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CONSTRUCTING AND EVALUATION PROTOTYPE MACHINE FOR INTER–ROW CULTIVATION SUGAR BEET CROP

Badawy, M. E.; I.S.Yousef and A. lotfy
Senior Researcher, Ag. Eng. Res. Inst. Dokki, Giza.

ABSTRACT

The aim of this study was to manufacture and evaluated the performance of the prototype of cultivating device during cultivating sugar beet crop.

The studied variable included: the kinematic index (λ) of 9.43, 14.14, 18.86 and 28.28, the number of cultivator blades of 8, 12, 16 and 24 and the cutting angle of cultivator blades 90°, 110° and 130° on weed control efficiency, injured sugar beet plant percentage, wheel cultivator slip, fuel consumption and energy requirements.

- The blade cutting angle of 90° gave the highest values of weed control efficiency and injured sugar beet plant percentage.
- The kinematic index (λ) of 18.86 and the number of cultivator blade 16 gave the best results of the weed control efficiency, injured plant percentage, and fuel consumption.
- The kinematic index (λ) range of 9.43 and 14.14 gave the lowest value of the specific energy requirements.

INTRODUCTION

Sugar beet grown as a field crop, for the high sucrose content of its roots. After sugar extraction, the by-products (molasses and pulp) may be used for raw or processed animal feed, or as fertilizer. Foliage may be used as fodder. Sufficient nitrogen from manure or compost application is important to ensure rapid the leaf development that will provide a dense leaf canopy and shade out the weeds. The farmer should be familiar with the main weeds and monitor his fields regularly.The control of weeds, both annual and perennial, is of paramount importance in beet because the crop establishes in cool conditions, the plants are widely spaced and the leaf canopy takes time to develop (Scott & Wilcockson, 1976). Sugar beet cultivars vary in their growth habit, some have an erect leaf rosette (cv. Carla) others have a more horizontal leaf arrangement (cv. Lucy) (Lotz et al , 1991). Weed seedling survival can be much less with the latter, demonstrating the importance of early ground cover establishment. Mechanical inter-row cultivation is important in early control of weeds. However, cultivation stimulates further weed seedlings to emerge. Using laser-guided implements to limit seedbed preparation to the narrow area of row due to be drilled and leave the inter-rows uncultivated has given little advantage in terms of reduced weed emergence (Van Zuydam et al., 1995). Also, when the inter-row was eventually hoed, the soil broke into clods that became lodged among the crop seedlings. Seedbed preparation in the dark made little difference to weed numbers, however, inter-row hoeing in darkness stimulated fewer new seedlings to emerge. The important period for weed control is during the eight weeks after crop emergence and before the crop canopy develops. Crop losses where weeds were not controlled ranged from 95% where tall weeds such as fat-hen (C.album) predominated to 50% when the lowergrowing chickweed (Stellaria media) and scentless mayweed (T.inodorum) were dominant (Scott et al., 1979). Weed beets are a particular weed problem and may occur in 25% or more of sugar beet fields. A density of one weed beet per m^2 can reduce sugar beet yield by up to 15% (Longden, 1989). Spring-tine weeders can be effective in sugar beet at low weed densities when the soil is drying and weeds are unlikely to re-root (Penny, 1994). The tines work at a shallow depth. If conditions are too wet soil clings to the tines and weeds can re-root. Weeds must be small, perennial or established tap rooted weeds like weed beet are not controlled. The crop have at least 6-leaves to withstand the tine weeder but must not be so large that the leaves catch on the tines and pull the crop out. Tine weeders can be run at right angles to the crop rows as well as parallel with them. Some damage is done to the crop but it recovers rapidly. Inter-row cultivation is an established technique in sugar beet, and the crops are usually tractor hoed at least once, often to control weed beet (Wiltshire et al., 2003). Intra-row weeds are more difficult to deal with. Using a computer-vision guided hoe it is possible to get in closer to the crop row. In tests of intra-row weeding, the Einbock spring-tine harrow was used at the 0-2, 6-8 and 8-12 leaf stages of the crop (Ascard & Bellinder, 1996). Cultivations were made at 3 km/hr at a depth of 0-4 cm or at 6 km/hr at a depth of 2- 4 cm. The crop was cultivated between the rows twice. Early cultivations caused severe damage. At later crop stages, plant stand was not significantly reduced but some larger beet were uprooted by the tines. Treatments reduced weed numbers and weed weight by 44% and 3% respectively at low speed and by 80 and 47% respectively at high speed. Accurate steerage was important intra-row brush weeding with brushes on a vertical axis did not reduce beet yield or cause any visible damage (Fogelberg & Johansson, 1993). The driving speeds used were 0.5 to 3.0 km/h, the working depth was 1.5 cm and the brushes rotated backwards. The sugar beets had about 18 leaves and were 20-25 cm high. The effectiveness of direct weed control operations depends in part on the density and size of the weeds. The fewer the weeds and usually, but not always, the smaller the weeds the better the level of control. It is important to keep weeds at a manageable level using a mixture of indirect control strategies and 'good housekeeping'. It may be possible to adapt weed detection systems developed for limiting herbicide use through patch spraying of weeds to identify areas of crop that need more intense weed management. One method uses online digital image analysis and global positioning systems (GPS) to identify weed patches (Gerhards & Christensen, 2003). Among the more unusual weed control techniques evaluated is an electric discharge system to kill tall growing weeds in sugar beet (Wilson & Anderson, 1981). An electrical charge vaporises the plant sap causing considerable tissue damage. Some weeds are more susceptible than others. The system has achieved 30-50% control of the weeds after up to 3 treatments with only minor damage to the sugar beet leaves. It is unlikely that however, that the system will ever be commercially available due to safety issues.

The current study was devoted to:

1- Determine the performance of the fabricated machine in the field under actual conditions.
2- Study the factors affecting the power requirement for the cultivation unit.
3- Select the suitable operating conditions for inter – row cultivation sugar beet.
4- Compare the mechanical weed control of sugar beet with its traditional.

MATERIALS AND METHODS

The main experiment was carried out at the kafr El_Sheikh Governorate.
The main objectives of the present study are:

- To modify and manufacture a prototype of cultivating machine.
- To evaluate and determine the performance of the new device during cultivating sugar beet plants (Kawamira variety) under different operating conditions.

The prototype of rotary cultivator consists of two units of cultivating and ridger units and other secondary parts as shown in Fig. (1). The rotary cultivator unit consists of four groups of fabricated blades fixed to four groups of mild steel flat plate of 125 mm, diameter and 10 mm thickness. Each flat plate divided to four different sets of blade (2, 3, 4 and 6) as shown in Fig.(1).The fabricated blades from old leaf springs of cars with respective shape of cutting edge. The three cutting angle of blades used in this rotary cultivator of 90°, 110° and 130°. The ridger that were attached on a frame to the rear rotary cultivator unit, to establish the irrigation canal at the same time of cultivation as shown in Fig. (1). In the same time, the rotary cultivator operator by a power tiller of 17 hp (lambordini).

The modified rotary cultivator was evaluated and tested at three cutting angle of cultivator blades (90°, 110° and 130°), with four sets of cultivator blades (8, 12, 16 and 24) and four values of kinematics index (λ) of 9.43, 14.14, 18.86 and 28.28 which get out under the linear velocity of the rotary blades (u) of 3.77 and 5.66 m/s and traveling speed of machine (v) of 0.33 and 0.67 m/s.

where as $y = u / v$ ……….. (klenin et, al.,1985).

The soil moisture content (d.b.) was determined using the oven method at (105 °c), for 24 hours. The soil bulk density was measured by using cylindrical probe of 100 cm^3.The soil samples were taken down to 200 mm. depth to determine the mean of soil moisture content and soil bulk density as presented (Table 1).

Soil mechanical analysis was carried out at Sakha Research Station Lab. Soil Department (Table 1).

Table (1): The mechanical analysis of the experimental field soil .

Depth, mm	Coarse Sand,%	Fine sand,%	Silt, %	Clay, %	Caco3, %	Texture class	M.C, %	Balk density, g/cm^3
0-200	1.48	14.92	30.22	53.38	3.58	clay	27.64	1.18

F1

The quantity of standing weeds were manually collected by hand before and after the treatments. The dry weight of weeds was determined by drying oven at 60 for 18 hours.(Jackson,1967).

The efficiency of weed control: The efficiency of weed control was calculated by using the following equation:

$$\text{The efficiency of weed control} = \frac{Mb - Ma}{Mb} \times 100 \quad \%$$

where: Ma = Dry mass of weed collected after treatment.

Mb = Dry mass of weed collected just before treatment.

Injured sugar beet plants: Injured plants were calculated by the following equation:

$$\text{Injured plants} = \frac{J1 - J2}{J1} \times 100 \quad \%$$

where: J1 = Number of sugar beet plants with in an adjusted distance.

J2 = Number of sugar beet plants after cultivation.

A tachometer was used for measuring the r.p.m. of rotary cultivator blades. Slip percentage was calculated by using the following equation.:

$$\text{Slippage} = \frac{\eta e - \eta t}{\eta t} \times 100, \quad \%$$

where: ηe is effective distance, and ηt is theoretical distance.

Consumed energy was calculated by accurately measuring the decrease in fuel level cylinder immediately after carrying out each treatment. The following formula was used to determine consumed power (Hunt, 1983).

$$Er = \left[Fc \times \frac{1}{3600}\right] \times \beta f \times L.C.V. \times 427 \times \eta th \times \eta m \times \frac{1}{75} \times \frac{1}{1.36},$$

kW.

Where: Fc=fuel consumption rate, l/h.,

βf =Density of the fuel k,/l(for solar fuel=0.85k,/l);

L.C.V.= lower calorific value of fuel kcal/kg; (average L.c.v. of solar fuel is 10000 kcal./kg);

427 = Thermo-Mechanical equivalent, kg.m/kcal.;

ηth = Thermal efficiency of the engine (considered to be about 35% for diesel engine); and

ηm =Mechanical efficiency of the engine (considered to be about 80% for diesel engine).

RESULTS AND DISCUSSION

Weed control effecting

Fig 2 shows the effect of the cutting angle of blades and the number of cultivator blades on the weed control efficiency during sugar beet cultivating operation by using the modified rotary cultivator. The results indicated that increasing the number of cultivator blades tends to increase the weed control efficiency. At the same time, increasing the number of cultivator blades from

8 to 24 leads to increase the weed control efficiency from 89.42 to 96.86%, from 820.2to 88.75 % and from 80.18 to 85.84% for the cutting angle of cultivator blades of 90°,110° and 130°, respectively.

On the other hand , the cutting angle of blade (90°) gave the highest values of weed control efficiency compared with other cutting angles of cultivator blades for different treatments .This my be due an increase in centrifugal force of throwing the soil mass and rate of cutting weeds from the soil surface.

From the data shown in Fig.3, it can be seen that, the weed control efficiency increased as the number of cultivator blades and kinematics index (λ), increased during sugar beet cultivating operation by using the modified rotary cultivator.

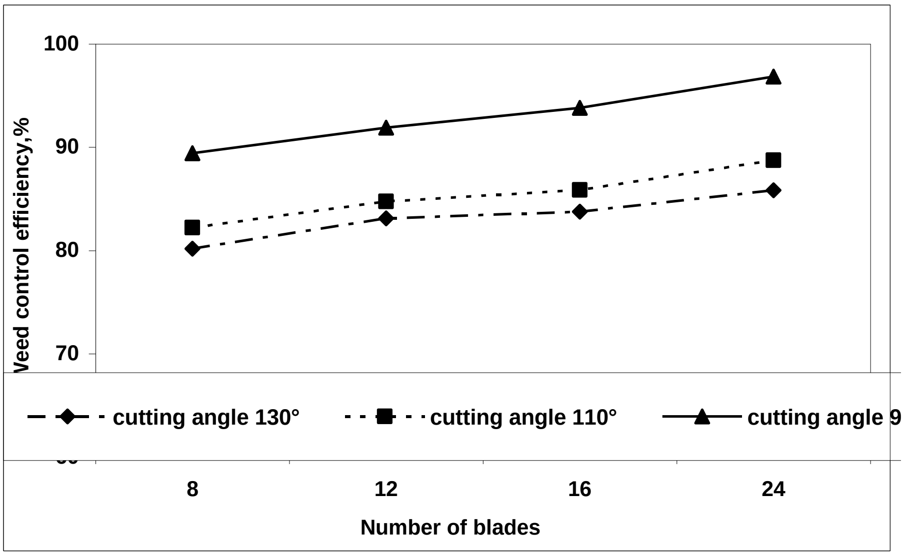

Fig. (2): Effect of the cutting angle and the number of cultivator blades on weed control efficiency.

In addition, the obtained results show that increasing the kinematic index (λ), from 9.43 to 28.28 cause corresponding increase in the weed control efficiency from 82.07 to 85.77 %, from 85.08 to 88.36 %, from 86.15 to 89.71% and from 88.89% to 92.13 % at the number of cultivator blades of 8, 12, 16 and 24, respectively.

This may be due to a decrease in cutting pitch of soil slice and an increase in throwing velocity of weed – soil mass.

From the data shown in Fig. 4, it can be seen that the injured plants increase as the number of cultivator blades increased during cultivating sugar beet plants. The results showed that the increase of the number of cultivator blades from 8 to 24 lead to increase the injured plants from 3.03 to 4.22%, from 1.75 to 3.42% and from 2.18 to 3.55% at the kinematic index (λ) of 14.14 for the cutting angle of cultivator blades of 90°, 110° and 130°, respectively.

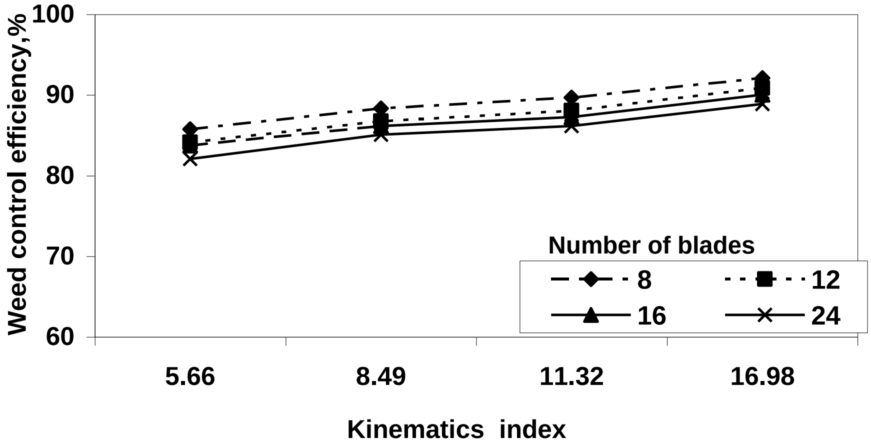

Fig. (3): Effect of kinematics index and the number of cultivator blades on the weed control efficiency at an angle of 90°.

On the other hand , the cutting angle of blade (90°) gave the highest values of injured sugar beet plants as compared with other cultivator blades for all treatments.

The results also indicated that the kinematic index (λ), of 18.86 gave the minimum percentage of injured plants, While the kinematic index (λ), of 14.14 resulted maximum injured plants percentage at all cultivation treatments.

Wheel cultivator slip:

Data in Table 2 showed that the effect of the kinematic index (λ), cutting angle and the number of cultivator blades on the wheel cultivator slip.

Table (2): The effect of the kinematics index (λ), cutting angle and the number of cultivator blades on the wheel cultivator slip.

Cutting angle of blade	90°				110°				130°			
No.of blade / λ	8	12	16	24	8	12	16	24	8	12	16	24
9.43	-1.14	-0.92	-0.75	-0.40	-1.27	-1.05	-0.88	-0.63	-1.36	-1.22	-1.15	-1.10
14.14	-1.09	-0.81	-0.51	-0.26	-1.20	-0.98	-0.76	-0.59	-1.30	-1.13	-1.02	-0.93
18.86	-1.68	-1.47	-1.16	-0.87	-1.74	-1.61	-1.20	-0.95	-1.91	-1.7	-1.35	-1.13
28.28	-1.5	-1.37	-1.08	-0.68	-1.66	-1.40	-1.17	-0.71	-1.75	-1.54	-1.21	-0.93

From these results, it can be observed that the rotary cultivator produced a negative wheel slip ratio which improved the traction of the cultivator. The results showed that the cutting angle of the cultivator blade gave the maximum values of wheel slip percentage compared with other blades. On the other hand, the kinematic index (λ), of 18.86 always recorded the minimum values of the wheel slip percentage compared with other the kinematic indexes followed by 28.28, 9.43 and 14.14, respectively for all treatments.

Fig .(4):Effect of the kinematics index, number of blades and cutting angle of blade on the injured sugar beet plants.

By other words, the data indicated that the wheel slip percentage increased as the number of cultivator blades increased. However, the results indicated that increasing the number of cultivator blades from 8 to 24 caused a corresponding increase the wheel slip percentage from – 1.68 to – 0.87% , from – 1.74 to – 0.95% and from -1.91 to – 1.13% for the cutting angle of cultivator blades of 90°,110° and 130°, respectively at the kinematic index (λ), of 18.86 .

Fuel consumption:

Fig. 5 shows the effect of the kinematic index (λ) , the cutting angle and the number of cultivator blades on fuel consumption. The results indicated that an increase of the number of cultivator blades gave an increment in fuel consumption l/h for all treatments. By other words, the cutting angle of blade (90°) gave the maximum values of fuel consumption compared with other cutting angle of blades followed by 110° and 130° respectively for all treatments. Also, it can be observed that the lowest values of fuel consumption were obtained for the kinematic index (λ) of 18.86 compared with other kinamatic indexes followed by 28.28 , 9.43 and 14.14, respectively.

Energy requirements:

Results in Fig. 6 show that the effect of the kinematic index (λ), the cutting angle and the number of cultivator blades on the specific energy requirements (kW.h/Fed) during cultivating operation of sugar beet plants. The results reveld that the specific energy requirements (kW.h./Fed.) increased by increasing the kinamatic index (λ) and the number of cultivator blades for cultivating sugar beet plants. This may be due to the increase of rotary blades speed and the centrifugal force of rotary blades. Meanwhile, the cutting angle of cultivator blade (90°) always recorded the highest values of specific energy requirement (kW.h ./Fed) compared with other different cutting angle of blades during cultivating sugar beet plants.

CONCLUSIONS

-The present study revealed the following important points :

The cutting angle of cultivator blade (90°) gave the highest values of weed control efficiency and injured sugar beet plant percentages of wheel cultivator slip, fuel consumption and specific energy requirements.

-The number of cultivator blade 16 gave the best results of the weed control efficiency, injured sugar beet plants percentage, wheel cultivator slip, fuel consumption and specific energy requirements.

-The kinematic index (λ) of 18.86 gave the best results of the weed control efficiency, injured sugar beet plants percentage, wheel cultivator slip fuel consumption.

-The kinematic index (λ) range of 9.43 to 14.14 gave the lowest value of the specific energy requirements.

Fig.(5):Effect of the kinematics index, number of blades and cutting angle of blade on the fuel consumption.

Fig.(6):Effect of the kinematics index, number of blades and cutting angle of blade on the specific energy requirements

REFERENCES

Ascard J & Bellinder R R B (1996). Mechanical in-row cultivation in row crops.Proceedings 2nd International Weed Control Congress, Copenhagen, 1121-1126.

Fogelberg F & Johansson T (1993). Mechanical weed control –Intra-row brush weeding in vegetables and sugarbeets. Proceedings 4th International IFOAM Conference on Non-chemical Weed Control, Dijon, 105-108.

Hunt, D. (1983). Farm power and machinery management. Iowa State University Press.

Jackson,M.L.,(1967).Soil chemical analysis. Perntic – Hall, India- Private LTD.N.,Delhi,India.

Klenin, N.I.,I.F. Popov and V.A. Sakum (1985).Agricultural machines. America publishing Co. Prt.Lid., New Delhi 633pp

Longden P C (1989). Effects of increasing weed-beet density on sugar-beet yield and quality. Annals of Applied Biology 114, 527-532.

Lotz L A P, Groeneveld R M W, de Groot N A M A (1991). Potential for reducing herbicide inputs in sugar beet by selecting early closing cultivars.Proceedings Brighton Crop Protection Conference – Weeds, Brighton, UK,1241-1248.

Penny E (1994). Have you the tine to weed. Crops 12 (4), 30-31.

Scott R K & Wilcockson S J (1976). Weed biology and the growth of sugar beet.Annals of Applied Biology 83, 331-335.

Scott R K, Wilcockson S J, Moisey F R (1979). The effects of time of weed removal on growth and yield of sugar beet. Journal of Agricultural Science,Cambridge 93, 693-709.

Van Zuydam R P, Sonneveld C, Naber H (1995). Weed control in sugar beet by precision guided implements. Crop Protection 14 (4), 335-340.

Wilson R G Jr & Anderson F N (1981). Control of three weed species in sugarbeets (Beta vulgaris) with an electrical discharge system. Weed Science 29 (1), 93-98.

Wiltshire J J J, Tillett N D, Hague T (2003). Agronomic evaluation of precise mechanical hoeing and chemical weed control in sugar beet. Weed Research 43, 236-244.

تصنيع وتقييم نموذج أولى لآلة عز يق بين خطوط محصول بنجر السكر

مجمد الشحات بدوى- ابراهيم صلاح الدين يوسف وعبد المحسن لطفى
باحث أول – معهد بحوث الهندسة الزراعية – الدقى – جيزة- ج.م.ع.

نظرا لان محصول بنجر السكر من أهم المحاصيل الحيوية والاقتصادية في مصر والذي مازال حتى الآن يتم التعامل معه حقليا بطرق بدائية يدوية خاصة عملية العز يق والتخلص من الحشائش مما يتطلب الكثير من العمالة والوقت مع زيادة نسبة التلف للنباتات وبالتالي نقص المحصول وارتفاع التكاليف.

الغرض من هذه الدراسة هو تصنيع نموذج أولى لوحدة عز يق دورا نية لتناسب متطلبات المزارع الصغيرة.

وقد تم دراسة العوامل الهندسية والتصميمية على أداء الوحدة المصنفة عمليا على النحو التالي:
تم تصنيع أسلحة دورا نية لها ثلاث زوايا قطع للتربة وهى 90،110،130 وكذلك أربعة مجموعات من الأسلحة السابقة بالوحدة وهى على النحو التالي 8 ؛ 12 ؛ 16؛ 24. وقد تم التقييم عند أربعة معدلات سرعة (λ) وهى 9.43 , 14.14، 18.86، 28.28 وقد تمت دراسة تأثير هذة العوامل الهندسية على كفاءة مقاومة الحشائش ونسبة التلف في نباتات بنجر السكر ونسبة الانزلاق واستهلاك الوقود والقدرة المستهلكة.

وقد أوضحت النتائج أن أفضل معدل للسرعة(λ) هو 11.32 وعدد الأسلحة هو 16 حيث أعطوا أفضل النتائج في كفاءة مقاومة الحشائش وكذلك اقل نسبة تلف لنباتات بنجر السكر وكذلك اقل نسب للانزلاق واستهلاك الوقود والطاقة المستهلكة.

كما أوضحت النتائج ان زاوية القطع للسلاح (90°) أعطت أعلى قيم لكفاءة مقاومة الحشائش 93.81% مقارنة بالزاويتين110°, 130°حيث سجلا 85.85 %، 83.75 % على التوالى عند استخدام 16 سلاح دوراني بوحدة العز يق المصنعة بينما سجلت الزاوية (90°) أعلى نسبة في النباتات التالفة 3.87 % وكذلك الانزلاق واستهلاك الوقود والطاقة المستهلكة مقارنة بالزاويتين الأخريين تحت الدراسة.

لذا يفضل استخدام السلاح ذو زوايا القطع110°, 130° حيث أعطوا نتائج جيدة ولا يوجد بينهما فرق واضح في النتائج عند جميع المعاملات.