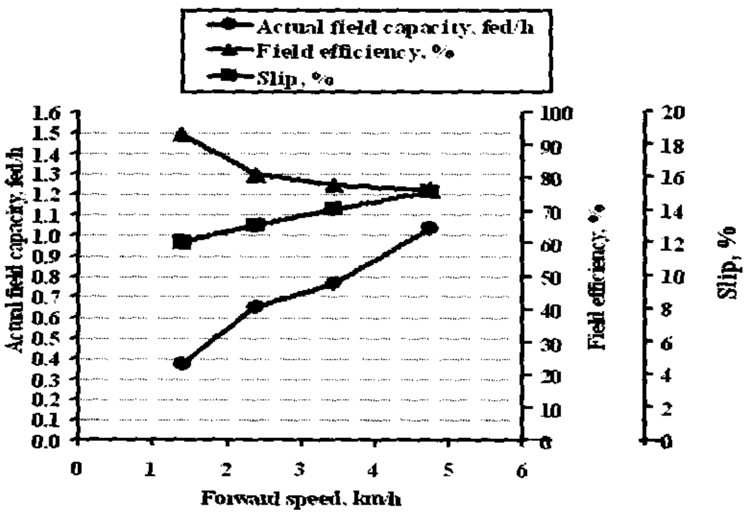


Fig. 11. Effect of forward speed on actual field capacity, field efficiency and slip percent

capacity of 0.37 fad./h was obtained with forward speed of 1.40 km/h.

The maximum field-efficiency of 93.22% was obtained with forward speed of 1.40 km/h. Meanwhile, the minimum field-efficiency of 76.32% was obtained with forward speed of 4.73 km/h.

The slip percent of press wheel increased with increasing forward speed. The maximum slip of 15.91 % was obtained with forward speed of 4.73 km/h. Meanwhile the minimum slip of 12.43 % was obtained with forward speed of 1.40 km/h.

Effect of forward speed on fuel consumption, required power and specific energy

Fig. 12 shows the effect of forward speed on fuel consumption, required power and specific energy.

The maximum fuel consumption, required power and specific energy of 1.52 L/h, 4.92 kW and 4.77 kW.h/fed were obtained with forward speed of 4.73 km/h. Meanwhile the minimum values of 0.46 L/h, 1.47 kW and 3.94 kW.h/fad. were obtained with forward speed of 1.40 km/h.

Cost of using the developed garlic-cloves planter

Representative values of both operational cost and cost per unit of production versus machine forward speed are given in figs. (13 and 14). Concerning the operational cost data obtained show that increasing forward speed from 1.40 to 4.73 km/h, decreased operational cost from 186.12 to 67.29 L.E/fad..

The minimum planting-costs at optimum conditions (forward speed of 3.44 km/h and cutoff clearance of 15 mm) were 90.78 L.E./fad. and 15 L.E./Mg. Meanwhile, the maximum planting costs of 186.12 L.E./fad. and 106.4 L.E./Mg were obtained at forward speed of 1.40 km/h and cutoff clearance of zero mm.

Conclusion

The obtained results reveal that maximum crop yield of 7.2 ton/fad. and minimum planting cost of 15 L.E/ton were achieved by using the developed garlic cloves planter under the following operating conditions:

- Metering device speed of 20 rpm.
- Agitator speed of 50 rpm.
- Forward speed of 3.44 km/h.
- Cutoff clearance of 15 mm.

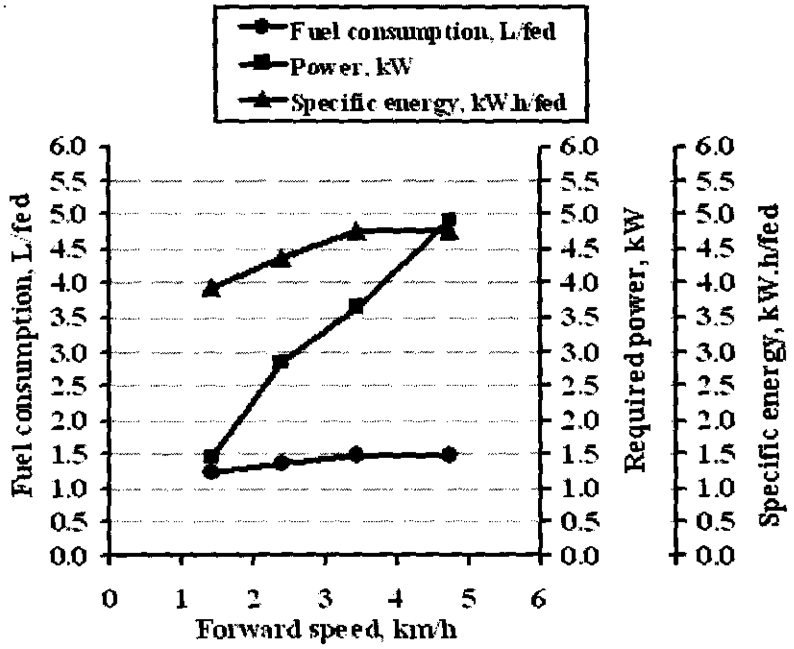


Fig. 12. Effect of forward speed on fuel consumption, required power and specific energy

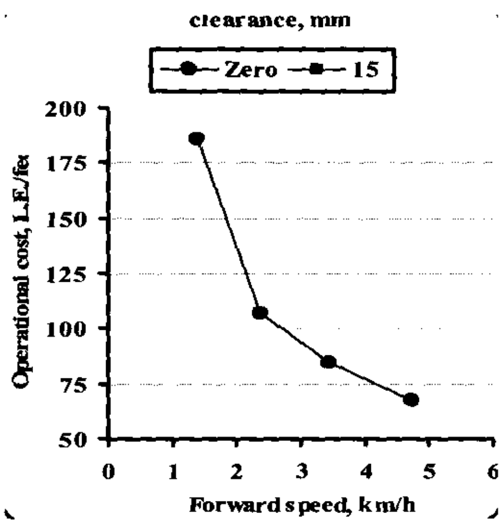


Fig. 13. Effect of forward speed and cutoff clearance on operational cost

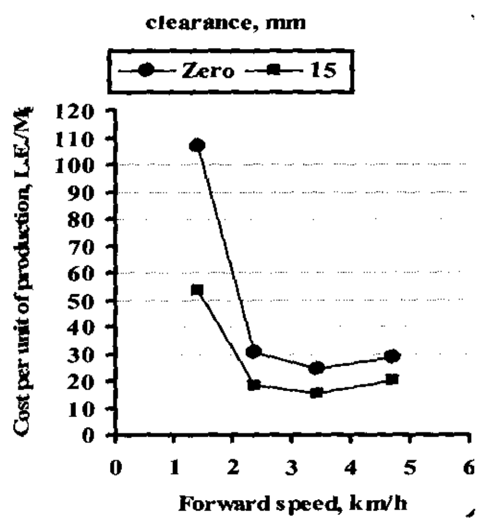


Fig. 14. Effect of forward speed and cutoff clearance on cost per unit of production

REFERENCE

Agric. Statistics Economic Affair Sector (2009). Agric. Statistics, Economical Issues Sector, Cairo, Egypt, 72-73.

Awady, M.N. (1978). Tractor and farm machinery. Text book, Faculty of Agric., Ain-Shams Univ., 164-167.

Awady, M.N., H.A. Abdel Mawla, I. Yehia and A.H. Mohamed (2000). Design of a drill metering-device for garlic cloves. 8th Conf. Misr Soc. Agr. Eng., 25–26, October 2000, 110-122. 110-122.

Bakhtiari, M.R. and M. Loghavi (2009). Development and evaluation of an innovative garlic clove precision planter. J. Agric. Sci. Tec., 11: 125–136.

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

El-Sharabasy M. M. A. and M. M. A. Ali (2011). Development and evaluation the planting unit of (Gaspardo planter) suits for planting garlic cloves. Misr J. Ag. Eng., 28 (2): 282–300.

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

Hunt, D.R. (1983). Farm power and machinery management seedling machines eight edition, 102-111.

Jarudchai, Y., K. Snoluch and B. Jiraporn (2002). Design and development of a garlic planter in Thailand. Agr. Eng. Dep., Fac. of Eng., King Mongkut's Ins. Tec. Lardkabang, Bangkok, Thailand, 10520: 1-10.

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.

Mohsenin, N.N. (1986). Physical properties of plant and animal materials. Gordon and Breach Sc. Pub., N. Y.

Rocha, F.E., C. De, T. Tsujimoto, S. Menezes, J. A. De and D. E. Castro (1991). Garlic planters with two the drill type mechanism. Informe Agropecuario, 15 (16): 37-39.

Yehia, I. (1993). Design of a seed drill attached to a power tiller, M. Sc. Th., Fac. of Agric. Ain Shams Univ.: 57-140.

Yehia, I. (1997). Factors affecting the design of a feeding device for crop seeders, Ph. D. Th., Fac. of Agric. Ain Shams, Univ., 109-116.

تطـــويـــر آلـــة محليـــة لـــزراعـــة فصـــوص الثـــوم

فاطمة الزهراء على عبد الجواد[1] – محمد محمد مراد حسن[2]

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يهدف البحث إلى تطوير آلة لزراعة فصوص الثوم تتكون من صندوق فصوص، قلاب كرنك ثلاثة أجنحة، ماسح البذور، جهاز تلقيم عبارة عن بكرة رأسية عليها تجاويف مثلثة الشكل، فجاج مزدوج القرص، عجلة لتغطية البذور. وتم تقييم الآلة معمليا وحقلياً. التجارب المعملية: تم فيها دراسة العوامل الآتية: ثلاثة أحجام من فصوص الثوم الصينى (٢٥ – ٢٩، ٣٠ – ٣٤، ٣٥ – ٤٠ مم)، ثلاثة أبعاد للتجاويف مثلثة الشكل (٣٠ × ٢٠ × ٢٠، ٣٥ × ٢٥ × ٢٥، ٤٥ × ٣٣ × ٣٠ مم)، ست سرعات لجهاز التلقيم (١٠، ٢٠، ٣٠، ٤٠، ٥٠، ٦٠ لفة/د أو ٠,١٠ ، ٠,٢١ ، ٠,٣١ ، ٠,٤٢ ، ٠,٥٢ ، ٠,٦٣ م/ث)، ست سرعات للقلاب (١٠ ، ٢٠ ، ٣٠ ، ٤٠ ، ٥٠ ، ٦٠ لفة/د أو ٠,٠٤ ، ٠,٠٩ ، ٠,١٣ ، ٠,١٨ ، ٠,٢٢ ، ٠,٢٧ م/ث)، وأربع خلوصات لماسح الفصوص (صفر ، ١٠ ، ١٥ ، ٢٠ مم)، وتم دراسة هذه العوامل على معدل التلقيم، تلف الفصوص. التجارب الحقلية: تم فيها دراسة تأثير أربع سرعات أمامية (١,٤٠ ، ٢,٣٨ ، ٣,٤٤ ، ٤,٧٣ كم/ساعة)، خلوصين لماسح الفصوص (صفر ، ١٥ مم)، على نسب الإنبات، انتظامية توزيع النباتات على طول الخط، الإنتاجية، انزلاق عجلة التغطية (التي تنقل الحركة لجهاز التلقيم)، استهلاك الوقود ومتطلبات القدرة والطاقة، معدل الأداء النظري والفعلي والكفاءة الحقلية، وحساب تكاليف الزراعة بالآلة. وكانت النتائج كالآتي: أعطت سرعة جهاز تلقيم ٢٠ لفة/د وسرعة قلاب ٥٠ لفة/د عند خلوص ١٥ مم معدل تصرف للفصوص ١٧٤,٠ – ١٧١,٨ – ٨٢,٢ كج/فدان وأقل نسبة تلف للفصوص ٢,١ – ٠,٨ – ٢,٥ % لفصوص الثوم الكبيرة والمتوسطة والصغيرة الحجم على الترتيب. أعطت السرعة الأمامية للآلة ٣,٤٤ كم/س عند خلوص ١٥ مم أفضل إنتظامية توزيع للفصوص (١٩,٦ %) وأعلى إنتاجية فصوص للفدان (٢,٤٢ طن/فدان) وأعلى إنتاجية رؤوس للفدان (٢,٥٠ طن/فدان) وأقل تكاليف إنتاج (١٥,٠ جنية/طن).