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DEVELOPMENT AND PERFORMANCE EVALUATION OF A NEW PNEUMATIC PRECISION METERING DEVICE FOR PLANTING MEDICINAL AND AROMATIC CROPS

Ola T.E. Ahmad[1*], M.M. Morad[1], M.M. Ali[1] and M.H. Abo-Elnaga[2]

1. Agric. Eng. Dept., Fac. Agric., Zagazig Univ., Egypt.
2. Agric. Eng. Inst., Agric. Res. Cen., Dokki, Egypt.

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ABSTRACT: The aim of the present work is to develop a simple and low cost pneumatic metering device to be suitable for planting some medicinal and aromatic seeds (dill and coriander). To fulfill this objective, a developed planter with the pneumatic precision metering device was fabricated and tested in both laboratory and field. The performance of the developed planter was studied under some different operating conditions and compared to the traditional method. Physical and mechanical properties of seeds were investigated to optimize the design of the planters components. The experimental results in laboratory revealed the following: The feeding rate and the application rate of dill and coriander seeds increased with increasing the metering device rotational speed, increasing vacuum tube hole numbers and increasing forward speed. The experimental results in the field revealed the following: The field capacity recorded (0.20 and 0.016 fad./hr.) and (0.29 and 0.025 fad./ hr.) for dill and coriander crops with the developed machine and manual planting respectively. While field efficiency recorded (95.25 and 95.35%) for dill and coriander crops with the developed planter. At longitudinal direction; the maximum values of coefficient of variation recorded (34.67 and 27.73%) for dill and coriander crops with manual planting, while the minimum values recorded (11.75 and 5.97%) for dill and coriander crops with the developed planter. The highest values of seed yield recorded (0.317 and 0.975 Mg/fad.) with the developed planter and manual planting for dill and coriander crops, respectively. The minimum values of consumed energy were (14.21 and 19.99 kW.hr./fad.) for coriander crop with manual planting and the developed planter. While the maximum values were (22.2 and 28.98 kW.hr./fad.) for dill crop under the same conditions. The lowest cost per unit of production it recorded (24.88 and 73.62 LE/fad.) for dill crop with the developed planter and manual planting, respectively. While with coriander crop it recorded (149.43 and 356.36 LE/fad.) under the same conditions.

Key words: Vacuum, pneumatic, precision, dill, coriander, metering, planting.

INTRODUCTION

The medicinal and aromatic crops are considered one of the most important untraditional agricultural commodities which can be used as a base for Egyptian national income development. The two main medicinal and aromatic crops are coriander (*Sativum coriandrum*) and dill (*Anethum graveolinus* L.). The cultivated area of these crops in Egypt reach up to 80000 Faddans (**FAO Statistical Year Book, 2017**).

Several types of metering devices are used for precision planters such as: a vacuum disk type, an inclined plate type, a belt type, a vertical rotor type, and a roller type. The roller metering device type is used most widely in the mechanized seeding of crops. It is generally known that the scattering of seeds is caused mainly by the improper design of the metering

* **Corresponding author: Tel. :** +201065727293
E-mail address: ola_taha2011@yahoo.com

device and seed tube. The effect of constructional properties (roll length, diameter, *etc.*) and operational variables (seed rate, travel speed, and seed spacing) on the flow metering device must be investigated. These include the produced vacuum pressure, physical and mechanical properties of seeds, the design feature of the metering mechanisms, seed quality, soil conditions, the skill of the operator and the operational conditions .

Shaaban (2010) tested a vacuum precision seeder prototype suitable for onion seeds and developed a mathematical model for predicting the optimum vacuum pressure of a precision vacuum seeder using onion seed properties, vacuum characteristics and the hole geometry of the seed plate. The precision vacuum seeder prototype was tested under four blower speeds, three seed plates with different hole diameters, four speeds of seed plate and three forward speeds. Soil bin and field tests showed that the most favorable conditions in terms of operating developed precision vacuum seeder will be 0.21 m/s disc speed at 4500 rpm blower speed with the seed plate of 1.0 mm hole diameter at 3.6 km/hr., forward speed for planting onion seeds under Egyptian conditions.

Karayel and Ozmerzi (2002) studied the effect of different forward speeds of hill dropping for some vegetable seeds using the seed metering unit of a precision vacuum seeder. They found that the coefficients of variation of hill distance and seed number in hill increased as forward speed increased for both seeds. The most suitable forward speed was 0.5 m/sec. Scattering distance ratios of forward speed 0.5 and 1.0 m/sec., were about 20 to 30%.

Kamel *et al.* (2003) investigated the effect of some operating factors on the uniformity of seeds distribution by using pneumatic seed drill comparing with mechanical seed drill at five different forward speeds after three levels of land preparation. The longitudinal and lateral scattering increased as the forward speed increased for both of the two drill seeders. The longitudinal and lateral scattering values ranged from 1.54 to 5.69 cm and from 0.18 to 2.85 cm, when the forward speed ranged from 0.56 to 2.34 m/sec., respectively under different land preparation levels.

M**orad *et al.* (2010)** showed that there was an inverse relationship between machine forward speed and emergence ratio. Increasing forward speed from 2.5 to 3.88 Km/hr., decreased emergence ratios from 92 to 88.2% and from 89 to 83.7% under 20 and 30 cm distance between plants in a row, respectively. The decrease in emergence ratio by increasing forward dispersion at high speeds resulting in low emergence ratio.

Adisa (2012) referred to crops usually planted using precision seed metering devices include most horticultural crops and maize, sorghum, sunflower, and beans. Typically, precision seed metering systems are used on what are generally as ‘row crop’ planters.

Locally, micro-seed crops lack planting machines, for this reason, such care had to be taken to design, develop and operate medicinal and aromatic crops planting machines with an accurate scientific guidance taking into consideration machine efficiency, seed uniformity, durability, energy, and cost requirements.

So, the objectives of this work are to:

1. Develop a pneumatic simple precision metering device from low cost and local material.
2. Estimate some different operating parameters affecting the performance of the developed seed metering device.
3. Fabricate a local planter with the precision metering device to be suitable for planting some medicinal and aromatic seeds.
4. Evaluate the developed planter from the economic point of view.

MATERIALS AND METHODS

This work aimed essentially to develop a simple and low-cost pneumatic precision metering device to suit planting some medicinal and aromatic seeds (dill and coriander) with a vacuum tube metering device by air suction. To fulfill this objective, a developed planter with the pneumatic precision metering device was fabricated in a local workshop at Meet - Ali - Dakahleia Governorate.

Materials

The used crops

Two medicinal and aromatic seeds (dill and coriander) were used. The physical and mechanical properties of these crops were showed in Table 1.

The developed planter

The developed planter was designed specifically for this work and was constructed at a private work shop in Dakahleia Governorate. The main dimensions of the developed planter are tabulated in Table 2 and Fig. 1.

The developed planter consists of the following main parts:

The frame

The frame was made of Beam Steel U-shaped of 12 × 6 cm with 105 cm of length, 50 cm of width and 76 cm of high, It was supported by three hitch points to suspension the planter behind the tractor. The frame is carried and fixed on the axial steel with two rubber wheels at a diameter of 50 cm. At the end of the frame, two steel rods at length of 80 cm were fixed with two furrow openers and cover wheel at a diameter of 20 cm and length of 25 cm. The steel rods can be adjusted at a suitable distance.

The seed hopper

The seed hopper is simple built and made of galvanized thin sheet iron (1mm) thick, the bottom side of seed hopper represent the form of a rectangular at dimensions of 95 × 15 cm, The front side of the seed hopper was formed as a rectangular at dimensions of 95 × 20 cm at a vertical position, while the rear side of the seed hopper as represented a rectangular at dimensions of 95 × 25 cm at a slope angle of 135 degrees, the upper side of the seed hopper represent the cover at dimensions of 95 × 30 cm, the inside size of seed hopper is divided into two sections by one barrey. The rear side of the seed hopper has two gates to deliver seeds. The funnel of plastic sheet was connected with a plastic tube to drop the seeds in the soil furrow.

The feeding device

The feeding device (A vacuum tube metering device) was made of aluminum tube at length of 65 cm, diameter of 5.08 cm and thick of 0.1 cm. At the tube perimeter, there are holes at diameters of 2 and 3 mm that are arranged as a circle form to be suitable for dill and coriander seeds. Also, a drum steel rod with a rubber lining at length of 50 cm and diameter of 2 cm was installed inside the feeding tube and touching the surface from the inside toward the gate out of delivering seeds to prevent air to permit seeds to flow out. The feeding device is fixed with two silicon bases at the bottom of seed hopper, one side of the tube is connected with suction engine by a plastic tube at diameter of 4.5 cm and length of 65 cm while, the other side is fixed with steel shaft at diameter of 2.5 cm with transmission gears at different teeth numbers of 15, 18 and 22 and the ground wheel by gear of 61 teeth.

Power source

Four-wheel tractor (Kubota V 1702 - DI-A) 34 HP (25.4 kW) Diesel engine was used in this study for operating the developed planter.

Vacuum cleaner motor

Vacuum cleaner motor was used for operating the feeding device with the following specifications (Table 3).

Power inverter

Power inverter was used to transform the battery capacity of 12 volts DC to 220 volts AC ability to operate the vacuum cleaner motor.

Methods

The experiments were divided into two separated parts: the first part was conducted in the laboratory under control conditions, while the second part was carried out in the field through two successful agricultural seasons of 2016 and 2017.

Laboratory Tests

Experimental conditions of laboratory tests

Laboratory tests were conducted under the following conditions:

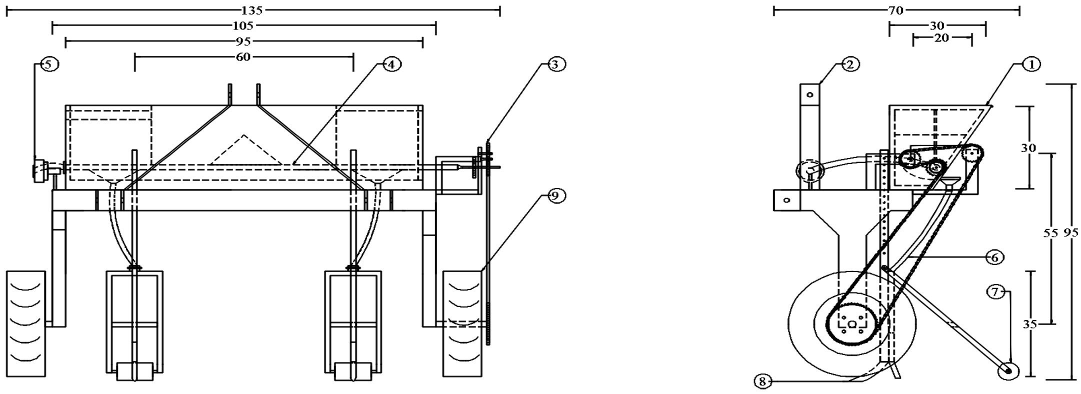
- Rotational speed of a vacuum tube of the metering device was varied as the following (15, 18 and 21 rpm), (29, 35 and 42 rpm) and (32, 40 and 48 rpm), respectively, under gears teeth numbers (15, 18 and 22 teeth).

Table 1. Physical and mechanical properties of dill and coriander seeds

	Property	Seeds	
		Dill	Coriander
Physical properties	Length, mm	3.88	-------
	Width, mm	1.84	-------
	Thickness, mm	1.2	-------
	Dimensions(Major), mm	-------	4.03
	Dimensions(Medium), mm	-------	3.42
	Dimensions(Minor), mm	-------	3.11
	Mass of 1000 seeds, g	3.18	8.60
	Seed moisture content (%)	5.53	5.85
	Volume, mm^3	8.57	19.56
	Arithmetic diameter, mm	2.30	------
	Geometric diameter, mm	2.85	3.49
	Surface area, mm^3	25.52	35.20
	Sphericity (%)	0.74	86.65
	Seed bulk density, g/cm^3	0.432	0.290
	Porosity (%)	61.88	63.84
Mechanical properties	Coefficient of friction	0.43	0.86
	Angle of repose (^{o})	31	28

Table 2. The main dimensions of the developed planter

Item	Value
Total length	135 cm
Total width	70 cm
Total height	100 cm
Total mass	87.6 kg



Elevation view

Side view

Dimensions in mm.

No.	Part name	No.	Part name	No.	Part name
1	Seed hopper	2	Hitch points	3	Gear
4	Feeding device	5	Vacuum cleaner motor	6	Planting tube
7	Seed covering wheel	8	Runner opener	9	Land wheal

Fig. 1. Elevation and side view of the developed planter

Fig. 2. Photo of the feeding device

Table 3. The main specifications of the used vacuum cleaner motor

Item	Value
Model	Class B
Current intensity	6.36 A
Electrical capacity	1400 W
Electrical power	220 V
RPM	32000
Electrical frequency	50/60 HZ

- Forward speeds of (0.65, 1.03 and 1.45 km/hr.).
- The vacuum tube holes numbers were adjusted as the following; (14, 19 and 28 holes per row).

According to preliminary experiments air stream velocity inside a vacuum tube metering device was kept constant and adjusted at 0.1 and 0.2 m/sec., for dill and coriander, respectively.

Before the field experiments, the machine was calibrated in the laboratory by the way of collecting the delivered seeds at different vacum tube rotational speeds and hole number to limit seeds feeding rate in kg/hr., and application rate in kg/fad.

Measurements of laboratory tests

The delivered seeds were collected during on certain duration at different vacum tube rotational speeds and different vacum tube hole numbers and weighed for measuring seed feeding rate in kg/hr., and application rate in kg/fad.

Field Experiments

Filed experiments were carried out to evaluate the developed planter compared to the manual planting during sowing dill and coriander crops. Depending on laboratory tests, filed experiments were conducted under constant forward speed of 1.45 km/hr., constant vacum tube hole number of 14 and rotational speed of 32 rpm.

Dill and coriander experiments

The dill and coriander balady variety was used in the field experiment. For both of dill and coriander crops, the experimental area was about 0.5 faddan divided into 6 equal plots having dimensions of 60 × 5.8 m per each. Two treatments namely, A (Mechanical planting by the developed machine) and B (Manual planting) were carried out and replicated three times in a completely randomized block design. The feeding rate of seeds was 2 kg/fad., for mechanical sowing and 2.5 kg/fad., for the manual planting while they were 6 and 7.5 kg/fad., for coriander and mechanical sowing and manual planting, respectively.

Measurements of Field Experiments

Plant characteristics

- Average germination ratio.
- Average number of plants per m^2 (plant population).
- Average uniformity of plants distribution.
- Average weight of fresh plant (dill) per m^2 and per faddan.
- Average weight of seed yield (dill and coriander) per m^2 and per faddan.

Uniformity of plant distribution

The uniformity of plant distribution was measured by using the following method. Deviation in the longitudinal direction from average number of plants at a standard length of 2 meters, the deviation of the plant from average number of the plant at a standard length of 2 meters was estimated according to the following equation:

$$CV = \frac{\sigma_{n-1}}{\overline{X}} \times 100$$

Where:

CV = Coefficient of variation in the longitudinal direction from average number of the plant at standard unit length.

$$\sigma_{n-1} = \sqrt{\frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1}}$$

Where:

σ_{n-1} = standard deviation, Σx = Summation of the number of plants on the longitudinal direction, Σx^2 = Summation of a square number of plants on the longitudinal direction, $\overline{X}$ = Average number of the plants at standard length, and n = Number of reading.

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

Field capacity and field efficiency

The theoretical field capacity of the sowing machine is the rate of field coverage. This will be obtained if the machine performed 100% of the time at the rated forward speed. It was determined from the following formula:

$$P_{th} = \frac{S \times W}{4200}$$

Where:

P_{th} = Theoretical productively of the machine, (fad./ hr.), S = Travel speed, (m/hr.), and W = Rated width (m).

The effective field capacity is the actual average rate of field coverage by the amount of actual time (lost time + productive time) consumed in the operation. It can be determined from the following equation.

$$P_{act} = \frac{60}{T_u + T_i}$$

Where:

P_{act} = The actual field capacity of the machine, (fad./ hr.), T_u = The utilized time per fad., in minutes, T_i = The summation of time lost per fad., in minutes.

The field efficiency of the machine (η_f) is calculated by using the following formula:

$$\eta_f = \frac{P_{act}}{P_{th}} \times 100$$

Human energy

For each operation, the consumed human energy (EH), was estimated based on the power of one laborer, which considered to be about 0.0746 kW (0.1 hp) (**Megbowon and Adewunmi, 2002**). Number of workers in the manual methods was 8 workers, and number of workers in Mechanical planting by developed machine was 1 worker. Human energy can be calculated as follows:

$$E_H = \frac{N_L \times 0.074}{P_{act}}$$

Where:

E_H = human energy, (kW.hr./fad.), N_L = number of laborers, (man), and P_{act} = Actual field capacity, (fad./hr.).

Mechanicals energy

Estimation of the required engine power (EP) for the different mechanical sowing treatments was carried out accurately by measuring the decrease in gasoline level in the fuel tank immediately after executing each sowing operation (**Hunt, 1983**):

$$E_p = \frac{F.c_h}{3600} \times P_f \times LCV \times 427 \times \eta_{th} \times \eta_m \times \frac{1}{75} \times \frac{1}{1.36}$$

Where:

E_p = Required engine power, (kW), $F.c_h$ = Fuel consumption rate (lit/hr.), P_f = the density of fuel (kg/lit) (0.85 and 0.73 kg/l for diesel and gasoline fuel, respectively), LCV = the lower calorific value of fuel (k.cal/kg), mean LCV of solar is 10000 k.cal/kg, η_{th} = the thermal efficiency of the engine, considered to be about 40 and 25% for diesel and gasoline respect, 427 = thermo-mechanical equivalent, (kg.m/kcal), and η_m= the mechanical efficiency of the engine, consider to be 80% for diesel and gasoline engine.

$$E_p = 3.16\ F.c_h \quad kW.$$

The engine energy required for each sowing treatment was calculated by using the following equation (**Hunt, 1983**):

$$\text{Mechanical energy (kW.hr./fad.)} = \frac{E_p\,(kW)}{P_{act}\ (fad./hr.)}$$

Total demand energy

Total demand energy was calculated as follows:

Total demand energy (kw.h/fed) = Human energy + Mechanicals energy.

Cost analysis

The machine hourly cost was calculated according to the conventional method of estimating both fixed and variable costs (**Hunt, 1983**).

The operational cost was calculated as follows:

$$\text{Operational cost (LE/fad.)} = \frac{\text{Machine hourly cost (LE/hr.)}}{\text{Field capacity (fad./hr.)}}$$

Cost per unit of production was calculated as follows:

$$\text{Cost per unit of production (LE/Mg)} = \frac{\text{Operational cost (LE/fad.)}}{\text{Crop yield (Mg/fad.)}}$$

RESULTS AND DISCUSSION

The obtained results under laboratory experiments were discussed under the following topics:

Laboratory Results

Effect of some operating parameters on dill seeds feeding rate

Fig. 3 shows the effect of different hole number in a vacuum tube metering on the feeding rate of dill seeds under the different rotational speeds of a vacuum tube metering device and forward speeds. The results indicated that, the feeding rate of dill seeds increased from 0.076 to 0.153, from 0.095 to 0.19 and from 0.114 to 0.228 kg/hr., by increasing of hole number in a vacuum tube metering device from 14 to 28 holes at constant forward speed of 0.65 km/hr., and different rotational speed of a vacuum tube metering device of 15, 18 and 21 rpm., respectively. While, Fig. 3 showed that, the feeding rate of dill seeds increased from 0.123 to 0.246, from 0.151 to 0.302 and from 0.187 to 0.362 kg/hr., at different rotational speeds of a vacuum tube metering device of 29, 35 and 42 rpm. under the same previous values of hole number in a vacuum tube metering device at forward speed of 1.03 km/hr. Too, Fig. 3 showed that the feeding rate of dill seeds increased from, 0.173 to 0.346, from 0.212 to 0.424 and from 0.254 to 0.509 kg/hr., under rotational speed of a vacuum tube metering device of 32, 40 and 48 rpm., the same previous values of hole number in a vacuum tube metering device at forward speed of 1.45 km/hr.

Data analysis confirmed the presence of a strong relationship between the holes numbers in a vacuum tube metering device and feeding rate of dill seeds. The increase in feeding rate is due to the increase in the hole number and the number of times of rotation of the vacuum tube in the time unit.

Effect of some operating parameters on the application rate of dill seeds

Fig.4 shows the effect of different rotational speeds of a vacuum tube metering device and different hole number of a vacuum tube metering device on the application rate of dill seeds at forward speed of 0.65 km/hr. The results indicated that, the application rate of dill seeds increased from 0.890 to 1.340, from 1.208 to 1.806, from 1.784 to 2.660, from 2.098 to 3.146, from 2.674 to 4.000 and from 3.882 to 5.806 kg/fad., by increasing vacuum tube rotational speed from 15 to 21 rpm under hole number of 14, 19, 28, 33, 42 and 61 holes, respectively. While, at forward speed of 1.03 km/hr., Fig. 4 indicated that, by increasing vacuum tube rotational speed from 29 to 42 rpm the application rate of dill seeds increased from 1.432 to 2.108, from 1.784 to 2.864, from 1.948 to 4.222, from 2.098 to 4.972, from 2.674 to 6.330 and from 3.882 to 9.594 kg/fad., under the same previous conditions. Too, at forward speed of 1.45 km/hr., Fig. 4 showed that by increasing vacuum tube rotational speed from 32 to 48 rpm the application rate of dill seeds increased from 2.016 to 2.964, from 2.736 to 4.024, from 4.032 to 5.932, from 4.752 to 6.988, from 6.048 to 8.896 and from 8.784 to 12.920 kg/fad., under the same previous conditions.

Effect of some operating parameters on coriander seeds feeding rate

Fig. 5 shows the effects of different vacuum tube hole number on the feeding rate of coriander seeds under different rotational speeds of the vacuum tube metering device and different forward speeds. The results indicated that, the feeding rate of coriander seeds increased from 0.209 to 0.419, from 0.257 to 0.514 and from 0.308 to 0.617 kg/hr., by increasing hole number of vacuum tube metering device from 14 to 28 holes at forward speed of 0.65 km/hr., and different rotational speeds of vacuum tube metering device of 15, 18 and 21 rpm., respectively. While, Fig. 5 at forward speed of 1.03 km/hr., and the same previous values of hole number of vacuum tube metering device, the results showed an increase in the feeding rate of coriander seeds from 0.332 to 0.666, from 0.409 to 0.817 and from 0.489 to 0.979 kg/hr., at different rotational speeds of vacuum tube metering device of 29, 35 and 42 rpm., respectively. Too, Fig. 5 at forward speed of 1.45 km/hr., and the same previous values of hole number of vacuum tube metering device, the results showed an increase in the feed rate of coriander seeds from, 0.467 to 0.935, from 0.573 to 1.146 and from 0.687 to 1.376 kg/hr., under rotational speed of vacuum tube metering device of 32, 40 and 48 rpm., respectively.

Data analysis confirmed the presence of a strong relationship between the hole number of a vacuum tube metering device and feeding rate of coriander seeds. The increase in feeding rate is due to the increase in the hole number and the numbers of times of rotation of the feed tube in the time unit.

Effect of some operating parameters on the application rate of coriander

Fig. 6 shows the effect of different rotational speeds of a vacuum tube metering device and

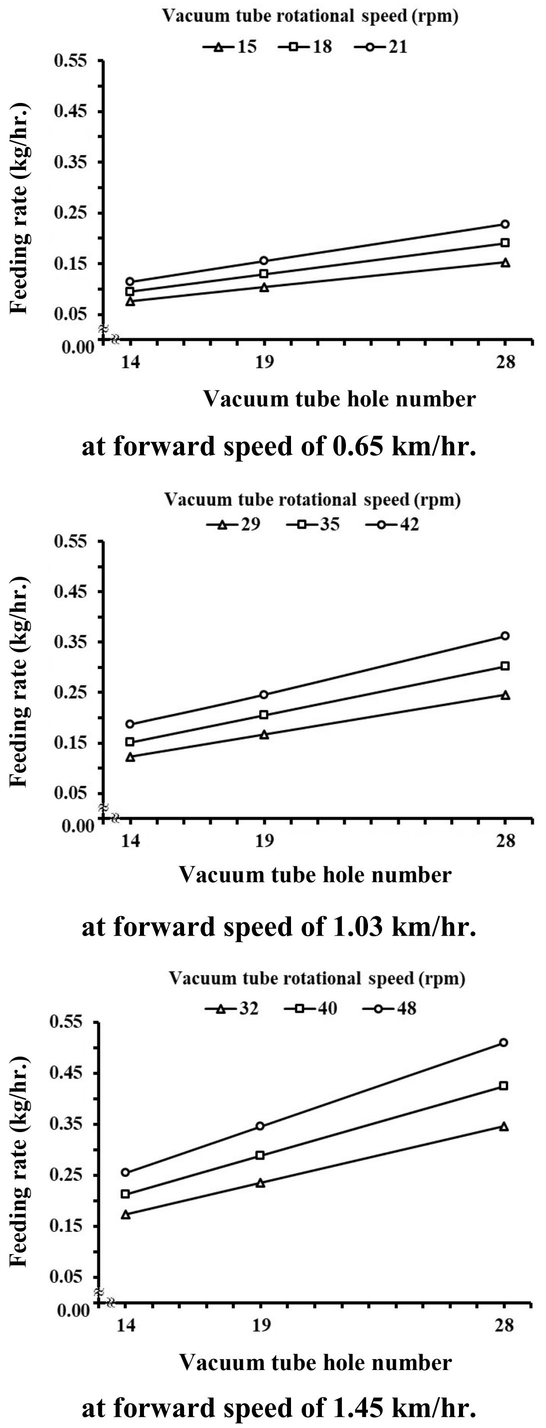


Fig. 3. Effect of vacuum tube hole number on the feeding rate of dill seeds under different vacuum tube rotational speeds at different forward speeds

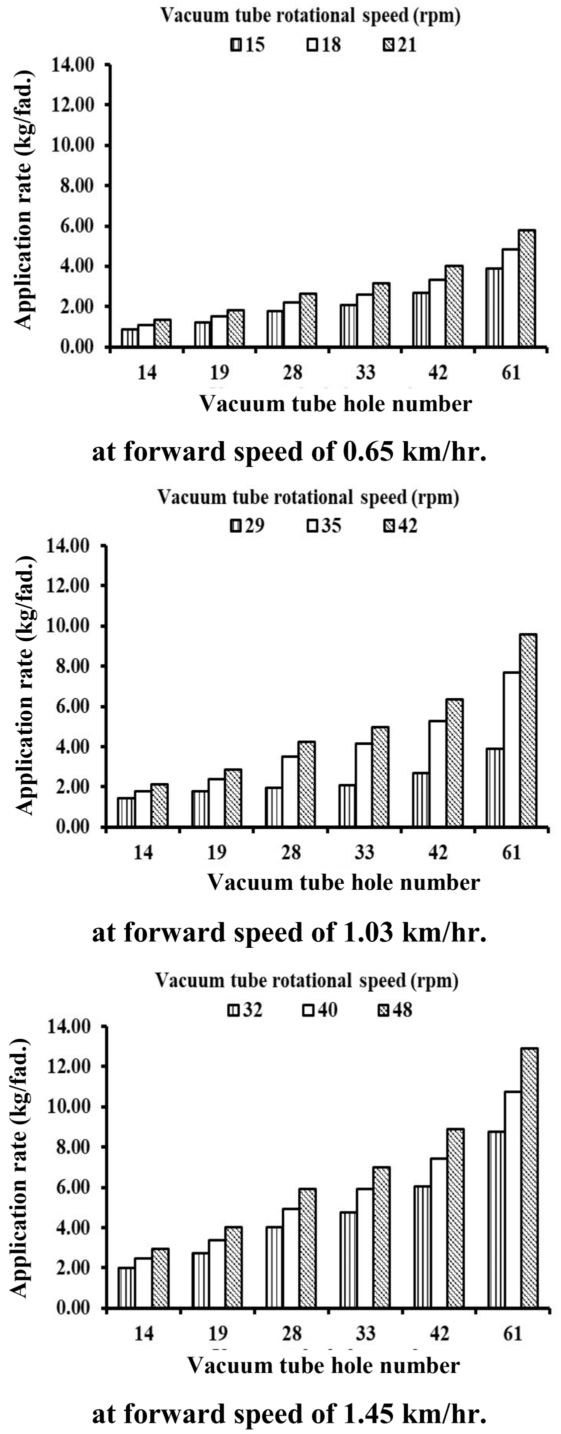
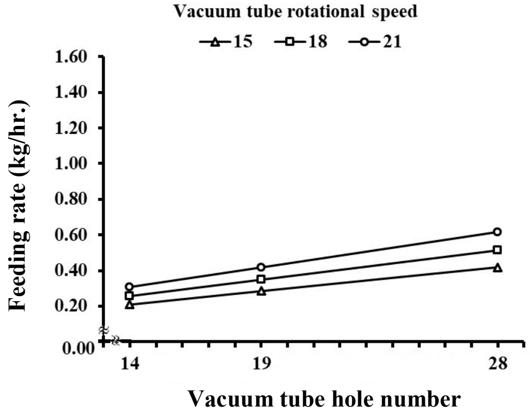
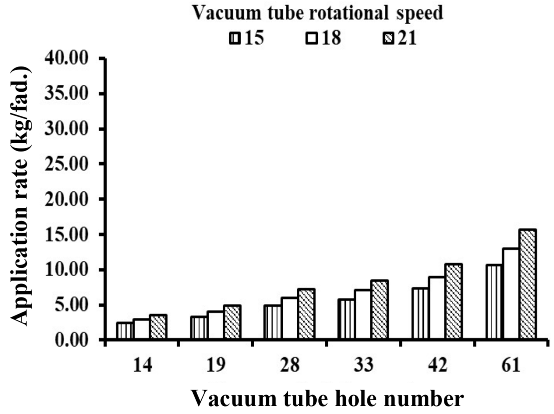


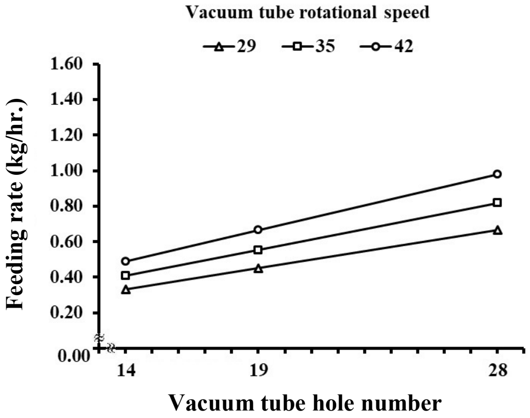
Fig. 4. Effect of vacuum tube rotational speed and vacuum tube hole number on the application rate of dill seeds at different forward speeds



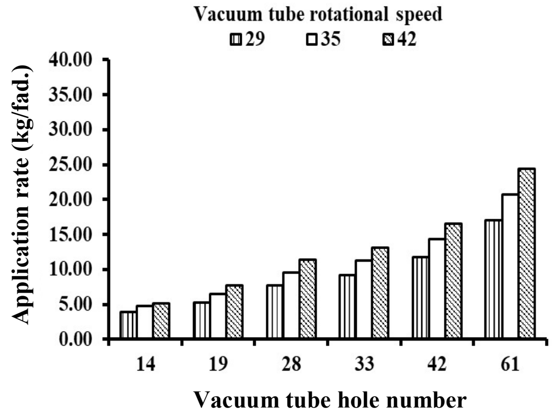
at forward speed of 0.65 km/hr.



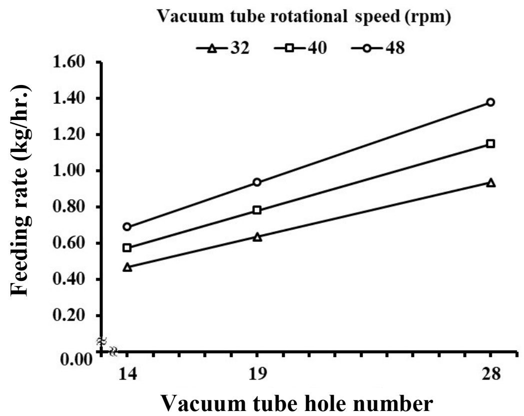
at forward speed of 0.65 km/hr.



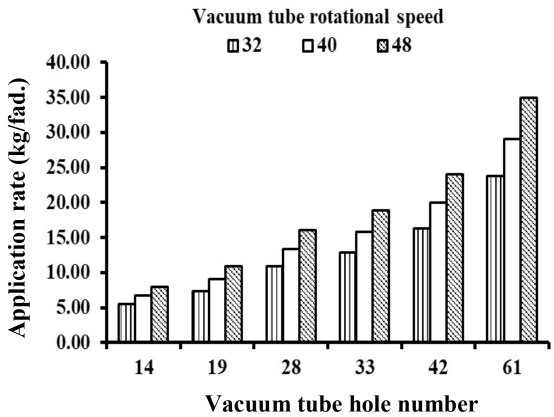
at forward speed of 1.03 km/hr.



at forward speed of 1.03 km/hr.



at forward speed of 1.45 km/hr.



at forward speed of 1.45 km/hr.

Fig. 5. Effect of vacuum tube hole number on the feeding rate of coriander seeds under different vacuum tube rotational speed at different forward speeds

Fig. 6. Effect of vacuum tube rotational speed and vacuum tube hole number on the application rate of coriander seeds at different forward speeds

different hole number of a vacuum tube metering device on the application rate of coriander seeds at forward speed of 0.65 km/hr. The results indicated that, the application rate of dill seeds increases from 2.442 to 3.589, from 3.322 to 4.867, from 4.8 86 to 7.200, from 5.764 to 8.474, from 7.328 to 10.798 and from 10.65 to 15.674 kg/fad., by increasing in rotational speed of a vacuum tube metering device from 15 to 21 rpm., under holes numbers of 14, 19, 28, 33, 42 and 61 holes, respectively. While, at forward speed of 1.03 km/hr., Fig. 6 indicated that, by increasing of rotational speed of a vacuum tube metering device from 29 to 42 rpm., the application rate of coriander seeds increases from 3.966 to 5.166, from 5.272 to 7.752, from 7.764 to 11.424, from 9.238 to 13.098, from 11.730 to 16.590 and from 17.00 to 24.342 kg/fad., under the same previous conditions. Too, at forward speed of 1.45 km/hr., Fig. 6 referring to, at increasing rotational speed of a vacuum tube metering device from 32 to 48 rpm., the application rate of coriander seeds increased from 5.452 to 8.016, from 7.404 to 10.882, from 10.906 to 16.048, from 12.856 to 18.898, from 16.358 to 24.064 and from 23.762 to 34.946 kg/fad., under the same previous conditions.

Field Results

Effect of different planting methods on the uniformity of plant distribution at longitudinal direction for dill and coriander crops

Reults in Table 5 show the effect of the developed planter and manual planting on the uniformity of plant distribution for dill and coriander in the field at the longitudinal direction. Values of the coefficient of variation (CV%) with the developed planter were 11.75 and 5.97% for dill and coriander plants, respectively. While with manual planting the values of the coefficient of variation were 34.67 and 27.73% for dill and coriander plants, respectively.

The results showed that, the lowest value of (CV%) was obtained by the developed planter with coriander plants comparing with the dill plants. The main reason for this difference is attributed to the different morphological shape of the seed, where it was in the form of spherical seed in coriander and in the form of rectangle in dill.

The coefficient of variation under 10% is considered excellent, between 10 - 15% is good, between 15 - 20% is fair. While with value more than 20% is poor as reborted by (**Coates, 1992**). The uniformity of distribution with coriander using the developed planter is excellent, while with dill is good. But, the (CV%) of the manual planting was poor (unacceptable), because, these value increased above (CV- 20%).

Effect of different planting methods on some characteristics of dill and coriander plants

The planting methods have a great effect on the plant features such as germination ratio and plants population. Results in Table 6 show that, the maximum germination ratio of 67 and 65% were remarked under the developed planter with coriander and dill, respectively. While the decreased value of the germination ratio to 56 and 53% under the manual planting with coriander and dill, respectively. Referring to the plants population, results in Table 6 show that, the highest number of plants per m^2 of 93 and 86 plants/m^2 were obtained under planting method of the developed planter with dill and coriander, respectively. While, the decrease value numbers of plants per m^2 of 73 and 77 plants/m^2 recorded under manual planting method with coriander and dill, respectively. This is due to variation in the accuracy of seed cover with soil in both planting methods in addition to variation in deep seed for manual planting method.

Field capacity and field efficiency for different planting methods

Field capacity and filed efficiency significantly varies from one to another planting method. Table 7 showed that, the field capacity values were 0.20 and 0.016 fad./hr., for the developed planter and manual planting respectively. Meanwhile, the field efficiency values were 95.25 and 76.33% under the same previous conditions for dill. While the values of field capacity for coriander were 0.29 and 0.025 fad./hr., for the developed planter and manual planting respectively. Meanwhile, the field efficiency values were 95.35 and 87.6% under the same previous conditions.

Table 5. Effect of different planting methods on the uniformity of plant distribution at longitudinal direction for dill and coriander crops

Item	Planting method			
	The developed planter		Manual planting	
	Dill	Coriander	Dill	Coriander
Coefficient of variation (C.V %)	11.75	5.97	34.67	27.73

Table 6. Effect of different planting methods on some plant characteristics for dill and coriander plants

Item	Planting method			
	The developed planter		Manual planting	
	Dill	Coriander	Dill	Coriander
Germination ratio (%)	65	67	53	56
Number of plants per (m^2)	93	86	77	73

Table 7. Field capacity and field efficiency for different planting methods for dill and coriander crops

Item	Planting method			
	The developed planter		Manual planting	
	Dill	Coriander	Dill	Coriander
Field capacity (fad./hr.)	0.20	0.29	0.016	0.025
Field efficiency (%)	95.25	95.35	76.33	87.60

Effect of different planting methods on Fresh and seed yield for dill and coriander crops

Both the fresh and seed yield of dill and coriander is greatly affected by the two planting methods. Results in Table 8 show that, the high average of green yield values for three cutting were 8.175 and 6.775 Mg/fad., with dill crop under the developed planter and manual planting, respectively. While, the high average of seed yield values was 0.317 and 0.297 Mg/fad., under the same previous conditions. Too, the high average of seed yield values of coriander crop was 0.975 and 0.935 Mg/fad., under the same previous conditions.

Total demand energy for planting methods of dill and coriander crops

The total demand energy of developed planter and manual planting for sowing dill and coriander crops were indicated in Table 9 the average values of Mechanical energy for planting dill and coriander by developed planter were 28.98 and 19.99 kW.hr./fad., while this values of human energy with manual planting were 22.2 and 14.21 under the same previous conditions. The variations in energy requirements with different planting methods is due to different soil resistance, soil reaction and rolling resistance against wheel. It is clear that the developed machine required the heights total

Table 8. Effect of different planting methods on fresh and fresh yield for dill and coriander crops

Item	Planting method			
	The developed planter		Manual planting	
	Dill	Coriander	Dill	Coriander
Fresh yield (Mg/fad.)	8.175	-	6.775	-
Seed yield (Mg/fad.)	0.317	0.975	0.297	0.935

Table 9. The total demand of energy and the actual demands of energy under different planting methods for dill and coriander crop

Item	Planting method			
	The developed planter		Manual planting	
	Dill	Coriander	Dill	Coriander
Forward speed (km/hr.)	1.45	1.45	-------	-------
Fuel consump (L/hr.)	1.54	1.54	-------	-------
Number of the laborers	1	1	8	8
Actual field capacity (fad./hr.)	0.20	0.29	0.016	0.025
Human energy (kW.hr./fad.)	2.775	1.776	22.2	14.21
Mechanical energy (kW.hr./fad.)	28.98	19.99	-------	-------
Total demand energy (kW.hr./fad.)	31.755	21.77	22.2	14.21

demand of energy 31.755 and 21.77 kW.hr./fad., for planting dill and coriander, respectively. While for manual planting the total demand of energy values were 22.2 and 14.21 kW.hr./fad., under the same previous conditions.

Cost analysis for planting methods of dill and coriander crops

The cost of field machinery is dependent on many factors due to the planter conditions and the mechanization system. Results in Table 10 represents the cost per fad., for different planting methods. In the dill crop, the manual planting required the heights cost 520.63 LE/fad., while the developed planter required 211.25 LE/fad. Too, in the coriander crop, the manual planting required the heights cost 333.2 LE/fad., while the developed planter required 145.69 LE/fad. Results in Table 10 represent the cost per unit of production for different planting methods of dill and coriander crops. The cost of total fresh and seed yield production per Mg can be arranged in descending order of manual planting and developed planter, respectively. On the developed planter recorded the lowest value per unit production 24.88 and 149.43 LE/fad., respectively.

Conclusion

From the obtained results, it is recommended to use a developed planter for planting dill and coriander crops to ensure more uniformity of seed distribution in row, higher crop yield, minimum cost and energy requirements under operational conditions including number of hole of feeding device of 14 holes, velocities of feeding device of 32 rpm and forward speed of 1.45 km/hr.

Table 10. Operational cost and cost per unit of production under different planting methods for dill and coriander crop

Item	Planting method			
	The developed planter		Manual planting	
	Dill	Coriander	Dill	Coriander
Actual field capacity (fad./hr.)	0.20	0.29	0.016	0.025
Hourly cost (LE/hr.)	42.25	42.25	8.33	8.33
Operational cost (LE/fad.)	211.25	145.69	520.63	333.2
Total fresh and seed yield (Mg/fad.)	8.492	0.975	7.072	0.935
Cost per unit of production (LE/fad.)	24.88	149.43	73.62	356.36

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تطوير وتقييم أداء جهاز تلقيم دقيق يعمل بشفط الهواء يناسب زراعة المحاصيل الطبية والعطرية

علا طه الأحمدى أحمد[1] ـ محمد محمد مراد[1] ـ محمود مصطفى على[1]ـ محمد حمزه أبو النجا[2]

١ـ قسم الهندسة الزراعية ـ كلية الزراعة- جامعة الزقازيق ـ مصر

٢ـ معهد بحوث الهندسة الزراعية- مركز البحوث الزراعية ـ الدقي- الجيزة ـ مصر

يهدف هذا البحث إلى تطوير جهاز تلقيم يعمل بشفط الهواء لزراعة كلا من بذور الشبت والكزبرة، حيث تم تطوير وتصنيع آلة زراعة مكونة من الاجزاء التالية (صندوق البذور – فجاجات – انبوب البذور- عجلة الارض- مروحة شفط) ومزودة بجهاز تلقيم مطور ثم إجراء تجارب معملية وأخرى حقلية عليه لتحديد المعايير المثلى التي تؤثر على أداء الة الزراعة المطورة وتم مقارنة نتائجها بنتائج الزراعة اليدوية، وكانت المعاملات ما يلى: سرعات الدوران لأنبوب جهاز التلقيم على النحو التالي (١٥ و١٨ و٢١ دورة في الدقيقة) و (٢٩ و٣٥ و٤٢ دورة في الدقيقة) و (٣٢ و٤٠ و٤٨ دورة في الدقيقة) مع عدد أسنان ترس نقل الحركة (١٥و ١٨ و٢٢ سنة)، سرعات التقدم (٠,٦٥ و ١,٠٣ و ١,٤٥ كم/ساعة)، عدد الخلايا في أنبوب جهاز التلقيم (١٤ و١٩ و٢٨ خلية/حلقة)، ولقد أظهرت النتائج المتحصل عليها السعة الحقلية للالة المطورة و الزراعة اليدوية كانت على الترتيب لمحصول الشبت (٠,٢٠ و ٠,٠١٦ فدان/ساعة) ومحصول الكزبرة (٠,٢٩ و ٠,٠٢٥ فدان/ساعة)، وكانت الكفاءة الحقلية لمحصول الشبت والكزبرة لآلة الزراعة المطورة (٩٥,٢٥ و ٩٥,٣٥%)، وبلغت نسبة الإنبات عند استخدام الة الزراعة المطورة (٦٧ و ٦٥%) لمحصولى الشبت و الكزبرة، بينما كانت نسبة الانبات فى الزراعة اليدوية ٥٦ و ٥٣% تحت نفس الظروف السابقة، حيث كانت اعلى كثافة نباتية (٩٣ و ٨٦ نبات/م^{2}) مع الة الزراعة المطورة لمحصولى الشبت و الكزبرة، بينما كانت هذه القيم (٧٧ و ٧٣ نبات/م^{2}) مع الزراعة اليدوية تحت نفس الظروف السابقة، وبلغ الانتاج الخضرى لمحصول الشبت (٨,١٧٥ و ٦,٧٧٥ طن/فدان) لآلة الزراعة المطورة و الزراعة اليدوية على التوالي، وكان أعلى إنتاج للبذور (٠,٣١٧ و ٠,٩٧٥ طن/فدان) لآلة الزراعة المطورة و الزراعة اليدوية لمحصولى الشبت والكزبرة، بينما كان أقل إنتاج (٠,٢٩٧ و ٠,٩٣٥ طن/فدان) تحت نفس الظروف السابقة، وكان الحد الأدنى لمتطلبات الطاقة (١٤,٢١ و ١٩,٩٩ كيلووات.ساعة/فدان) لمحصول الكزبرة مع الزراعة اليدوية وآلة الزراعة المطورة، بينما كانت (٢٢,٢ و ٢٨,٩٨ كيلووات.ساعة/فدان) لمحصول الشبت تحت نفس الظروف السابقة، وبلغ اقل مقدار لتكلفة وحدة الانتاج (٢٤,٨٨ و ٧٣,٦٢ جنيه/فدان) لمحصول الشبت مع الة الزراعة المطورة على التوالي، بينما سجل محصول الكزبرة (١٤٩,٤٣ و ٣٥٦,٣٦ جنيه/فدان) تحت نفس الظروف السابقة.

المحكمون :

١ـ أ.د. محب محمد أنيس الشرباصي أستاذ الهندسة الزراعية – كلية الزراعة – جامعة دمياط.

٢ـ أ.د. محمود عبدالرحمن الشـاذلـي أستاذ الهندسة الزراعية المتفرغ – كلية الزراعة – جامعة الزقازيق.