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DEVELOPING A VERTICAL WHEEL DEVICES FOR SMALL SEEDS

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ABSTRACT

The effect of four forward speeds (V) of 0.75, 1.03, 1.3 and 1.5 m/s and five metering speeds (R) of 0.09, 0.16, 0.20, 0.25 and 0.30 m/s with two disc cells (W) of 9 and 24 and their interaction were studied to evaluate metering process throughout planting sugar beet. Engineering parameters such as longitudinal and transversal dispersion, % were determined. Seed damage, % with distance between seeds were also evaluated. Actual distances ranged from 17.7 cm to 11.85 cm, the theoretical distances ranged from 69.4 to 10.4 cm. Under forward speed of 0.75, the best results were obtained by using metering speed of 0.16 m/s. The theoretical distance was 19.5 cm and the actual distance was 16.9 cm.. Lowest lateral dispersion of 40.2 % was obtained under the same previous conditions with disc cells of 24. for sugar beet. Lowest seed damage of 2.88 % was under the mentioned conditions.

INTRODUCTION

Seeding of agricultural crops is one of earliest farming operation to be mechanized after tillage. The main objective of most planting machines is to plant seeds irregularly in rows or on beds. To do that in the desired manner, the seeder must perform a number of functions. The basic functions of planters are: Open the seed furrow to the proper depth, Meter the seed, deposit the seed in the furrow in an acceptable pattern, cover the seed and compact the soil around the seed to the proper degree for the type of crop involved. Metering of seeds is considered the major and the most critical function of any planting machine. However, this function is performed by the metering mechanism. The Engineering characteristic, of the stream line flow involved the uniform seed path, the steady pouring of seed mass, and accurate seed distribution. These characteristic are affected planting uniformity, seed damage and feeding rates. Logically, the operational requirements and efficiency of the feeding devices are depending highly on the physical and mechanical properties of the sowing material and the engineering parameters of the feeding mechanism. Evidently the available models of feeding sets to plant (sugar beet) seeds in Egypt resulted in undesired longitudinal uniformity of seeding. Srivastava *et al.* (1993) showed that planting mechanisms and machine have been developed to permit and carry out any planting methods. Mukhin (1992), stated that the facilitate seed delivery in various types of seeding machine an adjustment mechanism was developed and its construction and operation are described and illustrated. The comparison between the planting methods on the basis of the amount of seeds required to plant one feddan was carried out by Mohamed (1991). He indicated that mechanical planting saved about 50% from seeds required to plant one feddan manually. The main problem face sugar beet planting is that whole local drilling machines are less efficiency especially seeds uniformity and seed rate. This is due to the wide dispersion in engineering and physical and seed rate. This is due to the wide dispersion in engineering and physical characteristics of sugar beet seed. The main aim of this study is to develop, fabricate and test a local metering device to obtain regular spaces suitable for planting sugar beet with high efficiency and less damage.

MATERIALS AND METHODS

The laboratory experiments were carried out in Agric. Eng. Dept. at Mansoura University on the test-trolley Lab (Ismail, 2004) to determined the performance of a vertical wheel device.

The metering device description

A vertical wheel seeding device as shown in Fig (1) is divided into three main parts namely, the case, seeding metering device and the seed box

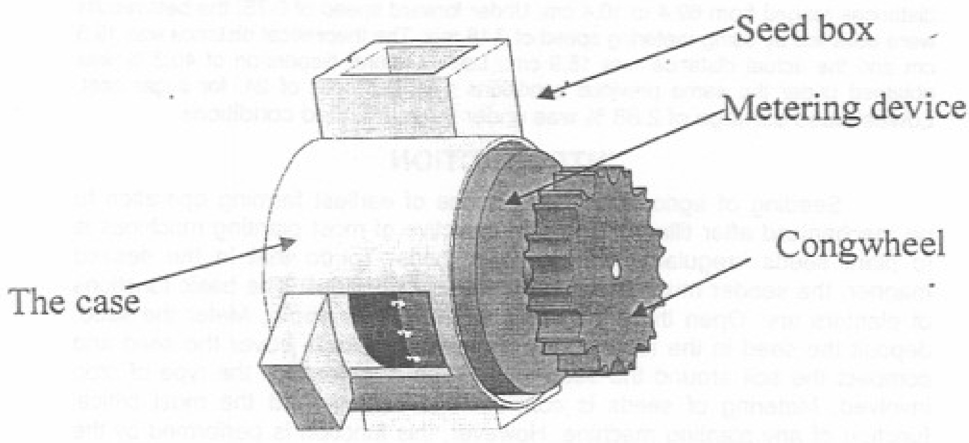

Fig (1): The metering device prototype

The case: It is cylindrical in shape with outer and inner diameters of 270 and 260 mm respectively and with total breadth of 90 mm as shown in Fig. (2). It is made locally from iron, the sleeve was connected to the centre of the case with dimensions of 40 mm diameter and length of 32 mm. To transport the motion for metering device, the main shaft was connected through the sleeve with length of 160 mm.

Metering device: As shown in Fig (3), the metering device was locally made of aluminum to be light in mass, with diameter of 260 mm and thickness of 35 mm in the front but in the centre the thickness of 20 mm. The 24 gapes of 9 mm diameter and depth of 20 mm are distributed on the circumference of metering device. The radius of pitch circular gaps radius is 9 mm (24 gaps).

Power supply to metering device

Power transmission with two functions, the first is to transmit the metering motion to metering disc with an electric motor of 0.5 hp (1450 rpm) and the second function is to transmit the linear motion to the front wheel with an electric motor of 3 hp (950 rpm) as shown in Fig (4).

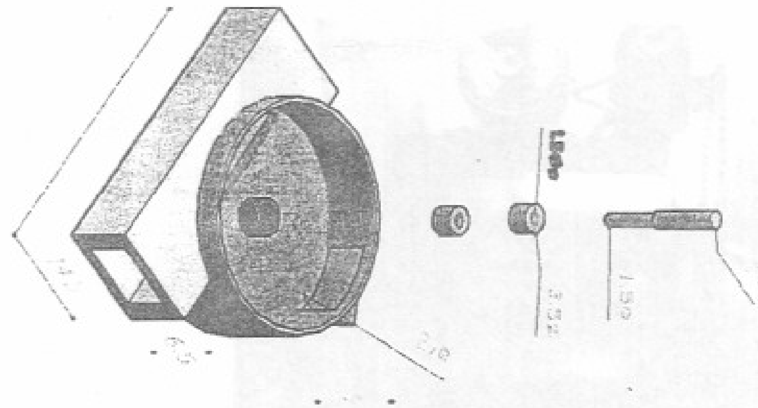

Fig. (2): The case

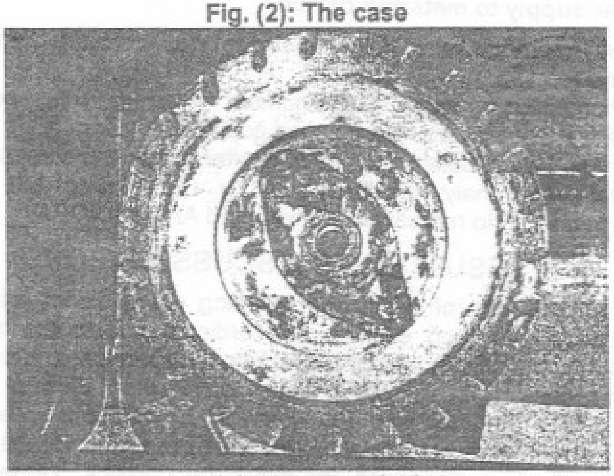

Fig (3): Metering device

Seed box: **The seed box of the prototype was manufactured locally from steel sheet with a thickens of 2 mm. It has a trapezoid shape cross section with dimensions were the length is140 mm, its breadth is 60mm and its height is 230 mm.**

Variables under study: Four forward speeds of 0.75, 1.03, 1.3 and 1.5 (m/s) accompanied by five rotating speeds of 0.09, 0.16, 0.20, 0.25 and 0.30 (m/s) with two metering discs of 9 and 24 cells were investigated under planting sugar beet.

Measured factors: Forward speed (m/s) was measured by calculating the actual distance in a certain time. Speedometer was used to measure the rotating speed (m/s). Longitudinal and lateral dispersion was measured by using a meter tape and a ruler. Seed damage was previously determined before planting.

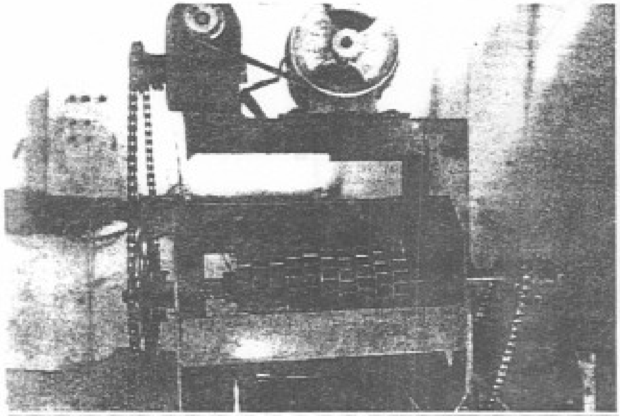

Fig (4): Power supply to metering device

Theoretical and actual distance was calculated according to the following formula:

Seed population = rotating speed x cells number seed / sec

Theoretical distance = forward speed / seed population cm

All obtained data was tabulated throughout after three replications for each treatment and was analyzed statistically by using MINITAB computer program and subjected to regression analysis and ANOVA.

RESULTS AND DISCUSSION

The performance of developed metering device for planting sugar-beet seeds was tested and evaluated according to the following criteria: Seeds longitudinal dispersion; seeds lateral dispersion; and seed damage.

Effect of forward speed (m/s) on the longitudinal dispersion

Figs from (5) and (6) illustrate the relationship between forward speed and means of distance between seeds under different metering speeds on longitudinal dispersion for sugar beet seeds. General trends clearly revealed that, the longitudinal dispersion is directly proportional to forward speed (V), meanwhile it is inversely proportional to metering speed (R). From mentioned Figs, under forward speed of 0.75 m/s with different metering speeds of 0.09, 0.16, 0.20, 0.25 and 0.30 m/s the distance were 17.7, 16.9, 16.2, 15.86 and 14.9 cm, respectively. By increasing forward speed to 1.03 m/s the actual distances were 16.2, 15.8, 15.5, 14.9 and 14.2 cm, respectively. With changing forward speed to 1.3 m/s. The distances were 15.87, 15.24, 14.46, 13.5 and 13.21, respectively. Increasing forward speed to 1.5 m/s, the distances were 13.9, 13.58, 12.9, 12.5 and 11.85 cm, respectively. These results were with theoretical distances of 69.4, 39.1, 31.2, 25 and 20.8 cm. All previous results were under using metering disc of 24 cells and at the same forward speed (1.5 m/s). There was approximately similarity between both theoretical and actual distances. As actual distances ranged from 17.7 cm (the highest limit) to 11.85 cm (the lowest limit) while sugar beet originally drilling on 15-20 cm distance intervals, the theoretical distances ranged from 69.4 to 10.4 cm. Under forward speed of 0.75, the best results were obtained by using metering speed of 0.16 m/s. The theoretical distance was 19.5 cm and the actual distance was 16.9 cm. This was acceptable result as it was in the right limit. With forward speed of 1.03 m/s accompanied by metering speed of 0.20 m/s, the acceptable result of 15.5 cm actual distance with 21.4 cm theoretical distance was obtained. Also, metering speed of 0.25 m/s gave a relative result. On the other hand, actual distance of 13.5 cm with theoretical distance of 21.6 cm was obtained under metering speed of 0.25 m/s and forward speed of 1.3 m/s. While, with forward speed of 1.5 m/s and metering speed of 0.30 m/s, the theoretical distance was 20.8 cm while the actual distance was 11.85 and it was the nearest limit but it was out of range. Finally, using forward speed of 0.75 m/s and metering speed of 0.16 m/s gave the best results in all treatments with sugar beet. Generally, any increment of forward speed resulted in increment of longitudinal dispersion (directly proportion) with metering disc of 24 or 9 cells. These results were logical as increasing forward speed led to and increase of machine vibration and consequently seeds drilled through feeder tube dispersed. This vibration and skipping had to dispersed seeds on the surface of soil specially with higher forward speeds.

Fig (7) and Fig (8) illustrate the effect of forward speed, V (m/s) and metering speed, R (m/s) under different disc cells of 9 and 24 on the lateral seeds dispersion,%. Data and figures showed that there was a directly proportion among the used parameters throughout the treatments. Obviously, the increment of forward speed resulted in increasing lateral dispersion. Increasing forward speed from 0.75 to 1.5 m/s increased lateral dispersion percentage from 63.1% to 66.4% under metering speed of 0.09 m/s. While increasing metering speed to 0.30 m/s caused an increase of lateral dispersion from 63.1% to 71.9% under forward speed of 0.75 m/s. These results were obtained under metering disc of 24 cells. From mentioned figures, with all metering speed (R) an increase in (R) led to an increase in lateral dispersion percentage. The data showed lateral dispersion percentage of 63.1, 63.4, 65.8, 66.1 and 71.9%, by increasing metering speed from 0.09 to 0.16 m/s and from 0.16 to 0.20 m/s and from 0.20 to 0.25 m/s and finally to 0.30 m/s, respectively. These results were under forward speed of 0.75 m/s with metering disc of 24 cells. Similar trends and increment was appeared under different forward speeds1.03,and1.5m/s. for metering disc of 9 cells. The same trend was shown as lateral dispersion percentage changed from 40.2 to 55.8 by increasing forward speed from 0.75 to 1.5 m/s at metering speed of 0.09 m/s. On the other side, increasing metering speed from 0.09 to 0.30 m/s changed lateral dispersion percentage from 40.2 to 53.8 at the same conditions. Medium forward speeds of 1.03 and 1.3 m/s with different metering speeds of 0.16, 0.20 and 0.25 m/s for both disc cells of 24 and 9 showed similar results and gave the same trend on figures. Shortly, under disc cells of 24 , the lowest values of lateral dispersion percentage of 63.1 was achieved under forward speed of 0.75 m/s at metering speed of 0.09 m/s . Meanwhile, the highest value was 73.9 % was under forward speed (V) of 1.5 and metering speed (R) of 0.30 m/s; while by changing disc cells from 24 to 9, the highest value of lateral dispersion 60 % was obtained under forward speed of 1.5 m/s with metering speed of 0.30 m/s. But, the lowest value was speed of 1.5 m/s with metering speed of 0.30 m/s. But, the lowest value was 40.2 % under (V) of 0.75 m/s and (R) of 0.09 m/s. These results may be due to soil aggregates and clods scattering on soil surface that obliged the unit to skip and vibrate especially with high forward speeds. This vibration and skipping had to dispersed seeds on the surface of soil specially with higher forward speeds.

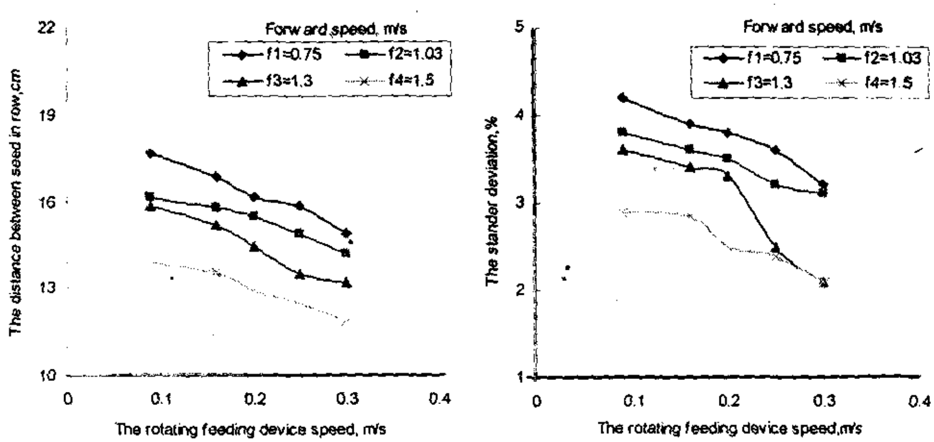

Fig (5): Effect of metering speed on dispersion with metering disc of 24 cells under different forward speed m/s

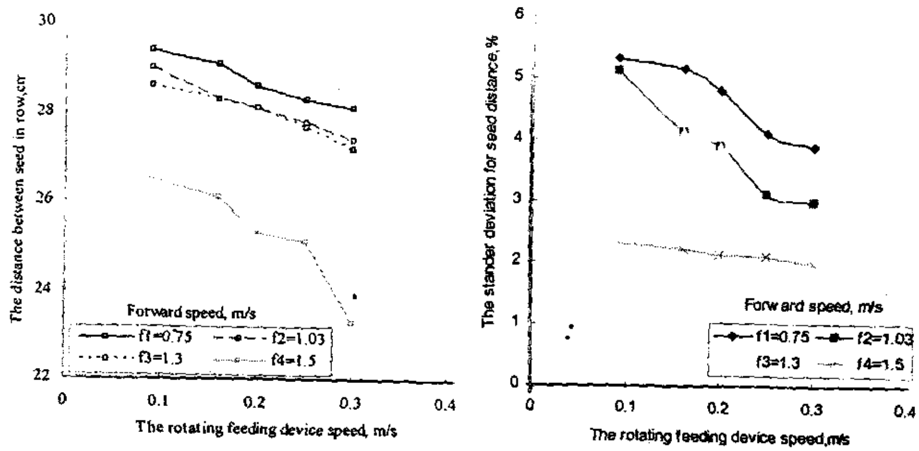

Fig (6): Effect of metering speed on dispersion with metering disc of 9 cells under different forward speed m/s Effect of forward speed (m/s) on the seeds lateral dispersion, %

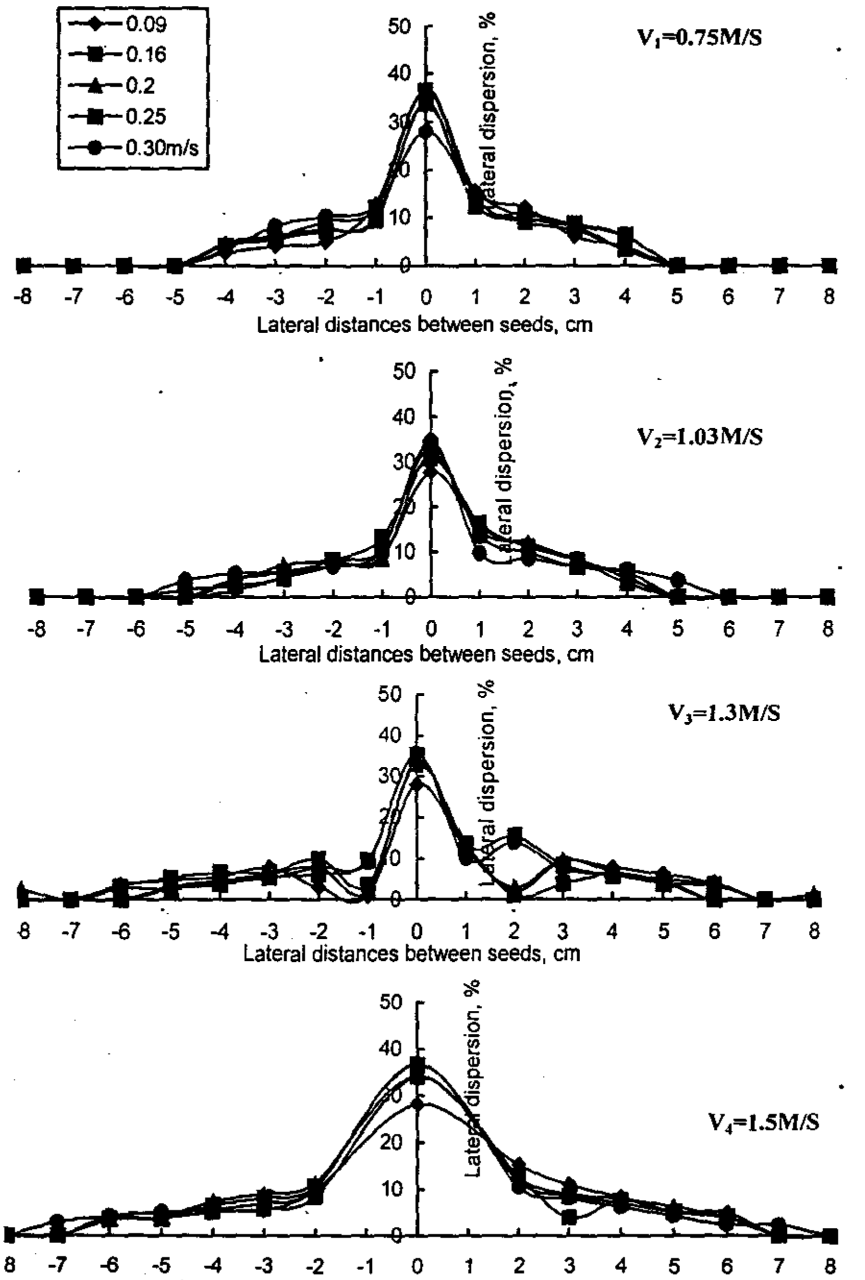

Fig (7): Effect of different rotating speeds on lateral dispersion with disc cells 24

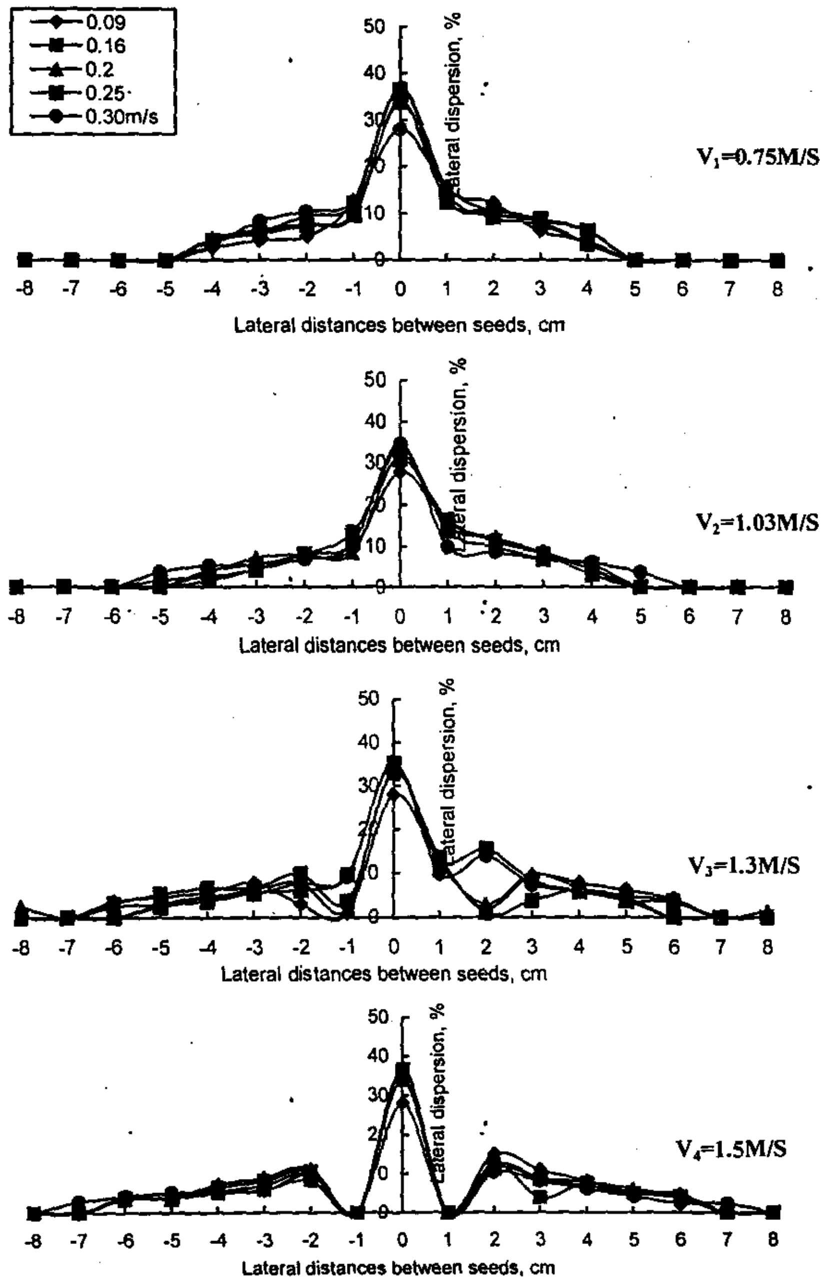

Fig (8): Effect of different rotating speeds, m/s on lateral dispersion with disc cells 9

Effect of forward speed, m/s on seed spacing uniformity

The data of distance between seeds percentage (spacing uniformity, %) of sugar beet for all parameters under study were summarized and plotted in Figures (9 and 10). They clearly show that, the average of distance between seeds percentage with all treatments decreased by increasing each of forward speed (V) and metering speed (R) under different disc cells (W) of 9 or 24. The distance between seeds was more uniform with lower forward and metering speeds and consequently higher planting speeds resulted in more skips, higher speed placement errors and higher average spacing. It is obvious that, increasing forward speed from 0.75 to 1.5 m/s resulted in decreasing seed spacing uniformity from 97.5 to 96 % on the same dropping row. at disc cell of 24 and metering speed of 0.09 m/s. Meanwhile, increasing metering speed from 0.09 to 0.30 m/s resulted in decreasing spacing uniformity from 97.5 to 71.3 % at forward speed of 0.75 m/s and the disc cells of 24.On the other side, by using disc cells of 9, increasing forward speed from 0.75 to 1.5 m/s resulted in decreasing seed spacing uniformity from 80 to 70.099 % on the same dropping row at metering speed of 0.09 m/s. Generally, the seed discharge decreased as the speed of feeding shaft increased for sugar beet. These results may be due to that the increase in metering speed causes disturbance in seed spacing that affected seed population. Also, seed size to disc cell size had an important effect on the accuracy of seed spacing, seed rate and seed damage. Increasing disc speed reduced cells fill and increased seed spacing along the row. Multiple regression analysis revealed a highly significant linear relationship as:

$$Y = ax + b$$

The constants of equation are tabulated in Table (1)

	9cells			24cells		
	a	b	R^2	a	B	R^2
0.09m/s	82.574	-3.186x	0.817	98.979	-0.5653x	0.9913
0.16	82.402	-3.5828x	0.9622	98.245	-1.6771x	0.9479
0.20	82.089	-3.7895x	0.7153	97.681	-1.3811x	0.8231
0.25	66.247	-3.9273x	0.931	89.88	-11.162x	0.9656
0.30	63.618	-2.0467x	0.8756	80.094	-10.628x	0.824

Analysis of variance was also employed to test the difference of disc cells with different forward speeds under different metering speed. This analysis indicated a highly significant difference of engineering parameters under study with all treatments.

Effect of metering speed (R) on seed damage percentage (SD)

Figs (11) showed the effect of metering speed (R) on seed damage percentage (SD). Staring directly to the shown figure, it is easy to notice that increasing metering speed (R) resulted in increasing seed damage percentage (directly proportion). Increasing metering speed from 0.09 to 0.16 m/s changed seed damage from 2.88 % to 3.50 %. In the same way increasing metering speed from 0.20 to 0.30 m/s resulted in increasing seed damage 4.57to 5.49 % at forward speed of 0.75 m/s. and disc 24cells. Meanwhile, under disc 9 cells, seed damage percentages were 5.30, 3.70, 3.90, 4.30 and 4.80 under metering speed of 0.09, 0.16, 0.20, 0.25 and 0.30 m/s, respectively. Analytically, forward speed (V) had no effect on seed damage percentage (SD) as no correlation between forward speed (V) and metering speed (R). These were logical results as increasing metering speed (R) affected speed of feeding system. This high motion of the disc may cause seed shoehorned in feeder disc. This shoehorning led to seed damage and gave the true obtained results. Multiple regression analysis revealed a highly significant linear relationship

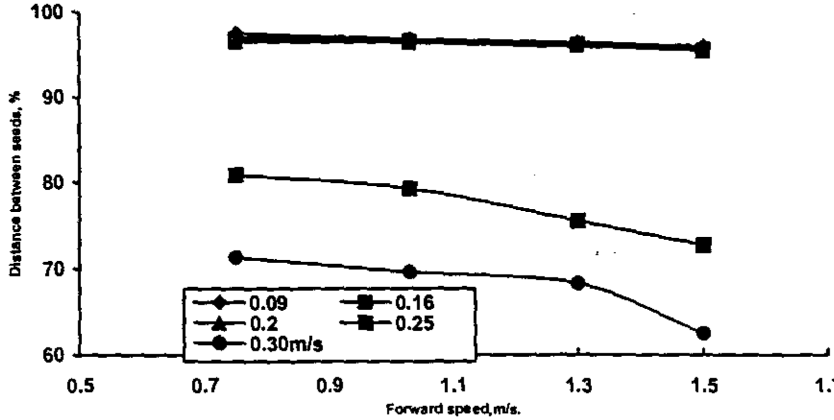

Fig (9): Effect of forward speed, m/s and metering speed, m/s on distance between seeds, % under disc cells 24 while planting sugar-beet seeds.

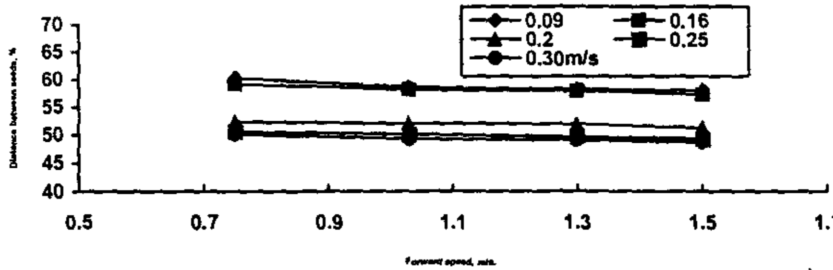

Fig (10): Effect of forward speed, m/s and metering speed, m/s on distance between seeds, % under disc cells 9 while planting sugar-beet seeds.

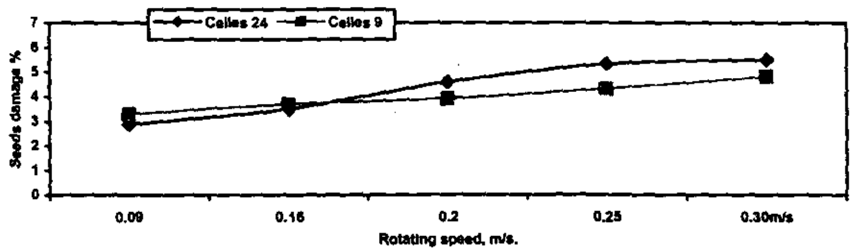

Fig (11) Effect of metering speed, m/s on seeds damage.

Conclusion

From the obvious results, it can be concluded that the developed metering device can be operated efficiently at metering speed 0.16 m / s and forward speed 0.75m/s=v1r2

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تطوير وحدة التلقيم الرأسى للحبوب الدقيقة

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*** قسم الهندسة الزراعية ــ كلية الزراعة ــ جامعة المنصورة**

**** معهد بحوث الهندسة الزراعية**

يعتبر محصول البنجر من أهم محاصيل الحبوب الغذائية والصناعية الهامة في كثير من منــاطق العــالم ، حيث ازدادت إنتاجية بنجر السكر في الفترة من (١٩٧٨-٢٠٠٢) من(١٣٧٢ إلى ٥٩٣,١٤ ألــف طــن) أي بنــسبة ١٣١ % من الإنتاج الكلي لعام ٢٠٠٢. وقد بينت نتائج التجارب أن آلات الزراعة المتاحة في الأسواق والتــي تــستخدم لزراعة هذا المحصول ذات كفاءة أداء منخفضة نسبياً وذلك من حيث انتظامية وضع البذور في التربــة وكــذلك معــدل تصرف البذور. ولقد أوضحت الدراسات أن ذلك يرجع إلى عدم ملائمة تصميمات أجهزة التلقــيم المركبــة علــو آلات الزراعة المتاحة بالأسواق المصرية. وحيث ان أهم أسباب ذلك هو المواصفات الهندسية لبذور البنجر خاصة شكل البذرة الغير منتظم. ولحل هذه المشكلة سيتطلب تطوير ودراسات على أجهزة تلقيم بمواصفات هندسية جديدة خاصــة العــضو الدوار لجهاز التلقيم لتؤدى فى النهاية إلى انتظام وضع البذور في التربة وبالتالي المحافظة على زيادة الإنتاج. بالإضافة إلى توفير كميه التقاوي عن طريق التحكم في تصرف البذور من الآلة.

لذلك كان الهدف من هذا البحث هو "التوصل إلى أفضل تطوير لجهاز تلقيم يلائم الزراعة الدقيقة لبذور البنجــر وذلــك باستخدام أسلوب علمي جديد يعتمد على التحكم في كمية البذور وكتلة البذور المتحركة في آن واحد".

ولتحقيق ذلك تم تطوير وحدة تلقيم ذات احتكاك لزراعة بذور الحبوب وتتكون من :

١- قرص تلقيم ذات فتحات جانبية ٢٤ فتحة ذات قطر ٩ ملي.

٢- قرص تلقيم ذات فتحات جانبية ٩ فتحات ذات قطر ١٢ ملي.

وقد روعي أن يتم تصميم الفتحات على القرص بحيث تناسب شكل وحجم البذرة للبنجر وقد خططت تجارب معملية لدراسة تأثير بعض العوامل على أداء هذه الأجهزة في عمليةَ تلقيم ووضع البذور.

تضمنت الدراسة المعملية عوامل الدراسة الآتية:

١- خمس سرعات دورانية لقرص التلقيم ٠,٠٩- ٠,١٦ -٠,٢٠ - ٠,٢٥-٠,٣٠ متر / ثانية.

٢- أربع سرعات أمامية ٠,٧٥-١,٠٣-١,٣ -١,٥ متر / ثانية. .

٣- أربعة وعشرون فتحة بقطر ٩ ملي للقرص الاول وتسع فتحات بقطر ١٢ ملي للقرص الثاني.

ولتقييم تأثير عوامل الدراسة السابقة على أداء أجهزة التلقيم تم تقدير كل مما يأتي:

١- مدى التشتت الطولي للبذور . ٢-مدى التشتت العرضي للبذور. ٣- مدى الضرر الحادث .

٤- مدى انتظامية البذور .

وكانت أهم النتائج:

١- كان أقل تشتت طولي للبذور عند استخدام السرعة التقدمية V1 = ٠,٧٥ م / ث مع السرعة الدورانية R2 =٠,١٦ م / ث

٢- كان أقل تشتت عرضى للبذور عند استخدام السرعة التقدمية V1- ٠,٧٥ م / ث مع الــسرعة الدورانيــة R1- ٠,٠٩ م / ث

٣- كان اقل نسبة كسر للبذور عند استخدام السرعة التقدمية V1- ٠,٧٥ م / ث مع السرعة الدورانيــة R1- ٠,٠٩ م / ث

٤- كانت أفضل انتظامية للبذور عند استخدام السرعة التقدمية V1 = ٠,٧٥ م /ث مــع الــسرعة الدورانيــة R1 = ٠,١٦ م / ث