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APPROPRIATE OPERATIONAL PARAMETERS OF THE ROTARY-CUTTER FOR SHREDDING SUNFLOWER STALK RESIDUES

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ABSTRACT

The optimum Kinematics parameter value (K) as the ratio of rotary-cutter peripheral velocity to tractor forward speed, and the suitable stalk moisture content levels (MC %) were determined for the appropriate cutting and shredding sunflower stalk residues. The combined effects of five different levels of parameter (K) and three stalk moisture content levels on the shredder performance were investigated. The shredding performance of rotary-cutter was indicated in terms of stalks cutting length, the stalk height left after shredding, and field efficiencies. Moreover, machine energy consumed, and operating cost were also estimated.

The obtained results showed the following important points:-

- The optimum kinematics parameter (K) level was 63.5, while the appropriate stalk moisture contents (MC %) was 13.8%. Whereas each of the resulted stalk cut length, and stalk height left after shredding were minimum. In addition, cutting, shredding, and field efficiencies were found to be higher at these parameter levels.
- The Kinematics parameter of 63.5, 31.6 and 17.2 were accomplished small, middle and large average cutting length of about 7.0.14.2, and 22.0 cm respectively. The corresponding, average stalk height left after shredding were 9.4, 12.7.and 21.0 cm respectively.
- The computed field efficiency was ranged from 74.15 to 88.62% depending on reducing stalk moisture from 18.2 to 13.8%. While the obtained field efficiency was ranged from 83.88. to 93.79.62% depending on increasing kinematics parameter values from 17.2 to 63.5.

As, the stalk moisture content was reduced from the upper to the lower level, the equivalent fuel consumed power was reduced from 37.8 to 30.0 kW, versus cutting energy consumption from 37.1 to 27.9 kW.h/fed. Using the rotary-cutter shredder for shredding sunflower stalks could saved 60: 85 % from the shredding operation cost, compared with manual shredding.

INTRODUCTION

Sunflower is one of the most important oily crops in the world; it ranks the second after soybeans with respect to oil production. In addition, residues revealed from sunflower harvesting may be used as fuel, livestock food and additive material in paper and wooden industry. Moreover, in some countries like Egypt, much of sunflower stalk residues are chopped, and mixed with soils at tillage to improve soil properties; especially in new reclaimed lands.

In Egypt, sunflower could be cultivated in the new reclaimed area and have high adaptability to a wide variation of soils and climatic conditions (Keshta *et al*., 1993). The sunflower heads are usually gathering manually or sometimes, combine harvesters with sunflower attachments, are used to harvest only the sunflower heads and eliminate as much stalk as possible. Therefore, the sunflower stalks are generally remains standing in the field and represent a great problem to the farmers.

Many studies have been conducted to determine appropriate operational parameters of chopping machinery. Unfortunately, most of these investigations were carried out on stalk material rather than sunflower stalk material. Morad (1981) reported that, the relation between the knife velocity and the forward speed must be considered to reduce the percentage of the uncut plants. El-Nakib (1985) studied that the performance of rotary cutter shredder in cutting cotton stalks. He pointed out that, for the machine used, a low speed of 1.65 km/h gave a clean cut with short stubbles of 8.1 cm mean height. He concluded that, a high speed of 6.3 k m/h gave ruptured cut with longer stubble of 18.7cm.

El-Khateeb (2001) studied that the performance of rotary mower in cutting and chopping of corn stalks. He tested the effects of five forward speeds (2.51, 3.0, 3.6, 4.0 and 4.51 km/h) and three knife speeds (16. 5, 23.5 and 31.5 m/s) on that machine performance. He showed that, increasing the forward speed from 2.51 to 4.51 km/h tended to increase both of the stubble height from 8.2 to 12.0cm, effective field capacity (0.6 to 1.4 fed/h), fuel consumption (3.5 to 5.4 L/h) and power requirement (11.6 to 17.6 kW). Also, he pointed out that increasing the forward speed, decreased each of the cutting area from 11.51 to 6.0 cm^2, cutting efficiency from (95.0 to 89.0 %), field efficiency from 82.0 to 66.0 %, degree of destruction from 35.0 to 21.0 %, cutting energy from 18.43 to 12.9 kW.h/fed and total cost from 12.03 to 5.61 LE/fed.

Habib *et al*. (2001) stated that, the main parameters affecting the performance of the free cutting blade during the cutting process of cotton and corn plants. They showed that main predominate parameter is the cutting blade velocity. Whereas decreasing or increasing the blade velocities less or more than certain velocities value will lead to an inefficient cutting operation. They added that increasing the plant diameter needs higher knife velocity for performing the free cutting operation. They pointed out that the consumed energy in cutting during the harvesting process is much lower than the energy consumed in crushing process due to the effect of moisture content. They concluded that the thickness of cutting tool edge showed no considerable effect on cutting energy. That parameter could be ignored during the cutting process of cotton and corn plants.

Ince *et al*. (2005) pointed out that working of chopping and shredding machines with inappropriate operational parameters at unsuitable date (unsuitable stalk moisture content) causes huge problems during tillage and sowing operations. Consequently, they recommended determining the different stalk material properties and proper operational parameters of the chopping machine in order to understand the behavior of stalk material having different stalk moisture.

Abou El-Magd *et al*. (2008) developed and tested the performance of locally fabricated stationary equipment for chopping the stalks and heads of sunflower crop. They arranged the main parameters affecting the performance effectiveness of that equipment into three parameter groups. The first group was related to the design feature of the cutting mechanisms. The second group was related to the equipment operational parameters. While, the third group was related to the plant materials prosperities, such as the stalk size and it's mass. They pointed out that the performance effectiveness of that equipment could be represented as follows:-average equipment productivity values of 217.4 kg chopped material/h, chopping efficiency of 84.7 % and power unit 10.75 kW.h/ton.

Considering the above reviewed literatures, it can be recognized that, there is a need for information about the main predominate parameters affecting on the performance of rotary-cutter shredder for accomplishing appropriate chopping sunflower stalk residues. The present study is focused on determining the effectiveness of a rotary-cutter chopper as affected by the variation in the kinematics parameters of that machine, and also as affected by the variation in the stalk moisture contents.

To overcome such problem, it should focus on the proper operational parameters for shredding machine that can chop and mix sunflower stalk residues with high efficiency and low cost.

MATERIALS AND METHODS

1. Research plan

The field experiments were conducted in order to investigate the performance of rotary–cutter during shredding sunflower stalks. These experiments were carried out in El-Serw District, Damietta Governorate, Egypt. In this research work, the effects of the kinematics parameter (K) (ratio of blade peripheral velocity to machine forward speed) as well as the effects of moisture content of sunflower stalk on the rotary–cutter performances were investigated.

In order to study the above mentioned effects, two field tests were done as follows:

- The first test was focused on determining the ability of the rotary-cutter to accomplish its function performance. That test was conducted in order to evaluate the effects of different levels of both parameters (K), and (MC %) in terms of the following indicators:-
  1. Stalk shredded lengths, and Reminder stalk heights,
  2. Cutting and shredding efficiencies %,
- The second field test was focused on determining the specific energy consumption (SEC) for stalk shredding operation using the rotary-cutter/ tractor combination. That test was done under the effect of a constant kinematics (K) value (that represent the optimum (K) value with respect to the first test indicators). The independent variable in the test was stalk moisture content (MC%). Where as the effects of three different levels of parameter (M1=13.8, M2=15.9 and M3=18.2 %) on the (SEC) was evaluated. To calculate (SEC), the following indicators were estimated:-
  1. Machine field capacity and efficiency.
  2. Energy consumed, and the specific energy consumption (SEC).
  3. Shredding operation cost.

The first and the second field tests were conducted according to ASAE standard. The procedure of evaluating the stalk shredding operation and machine energy consumption were conducted with the help of standard measurement methodology, and instrumentation.

2. Experimental procedure

The experiments were carried out during autumn season of 2007 on sunflower variety (Pioneer). The average plant populations were 10 plants per square meter, the average stalk heights, diameter and moisture content were 213 cm, 2.85 cm, and 18.2 % respectively. After harvesting sunflower heads, the rotary-cutter shredder was used to cut, chop and spread the shredded sunflower stalks on soil surface. The second step, the tillage lead to incorporating the shredding stalks with the soil surface especially in new reclaimed soils for improving its physical and mechanical prosperities

Fig. (1) shows the tested machine, that was a Rotary-cutter shredder-model MCP 1.5 ME (Romania made). The tested machine had 4 knives, which were set at knife angle of 30º. Each knife was of 8 cm length, and 1 cm thickness. The rotary-cutter shredder was adjustable through slide rails, at 150 cm cutting width, and at 4-16 cm, as cutting height. The power take off (PTO) of a 59.68kW, (80hp) diesel engine tractor, drove the investigated machine, during carried all the experimental treatments.

The kinematics parameter (K) for the rotary-cutter mower could be expressed according to Klenin and Papov (1970) as follow:-

$$K \geq \frac{2\pi r_o}{Z_H . L_H} \qquad (1)$$

Where:-

r_o = Disk radius, m

Z_H=Number of knives on disk

L_H=Knife length, m

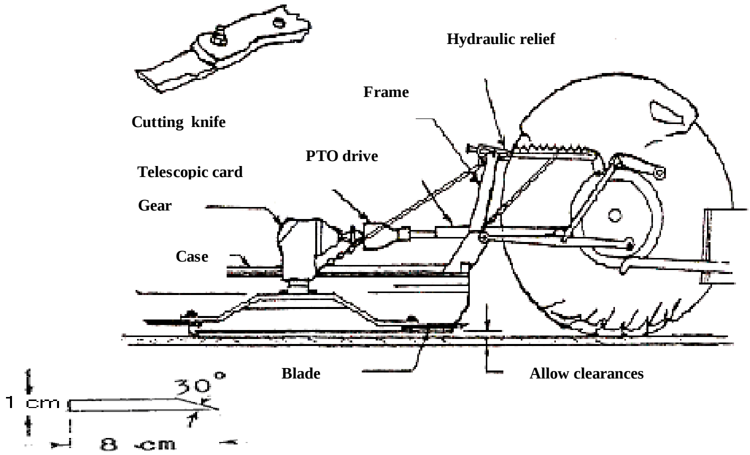


Fig. (1): Schematic view of rotary-cutter equipped with a tractor

The value of (K) could be calculated in accordance to the dimension of the rotary- cutter shredder under test using the previous equation, as follow:-

From the tractor travel distance and time, the average operation speed was computed for each experimental treatment. All experiments were running under a constant peripheral velocity of 30 m/s, for rotary-cutter shredder and average tractor forward speeds of 1.7, 2.55, 3.42, 4.67 and 6.28 km/h. These speed levels corresponded to different kinematics parameters of 63.53, 42.35, 31.58, 23.13, and 17.20 respectively. Steel tape was used to measure the length of the travel distance and length of the tested plots. While, a steel ruler was used to measure the shredded stalks length. Also a multi-range hand tachometer was used to measure the rotational speed (rpm) of the rotating shafts.

Measurements:-

The cutting efficiency was estimated by using the following equation according to (Hanna *et al.,* 1985) as follows:-

$$\eta = \frac{w_a - w_b}{w_a} x100 \quad (2)$$

where:-

w_a and w_b = weight of stalks above the soil before and after cutting g/m^2

Balance to measure the weight of stalks, which resulted from the tested treatments and their replicates.

The shredding efficiency (E_c) was calculated according to (Cravcenco *et al*., 1976) by using the following formula:-

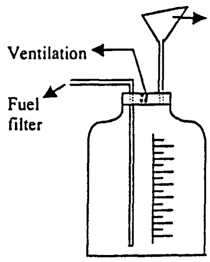
$$E_c = \frac{A - B}{A} x100 \quad (3)$$

where:-

A = stalks weight per square meter before shredding operation (g/m^2)

B= Weight of stalk piece which has length greater than 20cm in an area of square meter and after one pass of shredding machine in (g/m^2)

The fuel consumption versus each travel distance was measured for each experimental treatment. The fuel consumption was measured by using a small auxiliary tank of about 4-L content as showed in the side figure. The tank is merely a bottle closed with a rubber stopper. There are three holes in the stopper. Metal has been inserted in two holes. One reaches 0.5 cm above the bottom of the tractor fuel tank, and the second for filling the fuel by means of an attached funnel. The third hole serves as ventilator for the tank during filling.



Hence, the fuel equivalent power in (kW) was estimated for each experimental treatment according to Hunt (1995) and Srivastava *et al*. (1995), using the following formula:-

$$\text{Fuel equivalent power} = (F_c \; x \frac{1}{3600}) \rho_f \, xL.C.V.x \; 427 \, \eta_{Th} x \, \eta_m x \frac{1}{75} \, x \frac{1}{1.36} \, x \, , kW \quad (4)$$

where:-

F_C = the measured fuel consumption rate, L/h.

ρ_f = density of the fuel , kg/L(for solar fuel= 0.85 kg/L

L.C.V. = lower calorific value of fuel. k_{cal}/kg (average L.C.V. for solar fuel is 1000 kcal/kg).

Thermo-mechanical equivalent, ≈ 427 kg.m/k_{cal}.

η_{TH} = thermal efficiency of engine (assumed as 40% for diesel engine)

η_M = mechanical efficiency of the engine ≈ 80% for diesel engine.

After computing the effective machine capacity (fed/h) the specific energy consumption (SFC) could be calculated (in kW.h/fed) according to Srivastava *et al*. (1995), using the following formula:-

$$\textbf{Specific Energy Consumption(SFC)} = \frac{\textbf{Fuel equivalent power(kw)}}{\textbf{Machine capacity (fed/h)}} \qquad (5)$$

For the aim of estimating the effective machine capacity the areas under cutting and cutting time were computed. The area under cutting was estimated by multiplying the actual cutting width by the actual travel distance. Hence, the effective field capacity was computed by multiplying the actual speed by the actual cutting width. Moreover, the field efficiency (η F) was calculated by using the following formula:-

$$\eta_F = \frac{Effective\ field\ capacity}{Theoritical\ field\ capacity} x100 \qquad (6)$$

The shredding cost were estimated and compared for both manual and machinery shredding operations. The manual cost was estimated based the next assumptions the required labor number are 8 man/fed. and the labor wages was assumed as 15 LE/day. While, the machinery cost was estimated by assuming that, the rental price of the tractor and the rotary-cutter shredder was as 30 LE/h, according to the rental price of mechanization stations and related to prices of 2008.

The test steps could be summarized as follows:

-The rotary cuter-shredder was adjusted horizontally with tractor and all working parts were checked before carrying out each test.

-The speed of tractor was changed to obtain the required kinematics paramter level at constant knife speed level.

-After passing with the shredder, the shredded stalks for each experimemtal treatment was collected and placed in plastic bags to be weighted, meaured and sorted into eight length catogery.

-Each test was replicated three times and mean values were calculated and recorded.

RESULTS AND DISCUSSION

The obtained results could be discussed under the following headings:-

1. Shredding Performance

The Shredding performances of the rotary-cutter as a function of and kinematics parameter (K), and stalk moisture content (MC%) were evaluated in terms of the stalk cut lengths, the reminder stalk heights, frequency distribution of 8 cut length categories, stalk cutting and shredding efficiencies.

However, as seen in Fig. (1) the average stalk cut length decreased with decreases in moisture content. While increasing the parameter (K) decreased the average stalk cut length. Similar result could be observed for the effects of heights the parameters (K), and (MC %), on the average reminder stalk heights. But the effects of kinematics parameter (K), on the evaluated indicators was more obviously on stalk cut lengths compared to its effect on the reminder stalk heights.

The difference between the values at the average stalk cut length at the lowest and highest parameters (K), was about 69%. While the corresponding differences at the lowest and highest moisture contents was about 36%. On the other hand, the difference between the values for the reminder stalk heights at the lowest and highest parameters (K), was about 55%. While the corresponding differences at the lowest and highest moisture contents was 28 %. The average values for the stalk cutting length were found to be increasing 18.4, 13.6 and 11.8 for moisture contents of 18.2, 15.9, and 13.8%respectively.

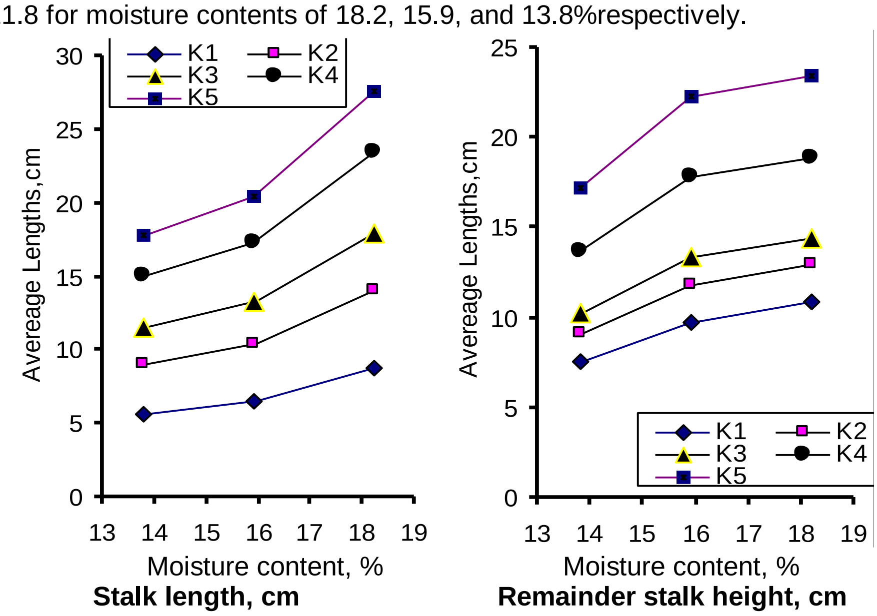


Fig. (1): Average stalk cut, and reminde r lengths as affected by stalk moisture, and parameters (k)

The frequency distribution curves of 8 cut length categories are shown in Fig. (2) as affected by the kinematics parameter (K), and at the proper stalk moisture content of 13.8 %.

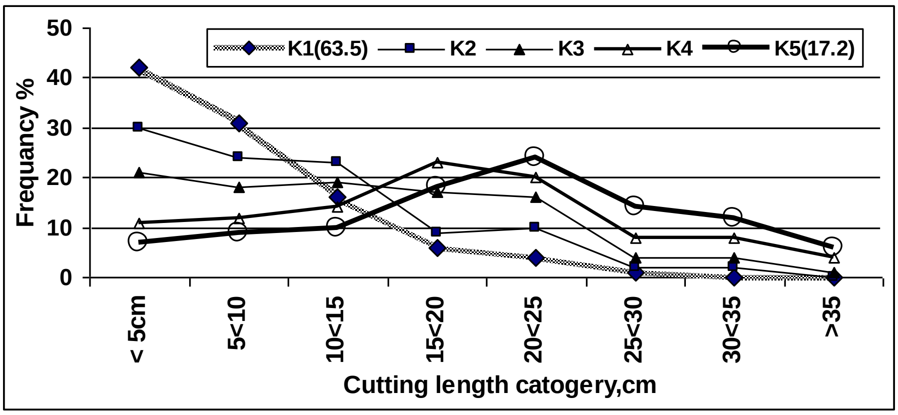


Fig. (2): Cutting length categories versus the kinematics parameter(k) at stalk moisture content of 13.8%.

Referring Fig. (2) it can be seen that, the percentage of shorter cut length category (0 - <5) and (5 - <10) increased with increasing kinematics parameter (K). That is due to increasing the number of cut knife impact as decreasing the forward speed, and keeping constant knife speed.

It can be stated that changing kinematics parameter from K1 to K5 leads to increase the cutting lengths category shorter than 10 cm by about (56 %). While the corresponding percentage of the category shorter than 20 cm can be noticed as 94, and 44% for K1, and K5.

The maximum percentage of short length cut were 40 and 30 % respectively was computed for maximum kinematics parameter value (63.5), while the minimum percentage of the same length of cut was 7 and 9 % respectively was remarked (K5 = 17.2).

From the same Figure (2) it can be noticed that stubble height increased with decreasing the kinematics parameter (K). It was remarked that the maximum percentage of shorter stubble height {(0 - <5) and (5 - <10)} were 15 and 76 respectively with higher kinematics parameter K1 = 153.1. While it was not found any percentage of small height (0 - <5) with (K4 = 56.6) and (K5 = 42) . Also it was noticed that stubble height increased with decreasing the kinematics parameter. It may concluded that, as the kinematics parameters decreased from 63.5 to 17.2 (increasing forward speed from 1.7 to 6.2 km/h) lead to increase both stem cutting length from (6.52 to 20.5 cm) and stubble height from (9.8 to 22.35 cm), and vice-versa.

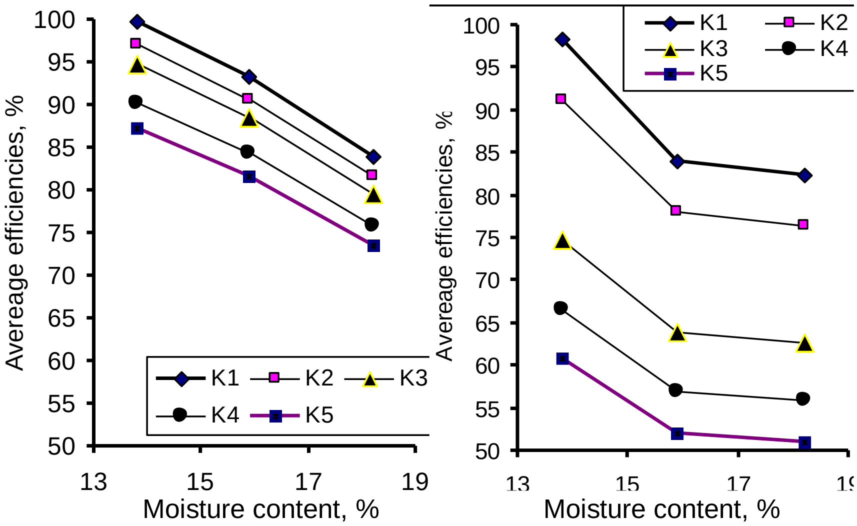
The stalk cutting and shredding efficiencies was evaluated as a function of kinematics parameter, and moisture content. Fig. (3) illustrate the average stalk cutting and shredding efficiencies as affected by stalk moisture content and kinematics parameter.

It can be seen that as the moisture content, of the stalks decreased the cutting efficiency increased by about 15%. Vice, versa trend, could be noticed as kinematics parameter decreased, whereas, the cutting efficiency increased by about 12 % as the parameter (K) increased.

2. Field work rate Performance

The effects of kinematics parameter and stalk moisture content and kinematics parameter on the field efficiency were evaluated. For the aim, the effective field capacity was computed. Hence, the field efficiency (η F) was calculated by using the following formula (6), and the obtained data are shown in Fig. (4).

However, as seen in Fig. (4), the field efficiency was decreased by decreasing kinematics parameter, while it was decreasing as moisture content of the stalks was increased. The decrement rates of field efficiency due to decreasing kinematics parameter were almost constant of about 4 : 5 %. On the other side, the decrement rates in field efficiency due to increasing the stalk moisture content could be observed only as the moisture content dropped from18.2 to 15.9%, while dropping the moisture content from 15.9 to 13.8%, had almost no effect on the field efficiency percentages.



Cutting efficiency, % **Shredding efficiency, %**

Fig. (3): The average stalk cutting and shredding efficiencies.

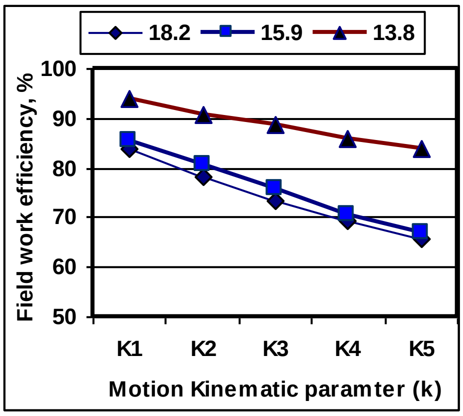


Fig. (4): he effects of kinematics parameter, and the stalk moisture content on the field efficiency

It may be concluded that the maximum field efficiency (93.79 %) was accomplished at kinematics parameter of 63.5,and stalk moisture content of 13.8%. While the minimum field efficiency (65.7 %) was obtained at kinematics parameter of 17.2, and stalk moisture content of 18.2%.

Specific shearing energy

To estimate specific shearing energy consumptions, averages fuel consumption rates (Fc), was firstly computed. Hence, the fuel equivalent power in (KW) was estimated for each experimental treatment according to equation (4). Then the specific shearing energy consumption (SEC) could be calculated (in kW.h/fed), using the formula No (5). The averages fuel consumption rates versus each travel distance was measured for each experimental treatment, and indicated as a function of both investigated parameters as shown in Fig. (5).

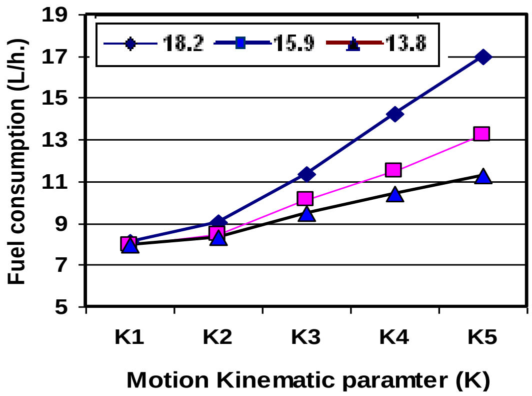


Fig.(5): The effect of moisture content on fuel energy consumption.

It can be seen from (Fig. 5), that the fuel energy consumption increased exponentially with increases in the kinematics parameter (K) for all levels of moisture content (MC %). This effect of parameters moisture content was also reported by Chen *et al*. (2004).

The values of fuel energy consumptions varied by about 21% (from 9.484 to 11.94 L/h) between lowest and highest kinematics parameter (K) without considering the effect of moisture contents. Considering the effects of moisture contents without considering the effect of kinematics parameter (K) effect, fuel energy consumptions varied by about 73% (from 8.00to 13.83 L/h).The reason for this difference may be expressed due to the viscous damping effect of moisture as reported by Persson (1987).

Hence, the fuel equivalent power in (kW) was estimated for each experimental treatment according to equation (4). Hence computing the effective machine capacity (fed/hr) the specific energy consumption (SEC) could be calculated (kW.h/fed) using the formula No (5).

However, specific energy consumptions values as affected by both parameters (K), and Mc% are shown in Fig. (6).

Figure 6 presents an exponentially decreasing relationship between the specific energy consumptions, and moisture content decreasing for all levels of parameter (K)

The highest specific energy consumptions (42.70 kW.h/fed) was obtained as the moisture content was at the highest level (18.2%). while the lowest SEC was found to be 22.58 kW.h/fed) in the case of operating at K5 middle at a moisture content of 13.8%.

The effect of parameters (K) on SEC was almost constant at middle moisture content level of 15.9%. While, The SEC decreased by decreasing parameter (K) values at the lowest moisture content of 13.8%. In addition, it can be seen a slight increasing in the SEC values by decreasing parameter (K) values at the highest moisture content of 18.2%. Whereas the SEC, is defined as the efficiency of using the energy by an implement. Thus, the cleared result trend reveled that using rotary-cutter can properly shredded sunflower stalks at almost SEC range from 23:43(kW.h/fed).

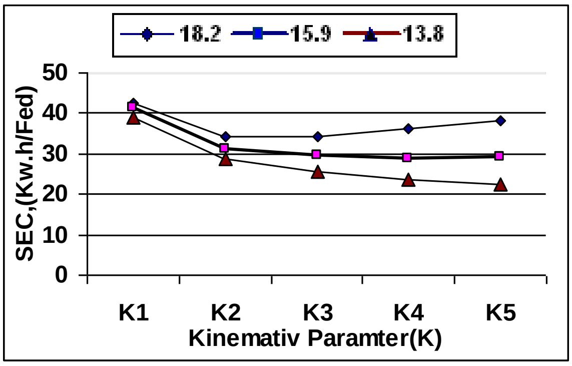


Fig. (6): Specific energy consumptions as affected by both parameters (K)and MC%.

Conclusion

The variation in the speed kinematics parameter value (K) and moisture content of sunflower stalks have to be known in order to limit cutting length and optimize the energy and economic performance of rotary-cutter shredder.

This result indicates that

In spite of decreasing the effective field capacity, as decreasing parameter value (K) each of the resulted stalks cut length, and stalk height left after shredding were minimum. In addition, cutting, shredding, and field efficiencies were found to be higher as decreasing parameter (K) value .

Shredding sunflower stalk at lower moisture contents can be recommended to minimize stalk cut length, and stalk height left after shredding, and the shearing energy requirements.

The results showed that shredding sunflower stalks at kinematics parameter of 63.5 required 73% more fuel equivalent power than shredding at kinematics parameter level of 17.2. In addition shredding reducing stalk moisture content from 18.2 to13.8% leads reducing fuel equivalent power by about 20%. Comparing the cost of manual shredding of sunflower stalk ,with shredding using the rotary-cutter, the later could save the shredding cost by a rates ranged from 60: 85 %, depending on increasing the forward speed level.

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عوامل التشغيل الملائمة لاستخدام المحشة الدورا نية لتقطيع وفرم سيقان دوار الشمس

عبد المحسن لطفي، محمد محمود عبد الجليل و ميرفت محمد عطا الله
معهد بحوث الهندسة الزراعية

نظرا لاتجاه الدولة في الوقت الحاضر لزيادة مساحات المحاصيل الزيتية لسد الفجوة بين الإنتاج والاستهلاك في زيت الطعام وذلك بزراعة بعض المحاصيل مثل دوار الشمس الذى تجود زراعته في معظم أنواع الأراضي خاصة الحديثة منها وفي ظروف مناخية مختلفة ونظرا لنقص العمالة اليدوية و ارتفاع أجورها خاصة في المدن الصناعية الكبرى مثل دمياط وكذلك مناطق الأراضي حديثة الاستصلاح. لذلك يهدف هذا البحث إلى استخدام محشة دورا نية في تقطيع سيقان نبات دوار الشمس والتغلب على عيوبها ومنها عدم انتظامية ارتفاعات القطع أو ترك نباتات بدون قطع وذلك عن طريق التوصل إلى أنسب علاقة بين السرعة الدورانية للمحشة وسرعة تقدمها (المعامل الكينماتيكي) عند نسب رطوبة مختلفة لسيقان النبات.

وقد تم تقييم هذه المحشة الدورانية من خلال القياسات التالية :-

١- أطوال القطع وأطوال الأجزاء المتبقية　　　　٢- كفاءة القطع والفرم .

٣- الطاقة النوعية اللازمة لعملية التقطيع . ٤- معدل الأداء والكفاءة الحقلية .
٥- التقييم الاقتصادي لعملية التقطيع .

وقد تبين من النتائج ما يلي :-

- سجلت اقل قيم لمتوسطات أطوال القطع والجزء المتبقي من الساق في الأرض (٧,٠٠ ، ٩,٤ سم على التوالي) مع أكبر معامل كينيماتيكي (K_1=٦٣,٥) واقل نسبة رطوبة (١٣,٨%). (بينما كانت أكبر متوسطات لأطوال القطع والجزء المتبقي هى (٢٢ ، ٢١ سم) مع أقل معامل كينيماتيكي (K_5= ١٧,٢) واعلى نسبة رطوبة (١٨,٢%).
- بانخفاض المعامل الكينماتيمي من ا ٦٣,٥ إلى ، ١٧,٢ انخفضت كفاءة القطع من ٩٣,٤ ، ٨٠,٨ % وانخفضت كفاءة الفرم من ٨٨,٢ إلى ٥٤,٦ %.
- انخفض كل من استهلاك الوقود والطاقة اللازمة للقطع بانخفاض المعامل الكينماتيكي ونسبة رطوبة الساق. حيث دونت اعلى قيمة لطاقة القطع مقدارها ٤٢,٧ كيلووات.ساعة /فدان مع أكبر معامل (٦٣,٥) واعلى نسبة رطوبة (١٨,٢%). بينما كانت أقل قيمة لطاقة القطع هي ٢٢,٥ كيلووات.ساعة /فدان مع أقل معامل (١٧,٢) واقل نسبة رطوبة (١٣,٨%)..
- أوضحت النتائج أن السعة الحقلية زادت من ٠,٦ إلى ١,٥٨ فدان/ ساعة بينما انخفضت الكفاءة الحقلية من ٨٧,٤ إلى ٧٢,٢ % وذلك بانخفاض المعامل الكينماتيكي من ٦٣,٥ إلى ١٧,٢
- بينت النتائج أن التكاليف الكلية لتقطيع سيقان عباد الشمس قد إنخفضت من ٤٧,٤ إلى١٨,٠ جنيه/ فدان وذلك بانخفاض المعامل الكينماتيكي من ٦٣,٥ إلى ١٧,٢ وذلك مقارنة بـ ١٢٠ جنيه تكاليف إخلاء فدان من سيقان دوار الشمس يدويا.

أهم التوصيات

يوصى البحث باستخدام هذا النوع من المحشات في تقطيع وفرم سيقان نبات دوار الشمس وبعض المخلفات الحقلية الاخرى حيث يمكن من التغلب على مشكلة نقص العمالة في المدن الصناعية الكبرى مثل دمياط ومناطق الأراضي الجديدة المستصلحة نادرة العمالة، وكذلك فإن إضافة الأجزاء المقطعة إلى الأرض وتقليبها أثناء الحرث ليحسن من خواص الأرض الطبيعية والميكانيكية خاصة الأراضي حديثة الاستصلاح. كما تقلل الوقت والجهد والتكاليف وسرعة إخلاء الأرض من بقايا المحصول.