Misr J. Ag. Eng., 26(1): 44- 55 FARM MACHINERY AND POWER

*DEVELOP AND EVALUATE SUGAR BEET TOPPER UNIT TO SUIT IN SMALL HOLDING

Tayel, S.A., A.A. El-Nakeeb**., M.F. Khairy***., and N.M. El- Bialee,******

ABSTRACT

The aim of this investigation is develop and evaluate a topper unit to suit small holding farms. Field experiment were carried out in Rice mechanization centers, Meet El–Deba, Kafr El–Shikh Governorate 2004 seasons. To evaluate the performance of the developed topper unit at different leveling methods (LASER and traditional), different forward speed (0.5, 0.75 and 1m/s) and different cutting disc speed (7.72, 12.54 and 16.72m/s), the Topping efficiency, technical topping efficiency, correct topped, over topped, under topped beets, topping losses, actual field capacity and field efficiency, were studied. The result indicated that increase speeds (topper forward speed & cutting disc speed) due to decrease both topping eff., technical topping eff., and correct topped beet. Hence, it is due to increase both under topped beet, over topped beet, topping losses, actual field capacity and field eff. at both leveling methods. Generally, the results recommended that topper unit can be used at LASER leveling land and speeds (0.5&7.72m/s)(1& 16.72 m/s) treatments. It was recorded highest values for topping eff. (97.39%), technical topping eff. (90.2%) correct topped beet (92.62%) at speeds (0.5&7.72m/s).On the other hand, it was recorded lowest value for undr topped beet (2.68%), over topped beet (4.7%) and topping losses (77.91kg/fed).Hence, the best value of actual field capacity (0.444 fed/h) and field eff.(86.4%) were recorded at speeds (1& 16.72 m/s). Leveling methods had high significant effect on topped and correct topped beet No. Meanwhile, topper forward speed had high significant effect on under topped beet.

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* This study is part of outcomes from El- Bialee Phd thesis.

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INTRODUCTION

The importance of sugar beet as a source of sugar increased in Egypt to face the local requirements of sugar. Therefore, the area of sugar beet in 1982 to 2005 has increased about 90% in area. However, Egypt produce in 2005 about 1,65 million tons of sugar, while the consumption of sugar is about 2,3 million tons. Hence, only 71.7 % self-sufficiency is achieved and about 28.3 % has to be imported (Sugar Crops Council, 2005). Kanafojski and Karwowski (1976) mention that beets can be topped before or after digging. Also he mention that the optimum cutting disc speed may be ranged in 10 - 13 m/s. Sugar beet topping is consumed labor, topping one fed. of beet required 10 man/day (Allam 1988). Mechanical topping of sugar beet in Egypt is very economical and favorable as it reduces cost about 34 % of manual topping . (Aly ,1998).

Raininko (1990) mentioned that if the topping cut is lower than zero level (the critical section of cutting), the loss is 1.8 t/ha and the percentage of sugar in this part is 10.5 %, if the topping cut is lower than zero level by 1cm, loss is 3.3 t/ha and the percentage of sugar is 16.4% and if the cut of topping is lower than zero level by 2 cm, loss is 3.5 t/ha and the percentage of sugar is 17.2 %.

Tayel (1990) cited that LASER leveled soil produced a more uniform roots than the traditional leveled soil. The roots had less height and bigger diameter in the LASER soil, because there were no secondary roots due to the availability of water in the soil.

Abou-Shieshaa (1996) excogitated topping unit, operated by using an air pressure produce from a compressor driven by PTO shaft. After that Aly (1998) developed a sugar beet toppers using available power tiller. Khodeir (2002) add two rotary knives rotating in a horizontal plane to cut sugar beet foliage to Mady’s harvester. Controlling of topping level was achieved by using spinner wheel fixed on the frame. Abd–Rabou (2004) constructed a leaves removing unit. A seriating knife type and beet conductor moving by automatic circle with mechanical movement Awad (2006) developed topping unit. The whole plant was picked up after pulling and topped by a pair of topping discs rotated opposite to each other, one of them is a smooth disc and the other is toothed. While, Mady (2001) citetd that mechanical planting lead to increase the root yield.

Bahnas (2006) detected that there is logical trend of the positive relation among the forward speed and both of field capacity, field efficiency and tops yield.

The aim of this study is to develop topper unit for sugar beet foliage and evaluate the possibility of utilizing it under Egyptian conditions.

MATERIALS AND METHODS

Topper unit design

One row topper unit was fabricated locally for topping beet foliage as shown in Fig.(1). It consists of main six parts: frame, cutting disc, vertical shaft, cut height controller and transmission systems (gear box, pulley and belt).

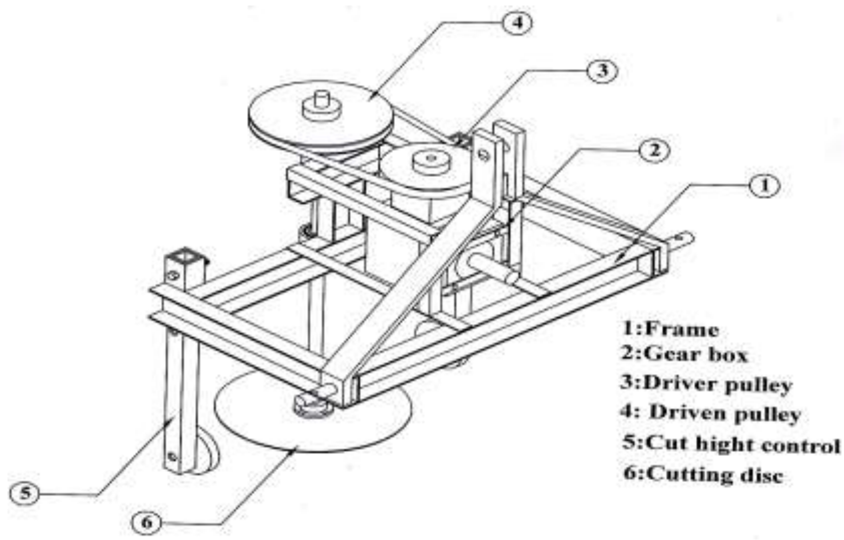

Fig. 1: Sugar beet topper unit sketch..

Frame; Manufactured from C section angle iron 80×40× 4 mm with length 500mm and width 820 mm. Three point hitching systems category II was manufactured from iron 16 mm thickness and welded on the frame.

Cutting disc; Saw type was used, made from austenitic stainless steels S31254., 355mm diameter, 3mm thickness and 1500g mass.

To select cutting disc diameter the following equation was used:

$$d_C \geq d_t + 2s \qquad \text{.........................(1)}$$

Where:

d_C = Cutting disc diameter, cm.

d_t = Root section diameter in topping place, cm.
s= Roots admissible deflection from row center line, (left and right), cm.
Tooth length and it's number at cutting disc was determined by Srivastava's equation (1998):

$$L_a = \frac{2\pi \times V_m}{n_t \times N_K} \text{ ....(2)}$$

Where :
L_a = Tooth length, mm.
V_m = Topper unit forward speed, m/s. According to Ismail et al. (1993). V_m = 15 / N_K
N_K= Cutting disc rotational speed, rpm. n_t = Teeth number .
Vertical shaft; ST 42.11., carbon 0.25 with, 25 mm diameter and 7200 mm length. The critical shaft diameter calculated by ASME code equation for solid shaft as follows :

$$d_S^3 = \frac{16}{\pi\, \delta_S} \sqrt{(K_b\, M_b)^2 + (K_t\, M_t)^2} \text{ ....(3)}$$

Where:
d_S = critical shaft diameter, m. δ_S = Material yield strength, N/m^2.
M_b=Maximum bending moment,Nm. M_t=Maximum tensile moment,Nm.
K_b = Combined shock and fatigue factor applied to bending moment.
K_t = Combined shock and fatigue factor applied to torsiona
Cut height controller; A pair of rubber wheel 120 mm diameter and 40 mm width mounted in a square pipe 50 mm in each sides of cutting disc to control the cutting height and also prevent cutting disc from striking the ground.
Transmission system
Gear box; used to transmit the motion perpendicularly by ratio 1:1. Horizontal inlet shaft 35mm diameter is connect to tractor PTO by universal joint. While, vertical outlet shaft of 40 mm diameter, driver pulley of 200 mm fixed on it to transmit the motion to driven pulley at vertical shaft through belt.
Pulley and belt: Three driven pulleys (260, 160 and 120 mm) were fixed on vertical shaft end to changing cutting disc rotational speeds.V-belt,

HB type is selected with nominal dimensions (16.7 mm width and 10.3 mm depth)

The experiments design

Tests and evaluation were carried out at Rice mechanization centers, Meet El – Deba, Kafr El – Shikh Governorate 2002–2003 season. The experime--ntal tests done at clay soil texture and the soil specification are in table (1).

Table (1): Soil physical analysis :-

Soil composition %					Soil texture
Clay, %	Silt, %	Clay + Silt ,%	Sand, %		
			Coarse	Fine	
52	18	70	3.2	26.8	Clay

Monogerm seed -Dell 939- variety was mechanically planting. The split plot design were used to evaluate the following studied parameters:

*Leveling methods; LASER and traditional methods.

* Topper unit forward speed; 0.5, 0.75 and 1 m/s.

* Cutting disc speed; 7.72, 12.54 and 16.72m/s.

Beet crop quality-

Topping eff., technical topping eff., correct topped, over topped, under topped, and broken beets were assessed in a percent as indicator for the topper unit performance. The above undependent variable were calculated by Richey's equations (1961).

$$\text{Topping efficiency } (\%) = \frac{N_t}{N_T} \times 100 \quad \ldots\ldots\ldots\ldots (4)$$

$$\text{Technical topping efficiency } (\%) = \frac{N_C}{N_T} \times 100 \quad \ldots\ldots\ldots\ldots (5)$$

$$\text{Correct topped beet } (\%) = \frac{N_C}{N_t} \times 100 \quad \ldots\ldots\ldots\ldots (6)$$

$$\text{Over topped beet } (\%) = \frac{N_O}{N_t} \times 100 \quad \ldots\ldots\ldots\ldots (7)$$

$$\text{Under topped beet } (\%) = \frac{N_U}{N_t} \times 100 \quad \ldots\ldots\ldots\ldots (8)$$

$$\text{Broken beet } (\%) = \frac{N_B}{N_T} \times 100 \quad \ldots\ldots\ldots\ldots (9)$$

Where :

N_t = Topped beet No. N_T = Total beet No.
N_C = Correct topped beet No. N_O = Over topped beet No.
N_U = Under topped beet No. N_B = Broken beet No.

Topper unit performance :

It can be evaluate by determine actual field capacity and field efficiency as follow:

$$AFC = 1/T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

$$\eta_f = \frac{AFC}{TFC} \times 100 = \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(11)$$

Where :

AFC = Actual field capacity, fed / h.

T = Actual total time in hours required per fed.

η_f = Field efficiency.

TFC = Theoretical field capacity, fed / h.

Topping losses

It was calculated as follows:

Topping losses (kg/fed)= Over topped beet(kg/fed)+Broken beet (kg/fed). According to Riananko., 1990.

Over topped beet (kg/fed) = Over topped beet (%) × (1.47×1000)

Broken beet (kg/ fed) = Broken beet (%)× (5.796 × 1000)

RESULTS AND DISCUSSION

Topping efficiency and Technical topping efficiency

Results presented in Fig.(2) show the effect of speeds (topper unit forward speed and cutting disc speed), and leveling methods on topping eff. and technical topping eff., respectively.

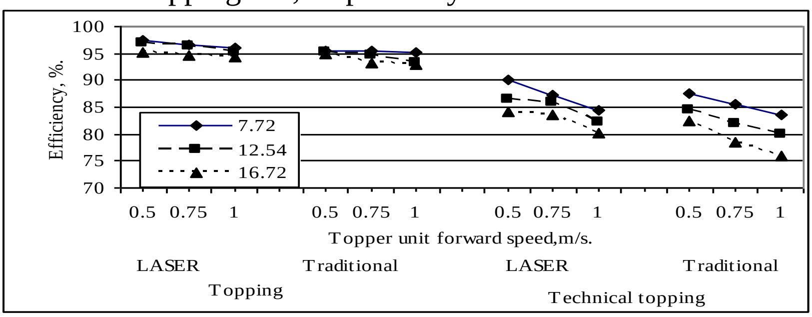

Fig. 2: Effect of speeds (topper unit forward speed and cutting disc speed), at different land leveling on topping eff. and technical topping eff.

It could be realized that topping eff. and technical topping eff. were recorded highest value at LASER treatment 97.39% and 93.02% by using speeds (0.5&7.72 m/s)., respectively. On the other hand, the lowest value were recorded 90.2% and 75.97% by using speeds (1 &16.72 m/s), respectively.

Correct topped beet

Fig. (3). shows that the topper unit forward speed increasing from 0.5 to 1m/s leads to decreasing topping accuracy percentage from (92.62% to 88.03%), (89.33% to 86.33%) and (88.49% to 85.03%) for LASER land leveling and from (91.54% to 87.6%), (88.52% to85.6%) and (86.92% to 81.67%) for traditional leveling at cutting disc speed 7.72, 12.54 and 16.72 m/s., respectively.

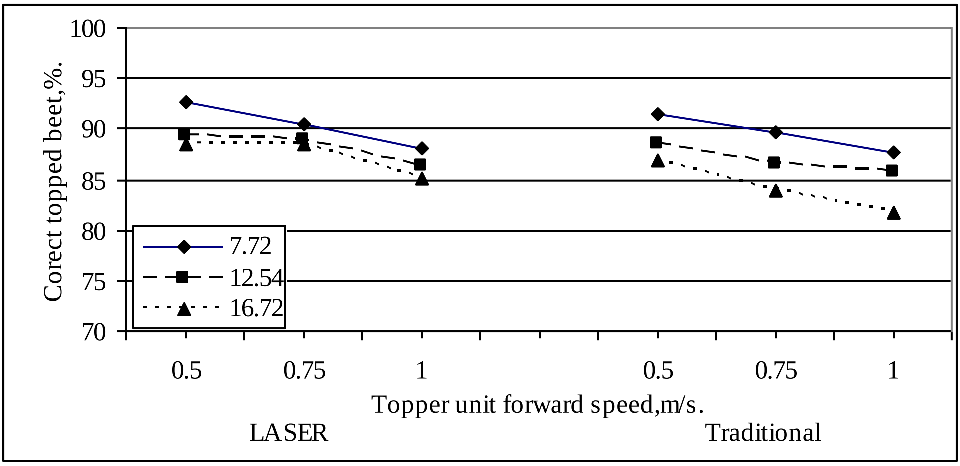

Fig. 3: Effect of speeds (topper unit forward speed and cutting disc speed), at different land leveling on correct topped beet.

Under topped beet:

Increasing the topper unit forward speed from 0.5 to1 m/s. the ratio of under topped beet percentage increased by about 0.84 times at cutting disc speed 7.72 m/s. The same trend was about of 1.71 times and 1.8 times at cutting disc speed of 12.54 and 16.72 m/s. for LASER leveling land. Meanwhile, at traditional leveling land the ratio of under topped beet percentage increased by about 1.05 times, 0.7 times and 2.88 times at cutting disc speed 7.72, 12.54 and 16.7 m/s. respectively. Fig (4)

Over topped beet:

It can be noticed that cutting disc speed increase from 7.72 to 16.72 m/s

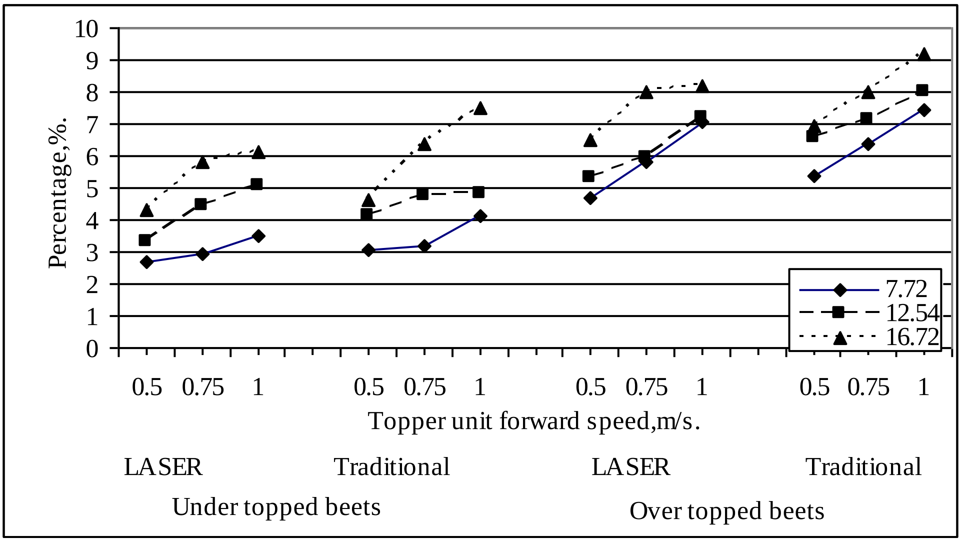

Fig. 4: The topped and over topped beets in percentage via topper unit forward speed and peripheral cutting disc speed at different leveling land.

leads to increased over topping percentage (1.77%,2.13% and 1.12%) and (1.54%,1.65% and 1.73%)for LASER and traditional leveling land at topper unit forward speed 0.5, 0.75and 1m/s., respectively. Fig.(4).

Actual field capacity and field efficiency:

Fig. (5) shows the effect of topper unit forward speed on actual field capacity and field eff. for both LASER and traditional leveling methods.

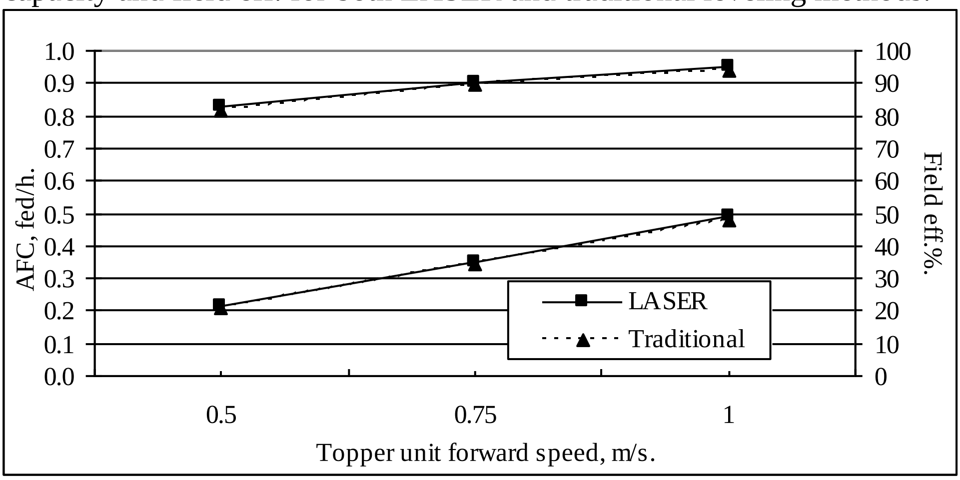

Fig. 5: Effect of speeds (topper unit forward and cutting disc speeds), on actual field capacity and field eff. at different land leveling.

It is obvious that, both actual field capacity and field efficiency were increased by increased topper unit forward speed. from 0.5 to 1 m/s., they were increased about (0.276 fed/h and 0.272 fed/h) and (12.32% and 12.27%) at LASER and traditional leveling land respectively.

Topping losses:

The data presented in Fig.(6, A and B) is illustrated the effect of (topper unit forward speed and cutting disc speed), and leveling methods on topping losses, kg/fed. for topper unit. Speeds (0.5 & 7.72 m/s) at LASER land leveling had recorded lowest value of losses (overtopped and broken beets), about 77.91kg/fed (77.91and 0 kg/fed)., respectively. Meanwhile, speeds (1& 16.72 m/s) at traditional land leveling was recorded highest value of topping losses about 266.27 kg/fed (128.33 and 137.94 kg/ fed)., respectively.

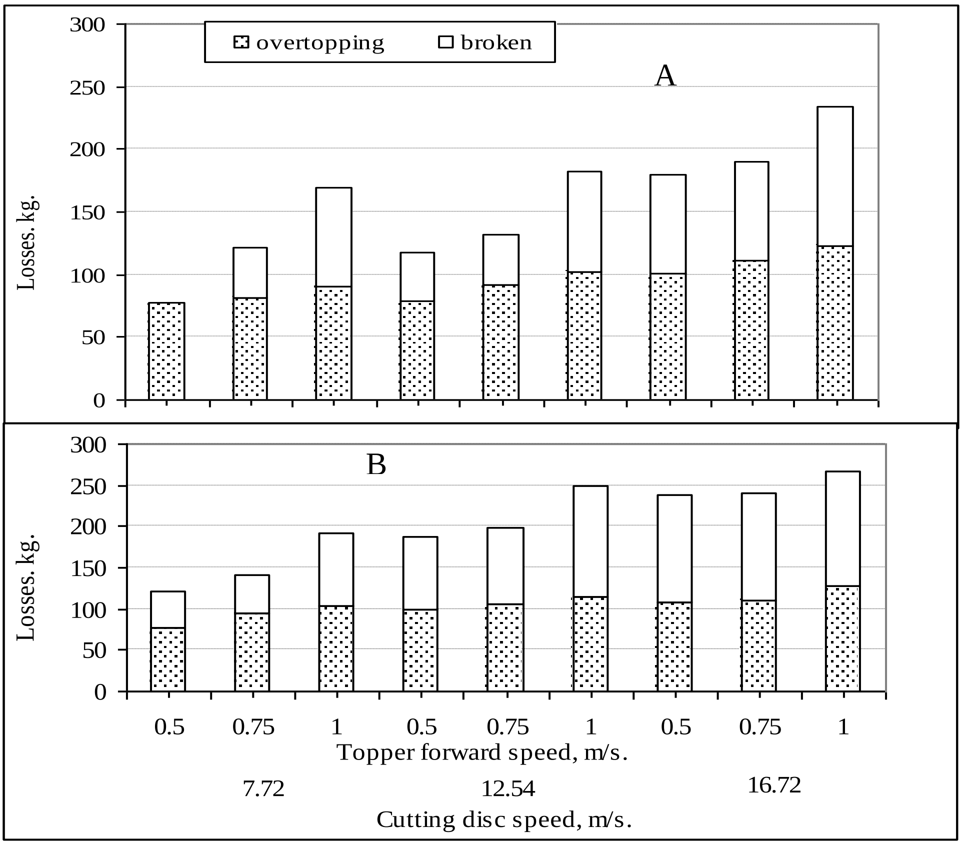

Fig.6: Effect of speeds (topper unit forward and cutting disc speeds),on topping losses at A) LASRE treatment and B)Traditional treatment.

CONCLUSION

The conclusions of this study can be summarized as follows:

* Increase speeds (topper forward speed & cutting disc speed) due to decrease both topping eff., technical topping eff. and correct topped beet. While, under topped beet, over topped beet and topping losses were increased at both treatments.
* The best results obtained at LASER leveling land and speeds (0.5&7.72m/s) which found the highest topping eff. (97.39%), technical topping eff. (90.2%) correct topped beet percentage (92.62%). Lowest under topped beet percentage (2.68%), over topped beet percentage (4.7%) and topping losses (77.91k/fed).
* Speeds 1& 16.72 m/s. recorded best value of actual field cabacity (0.444 fed/h) and heighest value of field eff. (86.4%), at LASER leveling land.
* Then, the staticall analysis cleared that the soil leveling method had a high significant effect on topped beet No. and correct topped beet No. Meanwhile, topper forward speed had high significant effect on under topped beet.

This study recommended to developed the topper unit to be multi units with vacated system for cutting foliage. This will help to increase the field capacity and topper efficiency.

REFERENCES

Abd-Rabou.A.F., 2004. Manufacturing a small machine to suit harvesting sugar beet under Egyptian conditions. Ph. D., Thesis. Agric. Mech. Dept., Fac. Agric., Kafr El – Sheikh.Tanta Univ.

Abou-shieshaa, R. R.,1996. A study on harvesting mechanization of sugar beet. Ph. D., Thesis. Agric. Mech. Dept., Fac. Agric. Kafr El – Sheikh. Tanta Univ.

Allam, A. I., A. M. Nour., and M. A. Farag.,1988. Prospective of sugar beet mechanical growing. Agric. Res. Review., Agric. Res. Center.,Giza., Egypt, 66 (3): 537-543.

Aly, A.H.,1998. Design and development of a sugar beet topper. Ph.D., Thesis. Agric. Mech . Dept., Fac.Agric., Ain shams Univ.

Awad, M.A., 2006. Developing of a pulling out mechanism for harvesting sugar beet crop. Ph.D. Thesis. Agric. Eng. Dept., Fac. Agric.,

Mansoura Univ.
Bahnas, O.T., 2006. The mechanical sugar beet harvest requirements in the reclaimed lands. Misr. J. Agric. Eng., 23(4): 909 – 928.
Ismail, Z. E., Y. M. El –Hadidi. and M.A. El – Saadany., 1993. The utilization of a developed disc mower to remove the vegetative tops of some tuber crops. Misr. J. Agric. Eng., 10(3): 508 – 524.
Kanafojski, C. Z. and T. Karwowski., 1976. Agricultural machine theory and construction (vol 2: Crop – harvesting machines). Published for the U.S. department of agriculture and the national science foundation, Washington, D.C. P: 830-920
Khodeir, M.A.A., 2002. Development of a small machine suitable for harvest sugar beet under Egyptian conditions. Ph.D., Thesis. Agric. Mechanization. Dept., Fac. Agric., Kafr El – Sheikh, Tanta Univ.
Mady, M.A., 2001. Mechanization of some operations for sugar beet production. Misr. J. Agric. Eng., 18 (2): 339– 355.
Raininko, K., 1990. Sweeden sugar beet production, J. of sugar. 1 (29) 32:62. [C.F. Aly, 1998]
Richey, C.B., P. Jacobson. and C. Hall., 1961. Agricultural engineers'Hand book. McGrow – Hill books Co, INC. New – York. USA. P:270 – 274.
Srivastava, A. k., C. E. Goering., P. R. Rohrbach., 1998. Engineering principles of agricultural machines. ASAE. Textbook, No (6). Pub. American Society of Agricultural Engineers. P: 45-60
Sugar crops council. 2005. Report on sugar crops and sugar production in Egypt. The central council for sugar crops. (In Arabic). Minstery of Agric and land reclamation. P: 18.
Tayel,S.A., 1990. A mechanized sugar beet system for small farms. final report. National agricultural research project., NARP. Al – Azhar Univ. Fac. of Agric. Agric. Eng. Dept: 61-75.

الملخص العربي

*تطويروتقييم وحدة تطويش لعرش بنجر السكر تناسب الحيازات الصغيرى

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***** أ.د. محمد فايد عبد الفتاح، **** ب.م. نذير محمد البيلي.**

الهدف من هذا البحث هو تطوير وتقييم وحدة تطويش معلقة تناسب الحيازات الصغيرة. تم إجراء هذا البحث في مزرعة مركز ميكنة الأرز – ميت الديبة – محافظة كفر الشيخ في موسم ٢٠٠٤. شملت عوامل الدراسة تأثير كل من: ١) طريقة تسوية الارض (التسوية بالليزر– الطريقة التقليدية). ٢) السرعة التقدمية لوحدة التطويش (ثلاثة سرعات ٠,٥ ، ٠,٧٥ ، ١ م/ث). ٣) سرعة سكينة التطويش (ثلاثة سرعات ٧,٧٢، ١٢,٥٤، ١٦,٧٢ م/ث). تم تقدير كفاءة أداء وحدة التطويش بحساب كل من كفاءة التقليع، الكفاءة الفنية للتقليع، نسبة الجذور المطوشه بشكل صحيح، نسبة الجذور ذات التطويش جائر، نسبة الجذور ذات التطويش السطحى، السعه الحقلية الفعلية، الكفاءة الحقلية، كمية الفواقد في المحصول.

* بزيادة السرعات (السرعة التقدمية لوحدة التطويش & سرعة سكينة التطويش) تؤدى الى تقليل كل من كفاءة التطويش و كفاءة التطويش الفنية وكذا نسبة الجذور التى طوشت بشكل صحيح. بينما يزيد كل من نسبة الجذور ذات التطويش السطحى ونسبة الجذور ذات التطويش الجائر و الفواقد في المحصول وذلك في كلا طريقتى التسوية.

* تحققت أفضل النتائج عند تطويش المحصول المنزرع في الأرض ذات التسوية بالليزر عند السرعات (٠,٥ & ٧,٧٢ م/ث). حيث سجلت النتائج أعلى قيمة لكل من كفاءة التطويش (٩٧,٣٩٪) و كفاءة التطويش الفنية (٩٠,٢٪) ونسبة الجذور النى طوشت بشكل صحيح (٩٢,٦٢٪) بينما سجلت أقل قيمة لكل من نسبة الجذور ذات التطويش الجائر (٢,٦٨٪) ونسبة الجذور ذات التطويش السطحي (٤,٧٪) وكذا الفواقد في المحصول (٧٧,٩١كجم/فدان).

* أعلى سعة وكفاءة حقلية (٠,٤٤٤ فدان/س، ٨٦,٤٪) تم تسجيلهما عند سرعات (١&١٦,٧٢م/ث) على التوالى .

* أوضح التحليل الإحصائي للنتائج أن طريقة تسوية الارض لها تاثير عالى المعنويه على كل من عدد الجذور المطوشة والجذور المطوشة بالشكل الصحيح. بينما كان للسرعه الامامية لوحدة التطويش تأثيرعالى المعنوية على عدد الجذور المطوشة تطويش سطحى.

توصى هذه الدراسة بتطوير وحدة التطويش لكى تتعدد مع وجود آلية لاخلاء الارض من العروش المقطعه لرفع الأداء .

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* هذه الدراسة جزء من النتائج المتحصل عليها من رسالة دكتوراه

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