DEVELOPMENT OF A FODDER BEET CHOPPING MACHINE

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ABSTRACT

The objective of the present investigation was to modify some parts of the local watermelon seeds extraction machine, where the developed machine can be used with the extraction of watermelon seeds and chop the fodder beet. The developed machine has been evaluated under three beet moisture contents of 86.2, 81.3 and 76.85 %, four rotor speeds of 325, 405,460 and 540 rpm and three number of knives rows of 2, 3 and 4 rows. The evaluation was based on the following parameters: The chopping sizes, machine productivity, consumed energy, and chopping cost.

The results recommended operating the machine at rotor speed of 540 rpm, number of knives rows of 4 row and beet moisture contents of 86.2 % to maximum values of beet sizes <2 cm (71%) and maximum machine productivity (10.25 ton h^{-1}), with consumed energy of 1.08 kW.h ton^{-1} and the minimum chopping cost of 20.49 L.E ton^{-1}.

***Keywords**: fodder beet, design, chopping, consumed energy.*

INTRODUCTION

Fodder beet (*Beta Vulgaris L.*) is considered a good source of energy for animal feeding, palatability and digestibility. Fodder beet cultivation may overcome the problem of animal feeding at the beginning of summer season but it still has a weak competitive ability against be clover seem as winter forage.

Fodder beet contains high water and sugar, it increases milk productivity and is suitable forage for dairy cows. The fodder beet is used by mixing it with straw in European countries. It is also reported that the plant is suitable for making silage (***Aky ld z 1983***).

In Egypt, the great shortage in animal feed stuffs and their distribution around the year are the main problems facing animal production. There is a shortage of fresh forage particularly during summer. Moreover, the cultivated area is very limited and is devoted to cultivation of strategic food crops such as wheat and faba beans during winter.

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On the other hand, the horizontal expansion of new reclaimed areas requires the cultivation of crops offering a source for satisfying income to the farmers (***Kassab et al., 2012***).

In Egypt, the fodder beet is grown each year, cultivated area is about 9674 ha and quantity of production was 244626 tons (***FAOSTAT, 2010***).

Increasing and expanding fodder beet can be realized by finding new and additional areas without changing the prevailing winter crop structure through intercropping with some winter crops (***Abou-Elela and Gadallah, 2012***).

Fodder beet offers a higher yield potential than any other arable fodder crop and when grown under suitable conditions, it can produce almost 20 t ha^{-1} dry matter yield (***DAF, 1998***) and also fresh yield more than 80 t ha^{-1}. (***Shalaby et al., 1989***). The above and below growth parts (leaves and roots) are used to feed the animals but, the main fodder is tuberous roots (***Ibrahim, 2005***). Therefore, the optimum plant density which produces maximum leaves and roots yield must be carefully determined. Fodder beet is good forage especially during the critical period of forage shortage such as early summer season in Egypt.

Chopping fodder beet roots are the main point for feeding small ruminants in this connection, **Gabra *et al*. (1993)** reported that biting roots by sheep was slow, hard and negatively affected daily intake. They concluded that chopping roots at small pieces are suitable for the pointed mouth of sheep and may increase feed intake and feeding values.

Hashish et al. (1994) indicated that the theoretical cut of 13 mm is usually considered fine enough for corn silage, longer cut (50 – 75 mm) are desirable for cured hay. With any crop, chopping into lengths shorter than necessary increase the energy requirements per megagram and may reduce the capacity of the chopper. ***Kholief (2001)*** pointed out that the increase of drum speed from 14.52 to 22.31 m s^{-1} leads to increase the unit energy consumption of chopped fodder beet by 16.36, 12.74, 11.05 and 10.97 % at feed rates of 100.2, 130.2, 169.8 and 199.8 kg h^{-1} respectively by using fodder beet moisture content of 72.34 % (w.b.).

Mohamed (1998) mentioned that the maximum force needed to cut the beet in the upper part was 540 N, the middle part 430 N and the root part was 188 N.

The objective of the present investigation was to modify some parts of the local extraction machine of watermelon seeds, where the developed machine can be used with the extraction of watermelon seeds and chop the fodder beer.

MATERIALS AND METHODS

The experimental work was carried out during summer season 2015 at Kafer El-Sheikh Governorate - Egypt. The developed mechanism was fabricated in private workshop. The fodder beet (Rota variety – Multi - embryos) was randomly collected from different farms from Kafr El-Sheikh Governorate. The specimens gathered from the field were weighed and dried at 103° C for 24 h (***ASAE, 1999 a***). The moisture content of fodder beet was 86.2% w.b.

1. The original machine

The original machine Fig. (1) performs its function in three processes. The first process for crushing watermelon fruits, while the second process for separating peel from the mixture of seed and flesh and the last process for cleaning the seeds from flesh. The machine consists of main hopper which contains two main shafts. The upper one drives the cutting knifes and the lower drives crushing shaft. The Machine was driven by a transmission system connected to the PTO of tractor (60 hp) by means of a pair of sprockets and chains, and a universal joint.

Fig. (1): The original machine

2. Design consideration

The some parameters were considered in the design of the some parts of the developed machine: easy of operation, reduction of the energy requirements, economy to make the machine affordable and within the capacity of the local farmers, using standard component and local available material.

Some physical and mechanical properties of fodder beet were studied that are related to cutting process.

2.1 Physical properties

Three axial dimensions (length, width, and thickness), mass and volume were measured according to ***Mohsenin (1986)***.

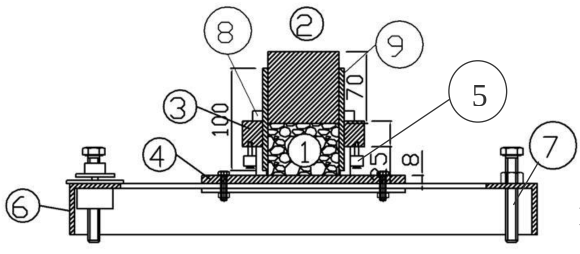
2.2 Coefficient of static friction

The static coefficient of friction of fodder beet against galvanized metal was determined at moisture content of 86.2% w.b. A device was used for the determination of the coefficient of friction as shown in figure (2) according to ***Ibrahim (2008)***. The static coefficient of friction was calculated as follows:

$$\mu = \frac{F_T - F_E}{W} \qquad \textbf{(1)}$$

Where

μ	:	Coefficient of static friction.
F_T	:	Force required to start motion of filled carriage, N.
F_E	:	Force required to start motion of empty carriage, N.
W	:	Vertical weight, N.



Dims. in mm

1-Sample **2**- Piston (vertical loads) **3**- Carriage
4- Sliding surface **5**- Rolling wheels **6**- Base
7- Adjustable screw **8**- Adjustable nut **9**- Cylinder

Fig. (2): The device used for measuring the friction force.

2.3 Shearing stress

The ultimate shear strength test was carried according to (***ASAE, 1999 b***). Cylindrical samples of fodder beet with a diameter of 25 mm were cut from the centre fodder beet using a cork borer and then trimmed to a height of 25 mm. The core samples were taken perpendicular to the major axis of the tubers.

The shear force was measured in double shear using a shear box (Fig. 3) consisting essentially of to fixed parallel hardened steel plates 15 mm apart, between which a third plate can slide freely in a close sliding fit. Shear force was applied to the cylinder specimens by mounting the shear box. The test was carried out between the standard Instron stainless steel polished platens of a model Instron Universal Testing Machine (Instron, USA) using a 1 kN load cell.

The shear stress was calculated as follows:

$$\tau = \frac{F}{2A} \tag{2}$$

Where

τ : Shear stress, MP_a.

F : Shear force at failure, N.

A : Initial cross – sectional area, mm^2.

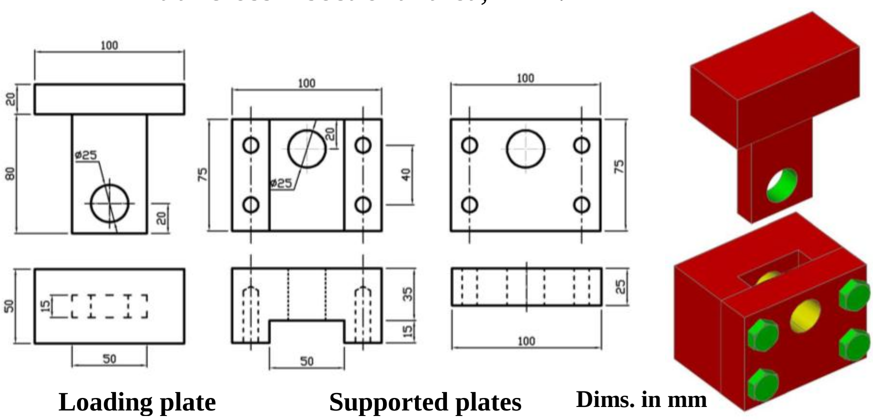


Fig. (3): The shear force measuring device.

The shearing energy was calculated by integrating the area under the shear force and displacement curve (***Chen et al., 2004***). The specific shearing energy was calculated from the following:

$$E_{SC} = \frac{E_S}{A} \qquad \textbf{(3)}$$

Where

Esc : Specific shearing energy, mJ mm^{-2}.

Es : Shearing energy, mJ.

A : Initial cross – sectional area, mm^2.

3. The developed machine

The developed parts of the original machine are cutting knives, cutting chamber, and the driving unit (Fig. 4).

3.1 Feeding unit

The major parameter governing the size and configuration of the feed hopper is the throughput capacity of the machine. The hopper must be able to accommodate enough fodder beets to achieve the required throughput capacity. It is cuboids shape and it was made of 2 mm thick plate. It was dimensioned 1200 ×750 × 300 mm and the opening rectangle hole in the base 500 x 500 mm, to deliver the beet to the cutting unit.

3.2 Cutting unit

The cutting unit works on shear cutting principle. When the cutting blade impacts on the cylindrical surface of the fodder beet, the surface gets cut by shearing along a plane. Spiral cutter was also reported to be used for chopping (***Persson, 1987***). The length and diameter of this cylindrical cutter were 500 mm and 150 mm respectively so that it could be fitted in the available machine.

The blades were made of MS plat of size 64 x 55 mm and 10 mm thickness. The cutting edge sharpened at the angle of 90^0. The 2 or 3 or 4 rows of knives (each row consist of 16 knives). The knives were welded directly on the cylindrical cutter shaft and they were fixed as spiral arrangement (Fig. 5).

Determination of the shearing force of the fodder beet: Considering the shear strength of the fodder beet and the area under shear, the impact force required to shear the fodder beet by one knife may be obtained from the following equation:

$$F_P = A_P \times \tau_P \qquad \textbf{(4)}$$

Where

F_P : Force required for shearing the fodder beet, N.

A_P : Area under shear (area of one knife).

τ_P : Shear stress of the fodder beet (Max. = <u>0.281 MPa</u>)

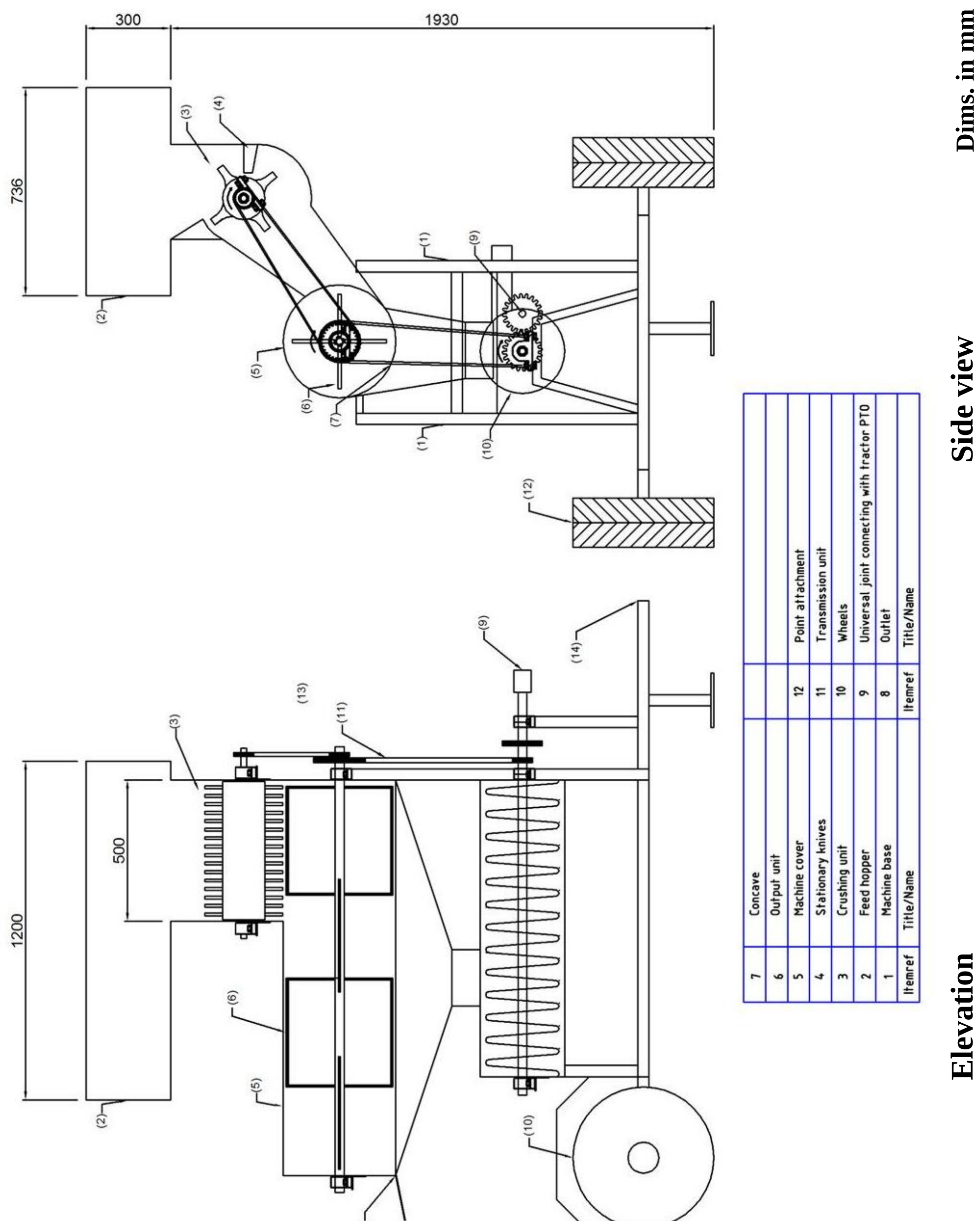


Fig. (4): Diagrammatic sketch of the modified machine.

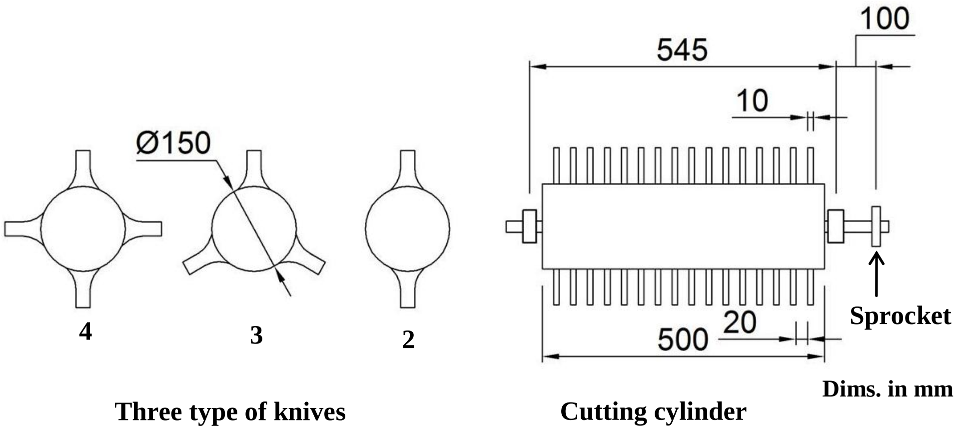


Fig. (5): Cutting cylinder and shaft of cutting unit.

The area of one knife was calculated (2046 mm^2). The average force required to shear fodder beet is 574.926 N.

Determination of the power required for cutting the fodder beet: The power required by the chopper to cut the fodder beet may be obtained from the following:

$$P_C = F_P \times N_k \times V_C \qquad \textbf{(5)}$$

Where

P_C : Power required by the cutter, N-m s^{-1}.

N_k : No. of knives that cutting at simultaneously (10 knives).

V_C : linear velocity of the cutting blade = 7.2 m s^{-1} (at 540 rpm).

From equation (5), the required power of cutting unit is 41.39 kW.

Design of the rotating shaft: In order to transfer the power from the shaft, the various members (such as pulleys, bearings, and cylinder) are mounted on it. The shaft in this case is exposed to bending moment and torsional forces since it is utilized for torque transmission and bending moment. Hence, the diameter of the shaft was calculated as follows (***Eric, 1976***):

$$d^3 = \frac{16}{\pi S_s}\sqrt{[K_b M_b]^2 + [K_t M_t]^2} \qquad \textbf{(6)}$$

Where

d : Diameter of shaft, m.

M_b : Resultant bending moment, N-m.

M_t : Torsional moment, N-m.

K_b : Combined shock and fatigue factor applied to bending moment.

K_t : Combined shock and fatigue factor applied to torsional moment.

S_s : Allowable shear stress of the shaft material, MN-m^{-2}.

The values of K_b and K_t were taken as 1.5 and 1.0 respectively for the gradually applied load on the rotating shaft and the allowable shear stress of the shaft (Ss) as 40 MN-m^{-2} based on ***ASME code***.

M_b was calculated by analyzing moments due to both horizontal and vertical loading in bending moment diagrams of the shaft.

M_t was calculated by the following equation:

$$M_t = \frac{P \times 60}{2\pi N} \qquad \textbf{(7)}$$

Using P = 41390 W and N = 540 rpm, M_t was calculated as **732.3** N-m.

For the cylinder: Weight of cylinder (W_C) is **109.56 N**.

The weight of knives = N_k × weight of one knife = 101 N, the total weight for cylinder and knives that acting vertical is **210.56** N.

For the chain: Weight of sprocket (Wp), (150 mm – diameter and 40 mm – thick), equals **54.48** N.

The total load or total tension (F_{Total}) on the driving side of the chain is the sum of the tangential driving force (F_T), centrifugal tension in the chain (F_C) and the tension in the chain due to sagging (F_S). **(*Khurmi and Gupta, 2005*)**.

$$F_{Total} = F_T + F_C + F_S$$

$$F_T = \frac{P}{v}, \; F_C = m.v^2 \;, F_S = k.mg.x \qquad \textbf{(8)}$$

Where

P : Power transmitted, W.

m : Mass of the chain in kg per meter length = 0.13 kg m^{-1}.

v : Speed of chain, m s^{-1} = 4.24 m s^{-1}.

g : Acceleration of gravity, g = 9.81 m s^{-2}.

x : Centre distance, m.

k : Constant = 2 to 6, when the centre line of the chain is inclined to the horizontal at an angle less than 40º.

F_{Total} = 9769 N, this load acts at 34° to the horizontal as shown in Fig. (6)

Resolving the load F_{Total} into vertical and horizontal components (Fig. 6), the vertical component = F_T sin 34° = **5462.8** N and the horizontal component of = F_T cos 34° = **8098.9** N.
Accordingly, the shaft is subjected to vertical and horizontal loads of the values presented in table (1) and figure (6).

Table (1): Vertical and horizontal loads on the shaft.

Type of load	At (A)	At (B)
Vertical	210.56 N (421.12 N-m^{-1})	5517.3 N
Horizontal	-	8098.9 N

The maximum resultant bending moment (M_b) and torsional moment (M_t) were calculated and were found **732.3** and **490** N-m respectively. By applying the calculated values of the different items in equation (6), shaft diameter should be equal or more than 51 mm.

3.3 Transmission unit

Figure (7) shows the modified transmission unit for developed machine. It used the sprocket and chain to transform the motion starting from PTO of tractor to cutting shaft. According to ***Khurmi and Gupta (2005)*** the relation between the speed and the number of teeth ad following:

$$N_1T_1 = N_2T_2 \qquad \textbf{(9)}$$

Where

N_1, N_2 : Speed of driving and driven shaft respectively, rpm.
T_1, T_2 : Number of teeth for driving and driven shaft respectively, teeth.

The machine will operate at four speeds at the cutting shaft: 325 (4.7), 405 (5.9), 460 (6.7) and 540 (7.2) rpm (m s^{-1}). The speed of PTO shaft is 540 rpm. So, Substituting the required speeds at the cutting unit, the teeth number of sprocket at The shaft of modified Cutting unit (T_6) were calculated according to the required speed.

4. Treatments

The development machine was evaluated at four different levels of moisture content of fodder beet, three numbers of arrange knives rows and three levels of rotor speed (table 2).

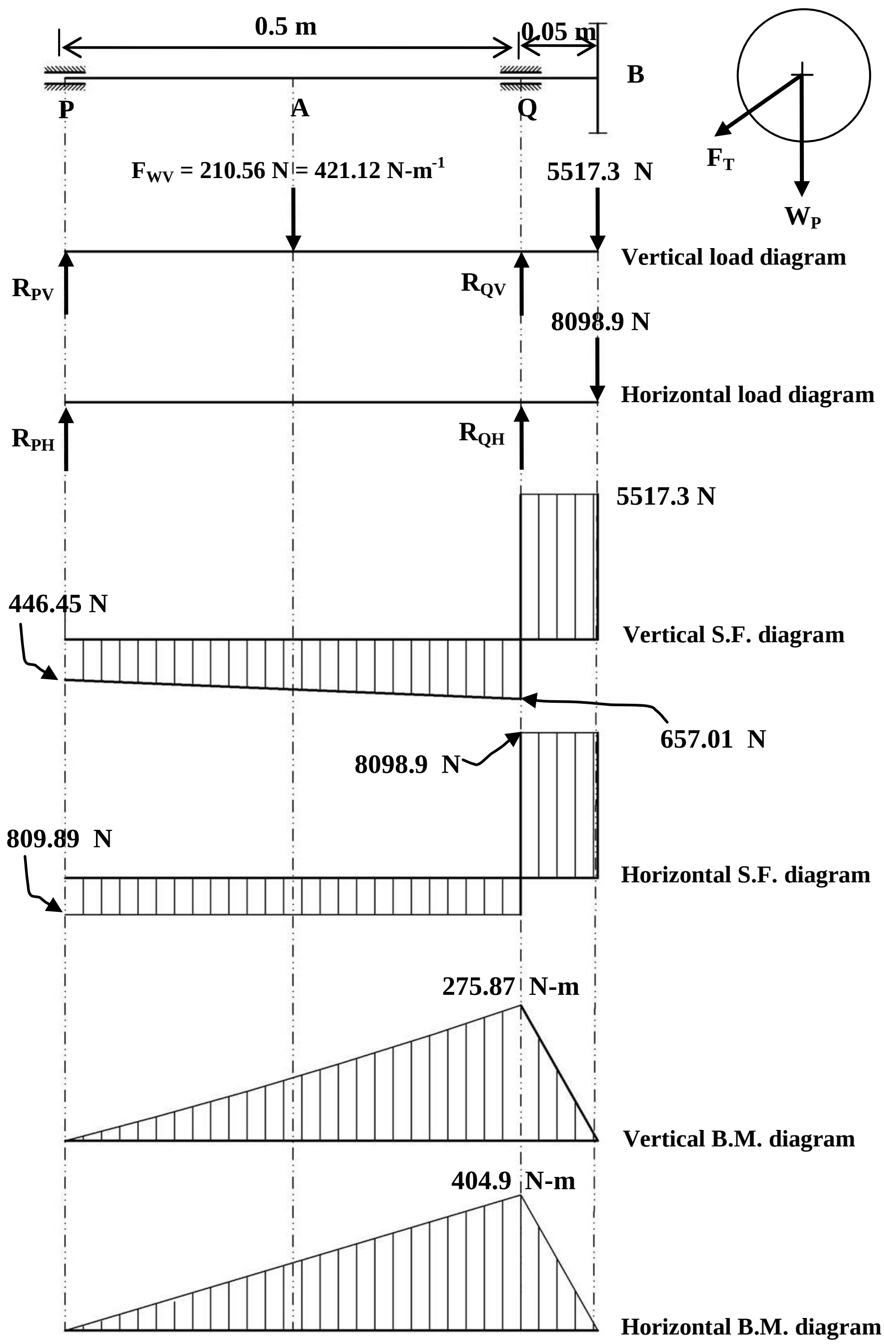


Fig. (6): The shearing and bending moment diagrams of the shaft.

Table (2): Experimental plan of the evaluation machine.

Variables	Levels
Moisture content, M_C (% w.b)	86.2, 81.3, 76.85
Number of knives rows, N_K	2, 3, 4
Rotary speed of cutting shaft, R_S, rpm (m s^{-1})	325 (4.7), 405 (5.9), 460 (6.7), 540 (7.2)

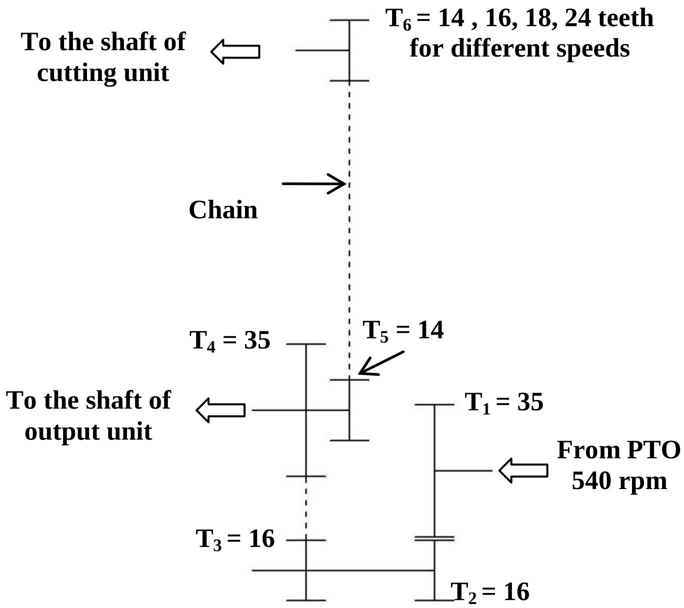


Fig. (7): Transmission system of modified machine.

5. Evaluation criteria

Evaluation of the machine was performed taking into consideration the following indicators:

5.1 Fineness degree modulus (FDM)

Three 100 g milled samples from the output fodder beet shall be shaken using a laboratory sieve shaker with standard screen sieves for a period of 10 min. After shaking, to determine the particle size distribution of the output product was determined (***ASAE 1999***a), based on the total weight of samples and the mass of each product categories were weighed. The cutting fodder beet samples were classified into four main categories according to ***Henderson and Hansen (1968)***. The first one is (< 2 cm), the second is (2-4 cm), the third is (4 - 6 cm) and the fourth is (> 6 cm).

5.2 Machine capacity (P_m)

The machine capacity was calculated as follows:

$$P_m = \frac{W}{T} \quad \textbf{(10)}$$

Where

P_m	:	The machine capacity, kg h^{-1}.
W	:	The mass of sample, kg.
T	:	Cutting time, hour.

5.3 Required power (RP) and consumed energy (CE)

The fuel consumption was measured using special device consists of 3 liter graduated cylinder was connected to fuel pump. The reduction of fuel in tube after executing each treatment was recorded.

Power consumption was calculated according the principles and assumption of ***Hunt (1983)***, ad using the following equation (***Embaby 1985***):

$$RP = \frac{FC \times \rho_f \times L.C.V \times 427 \times \eta_m \times \eta_{th}}{3600 \times 75 \times 1.36} \quad \textbf{(11)}$$

Where

RP	:	Required power, kW.
FC	:	Fuel consumption, l h^{-1}.
ρ_f	:	Density of the fuel, 850 kg m^{-3}.
L.C.V	:	Lower calorific value of fuel, 10000 kcal kg^{-1}.
427	:	Thermo – mechanical equivalent, kg. m $kcal^{-1}$.
η_m	:	Mechanical efficiency of engine, 80% and
η_{th}	:	Thermal efficiency of the engine, (considered to be about 35% for diesel engine).

The consumed energy (CE) is specific power per unit capacity; it was calculated by using the following equation:

$$\text{Consumed energy} = (P/P_m), \quad \text{kW. h ton}^{-1} \quad \textbf{(12)}$$

5.4 Costs

Machine cost was determined using the fixed costs and variable costs according to ***Srivastava et al. (2006)***. The operational cost was determined using the following equation:

$$\text{Oprating cost} = \frac{\text{Machine cost (L.E h}^{-1})}{\text{Machine capacity (ton h}^{-1})}, \quad \text{L.E ton}^{-1} \qquad \textbf{(13)}$$

RESULTS AND DISCUSSION

1. Fodder beet tuber properties

The measured physical and mechanical properties of the fodder beet are presented in table (1).

Table (1): Physical and mechanical properties of fodder beet tuber.

property	Value			
	Max.	Min.	Mean	Stand. Dev.
Length (cm)	28.6	25.5	27.3	1.4
Diameter (cm)	24.5	22.8	23.7	0.8
Mass (g)	4234	3518	3870	332.7
Volume (cm^3)	3636	2858	3465	361.5
Static coefficient of friction	0.357	0.533	0.433	0.14
Shearing stress (MPa)	0.235	0.341	0.281	0.13
Shearing energy (mJ mm^{-2})	3.895	5.797	4.91	1.51

2. Chopping sizes

Figures (8), (9) and (10) illustrate the effect of rotor speeds, number of knives rows and beet moisture contents on chopping sizes. The chopping sizes decreased by increasing the rotor speed. It is clear that, the highest values of beet sizes < 2 cm were 71% take found at rotor speed of 540 rpm, number of knives rows 4 rows and beet moisture content of 81.3 %. Hence, the highest values of beet sizes were 30% for the range of > 2-4 cm at rotor speed of 540 rpm, of knives rows 4 rows and beet moisture content of 86.2 %.

Meanwhile, the increase of rotor speeds decreases the beet sizes of 4-6 cm. Whereas, the minimum values were 0 % which occurred place at rotor speed of 540 rpm, of knives rows 4 rows and beet moisture content of 86.2 %. The obtained results showed that, the highest values of beet sizes >6 cm were 16% at rotor speed of 325 rpm, of knives rows 2 rows and beet moisture content of 76.85 %.

According to chopping size, it can be stated that the best treatment was moisture content of 86.2 %, rotor speed of 540 rpm, and knives rows 4 rows.

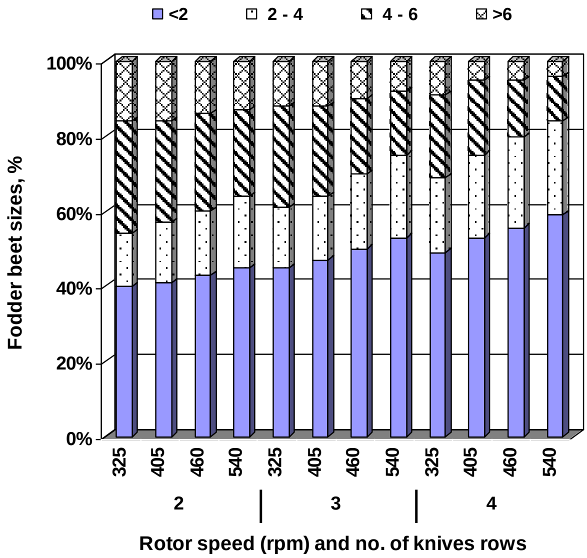


Fig. (8): The effect of number of knives rows and rotor speed on the beet size at 76.85 % moisture content.

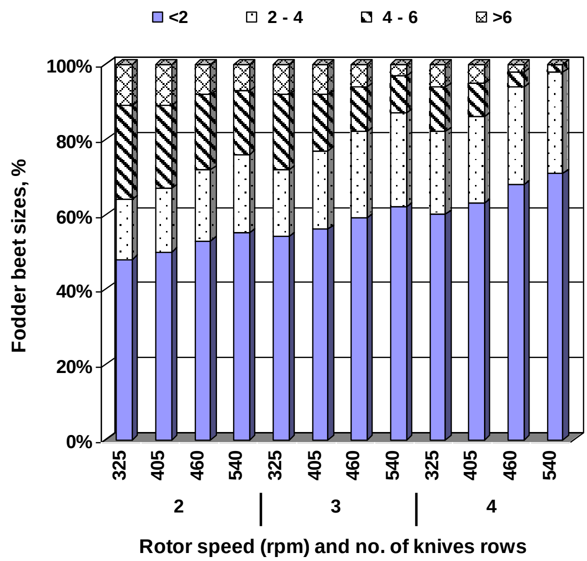


Fig. (9): The effect of number of knives rows and rotor speed on the beet size at 81. 3 % moisture content.

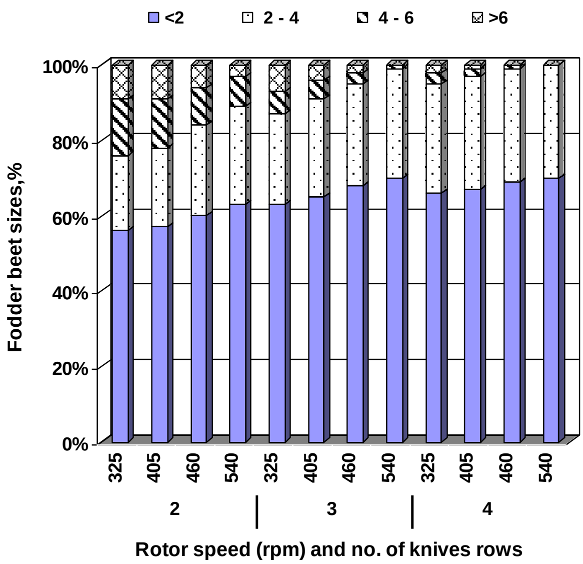


Fig. (10): The effect of number of knives rows and rotor speed on the beet size at 86.2 % moisture content.

3. Machine productivity

The figure (11) shows the productivity of the developed machine is affected by beet moisture content, rotor speeds, and number of knives rows. It is clear that the increment in beet moisture content from 76.85 to 86.2 % tend to increase the machine productivity. The maximum value of machine productivity was obtained with the rotor speeds of 540 rpm for all beet moisture content and number of knives rows. The data also revealed that the machine productivity increased when the number of knives rows increased for all the beet moisture contents and rotor speeds. Generally, it is clear that the beet moister content of 86.2%, rotor speed of 540 rpm and number knives rows of 4 rows gave the maximum machine productivity of 10.25 ton h^{-1}, but the minimum machine productivity of 7.15 ton h^{-1} was recorded with the beet moisture content of 76.85 %, rotor speed of 325 rpm and number knives rows of 2 rows.

According to the machine productivity, it can be stated that the best size treatment was moisture content of 86.2 %, rotor speed of 540 rpm, and knives rows 4 rows.

4. Consumed Energy

Fig. (12) shows the effect of beet moisture content, rotor speed and number of knives rows on the consumed energy. It is clear that, the consumed energy increased by decreasing the beet moisture content for all rotor speed and number of knives rows. The minimum value of consumed energy, 1.02 kW.h ton^{-1} was achieved at 86.2 % moisture content, 325 rpm rotor speed and 4 rows cutting knives. These results may be due to increasing rotor speed and number of knives rows led to increase consumed energy in unit time through the material of beet bulb.

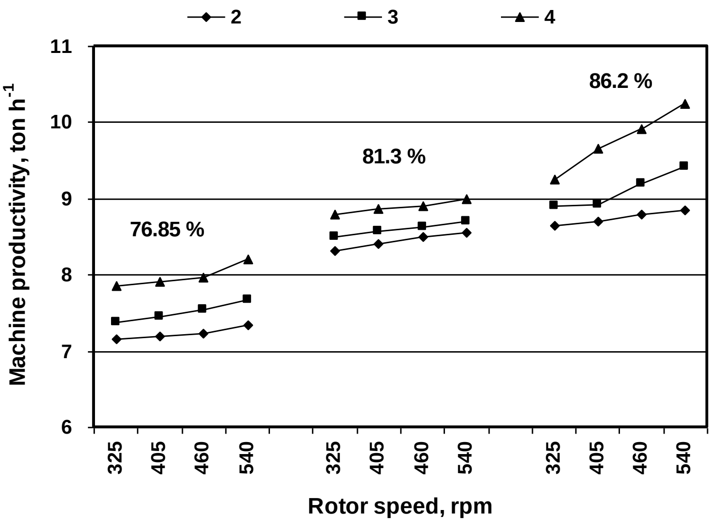


Fig. (11): The effect of moisture content, number of knives rows and rotor speed on the machine productivity.

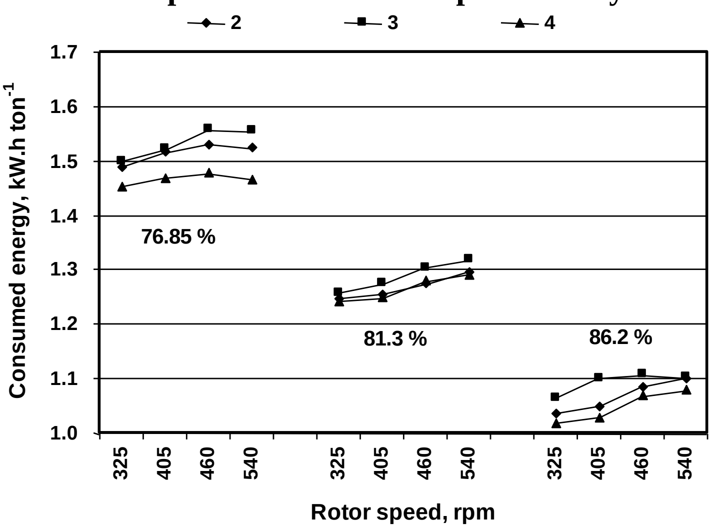


Fig. (12): The effect of moisture content, number of knives rows and rotor speed on the consumed energy.

5. Chopping cost

The Fig. (13) shows the effect of beet moisture content, rotor speed and number of knives rows on the chopping cost of beet. It was noticed that the increase in beet moisture content from 76.85 to 86.2 % tend to decrease the chopping cost of beet. The minimum chopping cost of beet was obtained with the beet moisture content of 86.2% for all rotor speed and number of knives rows. The data also showed that the chopping cost of beet decreased by increasing the number of knives rows from 2 to 4 rows for all the beet moisture contents and rotor speeds. The number of knives rows of 4 rows gave the maximum average value of chopping cost of 20.49 L.E ton^{-1} at moisture content of 86.2 % and rotor speed of 540 rpm. Generally, it is clear that the moister content of 86.2 %, number of knives rows of 4 rows and rotor speed of 540 rpm gave the least chopping cost of 20.49 L.E ton^{-1}.

The results recommended operating the machine at rotor speed of 540 rpm, number of knives rows of 4 row and beet moisture contents of 86.2 %.

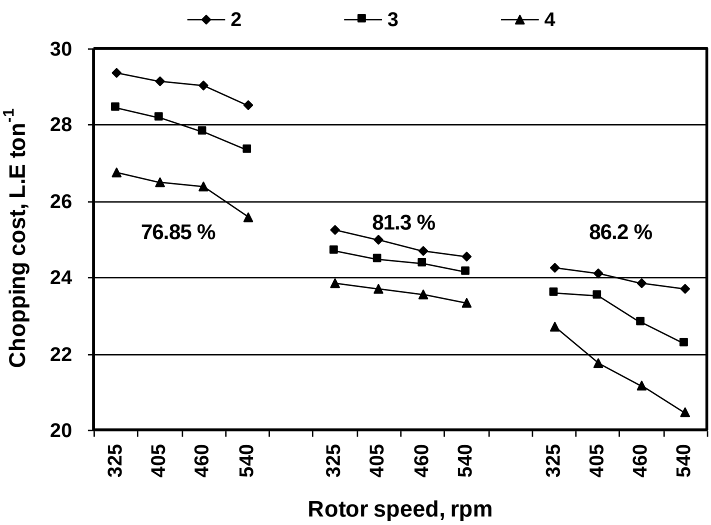


Fig. (13): The effect of moisture content, number of knives rows and rotor speed on the chopping cost.

CONCLUSION

The obtained results can be summarized as follows:

1. The developed machine for chopping fodder beet provided the optimum performance in chopping sizes where, the machine productivity reached 10.25 ton h^{-1}, consumed energy1.04 kW.h ton^{-1} and chopping cost of 20.49 L.E ton^{-1}.
2. The results showed that increasing both beet moisture content and rotor speed tend to increase the machine productivity, chopping sizes (< 2 and 2- 4 cm) for all the number of knives rows.
3. The results indicated that the increment in rotor speed tend to increase machine productivity and consumed energy while chopping cost decreased.
4. The data demonstrated that the beet moisture content of 86.2%, rotor speed of 540 rpm and number of knives rows of 4 rows recorded the maximum values of chopping sizes < 2 and 2- 4 cm.
5. It is recommended to operate the developed machine at beet moisture content of 86.2%, rotor speed of 540 rpm and number of knives rows of 4 rows to obtain the optimum performance.

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الملخص العربي

تطوير آلة لتقطيع بنجر العلف

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تعاني مصر من نقص فى الثروة الحيوانية نتيجة لنقص الاعلاف وتعتبر زراعة محصول بنجر العلف أحد الحلول الفعالة للتغلب على مشكلة نقص العلف الصيفى، وحيث أن إنتاجية الفدان الواحد من المادة الجافة لمحصول بنجر العلف والتى تمثل الغذاء الآساسي للحيوان يعادل إنتاج خمسة أفدنة من الذرة من المواد الكربوهيدراتية، علاوة على إرتفاع نسبة البروتين فيه أكثر من الذرة والمذاق الحلو الذي يزيد من شهية الحيوان لهذا النوع من الأعلاف الغير تقليدية، هذا فضلا عن إنتاجه فى شهر يونيو حيث قمة الإحتياج إلى المواد النشوية اللازمة للأعلاف.

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لقد تناول البحث حل مشكلة تقطيع درنات بنجر العلف إلي أجزاء مناسبة لتغذية الحيوان، من خلال تطوير آلة فصل بذور لب البطيخ لتناسب تقطيع بنجر العلف وذلك لزيادة ساعات التشغيل السنوية للآلة وإستخدامها فى أكثر من غرض مما يزيد العائد الاقتصادي للآلة حيث إنه لا يتم إستخدام الآلة أكثر من شهر فى العام. وقد تم التطوير من خلال مرحلتين للتعديل:

المرحلة الاولي وهي تعديل مجموعة التقطيع بإستبدال القطبان المعدنية المستخدمة مع البطيخ بشفرات قطع على شكل شبة منحرف مرتبة فى صفين وثلاثة وأربعة صفوف .

المرحلة الثانية وهى إستبدال الصدر المثقب أسفل درفيل الفصل والمعد لمرور بذور اللب بصدر مصمت ليعمل على خروج قطع البنجر المجزئه خارج الآلة لعدم الحاجة إلي مراحل التنظيف أثناء تقطيع درنات بنجر العلف.

وقد تم دراسة تأثير ثلاث مستويات من المحتوى الرطوبى للبنجر (٨٦.٢ ، ٨١.٣ ، ٧٦.٨٥ % على أساس رطب) وأربعة مستويات لسرعة سكاكين التقطيع (٣٢٥ ، ٤٠٥ ، ٤٦٠ ، ٥٤٠ لفة دقيقة $^{-1}$) و ثلاث مستويات لعدد صفوف سكاكين التقطيع (٢ ، ٣ ، ٤ صف) على كل من أحجام التقطيع وإنتاجية الآلة والطاقة المستهلكة وتكاليف عملية تقطيع بنجر العلف.

يمكن تلخيص النتائج المتحصل عليها فيما يلي:

١ - تزداد نسبة أطوال القطع لكل من الأقل من ٢ سم و ٢- ٤ سم بزيادة كلا من السرعة الدورانية لسكاكين التقطيع وعدد صفوف السكاكين فى حين إنها كانت تتناقص بتناقص المحتوي الرطوبي للبنجر .

٢ - وجد أن إنتاجية الآلة تزداد بزيادة كلا من السرعة الدورانية وعدد صفوف السكاكين والمحتوي الرطوبي للبنجر وقد بلغت أقصي إنتاجية للآلة حوالي ١٠.٢٥ طن ساعة $^{-1}$ عند سرعة دورانية ٥٤٠ لفة دقيقة $^{-1}$ وعدد ٤ صفوف ومحتوي رطوبي ٨٦.٢ %
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٣ - تزداد الطاقة المستهلكة بزيادة السرعة الدوانية عند إستخدام عدد صفوف ٢و٣ صف في حين إنها كانت تنخفض عند إستخدام عدد صفوف قدرها ٤ صف عند جميع مستويات المحتوي الرطوبي المستخدمة فى الدراسة.

٤ - تناقصت تكاليف عملية التقطيع بزيادة كلا من السرعة الدورانية لسكاكين التقطيع وعدد صفوف السكاكين والمحتوي الرطوبي. وقد بلغت أقل قيمة لتكاليف عملية التقطيع حوالي ٢٠.٤٩ جنية طن $^{-1}$ عند سرعة دورانية ٥٤٠ لفة دقيقة $^{-1}$ وعدد صفوف ٤ صف ومحتوي رطوبي ٨٦.٢ % .

٥- ينصح بتشغيل الآلة على عند محتوى رطوبى للبنجر ٨٦.٢ % وسرعة دورانية ٥٤٠ لفة دقيقة $^{-1}$ وعدد ٤ صفوف من السكاكين.