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COMPARATIVE STUDY BETWEEN MANUAL AND MECHANICAL METHODS OF HARVESTING SUGAR BEET CROP

Morad, M. M.* **G. H. Elsaid**** **M. M. A. El-Sharabasy*****
F. A. Abd elgawad****

ABSTRACT

Three sugar beet harvesting methods namely: traditional, chisel plow and sugar beet harvester were deduced and compared using two different planting methods. Experiments were carried out as a function of change in harvesting speed and soil moisture content to determine field capacity and efficiency, lifting efficiency, total crop losses, power and energy consumed, and total cost requirements for harvesting sugar beet crop. The results indicated that, the maximum field capacity and efficiency was 0.920 fed/h and 85.57 % obtained under mechanical planting and sugar beet harvester, compared with manual method which recorded 0.699 fed/h and 84.26 %, respectively. The maximum lifting efficiency and minimum total losses were 93.98 % and 8.31 % obtained under mechanical planting and sugar beet harvester, compared with manual method which recorded 92.73 % and 10.39 %, respectively. The minimum power and energy consumed was 23.72 kW and 36.15 kW.h/fed obtained under mechanical planting and sugar beet harvester, compared with manual method which recorded 24.67 kW and 46.34 kW.h/fed, respectively. The minimum total cost for harvesting sugar beet crop was 706.4 L.E/fed obtained under mechanical planting and sugar beet harvester, compared with manual method which recorded 738.9 L.E/fed.

INTRODUCTION

Sugar beet is considered one of the most important crops, not only for sugar production but also for fodder and organic matter for the soil. It is also considered as a double benefit crop to the farmers, where the roots are processed for sugar production and the green leaves

* Professor of Agric. Eng. Dept., Fac. of Agric., Zagazig Univ., Egypt.
** Head researcher and senior of Agric. Eng. Res. Inst., Dokki, Giza, Egypt.
*** Lecturer of Agric. Eng. Dept., Fac. of Agric., Zagazig Univ., Egypt.
**** Post graduate student, Agric. Eng. Dept., Fac. of Agric., Zagazig Univ., Egypt.

and tops are used for animal feeding. Sugar beet harvesting is still carrying out in Egypt manually by hand digging, pulling the roots out of the soil by shovel and hoe, or by a chisel plow.

Mechanical sugar beet harvesters are not common in Egypt, and manual methods are exhaustive, and impractical. In recent years some progress towards fully mechanized of sugar beet harvesting has been occurred. There are many types of sugar beet harvesters which were tested under Egyptian conditions. Some of them were multi rows; others were one or two rows. The selection of the appropriate machine for harvesting sugar beet is a vital problem to be considered to minimize both crop losses and operational costs. **Bartha (1977)** studied two sugar beet harvesters and indicated that, roots and sugar losses were 3.27 - 5.13 and 0.32 - 0.51 t/ha, respectively which amounted to 10 - 14 % at the average crop yield, 54 - 60 % of the sugar losses due to the roots lift in the field. The degree and quality of harvesting losses depends largely of field operations at sowing and harvesting. **Abdel-Galeil (1990)** during the harvesting operation of sugar beet reported that, the percentages of lifted tubers were increased by increasing forward speed from 1.8 to 2.8 km/h. While these percentages were decreased by increasing the forward speed more than 2.8 km/h. On the other hand, the continuous increasing of forward speed from 1.8 to 3.8 km/h increased the damaged tuber percent from 1.53 to 2.67 %. **Taieb (1990)** found that, the yield of the sugar beet roots in the manual and mechanical planting were 35.95 and 42.34 ton/fed, respectively. The total demands of energy in the manual and mechanical planting were 0.737 and 50.470 kW.h/fed. The cost per one unit of the consumed energy in the manual and mechanical planting was 10.43 and 0.37 L.E/kW.h. **Toth (1991)** tested the Matrot–M–31 self-propelled harvester which can perform topping, root lifting, cleaning and loading of sugar beet from 6 rows. Test results showed that the harvesting losses remained under 3% and root damage under 15% at 3.5-6.4 km/h operating speed. **Nasr (1992)** compared and evaluated the performance of different types of sugar beet harvesters in three different plot sizes in Netherlands and conditions similar to that in Egypt. The results could be summarized as follows: (a) the material capacity increased when the width of sugar beet harvester and the length of plot strip increased. (b)

the total cost per hectare decreased as the plot size or the width of the harvester increased. **Zaalouk (1994)** modified the 7-blades chisel plow and designed a fork lifter to be used with chisel plow for sugar beet harvesting. The result indicated that the performance of the designed fork lifter was satisfactory in general, since the average damage was 0.66 and 1.5 3 % with and without topping, respectively. And un-lifted roots were 4.06 and 5.41 % with and without topping, respectively. For the modified shanks chisel plow with wing lifter, the averages of damage were 4.21 and 3.6 % with and without topping, respectively. The averages of un-lifted roots were 6.70 and 8.61 % with and without topping, respectively. **Mady (1995)** found that the increase of forward speed 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 %. **EL-Sherief (1996)** stated that the cost of using tractor and harvester was reached 60.57 L.E/fed. Mechanical harvesting resulted a drastic reduction of 80 % in labor requirement per feddan and up to 71 % for total cost of sugar beet harvesting. **Kromer *et al.* (1998)** stated that according to the test and related surveys, sugar beet harvesters today have field capacities from 40 to 130 t/h, tank capacities from 5.5 t (2-rows) to 26 t (6-rows) and average harvesting qualities of 5.8 % dirt tare, 1.9 % total mass loss and 75.1 % acceptable topping. **Sharobeem *et al.* (2003)** developed and manufactured suitable equipment for harvesting sugar beet roots and study the possibility of utilizing it under Egyptian conditions. The experiments were carried out to evaluate the performance of the constructed harvester compared with the traditional chisel plow. Three traveling speeds (2, 3, and 3.8 km/h) were used. The results showed that, for the developed harvester, the maximum harvesting efficiency was about 84 % at 2 km/h forward speed and the minimum damage roots was about 4.5 % at the same speed. The maximum percentage of lifted roots was about 88.5 % with the developed harvester, while that obtained with chiseling was 76.4 %. The actual field capacities were 0.6, 0.9, and 1.14 fed/h at forward speeds of 2, 3, and 3.8 km/h, respectively for the developed harvester. In case of using the developed harvester, the minimum power required was 13.16 kW at forward speed of 2 km/h. While the maximum power required was about 25.96 kW at

3.8 km/h forward speed. The energy requirement for the developed harvester was about 22.77 kW.h/fed. It is very important to apply the most economical methods for harvesting sugar beet crop to obtain minimum losses and maximum yield. In Egypt, harvesting process of sugar beet crop is still carrying out using hand digging or chisel plow beside sugar beet harvesters. Therefore, this study aimed to evaluate three methods for harvesting sugar beet crop to optimize their performance in terms of field capacity and efficiency, lifting efficiency and total crop losses, power and energy consumed, and finally total cost requirements.

MATERIALS AND METHOD

The main experiments were carried out through two successive agricultural seasons of 2005 and 2006 at Meet EL-Dyba farm, Kafr EL-Sheikh Governorate to evaluate some different harvesting methods of sugar beet crop under Egyptian conditions. The mechanical analysis of the experimental soil was classified as a clay soil (Table 1).

Table (1): Mechanical analysis of the experimental soil.

Soil fraction, %			Soil texture
Clay	Silt	Sand	Clay
52	36	12	

(A) MATERIALS:

● ***Sugar beet crop:***

Sugar beet is considered a perennial plant, and it consists of the following two main parts as shown in Fig (1), **(Kipps, 1970)**.

Fig.(1): Sugar beet plant.

1. The root system which consists of the crown, the neck, the cone shaped taproot and its narrow extended taproot end, and
2. The vegetative growth, which consists of the leaves.

● ***Tractors:***

Two types of tractors were used to operate and draw the used equipment.

- Nasr tractor 44.77 kW (60 hp) engine power was used for operating the planter.
- Kubota tractor 69.35 kW (93 hp) energy power was used for operating both chisel plow and sugar beet harvester during the harvesting operation.

● ***Equipments:***

The following machines were used for planting and harvesting sugar beet crop.

a- Planter:

An American made planter type Powell (12 MX mutt flex model) was used in planting the experimental crop.

b- Chisel plow

Mounted type chisel plow with 9 blades was used for harvesting sugar beet.

c- Sugar beet harvesting equipment:

Sugar beet one row harvesting machine was used for harvesting sugar beet. The machine is equipped with one row pulling device. The pulling device consists of two pulling discs. The vertical angle between each two discs is 60º. The machine is equipped with a rotary elevator coated with rubber to avoid scratching the tubers. The elevator transfers the roots to the cleaning device. The machine is also equipped with two depth wheels to control the digging depth.

(B) METHOD:

The experimental area was about six feddans divided into two equal plots (three feddans each). One of the two plots was seeded with sugar beet manually while the other was seeded with sugar beet mechanically using the planter. Each plot was classified into three equal sub-plots (one feddan each) for the different three methods of harvesting.

1- Planting methods:

- Manual method: using the conventional method.
- Mechanical method: It was carried out using the planter.

In both manual and mechanical methods, the rows spacing and the hills in the same row were almost adjusted to be 50 cm and 20 cm, respectively. Both manual and mechanical methods require about 4 kg/fed of seeds. The planting depth was adjusted to be 2 cm and the planting forward speed was kept constant at 3.5 km/h. Fertilizing, irrigation and weed control were the same in all treatments according to the technical recommendations.

2- Harvesting methods:

- Manual harvesting: using the conventional method.
- Mechanical harvesting: mechanical harvesting was carried out using the chisel plow and sugar beet harvesting equipment. The harvesting operation was carried out through five different soil moisture contents of 15, 18, 21, 24 and 27 %, and four different forward speeds of 0.8, 1.5, 2.4 and 3.2 km/h.

■ MEASUREMENTS:

• ***Soil moisture content:***

Soil moisture content can be determined using the following formula:

$$M.C = \frac{m_1 - m_2}{m_1} \times 100, \quad \text{.....(1)}$$

Where:

$M.C$ = Moisture content, %.

m_1 = Sample mass before drying, g.

m_2 = Sample mass after drying, g.

• ***Soil mechanical analysis:***

Eight random samples were taken to determine soil mechanical analysis using the hydrometer method. The soil mechanical analysis was conducted in the Land and Soil Research Institute, Agric. Res. Center.

• ***Sugar beet dimensions:***

The root length (L), root width (W), diameter of root (D), height of leaves (H) and diameter of leaf cluster (d) were measured and recorded for random samples of sugar beet plant before harvesting operation.

• ***Sugar beet mass:***

Mass of plant (root and leaves) was estimated and ratio of root mass to the vegetative growth mass was also calculated for all treatments under test.

• ***Root volume:***

Root volume was calculated according to the following equation (assuming that sugar beet root is approximately conical shape).

$$V_r = \frac{1}{3}\pi r^2 L, \quad \text{.....(2)}$$

Where:

V_r = Calculated volume of roots, cm³.
r = Radius of root, cm.
L = Length of root, cm.

• ***Root yield:***

The yield of the harvested roots was determined by massing the roots lifted by harvesting by using the following equation (**Taieb, 1997**):

$$R_Y = \frac{M \times 4200}{A \times 1000} \quad (Mg / fed), \quad \text{.....(3)}$$

Where:

M= Mass of lifted roots, kg.
A = Harvested area, m².

• ***Field capacity:***

Actual field capacity was the actual average time consumed during digging operation (lost time + productive time). It can be determined from the following equation:

$$F.C_{act} = \frac{60}{Tu + Ti}, \quad (fed/h) \text{.....(4)}$$

Where:

$F.C_{act}$ = Actual field capacity of the cutting machine.
T_u = Utilization time per feddan in minutes.
T_i = Summation of lost time per feddan in minutes.

• ***Field efficiency:***

Field efficiency is calculated by using the values of the theoretical field capacity and effective field capacity rates as:

$$\eta_f = \frac{F.C_{act}}{F.C_{th}} \times 100 \quad (\%), \quad \text{.....(5)}$$

Where:

η_f = Field efficiency, %.

• ***Technical examination of sugar beet roots:***

The technical examination of sugar beet roots was done after clearing roots from clods to classify roots into five categories. Five random samples of roots were collected and mass for each treatment. Each sample was divided into five classes (lifted beets, un-lifted beets, bruised

beets, damaged beets and un-damaged beets). The mass of lifted beets, un-lifted beets, bruised beets, damaged beets and un-damaged beets were recorded.

• ***Total losses:***

Total sugar beet losses can be calculated using the following equation:

$$Total\ losses = Mass\ of\ unlifted\ beets + Mass\ of\ damaged\ beets \quad .....(6)$$

• ***Lifting efficiency:***

The lifting efficiency was calculated according to the following equation:

$$L_e = \frac{M_L}{M_T} \times 100 \quad .....(7)$$

Where:

L_e = Lifting efficiency, %.

M_L = Mass of lifted beets, kg.

M_T = Total mass of beets (lifted + un-lifted), kg.

• ***Energy consumed:***

To estimate the engine power during digging operation, the decrease in fuel level in fuel tank accurately measuring immediately after each treatment. The following formula was used to estimate the engine power (**Hunt, 1983**):

$$EP = \left[f.c\left(1/3600\right)\rho E \times L.C.V \times 427 \times \eta_{thb} \times \eta_m \times 1/75 \times 1/1.36\right], kW .....(8)$$

Where:-

$f.c$ = Fuel consumption, (l/h).

ρE = Density of fuel, (kg/l), (for Gas oil = 0.85).

$L.C.V$ = Calorific value of fuel, (11.000 k.cal/kg).

η_{thb} = Thermal efficiency of the engine, (35 % for Diesel engine).

427 = Thermo-mechanical equivalent, (kg.m/k.Cal).

η_m = Mechanical efficiency of the engine, (80 % for Diesel engines).

So, the energy can be calculated as following:

$$Energy\ \ requirement = \frac{Engine\ power, (kW)}{Field\ capacity, (fed/h)}, \ (kW.h/fed) .....(9)$$ •

Cost analysis:

Machine cost was determined by using the following equation (**Awady, 1978**):

$$C = \frac{P}{h}\left(\frac{1}{a} + \frac{i}{2} + t + r\right) + \left(0.9W.S.F\right) + \frac{m}{144}, \ (L.E/h) ....(10)$$

Where:

C = Hourly cost, L.E/h. P = Price of machine, L.E.
h = Yearly working hours, h/year. a = Life expectancy of the machine, h.
i = Interest rate/year. F = Fuel price, L.E/l.
t = Taxes, over heads ratio. r = Repairs and maintenance ratio.
m = The monthly average wage, L.E 0.9 = Factor accounting for lubrications.
W = Engine power, hp. S = Specific fuel consumption, l/hp.h.
144 = Reasonable estimation of monthly working hours.

Operational cost can be determined using the following equation:

$$Operating\ \cos t = \frac{Machine\ \cos t\,(L.E/h)}{Actual\ field\ capacity\,(fed/h)},\ (L.E/fed).....(11)$$

Criterion cost can be determined using the following equation:

Criterion cost (*L.E/fed*) = *Operational cost* + *Losses cost* …...…(12)

RESULTS AND DISCUSSION

The discussion will cover the results obtained under the following headings:

1. Sugar beet crop characteristics:

Table (2) summarized the physical measurements of sugar beet plants for mechanical and manual planting methods at average moisture content values of 17, 47.8 and 67 % for soil, sugar beet root and sugar beet leaves, respectively.

Table (2): Physical properties of sugar beet plants under manual and mechanical planting methods.

Physical properties of sugar beet plants	Manual planting			Mechanical planting		
	Mean value	Min. value	Max. value	Mean value	Min. value	Max. value
Root length, cm	27.21	15.50	30.30	25.17	18.20	32.10
Root width, cm	58.87	43.45	72.40	65.42	50.00	77.20
Root diameter, cm	12.25	8.80	14.80	13.78	10.15	16.10
Height of leaf, cm	41.37	30.40	51.80	43.32	35.00	52.00
Diameter of leaf cluster, cm	7.89	5.40	10.00	9.76	7.50	11.00
Volume, cm^3	1218.47	550	2210	1687.76	660	2750
Root mass, g	1300	580	2270	1550	700	2320
Leaves mass, g	610	315	910	720	450	1050

2- Effect of forward speed on field capacity and efficiency:

Field capacity and efficiency are highly affect with machine effective width, forward speed, soil moisture content and field conditions.

Results in Fig (2) show a remarkable drop in the field efficiency with a consequent sharp rise in the field capacity as the forward speed increased.

Increasing forward speed from 0.8 to 3.2 km/h leads to increase field capacity values from 0.297 to 0.919 fed/h and from 0.257 to 0.699 fed/h for chisel plow and sugar beet harvester, respectively under manual planting, and from 0.302 to 0.971 fed/h and from 0.282 to 0.920 fed/h for chisel plow and sugar beet harvester under mechanical planting, respectively. While with manual harvesting, field capacity values of 0.006 and 0.007 fed/h under manual and mechanical planting were recorded, respectively.

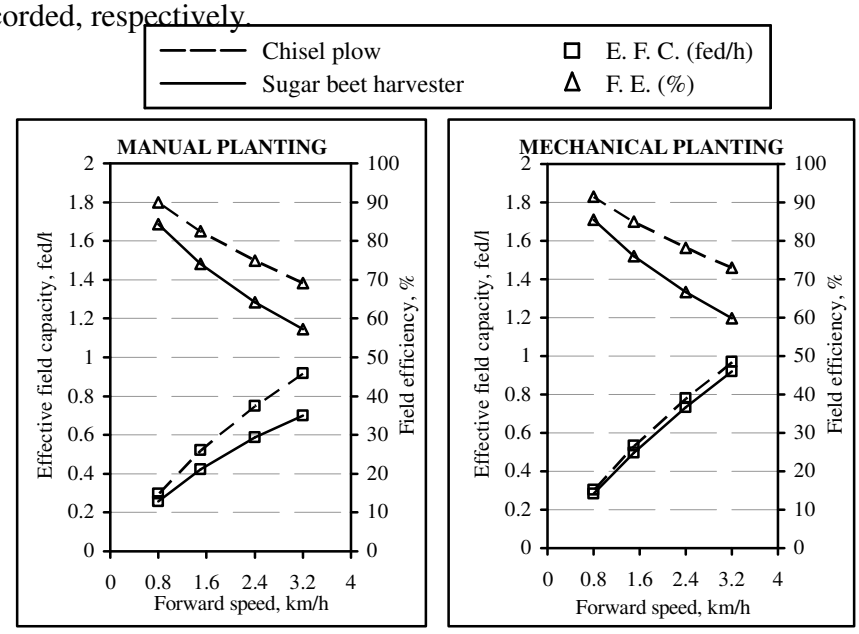

Fig (2): Effect of machine forward speed on field capacity and efficiency of different sugar beet harvesting methods under manual planting and mechanical planting, (S. M. C. = 24 %).

On the other hand, increasing forward speed from 0.8 to 3.2 km/h decreased field efficiency values from 90 to 69.10 % and from 84.26 to 57.34 % for chisel plow and sugar beet harvester, respectively under manual planting and from 91.52 to 73 % and from 85.57 to 59.89 %

under mechanical planting, respectively. The major reason for the reduction in field efficiency by increasing forward speed is due to the less theoretical time consumed in comparison with the other items of time losses. Mean while with manual harvesting, the field efficiency values were 75 and 87.5 % under manual and mechanical planting, respectively.

3. Lifted and un-lifted sugar beets:

a- Effect of forward speed on Lifted and un-lifted sugar beets:

Results in Fig (3) show the effect of forward speed on lifted and un-lifted beets. Increasing forward speed from 0.8 to 3.2 km/h increased the un-lifted beets values from 7.05 to 9.22 ton/fed and from 2.78 to 3.71 ton/fed for chisel plow and sugar beet harvester, respectively under manual planting. Increasing forward speed from 0.8 to 3.2 km/h increased the un-lifted beets values from 5.57 to 8.99 ton/fed and from 2.74 to 3.52 ton/fed for chisel plow and sugar beet harvester, respectively under mechanical planting, while, the un-lifted beets of manual harvesting was 1.36 ton/fed.

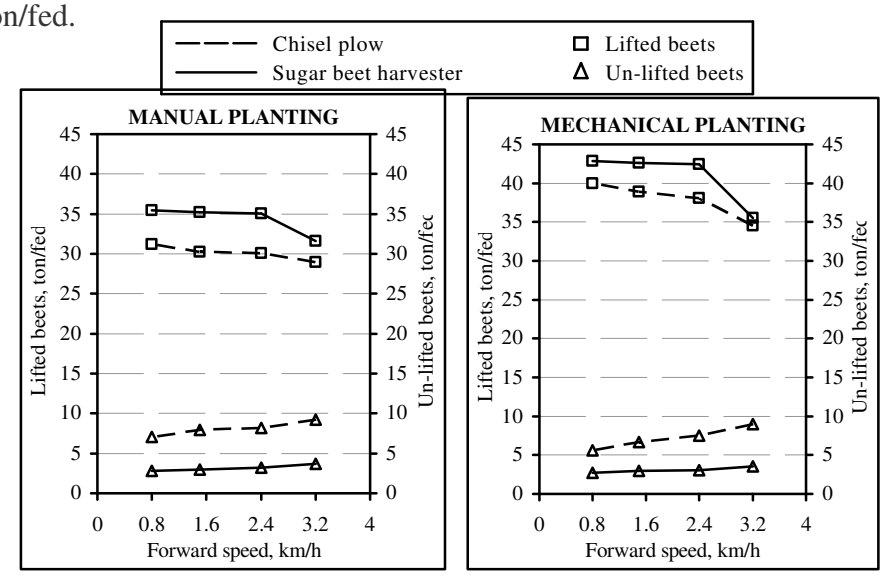

Fig (3): Effect of machine forward speed on mass of lifted and un-lifted beets using different sugar beet harvesting methods under manual and mechanical planting, (S. M. C. = 24 %).

b- Effect of soil moisture content on Lifted and un-lifted sugar beets:

Concerning the effect of planting and harvesting methods and soil moisture content on lifted and un-lifted beets, results obtained in Fig (4) show that the soil moisture content of 24 % is considered the optimum value during harvesting sugar beet crop which recorded the maximum

lifted beets and minimum un-lifted beets of 44.2, 1.36; 38.04, 7.53 and 42.42, 3.15 for manual, chisel plow and sugar beet harvester, respectively. Fig (4) shows that, the decrease or increase of soil moisture content less or more than 24 % leads to increase un-lifted beets and decrease lifted beets under all experimental conditions due to the increase in soil catching force at lower moisture and increase elastic soil conditions at higher moisture which causing more rolling and slippage for harvesting machine.

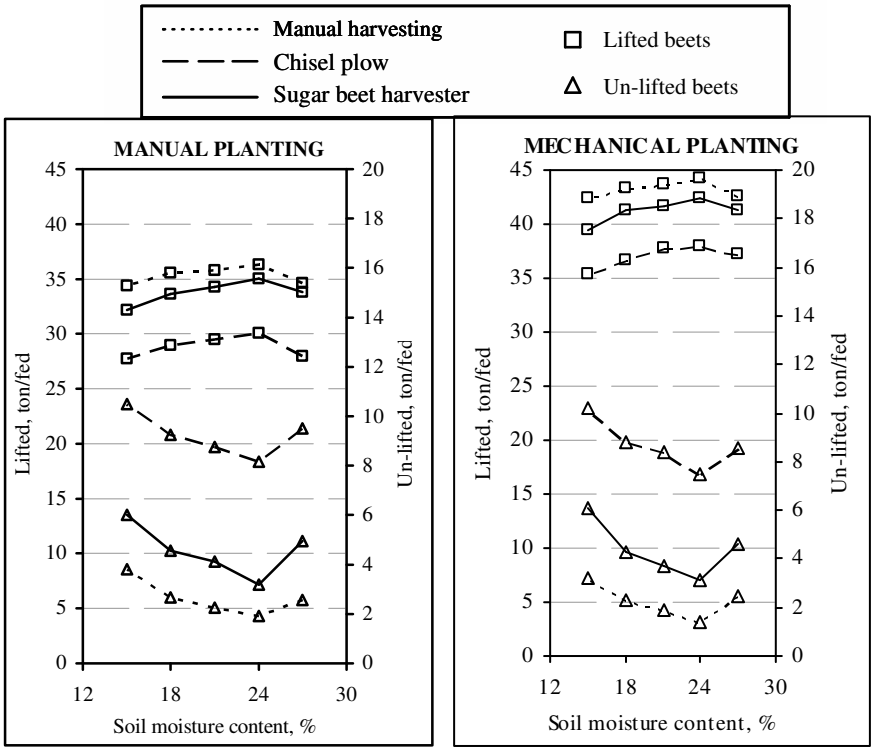

Fig (4): Effect of soil moisture content on mass of lifted and un-lifted beets using different sugar beet harvesting methods under manual and mechanical planting, (V = 2.4 km/h).

4. Un-damaged, damaged and bruised sugar beets:

a- Effect of forward speed on bruised and damaged sugar beets:

Fig (5) shows that increasing machine forward speed from 0.8 to 3.2 km/h increased bruised beets values from 3.15 to 4.57 ton/fed and from 1.4 to 2.03 ton/fed for chisel plow and sugar beet harvester, respectively under manual planting and from 3.09 to 4.08 ton/fed and from 1.22 to 1.85 ton/fed for chisel plow, and sugar beet harvester, respectively, under

mechanical planting. While with manual harvesting bruised beets of 0.68 ton/fed was recorded. Also, Increasing forward speed from 0.8 to 3.2 km/h increased the damaged beets values from 2.89 to 4.16 ton/fed and from 1.20 to 1.93 ton/fed for chisel plow and sugar beet harvester, respectively under manual planting and from 2.38 to 3.82 ton/fed and from 1.05 to 1.73 ton/fed for chisel plow and sugar beet harvester, respectively under mechanical planting. While with manual harvesting damaged beets of 0.46 ton/fed was recorded.

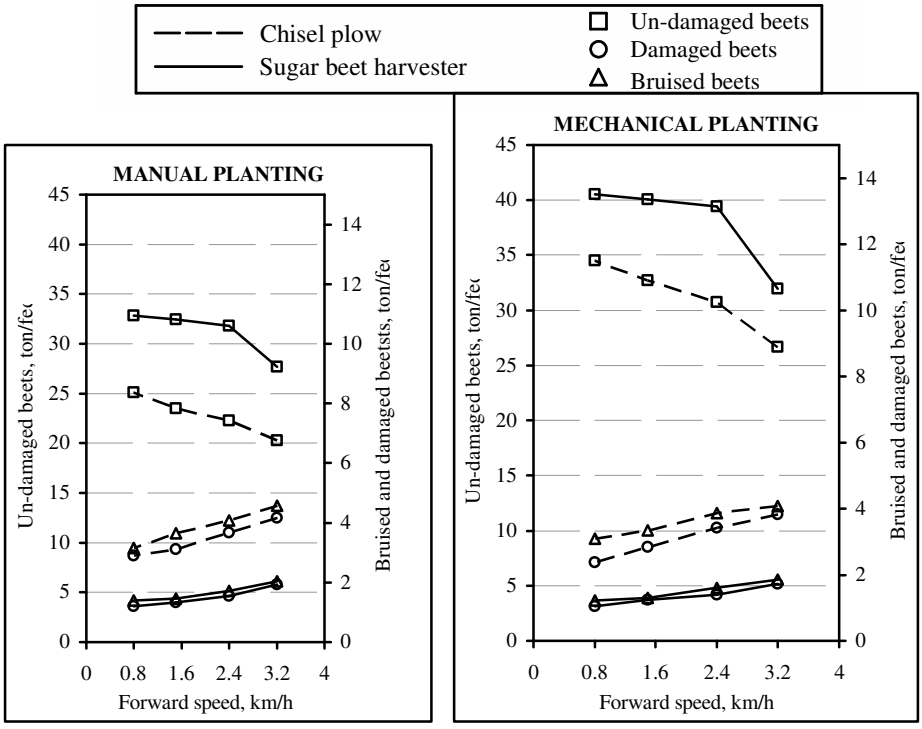

Fig (5): Effect of machine forward speed on mass of un-damaged, damaged and bruised beets of different sugar beet harvesting methods under manual and mechanical planting, (S. M. C. = 24 %).

b- Effect of soil moisture content on bruised and damaged sugar beets:

Generally, increasing soil moisture content increased un-damaged beets and decreased both damaged and bruised beets. Results obtained in Fig. (6) show that the soil moisture content of 24 % is considered the optimum value during harvesting sugar beet crop which recorded the maximum un-damaged beets of 43.06; 30.75 and 39.42 and minimum damaged and bruised beets of 0.46, 0.68; 3.42, 3.87 and 1.4, 1.6 for

manual, chisel plow and sugar beet harvester, respectively. Fig (6) shows also that, the decrease or increase of soil moisture content less or more than 24 % leads to increase both damaged and bruised beets and decrease un-damaged beets under all experimental conditions due to increase soil hardness at lower moisture and increase elastic soil conditions at higher moisture which give unsuitable conditions for harvesting causing more damaged and bruised beets.

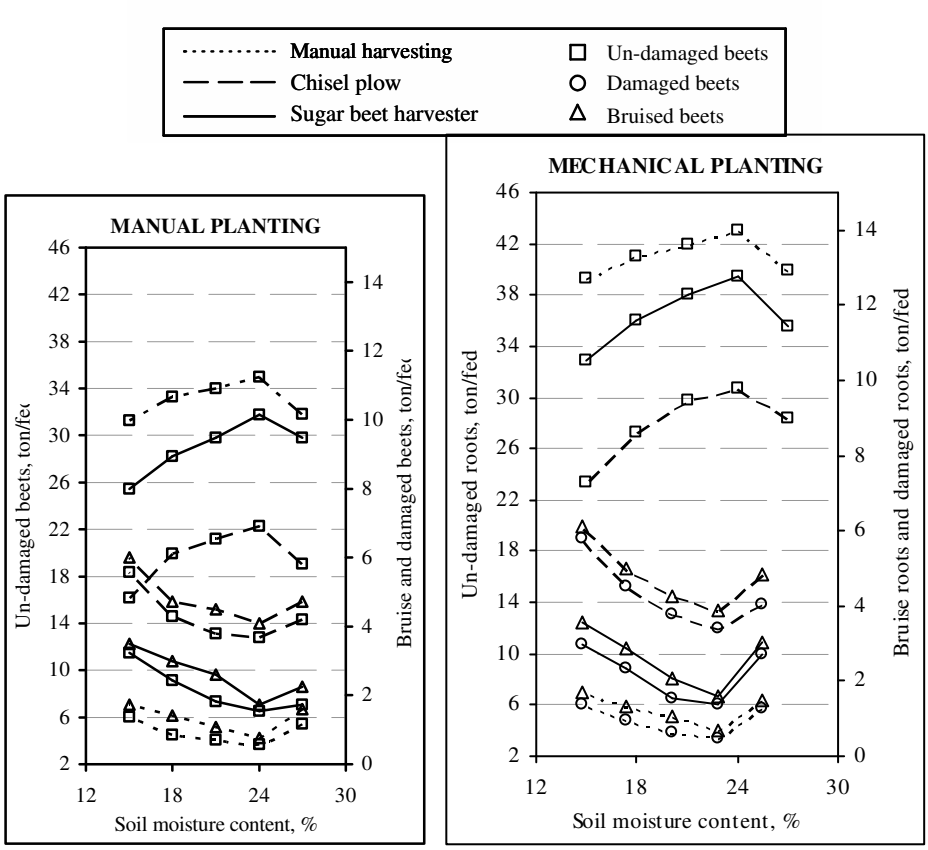

fig (6): Effect of soil moisture content on un-damaged, damaged and bruise beets of different sugar beet harvesting methods under manual and mechanical planting, (V = 2.4 km/h).

5. Total crop losses and lifting efficiency:

a- Effect of machine forward speed on total losses and lifting efficiency:

Fig (7) shows that increasing forward speed from 0.8 to 3.2 km/h increased the total losses values from 26 to 35 % and from 10.39 to 14.74

% for chisel plow and sugar beet harvester, respectively under manual planting and from 17.46 to 28.11 % and from 8.31 to 11.52 % for chisel plow and sugar beet harvester, respectively under mechanical planting. While with manual harvesting, total losses of 6.49 % and 3.99 % in both manual and mechanical planting were recorded, respectively. On the other side, increasing forward speed from 0.8 to 3.2 km/h decreased lifting efficiency values from 81.55 to 75.87 % and from 92.73 to 90.29 % for chisel plow and sugar beet harvester, respectively under manual planting, and from 87.76 to 79.36 and from 93.98 to 90.99 for chisel plow and sugar beet harvester, respectively under mechanical planting. While with manual harvesting, lifting efficiency of 95 % and 97 % under manual and mechanical planting were recorded, respectively.

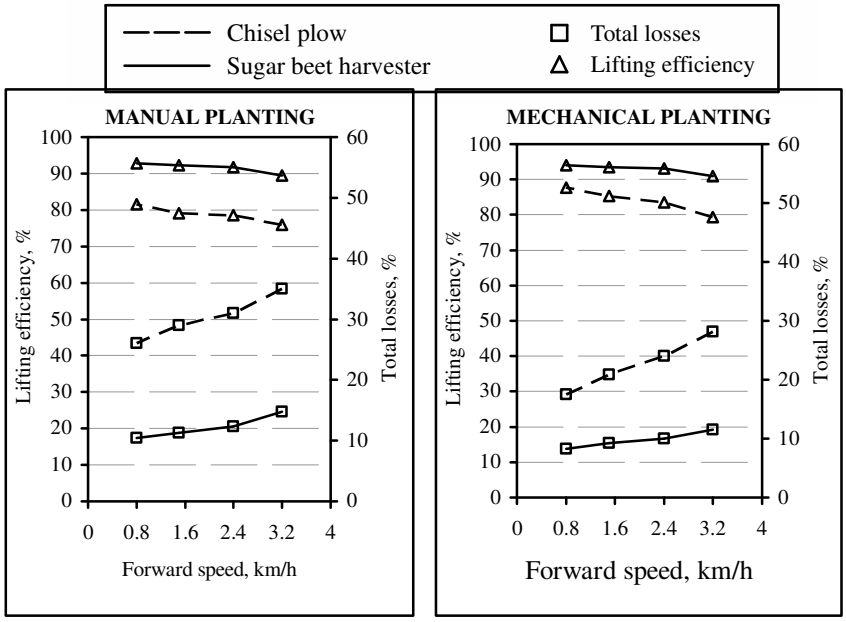

Fig (7): Effect of machine forward speed on lifting efficiency and total crop losses of different sugar beet harvesting methods under manual and mechanical planting, (S. M. C. = 24 %).

b- Effect soil moisture content on total crop losses and lifting efficiency:

Relating to the effect of planting and harvesting methods and soil moisture content on total crop losses and lifting efficiency, results obtained in Fig (8) show that the soil moisture content of 24 % is considered the optimum value during harvesting sugar beet crop which recorded the minimum total losses and maximum lifting efficiency of 3.99, 97.00; 24.02, 83.47 and 9.98, 93.09 for manual, chisel plow and sugar beet harvester, respectively. Fig (8) shows that, the decrease or

increase of soil moisture content less or more than 24 % lead to total crop losses and increase lifting efficiency under all experimental conditions due to increase soil catching force at lower moisture and increase elastic soil conditions at higher moisture which causing more rolling and slippage for harvesting machine.

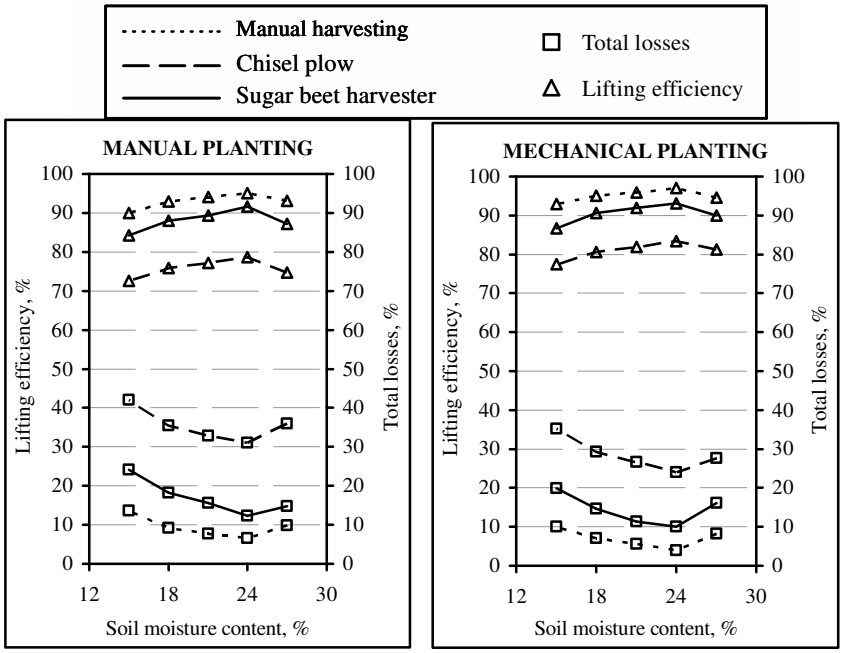

Fig (8): Effect of soil moisture content on lifting efficiency and total crop losses of different sugar beet harvesting methods under manual and mechanical planting, (V = 2.4 km/h).

6. Power and energy requirements:

a- Effect of machine forward speed on power, and energy requirements:

Fig (9) shows that increasing forward speed from 0.8 to 3.2 km/h increased power values from 20.88 to 30.05 kW and from 24.67 to 35.74 kW for chisel plow and sugar beet harvester, respectively under manual planting and from 19.93 to 27.52 kW and from 23.72 to 34.79 kW for chisel plow, and sugar beet harvester, respectively under mechanical planting. On the other hand, increasing forward speed from 0.8 to 3.2 km/h, decreased energy requirements from 70.30 to 32.70 kW.h/fed and from 95.99 to 51.13 kW.h/fed for chisel plow and sugar beet harvester, respectively under manual planting and from 65.99 to 28.34 kW.h/fed and from 84.11 to 37.82 kW.h/fed for chisel plow and sugar beet

harvester, respectively under mechanical planting. While with manual harvesting, power of 0.052 and 0.037 kW and energy of 8.667 and 5.286 kW.h/fed under manual and mechanical planting were recorded, respectively.

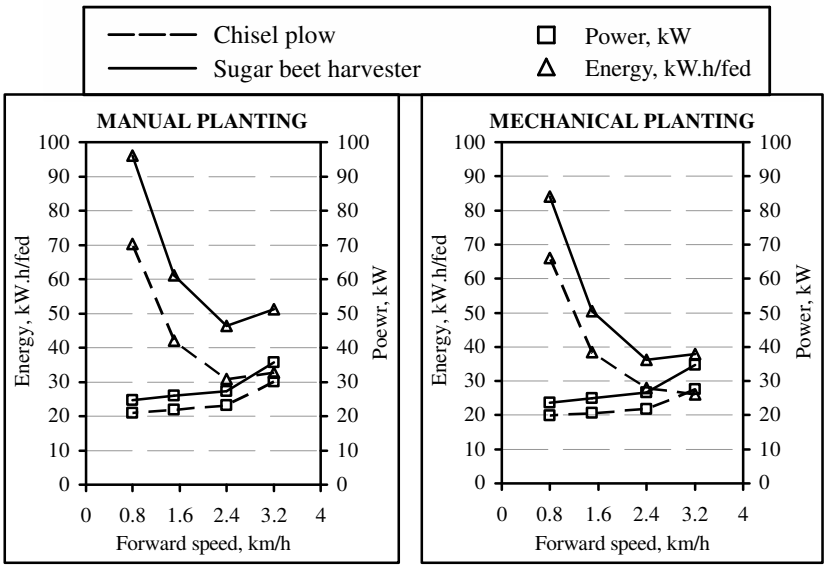

Fig (9): Effect of machine forward speed on power and energy requirements of different sugar beet harvesting methods under manual and mechanical planting, (S. M. C. = 24 %).

b- Effect of soil moisture content on power, and energy requirements:

Generally, increasing soil moisture content from 15 to 24 % decreased both power and energy consumed. Results obtained in Fig (10) show that the soil moisture content of 24 % is considered the optimum value during harvesting sugar beet crop which recorded the minimum values of power and energy consumed of 23.09 and 30.83 kW and 27.20 and 46.34 kW.h/fed for chisel plow and sugar beet harvester, respectively under manual planting. While the minimum values of power and energy of 21.83 and 27.95 kW and 26.57 and 36.15 kW.h/fed were obtained under mechanical planting for chisel plow and sugar beet harvester, respectively. Fig (10) shows also that, the decrease or increase of soil moisture content less or more than 24 % leads to increase both power and energy under all experimental conditions due to the increase in soil hardness at lower moisture and increase elastic soil conditions at higher moisture which give unsuitable conditions for harvesting.

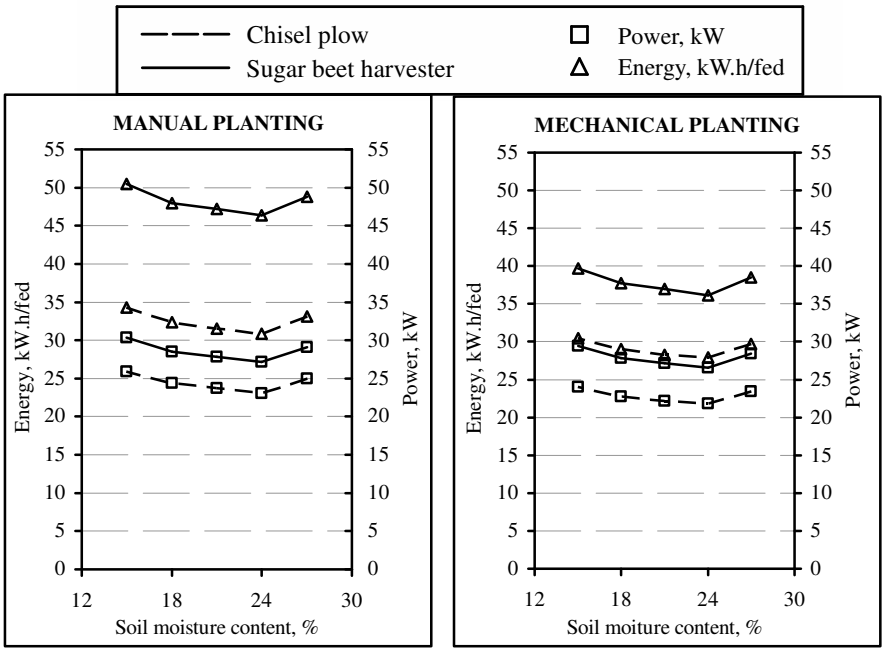

Fig (10): Effect of soil moisture content on power and energy requirements of different sugar beet harvesting methods under manual and mechanical planting, (V = 2.4 km/h).

7. Effect of sugar beet harvesting method on operational and criterion costs:

The operational cost and the criterion cost values of manual harvesting were 520.83 and 868.03 L.E/fed under manual planting and 446.43 and 701.23 L.E/fed under mechanical planting, respectively. Results in Fig (11) show that for mechanical harvesting methods, the operational cost decreased as the forward speed increased. Increasing forward speed from 0.8 to 3.2 km/h decreased the operational cost values from 104 to 33.61 and from 225.9 to 83.1 L.E/fed for chisel plow, and sugar beet harvester, respectively under manual planting and from 102.29 to 31.81 and from 205.9 to 63.1 L.E/fed for chisel plow, and sugar beet harvester, respectively under mechanical planting. Concerning to the effect of machine forward speed on criterion cost, results in Fig (11) show that forward speeds of between 1.5 and 2.4 km/h at soil moisture content of 24 % were considered the optimum conditions for harvesting sugar beet crop under both manual and mechanical planting due to the minimum total crop losses and maximum lifting efficiency and un-damaged beets.

So, using sugar beet harvester at forward speed of between 1.5 and 2.4 km/h and soil moisture content of 24 % recorded the least values of harvesting cost under both manual and mechanical planting methods.

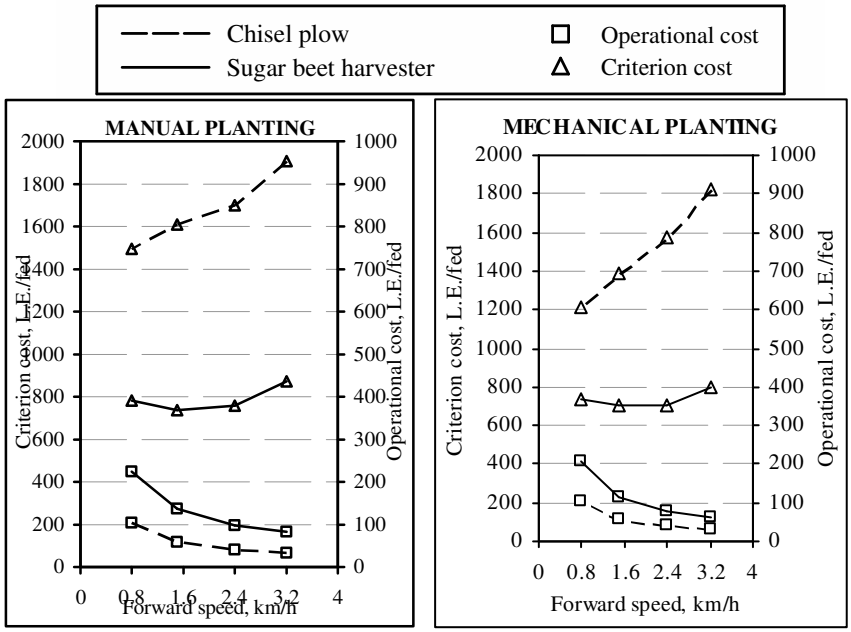

Fig (11): Effect of machine forward speed on operational and criterion cost of different sugar beet harvesting methods under manual and mechanical planting, (S. M. C. = 2.4 %).

CONCLUSION

The experimental 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.
- Harvester forward speed of between 1.6 to 2.4 km/h.
- Soil moisture content of between 21 to 24 %.

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الملخص العربي

دراسة مقارنة بين طرق الحصاد اليدوي والآلي لمحصول بنجر السكر

أ.د. محمد محمد مراد حسن* أ.د. جمال حسن السيد د.محب محمد أنيس الشرباصي*****
فاطمة الزهراء على عبد الجواد****

حظيت زراعة بنجر السكر باهتمام كبير من الدولة في الآونة الأخيرة لعدة أسباب منها أنه يستهلك كمية مياه أقل من محصول قصب السكر بنسبة الثلثين تقريباً، كما تجود زراعة البنجر في مختلف الأجواء ومختلف أنواع الأراضي مثل الأراضي الصحراوية حديثة الاستصلاح. وتزداد أهمية ميكنة محصول بنجر السكر حيث يعتبر العمل اليدوي مرهقاً ومكلفاً خاصة في الأراضي الحديثة. أجري هذا البحث في مساحة ستة أفدنة بميت الديبة - محافظة كفر الشيخ في الموسم الزراعي 2006/2005م بغرض دراسة مقارنة بين ثلاث طرق لحصاد بنجر السكر تحت طريقتين من طرق الزراعة هي الزراعة اليدوية والآلية. واشتملت الدراسة علي المتغيرات التالية:

- طريقتان للزراعة (الزراعة يدوية والزراعة آلية).
- ثلاثة طرق للحصاد (اليدوي - المحراث الحفار - آلة حصاد البنجر).
- السرعة الأمامية للحصاد (0.8 ، 1.5 ، 2.4 و 3.2 كم/س).
- نسب رطوبة التربة (15 ، 18 ، 21 ، 24 و 27 %).

وقد أظهرت النتائج أن الفاقد في المحصول وكذلك تكاليف الحصاد تكون أقل ما يمكن وأن كفاءة تقليع الجذور تكون أعلى ما يمكن تحت الظروف الآتية:

- أن يتم الحصاد باستخدام آلة حصاد البنجر وأن يسبق ذلك زراعة آلية للمحصول.
- أن تكون السرعة الأمامية لآلة الحصاد ما بين 1.6 إلى 2.4 كم/ساعة.
- أن تكون نسبة رطوبة التربة ما بين 21 إلى 24 %.

* أستاذ - قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق – مصر.
** أستاذ ومدير معهد بحوث الهندسة الزراعية – وزارة الزراعة – الدقي – الجيزة – مصر.
*** مدرس – قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق – مصر.
**** طالبة دراسات عليا - قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق – مصر.