Misr J. Ag. Eng., 24(4): 648-665 FARM MACHINERY AND POWER

DEVELOPING AND PERFORMANCE EVALUATION OF A LOCALLY FABRICATED SUGAR BEET PLANTER.

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ABSTRACT

A proper sugar beet planter was developed, and its performance was investigated in order to improve the environment of sugar beet root growth for better response to minimum irrigational water, and for facilitating excessive drainage. Consequently the production of beet root, and the sucrose percentage could be increased.

The performance tests for the machine before and after developing were carried out in terms of the following: The physical properties of root growth soil environment due to the action of a developed ridger, the seedling emergence percent, the root and sugar yields, and draft requirement.

The developed ridger planter resulted in better soil bulk density, lower soil resistance, and regular moisture distribution. Also due to the action of the developed ridger planter, the root and sugar yield were increased by about 25 % and 19 % respectively compared to the action of the machine before developing.

INTRODUCTION

Soil moisture is a major factor limiting sugar beet production. Also the surface irrigation often has a highly irregular distribution. Therefore, the water is excessive in some places or not adequate for successful seed beet emergence. The germination process, therefore, is sensitive to over-wet as well as to over-dry conditions. For these reasons, this study aims to develop the locally fabricated planter to form ridges during sowing operation. This result in control irrigation, improve drainage of excessive water, reduce the number of trips over the field, break down soil clods and create the optimum seedbed environment ready for seed germination. Thereby, these result in facilitate sugar beet seeding operation and to maximize crop yield. Dzhingov (1975) reported that the higher grain yields were obtained by planting maize in furrows of ridges than when planted on a flat seedbed followed by construction of ridges or no-ridges.

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Egrachenkov and Sysorov (1968) found that maize grown on ridges yielded 1000 kg/ha, whereas the conventional planting on flat land produced 610 kg/ha.

Klenin et al. (1985) Indicated that planting on ridges improves the drainage which is essential in regions with high soil moisture and in irrigated regions.

Fortune and Burke (1987) reported that in a wet, cool climate, seeds should be placed in a dry part of the soil; in Ireland, this has been achieved successfully by sowing in the tops of ridges.

Friessleben et al. (1988) reported that in Eastern Germany, a controlled-traffic system was tested in which ridges were formed in the autumn and the only subsequent spring cultivation was to level off the tops of these ridges.

Hillel (1982) reported that compacted soil has more small pores which hold water tightly in the soil matrix and reduce evaporation as compared with less dense soil.

Kepner et al. (1982) represented that bed planting is common for certain types of row crops in irrigated area. Combination bed-shaping and planting units are sometimes used for vegetables, sugar beet, and other similar crops. If the relationships have been properly selected, results should be better and more uniform than from separate operations.

Buchele (1954) studied the root bed environment in a ridged seedbed. He found the ridge was 2 to 4 degrees warmer than flat seedbeds and that corn seedling emerged earlier from the ridge.

Buchele and Morton (1967) concluded that sugar beets can be successfully planted with plow-plant equipment. Ridged sugar beets have a higher rate of emergence, total emergence and yield than flat-planted seedbeds.

Studies by Rathore et al. (1983) and Awadhwal and Thierstein (1985) recommended ridge planting under conditions where surface crusting occurred.

Panwar and Sirohi (1980) studied critical parameters of plant emergence and root growth in sandy soil. It can be concluded that:

1.a minimum soil moisture content of 10% is recommended for wheat and maize;

2. for both wheat and maize, soil cover of 1.3 and 1.9 g. cm^{-3} proved too high soil impedance for plants to emerge; and

3. a seedbed density of higher than 1.5 g. cm^{-3} restricted both root and plant growth.

Chaudhry (1985) reported that water through furrows increased the above ground plant growth, root growth, grain yield and water use efficiency.

Stibble and Terpstra (1982) in laboratory studies on silage corn, found that increased penetration resistance below and beside the planting slot delayed emergence. It was also found that with increasing penetration resistance, percentage emergence, plant height and dry matter yield decreased linearly.

The current study is therefore devoted to:

1- Develop, and fabricate, a ridging unit which could be mounted front of the local planting machine for estimating ridging and sowing in one operation.

2- Study the most engineering and design factors affecting the performance of ridging unit.

3- Compare the response of sugar beet crop to two planting machine types (the planter after developing and the planter before developing) by measuring physical environment of the root bed, seedling emergence percent, root and sugar yield and draft requirement.

MATERIAL AND METHODS

Planting unit:

A local beet planter fabricated by Abd El-Tawwb 2004 (Fig. 1) was developed and modified to performe ridging and planting sugar beet in one operation.

The main parts of local planter are as follow:

Metering plates were fabricated using vertical aluminum plates of 30 mm thickness and 160 mm diameter. The seed hopper was fabricated from a 2 mm steel sheet. Hopper bottom inclined 45° to horizontal. The planting unit was provided with two rubber wheels of 260 mm diameter. Power is transmitted from the ground wheel to the metering device by sprocket and chain arrangements. The machine frame was fabricated from square tubes with section area of 80×80×6 mm.

During this study the local planter was modified as follows:

Five ridging units were constructed and mounted on the front toolbar of machine while, the four planting units were mounted on the rear toolbar frame. The five ridging units distributed between the four planting units to form four precision ridges on the tilled ground, where the planter could utilize the top surface of the precision-shaped ridges for positive depth control. The ridger was designed to operate in fields which had been prepared for the conventional planters. During planting the planter constructed ridges with 15 cm height and 55 cm distance between consecutive two ridges. Also, this distance (55 cm) was the seed row spacing planted on the ridges and the distance between the seeds on the row was 15cm. During this study the ground drive wheel was also modified by adding turnbuckle to regulate the toolbar height. For best results, the toolbar should be held in a fixed working position of 50 cm above the seed planting depth. The turnbuckle provides fine adjustment.

The ridger bodies as shown in Fig. 2 were fabricated from iron steel. The distance between the ridger bodies could be easily adjusted on the machine frame. The ridger body consists of a front V-shaped cutting edge. The forepart of the cutting edge has a shovel share which facilitates the penetration of the ridger. The ridger body is provided with adjustable type of two wings fixed to the body by means of hinges and are connected by struts so that adjustments for different row spacing conversion of the profile of the ridge are possible. This instrument when engaged into the soil, the loose soil is pushed and lifted upwards and inverted on the two sides to form a ridge-furrow by the curvature of the wings. The penetration angle of the share (α) was determined according to the Fig. 3 (Klenin et al. 1985). The resultant R of normal reaction N and the friction force N tan φ. Let us resolve the resultant R into two components. One of the components R_x determines the resistance of the share to motion and the other R_z characterizes the ability of the share to penetrate further into the soil. The draft of the wedge may be characterized by the angle ψ, the angle between the axis Ox and the resultant R. From Fig. 3 we have:

$$\Psi = 90 - (\alpha + \varphi) \qquad \text{.........(1)}$$

Where:

α = Penetration angle, degree and

φ = Soil internal friction angle. It is measured to be 30 degree for clay soil.

For good draft, we must select a share with the smallest value of penetration angle α which consists of two parts (Fig. 3)

$$\alpha = \iota + \varepsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where:

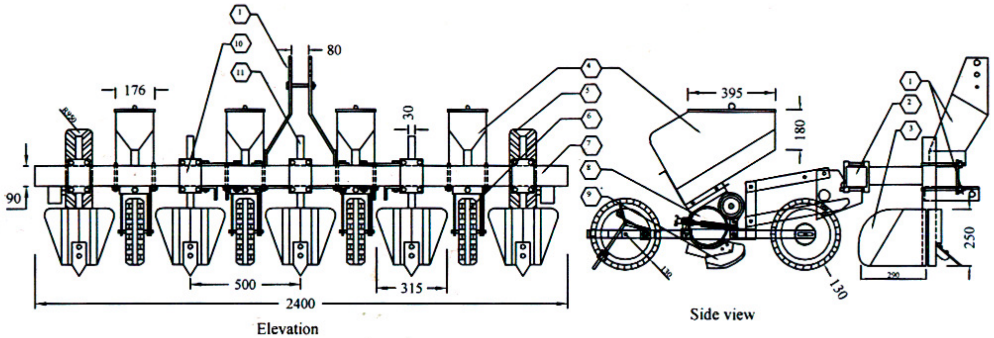
ι = Angle of taper of the share,

ε = Rear cutting angle (clearance angle).

The taper angle ι must not be less than 15° and the clearance angle ε should not be less than 10°. For small values of ε, the lower idle face of the wedge makes contact with the soil and disturbs the stability of its movement. For better penetration of the soil, the penetration angle of the share α should be $\geq 25^{\circ}$ to the ground.

According to (RNAM 1991) the wings setting angle (θ) was ranged to be 35 - 50° to the direction of travel.

The experiments were carried out at the experimental farm of Sakha, Agricultural Research Station, Kafr El-Kheikh Governorate, Egypt during agric season of 2005/2006. The experimental area was about 2 feddans. The soil texture under tests was defined as clay soil. The mechanical analysis of the soil was 31.24 % silt, 14.80 % sand, 53.96 % clay and 2.28 % $CaCo_3$. The field was prepared by using chisel plough (twice) and was used a hydraulic scraper to level and create an ultimate smooth surface. Agricultural operations such as fertilizing, irrigation and pest control were performed in a similar manner to that commonly practiced at the Kafr El-Kheikh farms. The soil moisture content was determined based on oven dry samples by the standard oven method. Samples were obtained from the field at depth of zero-15 cm, weighed, and oven dried to constant weight at 105°C, for 24 h. The average percent of moisture content was found to be 14.3 %. Multi-germ uncoated beet seeds were used in the present study. The experimental design was a randomized complete-block with split plots and with four replications at each location. Planter type were the main plots and planting speeds and the ridging unit parameters were subplots.



No.	Part Name
1	Hitch point
2	Rear toolbar
3	Ridger
4	Seed hopper
5	Ground drive wheel
6	Gauge wheel
7	Front toolbar
8	Metering device
9	Furrow opener
10	Clamp
11	Shank

Dimensions in mm

Fig. 1: The fabricated ridging precision planting machine.

No.	Parts Name
1	Tool shank
2	Cutting edge
3	Shovel share
4	Wings
5	Struts
6	θ = Wing setting angle
7	∝ = Penetration angle

Dimensions in cm

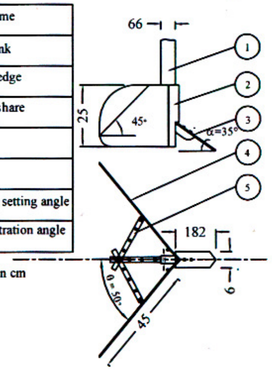


Fig. 2: Ridger with adjustable wing angle.

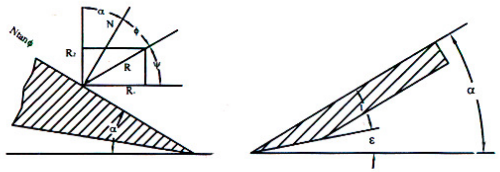


Fig. 3: Forces acting and sharping of the shovel share.

During the field experiments, the following parameters were examined:

1- Planter type:

Two types of sowing machines were applied as follow:

Treatment a: the planter before developing, where, soil was planted with the conventional local planter.

Treatment b: the planter after developing, where, soil was planted with planter used in treatment (a) except that ridging units were mounted on the front toolbar. Where ridges were formed and crop was sown on the ridges in one operation.

1- Forward speed:

Four different forward speeds were used for testing the planter. The average values of these speed, were about 1.83, 2.62, 3.63 and 5.4 km/h. The operating speed of the planter was measured in the field by recording the time of traveling 50 meters during a certain by using a measured tap and digital stopwatch. From the measured distance and the time, the operating speed was calculated.

3- Ridging unit parameters (Penetration angle, wing setting angle, and ridging depth):

Four penetration angles (α) of 16, 20, 24, and 28 degrees were studied. The wings setting angle (θ) was ranged to be 35 - 50° to the direction of travel. Four ridging depths of 7.5, 10, 12.5, and 15 cm were studied. Depth was measured vertically after executing the experiment from the soil surface to the ridger share tip inside the soil. This was done by digging behind the ridger.

The following indicators were determined to investigate the effect of studying factors on the developed planter performance:

1- Physical properties of root growth environment:

Soil moisture content, bulk density, and penetration resistance of soil around the seed were used to assess the effect of planter type on the soil physical environments. They were measured after planting and irrigation operations. The soil blocks were removed from the growth chambers and were processed to determine the soil moisture content, bulk density, and penetration resistance of soil around the seed. These parameters data were collected at depth of 0 to 25 cm. Where, sugar beet roots growth and extend to about 25 cm depth under the soil surface. Thin-walled cylinders (50mm dia. × 150 mm long) were forced into the soil and excavated. So that a known volume of soil was then weight and dried in an oven for 24 hours at 105 C°, and weighed again to determine the moisture content, and bulk density. While the penetration resistance was measured by using a soil cone penetrometer with a 3.2-cm^2 base (ASAE, 1979). The penetrometer was manually pushed into the soil and the maximum force, displayed by a dial gauge, was recorded. The aggregation was carried out by using a small trowel and manually collecting all disturbed soil from a 30 cm section of the seed furrow. The samples were processed through a rotary sieve into the following aggregate sizes > 4.8, 4.8-2, 2.0-0.83, 0.83-0.42, 0.42-0.25 and <0.25 mm. To simplify comparisons of aggregate size distribution between treatments the mean weight diameter (MWD) was calculated as the following formula:

$$MWD = \sum_{i=1}^{n} X_i W_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

where:

MWD = mean weight diameter, cm;

X_i = mean diameter of fraction, cm; and

W_i = proportion of fraction weight.

2- Seedling emergence percent:

It is the ratio of the number of seeds which emergence from the soil to the number of seeds planted, indicated stand establishment ability of the treatments. Emergence counts for this calculation were taken after four weeks of beet planting by using the following formula:

$$G_p = \frac{P}{S} \times 100, \% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where: G_p is the emergence percent, P - average plant number per fifty meters along the sowing row, and S - average number of delivered seeds per fifty meters along the planting row.

3- Root and sugar yield:

The average values of root yield was calculated after harvesting, as the direct indicator for suitability of planting machine. The yield of harvested roots was determined by massing the roots lifted by a manual shovel. The following equation was used:

$$R = \frac{4200 \times M}{1000 \times A}, Mg / fed \text{ ....(5)}$$

Where: R is the root yield; M - mass of lifted root, kg; and A - harvested area, m^2.

Sugar yield per feddan equals to root yield per feddan in Mg multiplied by sucrose percentage. The sucrose percentage, was measured in Sugar Crops Research Institute by using sucrometer instrument. It was estimated polarimertrically on a lead acetate extract of fresh macerated (Le-Docte 1927).

4- Draft requirement:

a. Determination of rolling resistance R. R.:

Rolling resistance of both operating tractor and ridge-planter in lifted position was determined (at no load) by dynamometer method at sowing speeds. Ten reading were recorded in each case and the mathematical mean was calculated.

b. Determination of the net draft and unit draft:

The hydraulic dynamometer was fixed between the 1st tractor and the 2nd tractor during different treatments, when recording the pull required for moving the operating tractor and the planter after developing in sowing operation position. The net draft and unit draft were determined according the following formulas:

$$D = P - RR \text{ ....(6)}$$

$$D_u = D / (w \times d) \text{ ....(7)}$$

where:

P = drawbar pull, kN;

RR = rolling resistance, kN;

D = net draft, kN;

D_u = unit draft, kN/ m^2;

w = planter width, m; and

d = ridging depth, m.

RESULTS AND DISCUSSION

1- Physical properties of root growth environment:

Physical of the root bed environment such as soil resistance to penetration, bulk density and moisture content were measured after sowing and irrigation operations from 0 to 25cm. Data in Table 1 shows the mean weight diameter of soil with two types of planters (the planter before developing and the planter after developing) was determined according to equation (3). MWD of the soil with the planter before developing and planter after developing was 4.42 and 2.45 cm, respectively. Also the planter after developing resulted in more soil loosening and a significantly lower bulk density than did the planter before developing from 0 to 25 cm depth. This means that ridging operation has a very high effect on soil pulverization. Also the Table shows the relation between planter type and soil penetration resistance. The soil penetration resistance was 289.2 and 202.5 N/cm^2 for the planter before developing and the planter after developing, respectively. The soil penetration resistance has a good indication of soil physical properties. The decrease of soil penetration resistance allows the roots of plants easily to penetrate the soil. A dramatic increase in soil moisture content resulted with the planter before developing compared with planter after developing. This is may be due to compacted soil has more small pores which hold water tightly in the soil matrix as compared with less dense soil.

Table 1: The effect of planter type on Physical environment of the root bed .

Planter type	MWD, cm	Soil penetration resistance , N/cm^2	Bulk density, g/cm^3	Moisture content, %
Planter before developing	4.42	289.2	1.23	28.6
Planter after developing	2.45	202.5	1.12	22.8

Fig. 3 shows an average soil-moisture profile for the soil with planter after developing and planter before developing. The data showed that there was real difference in the moisture content at some specific depth, ranging from 5-20 cm below the soil surface. It was noted in Fig. 3 that the maximum moisture content of the ridge was at the 15 cm depth while that of the flat-sowing was at the 10 cm depth. Considering the ridge to be approximately 15 cm high at time of sampling, the point of maximum moisture content of the ridge was found to be 10 cm above the similar point in the furrow. This may be because, after irrigation operation, the surface of the ridge dried ahead of that of the furrow because of its greater elevation.

Fig. 4 shows the bulk density profiles of the soil with the planter after developing and the planter before developing. The data showed that there was a real difference in the bulk density of soil between the two planters. Generally, for the two planters, the bulk-density of the soil increased with increasing of depth. Soil with the planter before developing was found to be more compact than in soil with planter after developing. Comparing the bulk density profiles of soil with the soil-moisture profile shown in Fig. 3 indicated that compaction materially reduced the downward movement of water and resulted in a decrease in moisture content with depth below the maximum moisture zone.

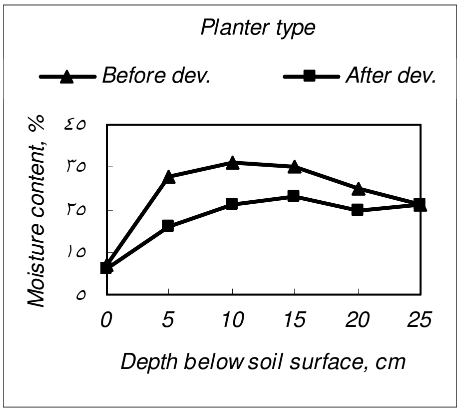


Fig. 3:Moisture content profile.

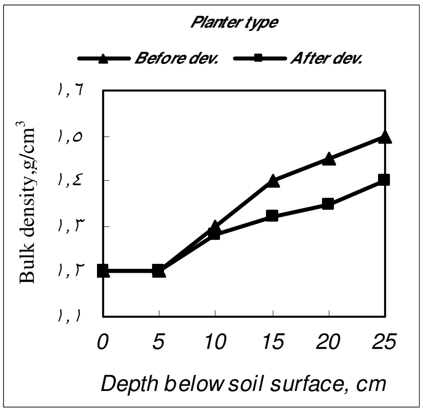


Fig. 4:Bulk density profile.

2- Seedling emergence percent:

The planter type, and forward speed had a highly significant effect on seedling emergence percent. Table 2 illustrates that at low forward speed of 1.83 km/h, the seedling emergence percent increased by about 15 % with planter after developing compared with the planter before developing. But, at higher forward speed of 5.4 km/h, the seedling emergence percent was 78.6 % and 66.2 % with planter after developing and planter before developing, respectively. It can be notice that there was not a significant difference among seedling emergence of planter after developing at 2.62 and 3.63 km/h. Therefore, to achieve the optimum machine field capacity, it is recommended to operate the developed planter at forward speed of 3.63 km/h. Meanwhile, the maximum seedling emergence 81.3 % of the planter before developing recorded at 3.63 km/h forward speed. Generally, data indicate that there was a significant difference between the seedling emergence for the two sowing planters.

Table 2: The effect of forward speed, and planter type on seedling emergence.

Forward speed, km/h.	Seedling emergence, %	
	Planter before developing	Planter after developing
1.83	77.8	89.5
2.62	78.5	91.8
3.63	81.3	90.4
5.4	66.2	78.6

These results may be due to:

1- Water is apply in furrows between ridges. The tops of the ridges dry sooner permitting earlier planting than would be possible with flat-land sowing.

2- In addition, an improved stand is obtained because the drier ridge warms up more quickly, improves germination of the seed and hastens plant emergence.

3- The coldiness of the soil in flat-sowing caused little moisture in contact with seeds in addition to disturbance in seed-depth uniformity and coverage and also seeds get lost in this clody-soil.

4- The flat planted soil was more compaction than ridge planted soil. And this compaction caused high mechanical impedance to seedling emergence.

5- It can be concluded that reduced oxygen diffusion by soil compaction were mainly responsible for reduced seedling emergence.

3- Root and sugar yield:

Root and sugar yield was a sensitive measure of the effectiveness of planter type in establishing sugar beet stands. As indicated in Fig. 5 the increasing of forward speed tended to decrease the root and sugar yield for the two planter type. Thus, the maximum value of root and sugar yield were about 36.2 and 5.85 Mg/fed, respectively, were recorded with planter after developing at 2.62 km/h. Generally, the root and sugar yield increased by 25 and 19 % respectively, for planter after developing compared with the planter before developing.

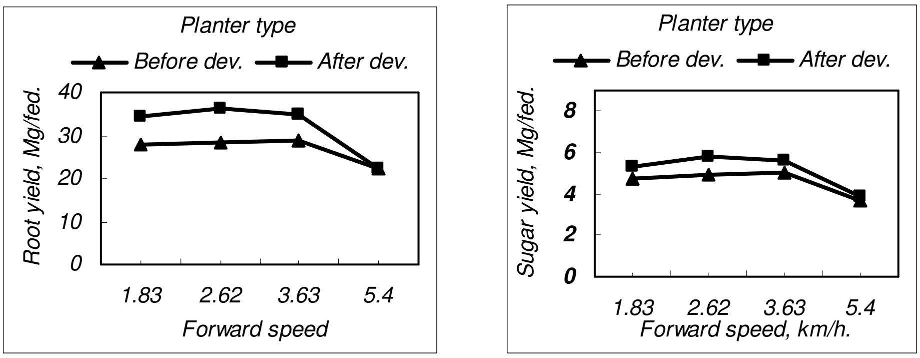


Fig. 5: Effect of Planter type and forward speed on root yield and sugar yield.

The difference in yield may possible be attributed to the change in the physical and engineering properties of soil brought about by the planter type. Where, the soil sowed by the planter before developing had high bulk density resulted in low yield because compacted soil has tendency to absorb moisture easily and, therefore, rapidly reduce the diffusion rate of oxygen which detriments to plant growth. Therefore, lower yield obtained with conventional planting is often linked to the over-soil moisture as well as to over-dry conditions during the early growth of sown beet crop. Also greater root yield following the planter after developing was probably due to earlier emergence.

4- Draft requirements:

Fig. 6 shows the effect of the speed and penetration angle on the value of net draft required for the developed planter. The relationship between speed and net draft (D) is not considered as linear for the three penetration angles, where, $D \alpha V^2$. It was appeared that the speed has low effect on the net draft at speed range under 2.62 km/h and a higher effect at speed range over 2.62 km/h. This is because of the accelerated force increased rapidly with the square of the speed.

Also, Fig. 6 shows the effect of the ridging unit parameters (penetration angle and wings setting angle) on the net draft for the planter after developing. In case of the penetration angle, the net draft decreased in the first stage (under 20-deg.). But it increases in the second stage (over 20-deg.). It means that the lowest value of net draft is at penetration angle of 20-deg. The initial high draft at very low penetration angles can be explained for small values of penetration angle, the lower idle face of the wedge makes contact with the soil and disturbs the stability of its movement (Klenin et al. 1985). In case of the wings setting angle there was a decrease in the draft as the angle increased up to 40-deg., but the draft increased as the angle increased from 40 to 50 deg. This phenomenon is may be due to the influence of soil frictional forces and frictional area of the tool surface on the value of draft force.

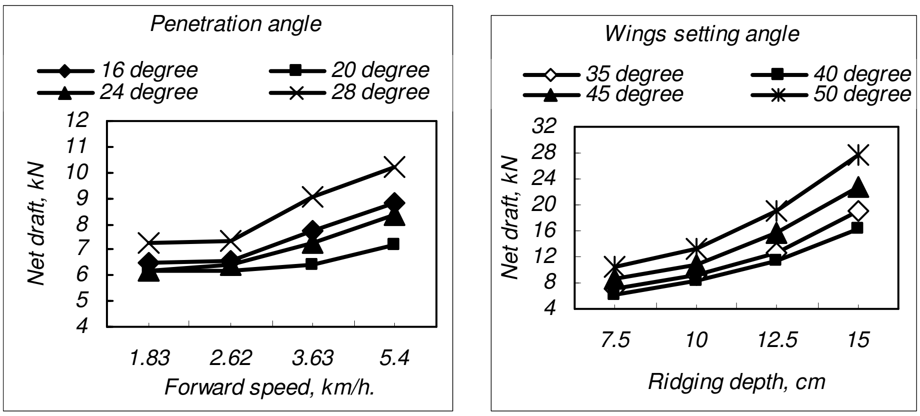


Fig. 6: The effect of forward speed, penetration angle and wings setting angle on the net draft requirement for the planter after developing.

Table 3 shows the average values of net draft and unit draft requirements for the developed planter under different forward speed and ridging depth. Increasing the forward speed and ridging depth tended to increase the net draft force and unit draft. It was found that the minimum net draft 6.14 kN and unit draft 40.93 kN/m^2 were recorded at the lowest forward speed of 1.83 km/h. and depth of 7.5 cm. Meanwhile, the maximum draft force 26.93 kN and unit draft 138.2 kN/m^2 were recorded with the highest forward speed of 5.4 km/h. and greatest depth 15 cm.

Table 3: Net draft "D" and unit draft "D_u" for the planter after developing at different forward speeds and ridging depth.

Planter width, m	Ridging depth, cm	Forward speed, km/h							
		1.83		2.62		3.63		5.4	
		D, kN	D_u, kN/m^2	D, kN	D_u, kN/m^2	D, kN	D_u, kN/m^2	D, kN	D_u, kN/m^2
2	7.5	6.14	40.93	6.21	41.4	7.85	52.33	8.99	59.93
2	10	9.59	47.95	9.69	37.8	11.19	55.95	12.29	61.45
2	12.5	13.69	54.76	14.09	56.36	15.69	62.76	18.89	75.56
2	15	15.38	51.26	19.39	64.63	20.79	69.3	26.93	138.2

CONCLUSION

The experimental results can be concluded as:

1- The planter after developing resulted in more soil loosening and a significantly lower bulk density than did the planter before developing at the 0 to 25 cm depth.

2- The soil resistance to penetration was 289.2 and 202.5 N/cm^2 for planter before developing and planter after developing, respectively.

3- The data showed that there was real difference in the soil moisture content, it was 28.6 % and 22.8 for the planter before developing and the planter after developing respectively.

4- The mean weight diameter of soil with the planter before and planter after developing was 4.42 and 2.45 cm, respectively.

5- It can be notice that there was not a significant difference among seedling emergence of planter after developing at 2.62 and 3.63 km/h. Therefore, to achieve the optimum field capacity, it is recommended to operate the developed planter at forward speed of 3.63 km/h.

6- The root and sugar yield increased by 25 and 19 %, respectively, for planter after developing compared with planter before developing.

7- The optimum design parameters were of ridging unit are 20 deg. penetration angle and 40 deg. wing setting angle.

8- As may expected, the depth had a considerable effect on the net draft. The net draft force increased 150 % and 200 % due to ridging depth increased from 7.5 cm to 15 cm at ridging speed of 1.83 km/h and 5.4 km/h, respectively.

9- Generally, experimental results have shown that the application of the developed planter is a practical approach towards increasing the efficiency of field crop production.

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الملخص العربي

تطوير وتقييم أداء آلة محلية الصنع لزراعة بنجر السكر

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يعد محصول بنجر السكر من المحاصيل الحساسة جدا للماء وذلك من حيث الزيادة أو النقص، فزيادة كميات المياه تؤدى الى موت البادرات، وفى مرحلة تكوين الجذور تؤدى الى تعفن الجذور، وفى كثير من الحالات تؤدى الى اختناق النبات وتشعب الجذور وبالتالي انخفاض إنتاجية المحصول والجودة. لذا فانه من الأهمية توفير مياه الري وإحكام عمليات الري في جميع مراحل نمو المحصول.

باحث اول بمعهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – الدقى – مصر.

لذلك كان الهدف من هذا البحث هو:

1- تطوير آلة زراعة محلية الصنع لمحصول بنجر السكر بإضافة وحدة تخطيط لإتمام عمليتى اقامة الخط و الزراعة فى عملية واحدة.

2- دراسة تأثير أهم العوامل الهندسية والتصميمية المؤثرة على أداء وحدة التخطيط.

3- تقييم ومقارنة أداء آلة الزراعة المحلية قبل وبعد التطوير.

تم اجراء التجربة البحثية بمحطة البحوث الزراعية بسخا- محافظة كفر الشيخ، على مساحة حوالى 2 فدان خلال الموسم الزراعي 2005 – 2006. وكانت اهم العوامل الهندسية التى تم دراستها اثناء التجربة هى: نوع آلة الزراعة (آلة الزراعة قبل التطوير – آلة الزراعة بإضافة وحدة التخطيط)، السرعة التقدمية لآلة الزراعة، عمق التخطيط ، زاوية الأختراق لسلاح وحدة التخطيط ، زاوية اجنحة وحدة التخطيط. وقد تم تقييم اداء الآلة المطورة عن طريق قياس الخواص الطبيعية لمرقد البذرة، نسبة الانبات، الإنتاجية، قوة الجر اللازمة للآلة.

وكانت أهم النتائج المتحصل عليها كما يلي:

1 - بلغت إنتاجية الفدان لجذور البنجر وسكر البنجر 36.2 طن /فدان و 5.85 طن /فدان على الترتيب بزيادة تصل الى 25 ٪ و 19 ٪ باستخدام آلة الزراعة المطورة مقارنة بآلة الزراعة قبل التطوير.

2- وجد ان أفضل العوامل التصميمية لسلاح وحدة التخطيط هي 20 درجة لزاوية اختراق التربة، 40 درجة لزاوية اتساع السلاح و 10 سم عمق الخط.

3- بينت النتائج ان قوة الشد اللازمة لآلة الزراعة المطورة تزداد بمقدار 150 ٪ - 200 ٪ بزيادة عمق الخط من 7.5 – 15 سم عند السرعة الأمامية للآلة 1.83 كم /ساعة و 5.4 كم/ساعة على الترتيب.