CONTENTS

6. SUMMARY AND CONCLUSION

Sugar beet harvesters are not common in Egypt, and manual harvesting is exhaustive, and impractical. Sugar beet harvesting is conducted in Egypt manually by hand pulling, lifting the roots out by shovel and hoe, or by using chisel plow and collecting the roots by hand. Without a harvester the lifting of the crop can be laborious time-consuming job.

Removing the vegetative top portion from root crops to obtain the optimum harvested roots is the ultimate goal. There are some factors that influence root crops harvesting. The most important factor is to remove the vegetative portion.

This investigation was mainly carried out in order to develop a simple constructed of sugar beet harvester to suit Egyptian farms. This harvester will help to overcome the shortage of agricultural labor, and to avoid the drawbacks and problems of using large harvesting machines.

The parts of the constructed of sugar beet harvester such as rotary cutting mechanism or topping operation, lifter wheels and transmission system were locally made.

Laboratory and field experiments were conducted at the experimental farm, Rice Mechanization Center, Meet El-Dyba, Kafr El-Sheikh Governorate. The harvester was used in sugar beet harvesting by using five different forward speeds, three different knife rotational speeds and three different tilt angles of the lifter wheel. This study was carried out to indicate the effect of the implement forward speed, knife rotational speed, tilt angle and planting methods on the following factors:

a) Field performance of sugar beet harvesting machine.

b) Root damage (cut and bruise damage), and

c) Fuel consumption and power required for harvesting operation.

On the other hand, the following factors were undertaken in the present study:

d) Cost analysis of owning and working sugar beet harvester,

e) Effect of forward speed, knife speed and planting method on topping accuracy (overtopping, undertopping and untopped beet).

The field experiments were planted in an area of about three Feddans during winter season of 2000/2001 (from 15/9/2000 to 15/3/2001).

The study revealed the following main points.

6.1. Field performance of sugar beet harvesting machine:

6.1.1.Topping operation:

a) Overtopping:

It can be concluded that, increasing the forward speed from 1.6 to 3.2 km/h leads to increase overtopping from 2.40 to 2.88, 2.62 to 3.08 and 3.06 to 3.42 % for knife speeds 9.42, 11.52 and 15.71 m/s (450, 550 and 750 rpm), respectively.

In the same manner, the same increment of the forward speed tends to increase overtopping from 2.60 to 2.73, 2.88 to 3.08 and 3.26 to 3.46 % for mechanical and manual planting methods, at forward speeds 1.6, 2.4 and 3.2 km/h, respectively.

b) Undertopping:

It can be said that, by increasing the forward speed from 1.6 to 3.2 km/h due to increased of under-topped beet from 1.69 to 3.64, 2.44 to 4.20 and 3.37 to 4.80 % for knife speeds 9.42, 11.52 and 15.71 m/s (450, 550 and 750 rpm), respectively. Meanwhile, the knife speed increase from 9.42 to 15.71 m/s (450 to 750 rpm) tends to increase under-topped beet from 1.69 to 3.37, 2.52 to 4.17 and 3.64 to 4.80 % for forward speeds 1.6, 2.4 and 3.2 km/h, respectively.

However, by using mechanical and manual planting leads to increase under-topped beet from 2.50 to 2.70, 3.46 to 3.76 and 4.35 to 4.61 % at forward speeds 1.6, 2.4 and 3.2 km/h, respectively.

c) Untopped beet:

By increasing the forward speed from 1.6 to 3.2 km/h tends to increase untopped beet from 2.55 to 3.96, 2.66 to 4.42 and 2.83 to 4.87 % for knife speeds 9.42, 11.52 and 15.71 m/s (450, 550 and 750 rpm), respectively.

In the same manner, the same increment of the knife speed from 9.42 to 15.71 m/s (450 to 750 rpm) due to increase untopped beet from 2.55 to 2.83, 3.48 to 4.03 and 3.96 to 4.87 % at the forward speed 1.6, 2.4 and 3.2 km/h, respectively.

On the other hand, the same increment of the forward speeds tends to increase untopped beet from 2.68 to 2.92, 3.75 to 4.03 and 4.42 to 4.62 % for mechanical and manual planting methods, respectively.

d) Topping accuracy:

By increasing forward speed from 1.6 to 3.2 km/h tends to decreased topping accuracy from 95.91 to 93.30, 95.04 to 92.52 and 93.75 to 92.38 % for knife speeds 9.42, 11.52 and 15.71 m/s (450, 550 and 750 rpm), respectively. In the same manner, when the knife speed increased from 9.42 to 15.71 m/s (450 to 750 rpm) leads to decrease the topping accuracy from 95.91 to 93.75, 94.85 to 92.75 and 93.30 to 91.38 % for forward speed 1.6, 2.4 and 3.2 km/h, respectively.

e) Topping efficiency:

It could be realized that, the knife speed of 9.42 m/s (450 rpm) had recorded the highest value of topping efficiency were (97.51 and 97.30 %) at forward speed of 1.6 km/h for mechanical and manual planting methods, respectively. In the same manner, the knife speed of 15.71 m/s (750 rpm) had recorded the lowest value of topping efficiency were (95.35 and 95.25 %) at forward speed of 3.2 km/h for mechanical and manual planting methods, respectively.

6.1.2. Lifting efficiency (Le):

a) Mechanical planting method:

Increasing forward speed from 1.6 to 3.2 km/h tends to decrease lifting efficiency from 93.88 to 88.58, 94.98 to 90.01 and 94.45 to 89.18 % for tilt angles 0.35, 0.44 and 0.52 rad (20, 25 and 30 deg) , respectively. The same increment in forward speed leads to decrease the lifted roots from 94.23 to 88.71, 94.68 to 89.85 and 94.40 to 89.21 % for knife speed of 9.42, 11.52 and 15.71 m/s (450, 550 and 750 rpm), respectively. Also, it can be noticed that, the tilt angle 0.44rad (25 deg) gave the highest percentage of lifting efficiency among the three different tilt angles.

b) Manual planting method:

The same tendency was obtained for lifting efficiency in the manunal planting method. The results indicated that increasing the forward speed from 1.6 tc 3.2 km/h tends to decrease the lifting efficiency from 92.23 to 85.73, 93.30 to 87.05 and 92.66 to 86.00 %

for tilt angles of 0.35, 0.44 and 0.52 rad (20 , 25 and 30 deg), respectively.

On the other hand, the lifting efficiency decreased from 92.51 to 85.89, 92.94 to 86.70 and 92.73 to 86.18 % by increasing the forward speed at the same mentioned above rate by using knife speeds of about 9.42, 11.52 and 15.71 m/s (450, 550 and 750 rpm), respectively.

Generally, mechanical planting gave the highest values of lifting efficiency in all cases compared with manual planting.

6.1.3. Root damage:

6.1.3.1. Cut roots:

a) Mechanical planting method:

Increasing forward speed from 1.6 to 3.2 km/h tends to increase cut roots from 3.17 to 4.33, 2.87 to 3.87 and 2.98 to 4.17 % for tilt angles 0.35, 0.44 and 0.52 rad (20, 25 and 30 deg), respectively. Meanwhile, the same increment in forward speed tends to increase cut roots from 3.12 to 4.53, 2.85 to 3.72 and 3.05 to 4.12 % for knife speeds of about 9.42, 11.52 and 15.71 m/s (450,550 and 750 rpm), respectively.

On the other hand, increasing knife speed from 9.42 to 15.71 m/s (450 to 750 rpm) tends to decreased the cut roots from 4.12 to 3.78, 3.67 to 3.43 and 3.92 to 3.65 % for tilt angles 0.35, 0.44 and 0.52 rad (20,25 and 30 deg), respectively.

b) Manual planting method:

The increment in forward speed from 1.6 to 3.2 km/h tends to increase the cut roots from 3.75 to 5.03, 3.13 to 5.04 and 3.42 to 4.89 % for tilt angles 0.35, 0.44 and 0.52 rad (20, 25 and 30 deg), respectively. Moreover, the forward speed increase from 1.6 to 3.2 km/h tends to increase the cut roots from 3.52 to 5.42, 3.13 to 4.52 and 3.47 to 5.03 % for knife speeds 9.42, 11.52 and 15.71 m/s (450, 550 and 750 rpm), respectively.

On the other hand, increasing the tilt angle from 0.35 to 0.52 rad (20 to 30 deg) tends to decrease the cut roots from 4.46 to 4.37, 4.08 to 3.69 and 4.27 to 4.22 % for knife speeds 9.42, 11.52 and 15.71 m/s (450, 550 and 750 rpm), respectively.

Generally, mechanical planting method gave the lowest values of cut roots compared with manual planting method.

6.1.3.2. Bruise damage:

a) Mechanical planting method:

It can be noticed that, by increasing forward speed from 1.6 to 3.2 km/h tends to increase the bruise damage from 3.35 to 3.8, 2.68 to 3.49 and 3.02 to 3.62 % for tilt angles 0.35, 0.44 and 0.52 rad (20, 25 and 30 deg) , respectively. Also, increasing the forward speed from 1.6 to 3.2 km/h due to increase the bruise damage from 3.52 to 5.42, 3.13 to 4.52 and 3.47 to 5.03 % for knife speeds 9.42, 11.52 and 15.71 m/s (450, 550 and 750 rpm), respectively.

On the other hand, by increasing tilt angle from 0.35 to 0.52 rad (20 to 30 deg) tends to decrease the bruise damage from 3.70 to 3.40, 3.47 to 3.17 and 3.55 to 3.37 % for knife speeds 9.42, 11.52 and 15.71 m/s (450, 550 and 750 rpm), respectively.

b) Manual planting method:

It was evident that, by increasing forward speed from 1.6 to 3.2 km/h tends to increase the bruise damage from 4.12 to 4.72, 3.67 to 4.55 and 3.88 to 4.69 % for tilt angles 0.35, 0.44 and 0.52 rad (20, 25 and 30 deg), respectively. In the same manner, increasing bruise damage from 3.91 to 4.77, 3.77 to 4.46 and 3.99 to 4.73 % for knife speeds 9.42, 11.52 and 15.71 m/s (450, 550 and 750 rpm), respectively, at forward speeds 1.6, 2.4 and 3.2 km/h, respectively.

But, by increasing tilt angle from 0.35 to 0.44 rad (20 to 25 deg) tends to decrease bruise damage from 4.58 to 4.27 and 4.30 to 4.18 % for knife speeds 9.42 and 11.52 m/s (450 and 550 rpm), respectively.

Generally, mechanical planting gave the lowest values of bruise damage among the two different methods of planting.

6.1.4. Undamage roots:

The highest undamaged roots (94.45 and 93.18 %) were found by using tilt angle of 0.44 rad (25 deg) with the forward speed of 1.6 km/h, for mechanical and manual planting methods, respectively. Meanwhile, the tilt angle of 0.35 rad (20 deg) combined with forward speed of 3.2 km/h, recorded the lowest undamaged roots which were (91.87 and 89.97 %) for mechanical and manual planting methods, respectively.

6.1.5. Effective field capacity, feddan/h:

a) Mechanical planting method:

The maximum value of the effective field capacity, was (0.843 feddan/h) obtained at forward speed of about 3.2 km/h and tilt angle of about 0.35 rad (20 deg) with knife speed of about 11.52 m/s (550 rpm). While, the minimum value of the effective field capacity, was (0.443 feddan/h) obtained at forward speed of about 1.6 km/h and tilt angle of about 0.52 rad (30 deg) with knife speed of about 11.52 m/s (550 rpm).

b) Manual planting method:

The maximum value of the effective field capacity, was (0.811 feddan/h) obtained at forward speed of about 3.2 km/h and tilt angle of about 0.35 rad (20 deg) with knife speed of about 15.71 m/s (750 rpm). While, the minimum value of the effective field capacity, was (0.433 feddan/h) obtained at forward speed of about 1.6 km/h and tilt angle of about 0.52 rad (30 deg) with knife speed of about 9.42 m/s (450 rpm).

6.1.6. Field efficiency:

From the data,. it can be noticed that, the forward speed of about 1.6 km/h gave the highest value of field efficiency compared with the following forward speeds of about 2.4 and 3.2 km/h for all tilt angles. It were recorded (87.37 and 85.03 %) for mechanical and manual planting methods, respectively with tilt angle of 0.35 rad (20 deg). While, the forward speed of about 3.2 km/h gave the lowest value of field efficiency. It were recorded (68.73 and 65.37 %) for mechanical and manual planting methods, respectively with tilt angle of 0.52 rad (30 deg).

6.1.7. Slip ratio, %:

The maximum value of slip precent were (11.83 and 11.91 %) for mechanical and manual planting methods, respectively at forward speed of 3.2 km/h with tilt angle of 0.52 rad (30 deg). However, the minimum value of slip ratio were (6.74 and 7.16 %) for mechanical and manual planting methods, respectively at forward speed of 1.6 km/h with tilt angle of 0.35 rad (20 deg).

6.2. Fuel consumption rate, power and energy requirements for harvesting:

6.2.1. Fuel consumption by sugar beet harvester:

The results showed that, the fuel consumed in sugar beet harvesting increased by increasing both of forward speed and knife speed for all tilt angles and planting methods. From the obtained data, found that the highest value of fuel consumption was 3.36 l/h at forward speed of 3.2 km/h and knife speed of 15.71 m/s (750 rpm) with tilt angle of 0.52 rad (30 deg) for manual planting. While, the lowest value of fuel consumed in sugar beet harvesting of 0.95 l/h was obtained by using tilt angle of 0.35 rad (20 deg) at forward speed of 1.6 km/h and knife speed of 9.42 m/s (450 rpm) for mechanical planting.

6.2.2. Power and energy requirements of sugar beet harvester:

It could be realized that, forward speed of 1.6 km/h recorded the lowest value of power requirement for sugar beet harvesting (3.67 and 3.87 kW) at knife speed of 9.42 m/s (450 rpm) for mechanical and manual planting methods, respectively. Meanwhile, the forward speed of 3.2 km/h recorded the lowest value of energy requirement for sugar beet harvesting (7.40 and 8.09 kW.h/feddan) at knife speed of 9.42 m/s (450 rpm) for mechanical and manual planting methods, respectively.

On the other hand, the forward speed of 3.2 km/h recorded the highest value of power requirement for sugar beet harvesting (8.62 and 9.53 kW) at knife speed of 15.71 m/s (750 rpm) for mechanical and manual planting methods, respectively. Meanwhile, the forward speed of 1.6 km/h had recorded the highest value of energy requirement for sugar beet harvesting (11.93 and 13.24 kW.h/feddan) at knife speed of 15.71 m/s (750 rpm) for mechanical and manual planting methods, respectively.

6.3. Cost analysis of owning and operating sugar beet harvester implement:

From the economic point of view, it can be evident that, the total harvesting cost can be calculated as the sum of the total cost per use of the tractor and sugar beet harvesting implement. So, the total cost of using tractor and harvester usage reached 51.90 L.E./feddan. Mechanical harvesting resulted a drastic reduction of 85 % in labor requirement per feddan and up to 78 % for total cost of sugar beet harvesting. While manual harvesting cost reached 238 L.E./feddan.

6.4. Applied recommendations:

1- The highest values of lifting efficiency were obtained by using the tilt angle 0.44 rad (25 deg) at forward speed of 1.6 km/h and knife speed of 11.52 m/s (550 rpm).

2- The tilt angle 0.44 rad (25 deg) gave the lowest values of total damage at forward speed of 1.6 km/h and knife speed of 11.52 m/s (550 rpm).

3- The lowest percentage of overtopping, undertopping and untopped beet are the ultimate goal of farmer and manufacturer. So, the optimum conditions of the topping unit operation were at forward speed 1.6 km/h and knife speed of about 9.42 m/s (450 rpm).

4- Mechanical planting method gave the highest percentage of lifting efficiency (95.15 %), topping accuracy (95.91 %), topping efficiency (97.51 %), undamaged roots (94.45 %), harvester efficiency (89.43 %), the lowest values of total damage (2.62 %), slip ratio (6.74 %) and the lowest percentage of overtopping (2.40 %), undertopping (1.69 %) and untopped beet (2.55 %), compared with manual planting.

5- Forward speed of 1.6 km/h recorded the lowest value of power requirement for sugar beet harvesting (3.67 and 3.87 kW) at knife speed of 9.42 m/s (450 rpm) for mechanical and manual planting methods, respectively.

6- Mechanical harvesting resulted a drastic reduction of 85 % in labor requirement per feddan compared with manual harvesting and up to 78 % for total cost of sugar beet harvesting. So, the mechanical harvesting needs 5 labors/feddan.