DEVELOPMENT AN IMPORTED SUGAR BEET HARVESTING MACHINE.

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ABSTRACT

Field experiments were carried out at sakha Agri. Res. Station using a developed sugar beet harvesting digger- type of SAMAKA (after modification) to study the effect of forward speed of 1.2, 1.7, 2.3 and 2.8 km/h, topping knife speed of 2.71, 3.41 and 4.14 m/s, digging depth of 0.20, 0.25 and 0.30 m and soil moisture content of 24.5, 20.8 and 17.6 % on field capacity and efficiency, topping efficiency, lifting efficiency and total damaged roots. And also, determination of specific fuel consumption and cost of sugar beet harvesting were done. The results indicated that, maximum of topping efficiency and lifting efficiency were 97.83%and 95.7% respectively. Also , the maximum field capacity of machine was 1.00 Fed/h and field efficiency was 93.8% , On the other hand, a minimum of total damaged roots , specific fuel consumption and cost harvest were 2.81%, o.386 l/kW.h and 31.54 L.E /Fed , respectively. Finally, the performance characteristics of machine were influenced by the investigated variables.

keywords. sugar beet, topping efficiency, lifting efficiency, total damaged roots, specific fuel consumption.

INTRODUCTION

Sugar beet is coming as one of the most important crops in Egypt. Whose cultivated area is about 257667 fed/year to produce about 19،919 Mg /fed equal total yield 5132589 Mg / year (The Ag. Statistics Book, 2008). The important of sugar beet is not only limited to being a supplement for sugar production but also extend for many economical by products such as animal feed and it’s other secondary industries. Sugar beet harvesting is carried out in Egypt manually by hand digging, pulling

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the roots and by using chisel plow and collecting the roots manually.Therefore, this process's required a lot of work, time and more costs, so using machines in sugar beet production becomes one of the most essential targets for minimizing the production cost. Mechanical harvested of sugar beet resulted in drastic reduction of 86% in labor requirement per Mg of harvested beets and up to 69% of cost of harvest (*Allam et al., 1988*). *Hemeda et al. (1992)* investigated some operating factors such as forward speed, share angle, share width and operating depth for developed sugar beet harvesting unit. They found that, at 20º tilt angle, 23cm share width and 3.5 km/h forward speed, the share gave the maximum beet lifting efficiency of 98.5%. *Mady (2001)* noticed that, forward speed increasing from 1.9 to 3.6 km/h, increases the bruised roots from 3.5 to 4.0 %, the cut roots from 4 to 4.9% in addition decreasing the percentage of lifted roots from 90.8 to 89.5%. *Abou- shieshaa (2001)* reported that the increment in forward and flail rotational speeds increases both broken and overtopping. The minimum value of overtopping and broken beet were 3.42 and 1.15%, respectively at forward speed of 1.83 km/h and flail speed of 8.36m/s for mechanical planting and field chopper. Meanwhile, the percentage of under topped was 6.35 under the same conditions. *Bahnas (2006)* examined the required operational factors of the mechanical sugar beet harvest in the reclaimed lands. He found that, the highest beets lifting efficiency of 95% was recorded at forward speed of 2.65km/h, lifting depth of 0.30 m and share lifter tilt angle of 25°. While, the lowest mechanical damage loss of 1.12% was obtained at forward speed of 1.23km/h and the same previous lifting depth and share lifter tilt angle. *Morad et al. (2007)* reported that results reveal that total crop losses as well as harvesting cost are minimum and lifting efficiency is maximum under following conditions:

- Harvesting sugar beet crop under mechanical planting using the sugar beet harvesting machine.
- Harvesting forward speed of between 1.6 to 2.4km/h.
- Soil moisture content of between 21 to 24%.

Bahnas (2006) reported that mechanical harvest of sugar beet achieves 1.02 Fed/h, 68.64 MJ/Fed and 140.47 L.E/Fed for field capacity, required energy and harvesting costs. While, its were traditional harvest of sugar beet achieves0.09 fed/h, 35.25 MJ/Fed and 286.75 L.E/Fed, respectively. *Maughan (1983)* stated that sugar beet harvesting losses are due to whole beet being left on or the soil, tail breakage, over-topping or stand topping. Harvest losses were estimated by cleaning a 100 m² area of field and calculating tonnage loss, measuring tail loss, and calculating percentage loss due to over-and stand topping. *El-sheikha (1989)* showed that the chisel plow had the lowest value of fuel consumption and the rotary plow gave the highest value. *Ibrahim et al. (1989)* developed and tested a two-row sugar beet harvester. They found that, it was more economic and reduced about 90% of total costs for lifting operation. The objectives of this work are:

-Development two sugar beet harvester machine was designed for lifting sugar beet tubercles only, by addition oscillating mower at front of used tractor to make this machine suit the topping and lifting of sugar beet in one process.

-Investigation effects of forward speed, topping knife speed, harvesting depth and soil moisture content on field capacity and efficiency, topping and lifting efficiency.

-Determination minimize of damaged roots, specific fuel consumption and harvesting cost.

MATERIALS AND METHODS

The experiments were carried out at Sakha Agri. Res. Station during summer of season 2008 at harvesting sugar beet crola variety, to study the effect of engineering factors for sugar beet harvester machine was used in this study before and after development on field capacity and efficiency, to estimate topping and lifting efficiency, the specific fuel consumption and sugar beet harvesting costs.

1- Materials:

A- Sugar beet harvester machine before developing:

Drawing plan view of the Danish sugar beet harvester machine type of SAMAKA used in this study is shown in Fig (1), it consists of a steel frame, two wheel tiers, lifting unit consists of four saw-toothed wheels made from cast iron, crack soil unit consists of two share lifting is fixed on an upper crank and control lifting depth wheel is mounted in each console blade, beet conveyer unit, simple hydraulic cycle, gear box, power source (tractor P.T.O.). Table 1 show means specifications of machine.

Table 1: The technical specifications of harvester machine.

Specifications	**Value**
Total length, m	3.7
Total width, m	1.6
Operative width, m	1.1
Total height ,m	1.3
Total mass, kg	950
Source of manufacture	Danish
type	Samaka
Number of rows	two
Source of power	Tractor p.t.o.
hitching	Three points
Share shape	Saw-toothed wheel
Share diameter, m	0.60

This machine was used only for lifting sugar beet from under ground, because of that, it usually used after removing the vegetative tops manually or by using mower. Therefore, this operation consumed along – term work and costs.

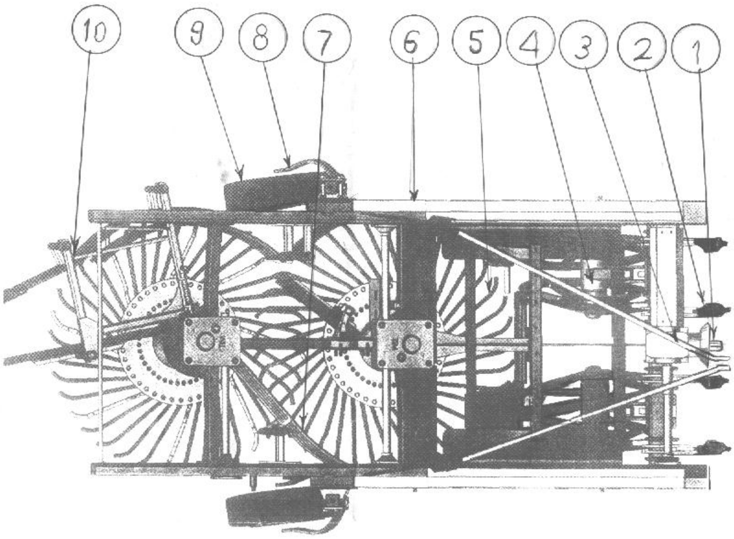
B- Development harvested machine:

Fig 2 is shown an engineering drawing plan view of the development machine. Where, some developments were inserted on the same previous machine as follows:

1- Constitution mower cutter bar at front of fundamental used machine. This mower consists of pair of knife bars, knife heads, cutter bar holder, knife guides, knife supports and pair of knife drive arms. The specifications of mower cutter bar are shown in Table 2.

2- Three different diameter pulleys named 11.5, 14.5 and 17.5 cm were used on arrival three different knife speed levels named 2.71, 3.41 and 4.14 m/s.

3- The mower fixed on two hydraulic pistons was used for adjustable removing height levels.



No.	Machine Parts
1	Main drive shaft.
2	Blade arm.
3	Hitching point.
4	Beet elevator unit.
5	Cleaning fan.
6	Machine frame.
7	Guide.
8	Scraper
9	Press wheel.

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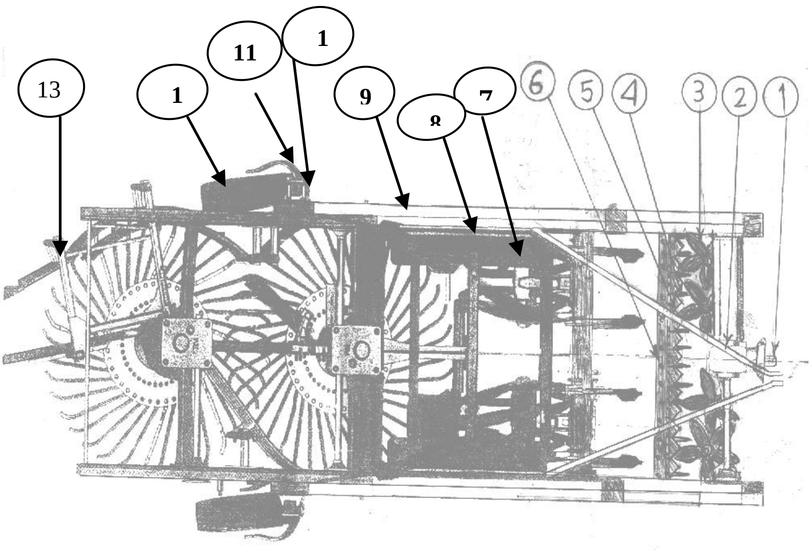
Fig. (1) : A drawing plan view of Sugar beet harvester machine **before** development



No.	Machine Parts
1	Main drive shaft.
2	Blade arm.
3	Hitching point.
4	.Guard
5	Knife blade
6	Knife main bar
7	Beet elevator unit
8	Cleaning fan.
9	Machine frame.
10	Guide
11	Scraper
12	Press wheel
13	Out let

Fig. (2) : A drawing plan view of Sugar beet harvester machine **after** development.

Table 2: specifications of mower cutter bar used.

Item	Value
Operating width , m	1.4
Source of power	Tractor P.T.O.
Number of blades knife	20
Number of knife bars	pair
Number of guides	5
Number of supports	5
Number of knife drive arms	pair

C- Tractor: A tractor type Bellerose 77 hp (47.79 kW) was used in these experiments.

2- METHOD:

The experiments were carried out in about 3 feddans sugar beet – the multigerm seeds crola type was planted mechanically. The distance between furrows was about 0.65 m and the distance between plants in same row was about 0.20 m. Table 3 present some of measured physical properties of sugar beet crop used.

Table 3: physical properties of sugar beet crop used.

lot no.	Root mass ,g	Top mass, g	Leaves mass, g	Top and leave mass, g	No, of plants /m²	No. of plants/ Fed.	Root yield, Mg/Fed.	Top and leave mass, Mg/Fed.
1	1098.3	163.71	550.3	714.01	6.36	26712	29.337	19.07
2	1352.5	159.37	643.2	802.57	6.24	26208	35.446	21.03
3	1411.2	175.30	731.3	906.60	5.12	21504	30.346	19.49
4	1136.7	143.10	678.6	821.70	4.81	20202	22.963	16.59
5	1231.9	150.80	811.4	962.20	5.27	23394	28.819	22.51
Average	**1246.12**	**158.45**	**682.96**	**841.41**	**5.62**	**23604**	**29.380**	**19.74**

Treatments:

1- The harvesting operation parameters:

-Tractor forward speed: Four forward speeds named 1.2, 1.7, 2.3, and 2.8 km/h.

-Topping knife speed of 2.71, 3.41 and 4.14 m/s.

- Harvesting depths of 0.20, 0.25 and 0.30 m.

2- Soil moisture content:
It was determined before harvesting directly by using soil up to 30 cm depth. The moisture content was 24.2, 20.8 and 17.6 % (w.b). The soil moisture content was determined in the lands and soil Res. inst., Agric. Res. Center.

Measurements:
Field measurements were carried out to determine the following:
1- Effective field capacity: it was calculated by using the following formula (kepner et al., 1982)

$$FC\ act = \frac{1}{T} \quad , \quad Fed/h \qquad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where:
FC act = Effective field capacity of the harvesting machine.
T = Total time per feddan, h.

Also, $T = (t+t1+t2+t3+\ldots.) \qquad \ldots\ldots\ldots\ldots\ldots\ldots 2$

Where:
t = Theoretical time;
$t_1+t_2+t_3$ = Time lost for turning +Time lost for adjusting +Time lost for repairing.

2- Field efficiency: it was calculated as follows from the tested data (kepner et at. 1982)

$$\eta f = \frac{FC\ act}{FC\ th} \times 100 \quad , \quad \% \qquad \ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where: η_f = Field efficiency, %;
FC act = Actual field capacity, fed/h and
FC th = Theoretical field capacity, fed/h.
Also,

$$FC\ th = \frac{V \times W}{4.2} \quad , \quad fed/h \qquad \ldots\ldots\ldots\ldots\ldots\ldots 4$$

Where:
V = The rated forward speed, km/h, and

W = The machine operating width, m.

3- Topping efficiency, %: it was determined by using the following formula (Richey et al., 1961)

Topping efficiency, % = 100 – (untopped beet, % + broken beet, %) …5

4- Lifting efficiency, %: the lifting efficiency was calculated according to the following equation (Mohamed, 1998):

$$Le = \frac{Ml}{Mt} \times 100 \quad , \quad \% \ldots\ldots 6$$

Where:

Le = Lifting efficiency, %;

Ml = The mass of lifted beets, kg and

Mt = The total mass of beet (lifted and unlifted), kg.

5- Total damaged roots percentage: it was calculated by using the following equation:

$$Dr = \frac{Nd}{Nd + N\,S} \times 100 \text{ , \%} \ldots\ldots 7$$

where:

Dr = Total damaged roots percentage, %;

Nd = Mass of the damaged roots harvesting, kg and

Ns = Mass of the undamaged roots harvesting, kg.

6- Specific fuel consumption: the specific fuel consumption calculated by using the following formula (suliman et al., 1993):

$$S.F.C = \frac{\text{Fuel consumption, l/h}}{\text{Power consumed, kW}} \text{ , l/kW.h} \quad \ldots 8$$

7- Sugar beet harvesting cost: to calculate the harvesting cost of the machine a formula that refers to (awady et al., 1982) was used. Also,

$$\text{Operating cost, L.E. /Fed} = \frac{\text{Machine cost, L.E /h}}{\text{Effective field capacity, Fed/h}} \ldots\ldots 9$$

- Harvesting criterion cost, L.E. / Fed = operating cost per Fed + total damaged and losses cost per Fed…………………….……10

8- Statistical Analysis : The collected data were averaged and statistically analyzed by standard analysis of variance procedures. The previously described treatments were replicated three times using sub-split split block design and differences between treatment means were separated by the DUNCAN'S Multiple range test at 0.05 and 0.01 levels of confidence.

RESULTS AND DISCUSSION

A- Primordial test:

Primary experiment was carried out during season 2008 at harvesting sugar beet crop with using harvesting digger type of SAMAKA(before developed), to determine the effect of some independent variables such as forward speed, harvesting depth and soil moisture content on machine performance. Results show that, no significant differences between machine before and after developed at determination of field capacity, field efficiency, lifting efficiency and total damaged roots. But the final product consisting in complete plants and its need to manual lifting process to separate sugar beet tubercles away from tops and leaves. This operation need about ten men's for feddan and it was cost about 300 L.E./Fed. , in addition to before development machine harvesting cost which arrive to about 60 L.E./Fed. So, using this machine cause increasing operation cost.

B-Performance of development sugar beet harvesting digger:

1- Field capacity and field efficiency:

Mean squares for the analyses of variance for the dependent variables in the study are noticed that the most important significant factor affected on field capacity was forward speed while moisture content was the important significant affected on field efficiency. Data noticed that field capacity and field efficiency recorded high value at soil moisture content of 20.8 % w.b ,because of sticky equilibrium in the field soil . Figures 3 and 4 show the effect of forward speed on both of field capacity and field efficiency at soil moisture content of 20.8 % with different topping knife speeds and harvesting depth. It is clear that increasing forward speed at the same topping knife speed, harvesting depth and soil moisture content tends to increase field capacity and field efficiency . Whereas, with soil moisture content of 20.8 % w.b, harvesting depth of 0.20 m and topping knife speed of 4.14 m/s, increasing forward speed from 1.2 to 2.8 km/h led to increase field capacity from 0.41 to 1.00 feddan/h (+143.9%) . As well as, at the same condition field efficiency increased from 89.7 to 93.8

% (+4.57%). On the other hand, increasing topping knife speeds at constant all of forward speed, harvesting depth and soil moisture content levels tend to increase both of field capacity and field efficiency. Whereas, with moisture content of 20.8 % w.b, harvesting depth of 0.20 m and forward speed of 2.81 km/h, increasing topping knife speed from 2.71 to 4.14 m/s led to increase field capacity slightly from 0.92 to 1.00 (+8.69%) and increase field efficiency from 86.3 to 93.8 % (+8.69%) respectively. The greatest field capacity of 1.00 feddan/h and field efficiency of 93.8 % recorded with using high value of forward speed was 2.8 km/h and high value of topping knife speed was 4.14 m/s.

2- Topping efficiency :

Comparison of the difference between the means of the analyses of variance indicates that increasing forward speed led to decrease topping efficiency while increasing topping knife speed led to increasing topping efficiency at constant both of soil moisture content and harvesting depth as shown in Fig. 5 . On the whole results recorded high value of topping efficiency at soil moisture content of 17.6 % w.b. So , at using moisture content of 17.6 %, harvesting depth of 0.20 m and topping knife speed of 2.71 m/s, increasing forward speed from1.2 to 2.8 km/h result in decreasing topping efficiency from 97.2 to 94.5% (-2.77%).While , the same previous condition of soil moisture content and harvesting depth, at forward speed of 1.2 km/h, increasing topping knife speed from 2.71to 4.14 m/s caused that, increasing topping efficiency from 97.2 to 97.83 % (+0.648%). Finally, the high value of topping efficiency was97.83 % registered with soil moisture content of 17.6 % w.b , harvesting depth of 0.20 m , forward speed of 1.2 km/h and topping knife speed of 4.14 m/s. Also, analyses of variance illustrated that harvesting depth and harvesting forward speed were important factor affected on topping efficiency.

3- Lifting efficiency :

Analyses of variance illustrated that all of dependent variables and all of dependent variables interactions were having significant affect for lifting efficiency. From means of lifting efficiency , it is clear that decreasing forward speed or increasing topping knife speed tends to increase lifting efficiency .

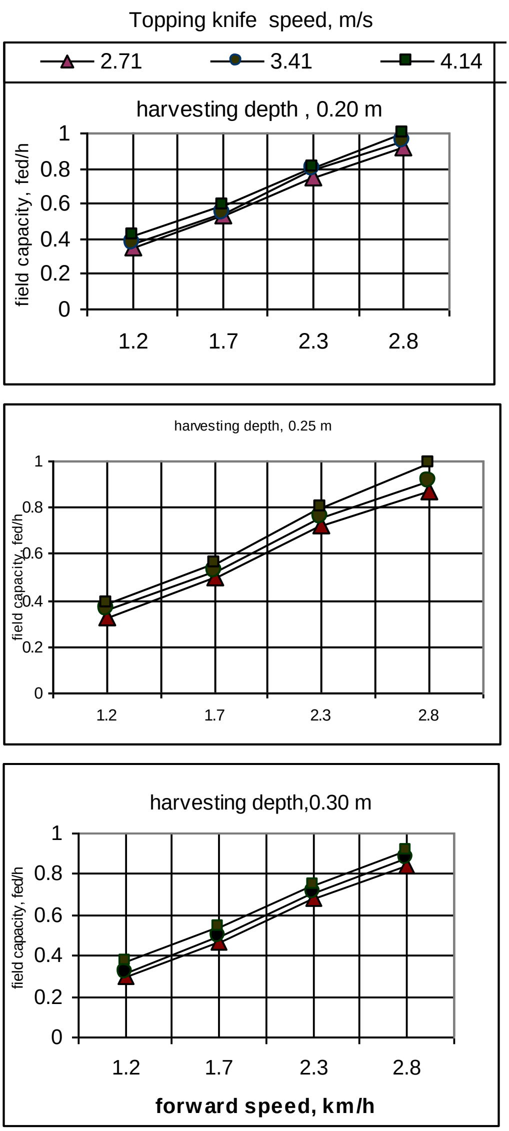


Fig 3: Relationship between forward speed and **field capacity** at different topping knife speed , harvesting depth and soil moisture content of 20.8% w.b.

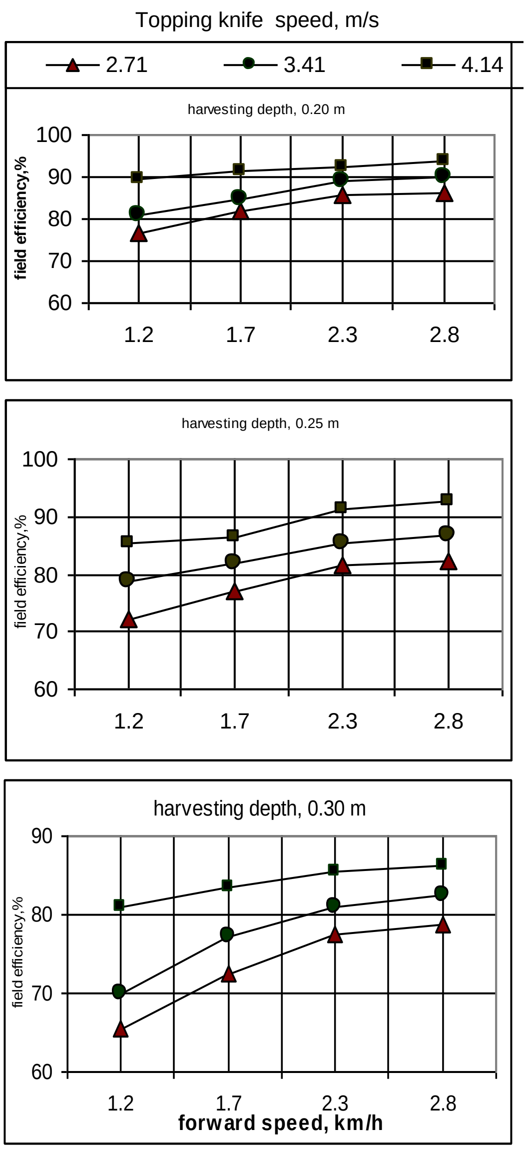


Fig 4: Relationship between forward speed and **field efficiency** at different topping knife speed , harvesting depth and soil moisture content of 20.8% w.b.

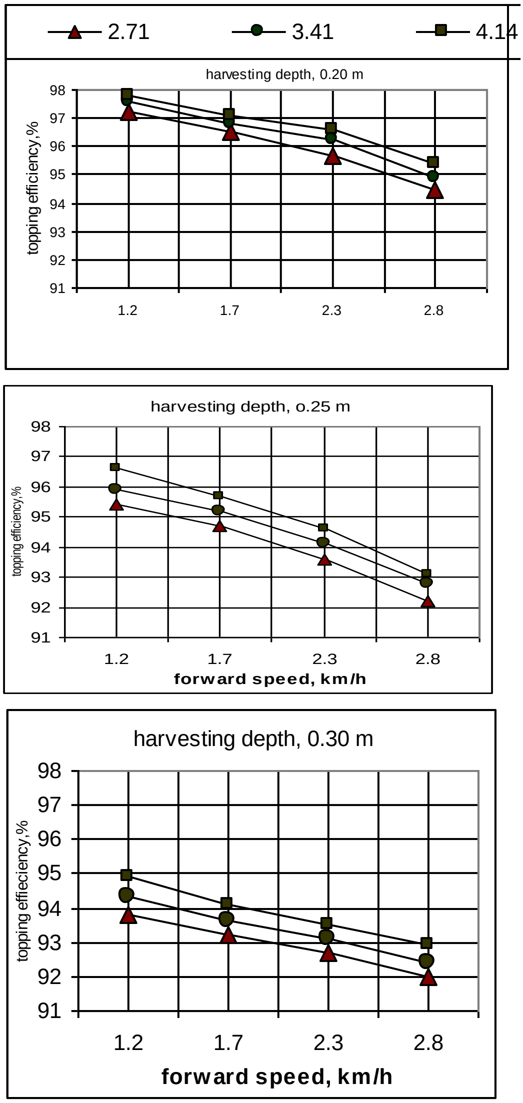


Fig 5: Relationship between forward speed and **topping efficiency** at different topping knife speed , harvesting depth and soil moisture content of 17.6% w.b.

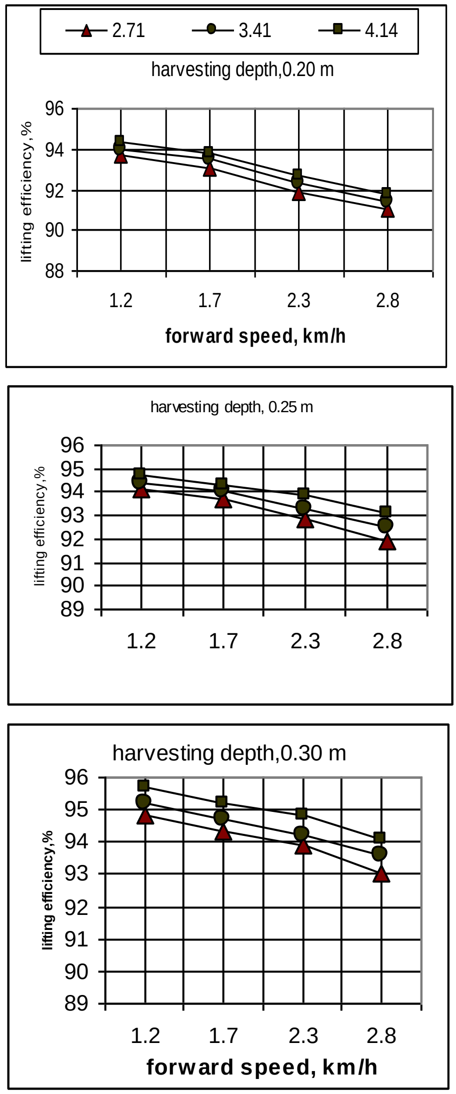


Fig 6: Relationship between forward speed and **lifting efficiency** at different topping knife speed , harvesting depth and soil moisture content of 20.8% w.b.

As shown in Fig. 6 it was found that, harvesting sugar beet at soil moisture content of 20.8 % w.b, harvesting depth of 0.20 m and topping knife speed of 2.71 m/s, decreasing forward speed from 2.8 to 1.2 km/h tend to increase lifting efficiency from 91 to 93.7 % (+2.96%). While, at the same previous soil moisture content and harvesting depth and forward speed of 1.2 km/h , increasing topping knife speed from 2.71 to 4.14 m/s tends to increase lifting efficiency from 93.7 to 94.3 % (+0.64%). Besides, results noticed that maximum value of lifting efficiency was 95.7% recorded at using soil moisture content of 20.8 % w.b, harvesting depth of 30 cm, forward speed of 1.2 km/h and topping knife speed of 4.14 m/s.

4- Total damaged roots percentage:

Total damaged roots percentage as connected with harvesting forward speed, harvesting depth and topping knife speed are shown in Fig. 7 . From analyses of variance , it can be noticed that forward speed consider an important significant affect on total damaged roots percentage . Also, means of total damaged roots percentage showed that harvesting forward speed and harvesting depth were having the important significant affect. For example, increasing forward speed from 1.2 to 2.8 km/h at soil moisture content of 24.5 % w.b, harvesting depth of 0.20 m and topping knife speed of 2.71 m/s, total damaged roots percentage increased from 4.27 to 5.20 % (+21.78%) . while, at the same previous soil moisture content ,harvesting depth and forward speed of 1.2 km/h increasing topping knife from 2.71 to 4.14 m/s, total damaged roots percentage decreased from 4.27 to 3.89 % (-8.83%). the minimum value of total damaged roots percentage was 2.82 % listed at using soil moisture content of 24.5 % w.b., harvesting depth of 0.30 m, forward speed of 1.2 km/h and topping knife speed of 4.14 m/s.

5- Specific fuel consumption

Specific fuel consumption was depending on forward speed, soil moisture content, topping knife speed and harvesting depth as shown in Fig . 8 Analyses of variance illustrated that soil moisture content and forward speed were high significant variables affected. Whereas,

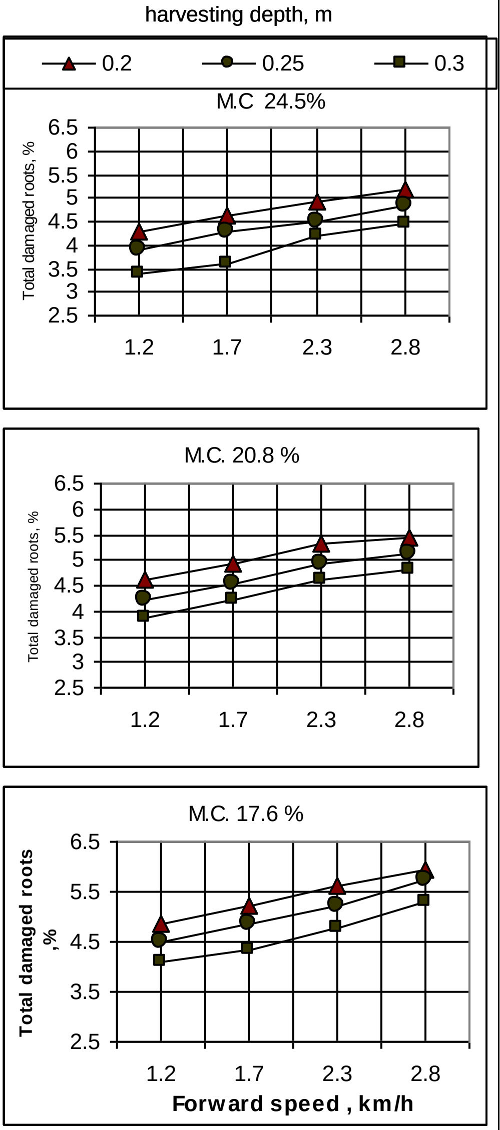


Fig 7: Relationship between forward speed and **total damaged roots** at different harvesting depths and soil moisture contents.

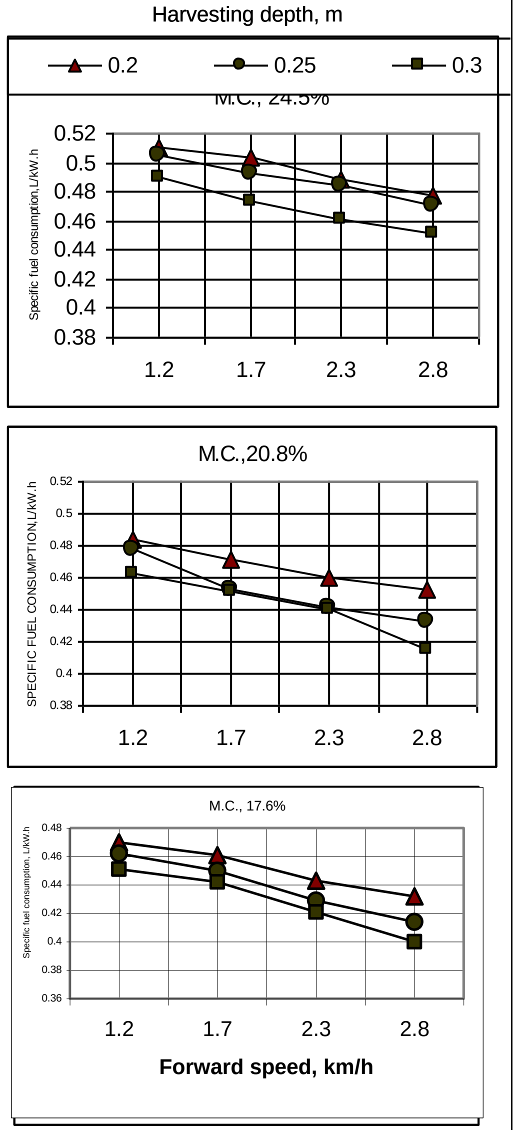
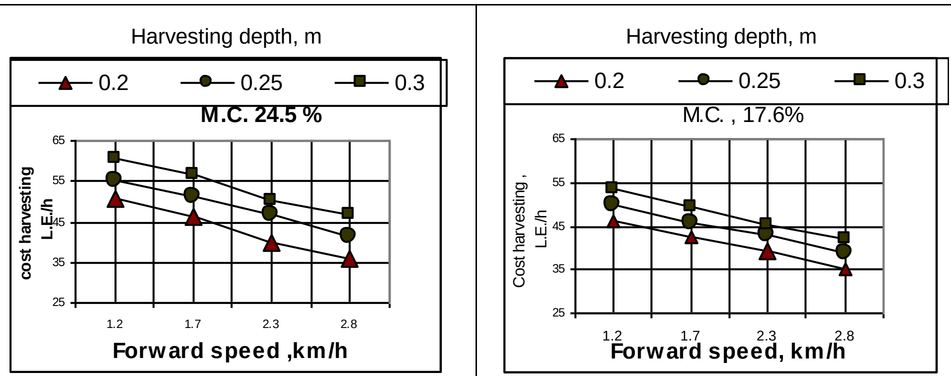


Fig 8: Relationship between forward speed and **Specific fuel consumption** at different harvesting depths and soil moisture contents.

increasing speed from 1.2 to 2.8 km/h at soil moisture content of 24.5 % w.b., harvesting depth of 0.20 m and topping knife speed of 2.71 m/s, specific fuel consumption decreased from 0.511 to 0.477 l/kW.h (-6.65%). Also, at the same previous soil moisture content, harvesting depth and forward speed of 1.2 km/h, increasing topping knife speed from 2.71 to 4.14 m/s, specific fuel consumption decreased from 0.511 to 0.489 l/kw.h (- 4.31%) . Maximum value of specific fuel consumption was 0.511 l/kW.h recorded at using forward speed of 1.2 km/h , topping knife speed of 2.71 m/s, harvesting depth of 0.20 m and soil moisture content of 24.5 % w.b., while minimum value of specific fuel consumption was o.386 l/kw.h recorded at using forward speed of 2.8 km/h, topping knife speed of 4.14 m/s, harvesting depth of 0.30 m and soil moisture content of 17.6 % w.b.

6- Cost harvesting :

For example, increasing forward speed from 1.2 to 2.8. Results noticed that increasing both of forward speed and knife speed also, decreasing moisture content from 24.5 % until above of 17.6 % w.b. led to decrease cost harvesting vice versa with increasing harvesting depth.



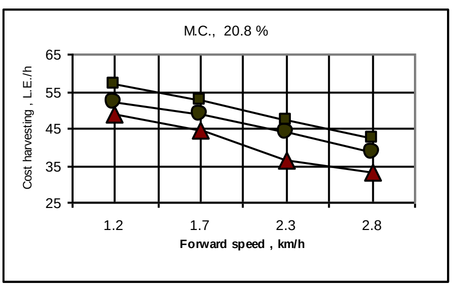


Fig 9: Relationship between forward speed and **Cost harvesting** at different harvesting depths and soil moisture contents

Data in Fig. 9 show that forward speed and harvesting depth were considered high important factor affecting on harvesting sugar beet cost. Mean squares for analyses of variance noticed that all dependent variables under study were significant affect on cost harvesting analyses. Results showed also that , minimum value of harvesting cost was 31.54 L.E./h recorded at using forward speed of 2.8km/h, harvesting depth of 0.20 m , topping knife speed of 4.14 m/s and soil moisture content of 20.8 % w.b. while, maximum value was 60.70 L.E./h recorded with forward speed of 1.2 km/h, harvesting depth of 0.30 m , topping knife speed of 2.71 m/s and soil moisture content of 24.5 % w.b

CONCLUSION

The obtained results can be concluded as follows:

1- At determination both of field capacity and field efficiency for developed harvesting machine. It were agreed directly with forward speed and topping knife speed. while it were reversely relation with harvesting depth and soil moisture content.

2- the maximum value of field capacity was 1.00 Feddan/h and maximum value for field efficiency was 93.8% recorded at using forward speed of 2.8 km/h, topping knife speed of 4.14 m/s, harvesting depth of 0.20 m and soil moisture content of 20.8 % w.b.

3- high value of topping efficiency was 97.83 % recorded with forward speed 1.2 km/h, topping knife speed of 4.14 m/s and soil moisture content of 17.6 % w.b.

4- lifting efficiency was agreed reversely with forward speed and directly with harvesting depth and topping knife speed. on the other hand, maximum value of lifting efficiency was 95.7 % recorded at forward speed of 1.2 km/h, topping knife speed of 4.14 m/s and harvesting depth of 0.30 m ,respectively.

5- minimum value of total damaged roots percentage was 2.81 % recorded at forward speed of 1.2 km/h, harvesting depth of 0.30 m, topping knife speed of 4.14 m/s and soil moisture content of 24.5 % w.b.

6- specific fuel consumption was agreed reversely relation with forward speed, topping knife speed and harvesting depth and agreed directly relation with soil moisture content .
7- minimum value of cost harvesting was 31.54 L.E./Fed recorded at forward speed of 2.8 km/h , topping knife speed of 4.14 m/s, harvesting depth of 0.20 m and soil moisture content of 20.8 % w.b. while maximum value was 60.70 L.E../Fed recorded at forward speed of 1.2 km/h , topping knife speed of 2.71 m/s, harvesting depth of 0.30 m and soil moisture content of 24.5% w.b., respectively.

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الملخص العربى

خصائص الأداء لآلة مطورة لحصاد بنجر السكر

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محصول بنجر السكر يعد من أهم المحاصيل السكرية في مصر و يعتبر من المحاصيل التي تدر ربحا كبيرا للمزارع مقارنة بالمحاصيل الأخرى. وقد تم زراعة مساحة ٢٥٧٦٦٧ فدان و قد أنتجت كمية ٥١٣٢٥٨٩ طن بمتوسط إنتاجية للفدان ١٩,٩١٩ طن/للفدان (الإحصائية الزراعية في مصر لسنة ٢٠٠٨ – وزارة الزراعة). وتعتبر عملية الحصاد للبنجر من اكبر العمليات الزراعية تكلفة على المزارع حيث مازال يعتمد في كثير من الأحيان على الحصاد اليدوي المكلف و المجهد نظرا لارتفاع أجور العمالة و قلتها.لذلك كانت الفكرة من هذا البحث هي إجراء تطوير على آلة تستخدم في تقليع درنات البنجر إلى آلة تقوم بإجراء عمليتي تطويش المجموع

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الخضري والتقليع في أن واحد عن طريق تزويد مقدمة الالة المستخدمة بمحشة ترددية تقوم بتطويش الأجزاء الخضرية ثم تأتى الآلة لتقليع الدرنات من التربة وذلك بغرض رفع درجة أداء الآلة و تقليل تكاليف عملية الحصاد وتوفير الوقت.

العوامل تحت الدراسة:

١- سرعة التقدم الأمامية : تم استخدام أربعة سرعات أمامية كانت ١,٢ ، ١,٧ ، ٢,٣ ، ٢,٨ كم / ساعة.

٢- سرعة سكينة التطويش : تم استخدام ثلاثة سرعات كانت ٢,٧١ ، ٣,٤١ ، ٤,١٤ م/ث.

٣- عمق الحصاد : تم استخدام ثلاثة أعماق للحصاد كانت ٠,٢٠ ، ٠,٢٥ ، ٠,٣٠ م.

٤- المحتوى الرطوبى للتربة : تم إجراء التجارب عند ثلاثة محتويات رطوبية للتربة كانت٥ ,٢٤ ، ٨ ,٢٠، ٦ ,١٧ % على أساس رطب.

وقد تم تقييم أداء الآلة من خلال دراسة مؤشرات الكفاءة الآتية:

١- السعة الحقلية، فدان/ساعة.
٢- الكفاءة الحقلية، %.
٣- كفاءة التقليع، %.
٤- كفاءة التطويش، %.
٥- اجمالى الفقد و التلف في الجذور، %.
٦- الاستهلاك النوعي للوقود لتر/كيلووات.ساعة.
٧- اجمالى تكاليف عملية الحصاد، جنية /فدان.

أهم النتائج:

١- إضافة وحدة لتطويش الأجزاء الخضرية للآلة المطورة عند حصاد بنجر السكر كانت ذات تأثير معنوي و أدت إلى تقليل الوقت و الجهد المستهلك في حصاد الفدان و أدت إلى رفع الكفاءة الحقلية والسعة الحقلية للآلة المطورة.

٢-السعة الحقلية (فدان/ساعة) و الكفاءة الحقلية (%) للآلة المطورة كانت تتناسب طرديا مع سرعة تقدم الآلة وسرعة سكينة التطويش بينما كانت تتناسب عكسيا مع عمق الحصاد والمحتوى الرطوبى للتربة.

٣- أعلى سعة حقلية للآلة المطورة كانت ١ فدان /ساعة و أعلى كفاءة حقلية كانت ٨ , ٩٣ % وسجلت عند استخدام سرعة تقدم ٢,٨ كم / ساعة ، سرعة سكينة تطويش ١٤, ٤ م/ث ، عمق حصاد ٠,٢ متر و محتوى ر طوبى للتربة ٨ ,٢٠ % .

٤- كفاءة التطويش (%) كانت تتناسب عكسيا مع سرعة التقدم وطرديا مع سرعة سكينة التطويش وبلغت أعلى قيمة لها
٣ ٨ , ٩٧ % سجلت عند استخدام سرعة تقدم١,٢ كم/ساعة ، سرعة سكينة تطويش ١٤, ٤ م/ث و محتوى ر طوبى ٦ , ١٧ %.

٥- كفاءة التقليع (%) كانت تتناسب عكسيا مع سرعة التقدم و طرديا مع عمق الحصاد ومع سرعة سكينة التطويش و كانت أعلى قيمة لكفاءة التقليع ٧ , ٩٥ % سجلت عند استخدام سرعة تقدم ١,٢ كم / ساعة ، سرعة سكينة تطويش ١٤, ٤ م/ث ، عمق حصاد ٠,٣ متر و محتوى رطوبى للتربة ٨ ,٢٠ % .

٦- اجمالى الجذور التالفة (%)كانت تتناسب طرد يا مع سرعة التقدم و عكسيا مع عمق الحصاد و المحتوى الرطوبى و سرعة سكينة التطويش . و كانت اقل نسبة للجذور التالفة هي ١ ٨ ,٢ % سجلت عند استخدام سرعة تقدم ١,٢ كم / ساعة ، سرعة سكينة تطويش ١٤ ,٤ م/ث ، عمق حصاد ٠,٣ متر و محتوى رطوبى للتربة ٥ ,٢٤ % .

٧- الاستهلاك النوعي للوقود (لتر/كيلووات.ساعة) كانت تتناسب عكسيا مع سرعة التقدم ومع سرعة سكينة التطويش وعمق الحصاد و طرديا مع المحتوى الرطوبى للتربة.

٨- تكاليف الحصاد(جنية/فدان) كانت تتناسب مع سرعة التقدم و سرعة سكينة التطويش وطرديا مع عمق الحصاد و المحتوى الرطوبى للتربة. و بلغت اقل قيمة لها ٥٤ ,١ ٣ جنية/فدان عند استخدام سرعة تقدم ٢,٨ كم / ساعة ، سرعة سكينة تطويش ١٤ ,٤ م/ث ، عمق حصاد ٠,٢ متر و محتوى رطوبى للتربة ٨ ,٢٠ % .بينما بلغت أعلى قيمة لها ٧٠ ,٠ ٦ جنية/فدان عند استخدام سرعة تقدم ١,٢ كم / ساعة ، سرعة سكينة تطويش ٧١ ,٢ م/ث ، عمق حصاد ٠,٣ متر و محتوى رطوبى للتربة ٥ ,٢٤%.