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DEVELOPMENT AND PERFORMANCE EVALUATION A CENTRIFUGAL BROADCAST SEEDER

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ABSTRACT

This work was carried out to develop and evaluate a fertilizer broadcasting machine to be suitable for spreading small seeds such as linseed. The developed spreader was evaluated and tested at EL-Gemmiza Agricultural Research Station, EL-Gharbia Governorate under four forward speeds : 1.74 , 2.82 , 3.99 and 5.07 km/h, four disc revolving speeds of 270, 350 , 430 and 510 rpm (6.08, 7.88, 9.68 and 11.48 m/s) and three ratio of feeding screw to land wheel speed (kinematic parameters) of 1.61 , 2.23 and 4.14 gave twelve rotating speed of screw which were 27.77 , 38.47 , 45.08 , 62.44 , 64.24 , 71.42 , 81.56 , 88.98 , 112.97 , 115.92 , 165.19 and 209.73 rpm. Spreader productivity, energy requirement and distribution uniformity had been determined. The results showed that, it is possible to use the centrifugal broadcast machine after adding feeding device and making some modifications on its motive power in spreading small seed crops. The optimum value for the operation conditions were obtained at forward speed 3.99 km/h, spinner speed 510 rpm (11.48 m/s) and feeding screw speed 88.98 rpm (0.35 m/s kinematic parameter 2.23) were as given the best result of productivity rate (5.32 fed/h), energy consumption (16.37 Mj/fed) and distribution uniformity with coefficient of variation 33.32% .

INTRODUCTION

Up till now, the hand sowing of most crops is still the common practice followed by the majority of the farmer in Egypt. The principle disadvantage of hand sowing is the non uniformity of seeds which ultimately results in poor yield. The centrifugal spreader is more popular because of their compactness, low cost, easy maintenance and wide working width (up to> 15m machine widths)

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the main disadvantage of this machine is the high sensitivity of spread pattern to flow rate variations, **(Olieslagers et al. 1996)**. The lack of uniform seed metering in conventional broadcast seeder has been a problem in broadcasting **(Badr and Elashry 2003).**

This led to the study of feasibility of multi-flight augers as seed metering device for broadcast seeder to improve the performance of seed discharge uniformity.**Griffis et al. (1983)** reported that most spreading problems could be corrected or at least improved by adjusting the placement of material on the spinners.**Morad (1990)** stated that the pattern width and uniformity of fertilizer distribution are clearly affected by the spreader speed. He showed that increasing the spreader speed increase the distribution width and improves the uniformity of distribution but on the other hand a low discharge rate of fertilizer is observed. The spreader speed of 56.5 rad/sec. (540 rpm) is considered the optimum to produce the best performance. **Ahmed et al. (1990)** evaluated the distribution pattern of the spreader. The best results from the field experiments for granular and coarse fertilizer were obtained at spinner speed of 540 rpm and spinner diameter of 500 mm. **Morad et al. (2002)** developed a computer program and used it to predict the spinning disc performance. An experimental apparatus of distribution was designed and constructed to measure the experimental distribution pattern. Experimental results of spinning disc performance showed that the spinner speed of 480 rpm and spinner radius of 250 mm gave an optimum fertilizer distribution pattern. **El-Nakib (1990)** stated that the effect of forward speed on application rate is clearly indicated. The application rate linearly decreases with the forward speed. Srivastava et al. (1993) maintained that the flow rate of seeds varies with the rotational speed of the rotary element. **Bansal et al. (1989)** reported that the performance of a planting machine depends on many factors: metering mechanism, seed box, seed characteristic, and seed gate. **Hamad and Banna (1980)**, showed that the length of feeding wheel mechanism, its speed, and transmission rotar have positive effect on the amount of sowing rate. **Awady and El-said (1985)** investigated the effect of design factors on a simple grain-drill feeding mechanism, they found that the feed rate of wheat seeds increased linearly with the gate opening. The agitation improved uniformity of feeding rate and seed distribution. The visible seed-damage in grain seeders increased and germination percent decreased by increased feeder speed. This was considered due to increasing the impact force by increasing the acceleration resulting in visible seed damage. **Reed and Wacker (1970)** reported that bulk density and particle size have a significant effect on the distribution pattern as width and shape.

The objective of the present study was to develop and evaluate the performance of a centrifugal broadcasting machine to be suitable for planting small seed crops and the effect of some parameters such as, forward speed and feeding speeds on spreader productivity, energy requirement and distribution uniformity.

Theoretical consideration

The theoretical approach discussed in the present study considers feeding screw which fitted on the bottom of the hopper and supplied its drive from land wheel to coordinate automatically the application rates of different seeds to the forward speed of the speeder. The performance of the developed spreader is affected by the screw geometry and the screw operating parameters. From ASEA Standard, (1997) the pitch /outside of screw augers, is not less than 0.9 and not more than 1.5 times.

The following empirical equation has been used for designing the feeding screw.

$$Q = 60 \frac{\pi}{4} \left(D^2 - d^2 \right) p \, n \, \lambda \, \varphi$$ Srivastava et. Al, (1993).

Where :

Q	: is the output capacity, kg/h.
D	: is the screw flights diameter, which was 0.075 m
d	: is the screw shaft diameter, which was 0.050 m
p	: is the screw pitch length, which was 0.075 m
n	: is the screw rotational speed which were (27.77, 45.08, 64.24, 81.56, 38.47, 62.44, 88.98, 112.97, 71.42, 115.92, 165.19 and 209.73 rpm)
λ	: is the density of the seeds, which was 625 kg/m^3
φ	: is the coefficient depending on uneven load of material or on under loading, which was 0.9

The choose parameters (screw specifications and revolving speeds) gave acceptable feeding rate using this equation with the maximum and minimum revolving speeds (209.73 and 27.77 rpm) were 1302.42 and 172.45 kg/h.

The amount of application rate for flax crop is 60 - 80 kg/fed **(Badr and Elashry, 2003)**. To achieve this application rate, screw speeds 88.98 rpm was used.

MATERIALS AND METHODS

Materials:

To fulfill the objectives of this study, a fertilizer broadcasting machine has been adapted, modified and tested for the work of this paper. The technical specification and operating parameters of the developed broadcasting machine is shown in table (1) and Fig (1).

Table (1) : Technical specifications of the developed broadcasting machine.

	Item	Specifications
Main dimensions	Over all length, cm;	81.3
	Over all width, cm;	81
	Over all height, cm;	114.1
Spinner	Diameter of disc, cm;	43
	N, of blades,	4
	Shape blades,	C- shape
Hopper	Length, cm;	83.5
	Average diameter, cm;	40
	Shape	Cone- shape
	Volume, m^3	0.5

Spreader after development:

Such development had been introduced to overcome the problems noticed under the planting operation using the ordinary spreader. The ordinary spreader is not suitable for planting successfully, the seeds stored in the hopper travel to the spinner by gravity, revealed that the seed uniformity is impaired due to sudden release of seed batches. . There are many factors affecting the flow uniformity of the seed mass.

Confining that, the state of seed gate body (in static or kinematics state, when the seed mass is passing from it) is the most important factor, so the used spreader is developed by adding multi-flight screw as seed metering and feeding device. It was designed according to seed physical and mechanical properties, (Fig. 2), has outlet diameter 75mm, shaft diameters, 50mm and pitch, 75mm. The feeding device was fitted on the bottom of fertilizing hopper to control the flow seed mass and draws seed from the bottom of the hopper into spinner.

The motion is transmitted from the ground wheel (driving wheel 53 cm) to the shaft of the seed feeding mechanism through a 29 teeth sprocket wheel to changeable sprockets (18, 13 and 7 teeth) by using 113 cm chain.

A 35 hp (26.25 kW) Massy Ferguson tractor was used to power the above mentioned spreader .

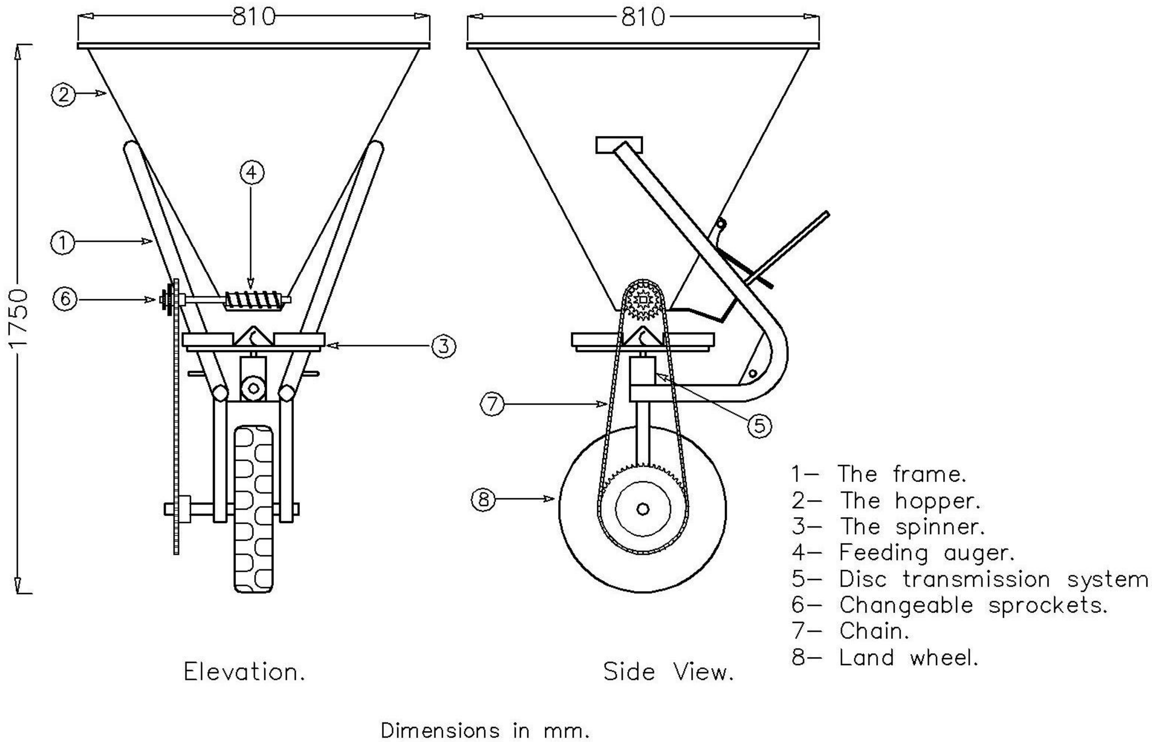


Fig (1) : Elevation and side view of the developed broadcasting machine.

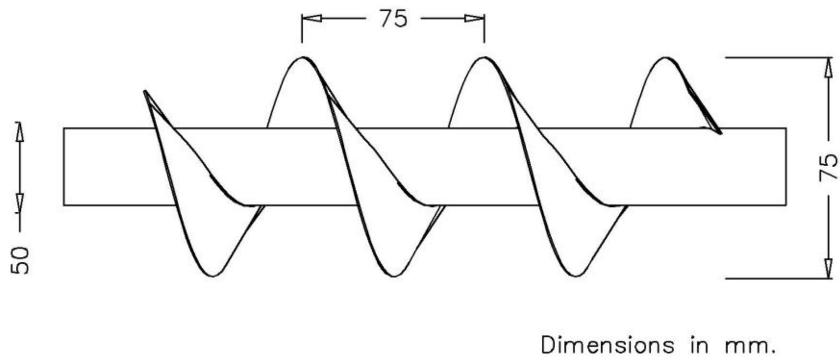


Fig. (2) : The constructed feeding screw.

Experimental crop :

Linseed (variety Giza 8) was used in this investigation. The flax is flat and oval with a pointed end the average value of the three principal dimensions and hardness for this variety are indicated as the following :

Length 4.91 mm , Width 4.45 mm , Thickness 0.98 mm
Hardness 14 kg , Moisture content 8.7 % , Specific weight 625 kg/m^3
The experiments were carried out at Gemmiza Research Station Gharbia Governorate.

Treatments and experimental measurements :

During the experiments, the following parameters were examined :

1- Disc revolving speeds (270 , 350 , 430 and 510 rpm).
2- Ground wheel speeds (1.74 , 2.82 , 3.99 and 5.07 km/h).
3- Speed ratio between feeding screw and land wheel (1.61 , 2.23 and 4.14), which gave twelve rotating speed of screw, which were (27.77 , 38.47 , 45.08 , 62.44 , 64.24 , 71.42 , 81.56 , 88.98 , 112.97 , 115.92 , 165.19 and 209.73 rpm.)

Measurements :

During test performance of the modified spreader the following items were measured.

Uniformity of distribution :

The tray arrangement was used to collect the seeds delivered from the broadcaster according to the standard method system as given by the

ASAE (1997). The dimensions of trays used were 32 × 15 × 13 cm. trays were put in 3 rows 100 cm apart and perpendicular to the direction of travels. The seeds received by each tray was collected in small polyethylene bags and weighted.

Coefficient of variation (C.V., %) :

The coefficient of variation (C.V., %) can be used to determine and express the uniformity of distribution of applications.

The mean value, standard deviation, and C.V. are determined as follows :

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

Where :

x_i : The individual reading,

x^- : Mean reading = $\frac{\sum x_i}{n}$, and

n : Total number of readings.

$$\text{Coefficient of variation} = \frac{\text{Standard deviation}}{x^-} \times 100$$

$$C.V. = \frac{\sigma}{x^-} \times 100$$

The seedling emergence (e):-

Five hundred seeds were germinated to determine the seedling emergence before passing through planting machine.. The seedling emergence was estimated after two weeks from sowing and irrigation by the following formula:

$$e = \frac{p}{d}$$

Where:

p : average plant number per/m^2

d : average number of delivered seeds per 1 m^2 . The (d) value calculated during the spreader calibration.

Application rate :

The application rate (Q) was calculated by the following equation :

$$Q = \frac{q}{R_a}$$

Where :

Q : application rate, kg/fed.

q : feeding rate of seeds. Kg/h; and

R_a : effective field capacity, fed/h.

RESULTS AND DISCUSSION

In order to evaluate the performance of modified broadcasting machine during planting flax crop, the different factors related to distribution pattern, uniformity of distribution, field capacity, and energy requirements were taken into consideration.

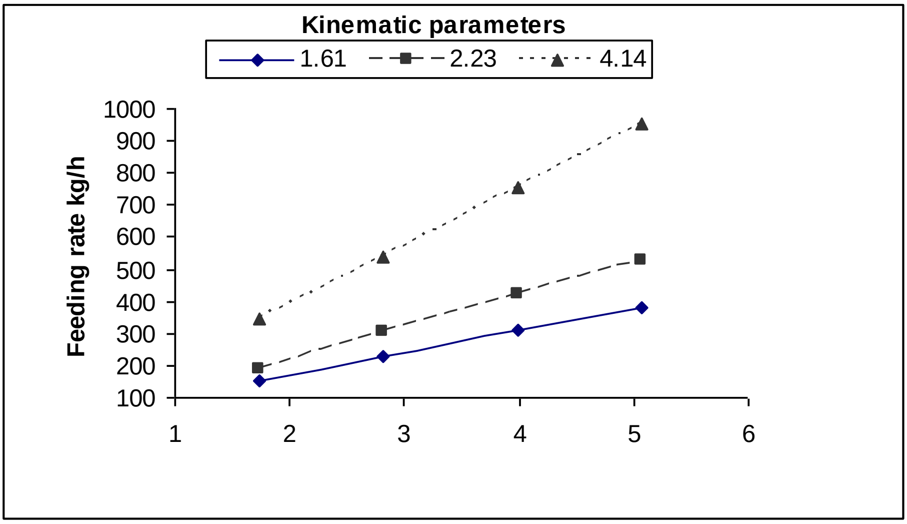
Feeding rate and specific feeding load:-

Increasing the screw speed tended to increase the feeding rate and decrease the specific feeding load during planting operation as indicated in Fig (3).

The results indicated that the increase of kinematic parameter (ratio of feeding screw to land wheel speed) from 1.61 to 4.14 tended to increase the feeding rate from 151.68 to 344.05, 230.23 to 536.57, 310.67 to 753.45 and 380.15 to 952.555kg/h at forward speed of about 1.74, 2.82, 3.99 and 5.07km/h respectively.

Specific feeding load drops more rapidly with the increased of screw speed. It was noticed that increase of screw speed from 27.77 to 209.73 r.p.m (0.11 to0.82 m/s) tended to decrease the specific feeding load from 91.03 to 75.69 gm/rev.

Fig (4) showed that the theoretical feeding rate which calculated from the equation as affected by the auger speed. As shown in the figure, the increase of screw speed tended to increase the feeding rate. The feeding rate is a linear function of screw speed.



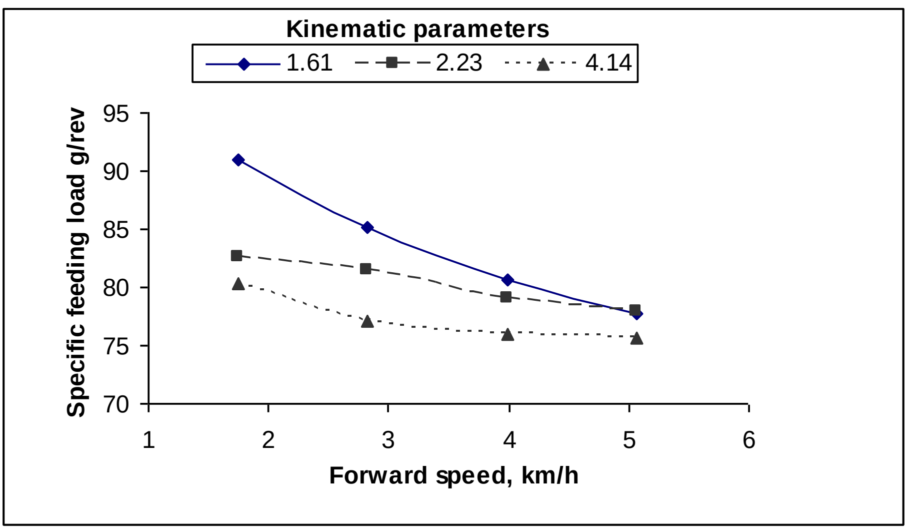


Fig.(3) : Effect of different forward speeds on feeding rate and specific feeding load at different kinematic parameters.

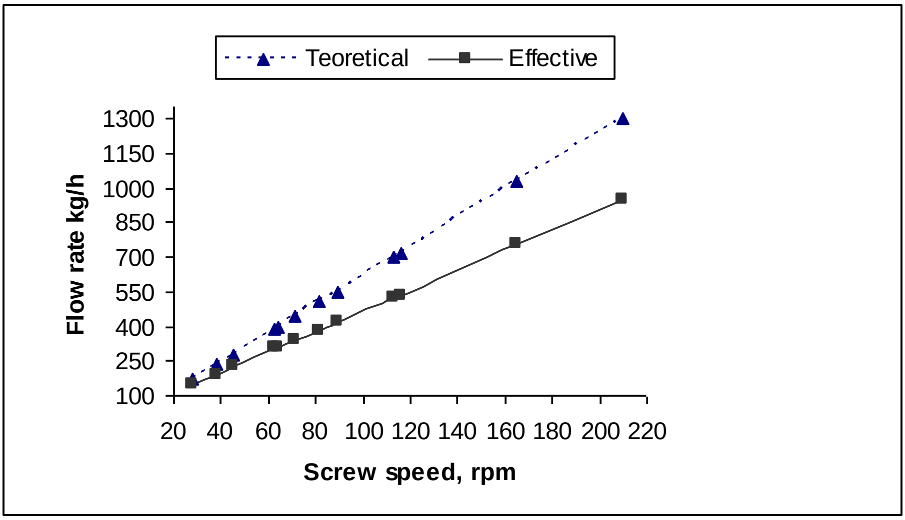


Fig (4) : Effect of different screw speeds on the flow rate.

The relationship between the theoretical and experimental results can be seen in Fig (4). As shown in the figure the theoretical and experimental result were having the direction and the difference between them was small and increased with increasing the screw speed. This is because there is a slip between the seeds and the channel wall. The slip in increase with increasing the screw speed.

Uniformity of distribution :

Uniformity of seed distribution is considered one of the most important functions for spreading. Fig (5) shows the effect of disc rotating speed, forward speed and kinematic parameter on the uniformity of distribution (Coefficient of variation). The data revealed that at any kinematic parameter, the coefficient of variation decreased as the disc speed increased. The results indicated that, increasing disc speed from 270 to 510 rpm cause a corresponding decrease in coefficient of variation from 41.65 to 22.42, 43.37 to 27.51, 48.15 to 33.32 and 51.71 to 38.55 at four different forward speeds of 1.74, 2.82 3.99 and 5.07 km/h at 2.23 kinematic parameter. The decrement in coefficient of variation while increasing disc speed is due to the excessive kinetic energy which transfer from the rotating disc to seeds.

Meanwhile, the data indicated that coefficient of variation tends to increase as the kinematic parameter increased from 1.61 to 4.14. This increase in coefficient of variation with the increasing in the screw speed may be attributed to the increase in the soil wheel sliding with increasing the forward speed. The minimum value of coefficient of variation (17.32 %) was obtained at spinner speed of 510 rpm (11.48 m/s).

Distribution pattern:-

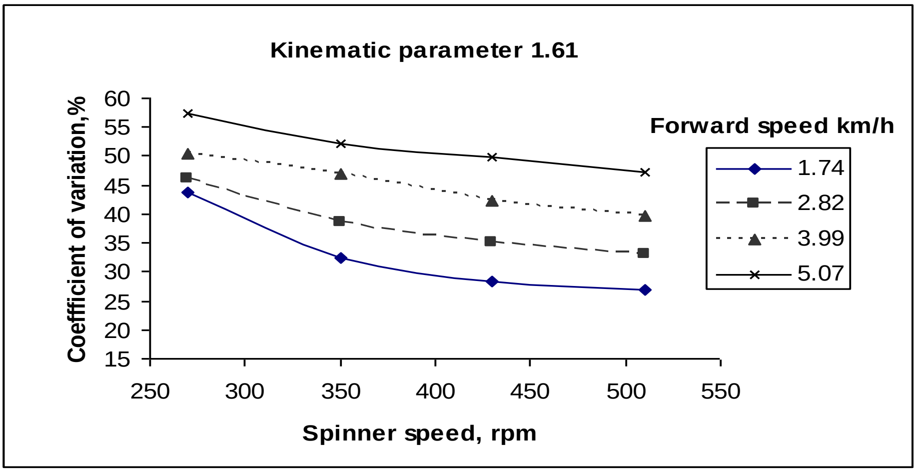
The observations in Fig (6) show the effect of spinner speed on distribution of seeds across the swath (gm/m^2) on the soil. It is clear that, for all screw speeds, the application rate (gm/m^2) decreased as the distance between the strips and spreader axis increased on the both sides.

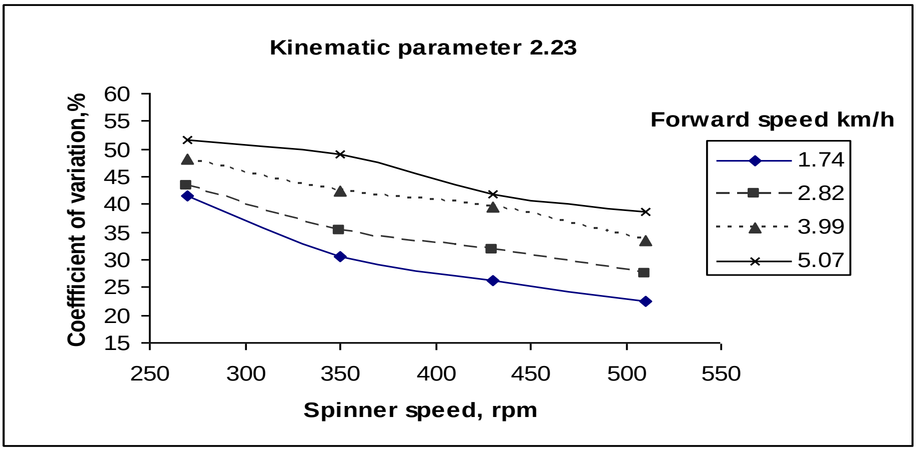
The indicator distribution curve in case of 510 rpm spinner speed was wide in contrast of other speeds which produced sharp curves.

Field capacity, and energy requirements:-

The field capacity was affected mainly by the forward speed. From the collected data, we can estimated the best width of spread, its was 7m for flax seed. The results revealed that, the actual field capacity was increased from 2.47 to 6.33 fed/h as the spreader forward speed increased from 1.74 to 5.07 km/h, at the same disc speed of 510 rpm (11.48 m/s).

The increasing forward speed tends to increase the power requirement and decrease the energy requirement for spreading operation. This is due to increasing in actual field capacity by increasing the forward speed. The results indicated that, when the forward speed increased from 1.74 to 5.07 km/h tended to decrease the energy requirement from 22.35 to 16.37 Mj/fed.





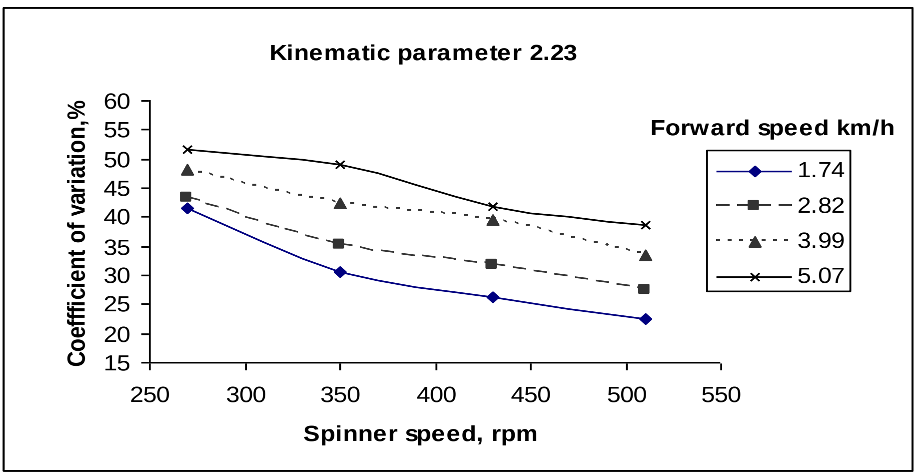


Fig (5) :The effect of spinner speed and forward speed on coefficient of variation at the different of kinematic parameters.

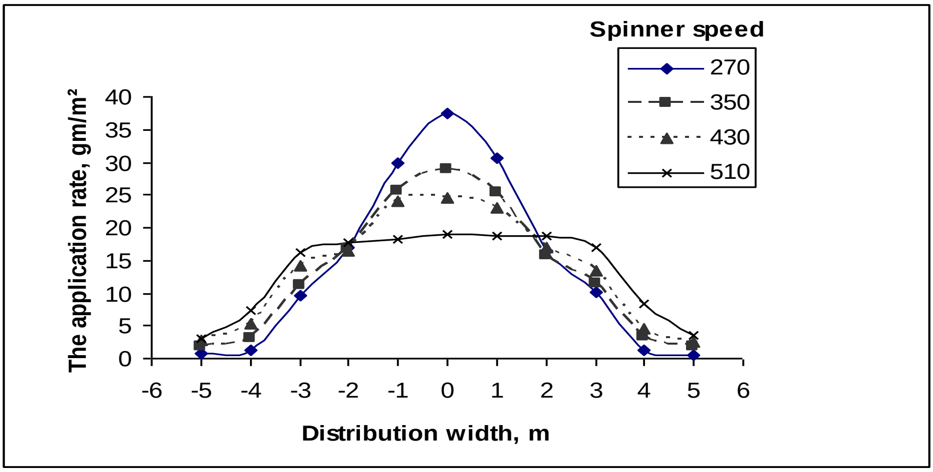


Fig (6) : The effect of spinner speed on distribution pattern of seeds.

The germination ratio (g) :

The germination ratio is an indicator to the percent of seed damage (visible and invisible) which affected mainly by feeding screw speed. Fig (7) showed the effect of different forwards on germination ratio.

The highest value of seedling emergence (99.4 %) was obtained at forward speed 1.74 km/h and screw speed 0.11 m/s (kinematic parameter 1.61). Meanwhile the lowest seedling emergence (94.2 %) was obtained at forward speed 5.07 km/h and screw speed 0.82 m/s (kinematic parameter 4.14).

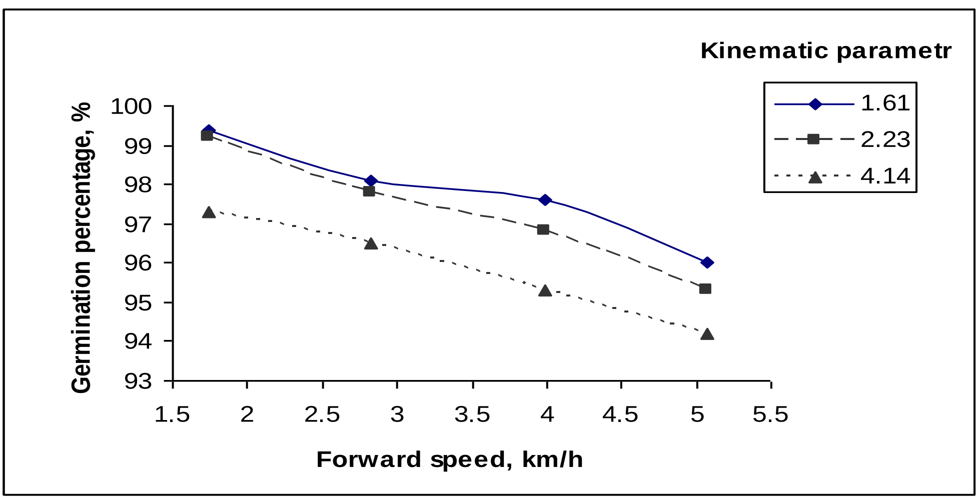


Fig (7) : The effect of forward speed and kinematic parameter on germination ratio.

CONCLUSION

The results showed that, possibility to use the centrifugal broadcaster after adding feeding device and making some modification on its motive power gave better distribution pattern in spreading small seeds.

The best operating of the developed spreader was found to be as follows : forward speed 3.99 km/h, spinner speed 510 rpm (11.48 m/s) and feeding screw speed 88.98 rpm (0.35 m/s) kinematic parameter (2.23) were gave the best result of productivity rate, energy consumption and distribution uniformity.

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الملخص العربى

تطوير وتقيم أداء آلة لنثر البذور بالطرد المركزي

***جابر غمري رضوان و **عبده شوقي العشري**

حتى الآن في مصر الطريقة اليدوية هي الأكثر شيوعا في زراعة المحاصيل الكثيفة (الكتان) وللحصول على محصول عالي الإنتاجية لابد من إتباع نظام جيد في انتظام توزيع البذور في وحدة المساحة إثناء عملية الزراعة. كما لوحظ انخفاض دقة وانتظام توزيع البذور أثناء استخدام آلة نثر السماد ذات القرص التي تعتمد على القوة الطاردة المركزية في نثر بذور محصول الكتان (بدر والعشري ٢٠٠٣) وذلك لان تلقيم البذور من الخزان إلى قرص الطرد المركزي يعتمد على السقوط الحر وبالتالي فان معدل التلقيم لا يعتمد على سرعة تقدم الآلة.

ويهدف هذا البحث لتطوير آلة نثر السماد ذات القرص والاستفادة منها في زراعة محاصيل البذور الصغيرة ودراسة بعض العوامل المؤثرة في أداء تلك الآلة للوصول إلى القيم المثلى لبعض عوامل التشغيل للآلة المطورة. واشتملت الدراسة على أربعة مستويات للسرعة الأمامية (١.٧٤ ، ٢.٨٢ ، ٣.٩٩ و ٥.٠٧ كم/ساعة). وأربع مستويات للسرعة الخطية لقرص النثر(٦.٠٨ ، ٧.٨٨ ، ٩.٦٨ و ١١.٤٨م/ث) وثلاث مستويات للنسبة بين سرعة بريمة التغذية والسرعة الأمامية (١.٦١ ، ٢.٢٣ و ٤.١٤).

وأظهرت النتائج المتحصل عليها إمكانية استخدام آلة نثر السماد ذات القرص بعد عمل بعض التعديلات على جهاز التغذية في نثر البذور الصغيرة. كما أظهرت النتائج المتحصل عليها إن العوامل المثلى لتشغيل الآلة كانت باستخدام سرعة أمامية ٣.٩٩ كم/ساعة وسرعة خطية لبريمة التغذية ٨٨.٩٨ لفة/ دقيقة (معامل كينماتيكي ٢.٢٣) وسرعة خطية لقرص النثر ١١.٤٨ م/ث . حيث أعطت الآلة عند تشغيلها تحت هذه الظروف أفضل النتائج من حيث انتظامية وكثافة الزراعة.

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