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A STUDY ON SOME ENGINEERING PARAMETERS WHILE THRESHING BLACK SEED

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ABSTRACT

Experiments were carried out using a developed threshing machine with two rubber cylindrical drums to study the effect of drum clearance (2, 2.5, 3 and 3.5 mm) and relative peripheral drum speed (1.1, 2.2, 3.3 and 4.4 m / sec) on Black Seed properties, seed losses and threshing efficiency. And also, determination of power requirement and cost of Black Seed threshing.

The test results indicated a maximum of 99.68 % threshing efficiency and 91.92 % cleaning efficiency, a minimum of 0.97 % total seed losses and a maximum germination of 87.8 %. The average output capacity of machine was 88.61 kg / h of seed and 19.90 kW.h / ton minimum power requirement. Producing one ton of Black Seed grain, using threshing machine costs about 752 L.E The performance was found to be influenced by all the study variables.

INTRODUCTION

Medicinal plants are expected to play an important role in such integration. This role can be enhanced by expanding machinery use in planting and producing of medicinal plants to increase their productivity and quality. In this study we have an example of medicinal plants; this example is Black Seed [Black cumin].

Black Seed (Nigella sativa) is cultivated in the southern districts of Egypt more than the northern ones. The farmers in these areas are using the manual threshing method to get Black Seed grains. This threshing method is very rudimental and slow. Whereas the plants were collected in form of heaps and hit with sticks for many times and several stages. Soft materials from these stages which contained the grain and other plant residues are taken and sieved for a long time using several sieves to extract Black Seed grains. This method is costly and takes more time and produces grains with high percentage of damage (estimated about 10 - 15 %), so in this study we just tried to replace threshing with the mechanical method to save time, quality and money.

The two factors in this study were discussed in many researches that used mechanisms close to the used mechanisms in this study (rubber covered drum) as follows:

Saud *et al.* (1981) studied the milling efficiency and quality of Rice Japanese 47(an Egyptian variety) with moisture content of (13.43, 12.98, 12.59 and 11.98 % d.b) using a Japanese husker (22 cm rubber roller diameter) with four speeds of shelling rollers (10.93, 12.65 and 14.38 m / sec) and with three clearances, between the shelling rollers (1, 1.5 and 2 mm).

He found that the highest efficiency and quality were obtained at shelling roller speeds of 12.65 m / sec (1100 rpm), shelling rollers clearance of 1 mm and at paddy grain moisture content of 13 %.

Hunt (1983) reported that the cylinder losses should be less than 1% and inversely related to the severity of threshing. However damage to the grain limits to which severe may be employed. A compromise must be reached. The operator manual of each combine indicates a range of cylinder speeds for specific crop (30-36, 18-23, 12-15 and 8-15 m/ sec for Wheat, Sorghum, Corn and Peas).

Radwan (1987) studied the effect of roller speed and rollers clearance on Rice grain damage using a rubber roller husker for hulling rice in Egypt. He noticed that the optimum roller velocity was 12.5 m / sec, after this velocity the damage percentage is sharply increased and at the same time the unhulled grain percentage stayed fixed. This means that any increase in velocity after 12.5 m / sec does not add any value to the hulling efficiency, but only increases grain damage for all types of rubber rolls used in this study. He also, concluded that the optimum rollers clearance was found to be 1.5 mm. The minimum values of grain damage were found at rollers clearance of 2 mm which gave also the minimum values of hulling efficiency. On the other hand the maximum values of hulling efficiency were found at rollers clearance of 1 mm which gave the higher values of grain damage.

Soliman (1987) reported that hulling efficiency, broken percentage and power consumption for a husker machine are affected significantly by roll clearance, feeding rate and speed ratio adjustments. Proper selection of clearance adjustments, speed ratio and feeding rate plays a major role in the effectiveness of the milling process as it improves the hulling efficiency. He found that the optimum clearance should be adjusted at 1 mm between the two rubber rolls at feeding rate of 1 kg / min .

Alizadeh and Payman (2004) evaluated and compared rice losses in the two common rice milling methods in Gilan province, Iran, including (1) rubber-roll husker + blade type whitener; and (2) blade-type husker + blade-type whitener, some samples were collected from the outlet of husker and whitener in each method, and percentage of broken rice (brown and white rice) was determined. The results revealed that there was a significant difference between the average of percentage of broken (brown and white) rice in the two methods for all varieties at 1% level. The percentage of broken (brown) rice in first method was 7.06% compared to 10.05 for the second method. The percentage of broken rice (white) in the first method was 19.41% and that of the second method was 22.60%. The total percentage of broken rice in first method was 3.20% lower compared to the second method.

Takekura *et al.* (2004) examined quality characteristics of brown rice husked with a roll-type husker and an impeller-type husker. Brown rice husked with a roll-type husker and an impeller-type husker was stored, and the influence of the difference in husking systems on the quality of brown rice after storage was investigated. Greater percentage of embryo-removed rice and broken rice were found in brown rice husked with an impeller-type husker than in brown rice husked with a roll-type husker. Vigour rate, germination rate, whiteness, and translucency after storage of brown rice husked with an impeller-type husker were much less than those of brown rice husked with a roll-type husker, and free fat acidity after storage of brown rice husked with an impeller-type husker was much higher than that of brown rice husked with a roll-type husker. The results indicate that an impeller-type husker is not suitable for husking brown rice to be stored.

MATERIALS AND METHODS

The experiments were carried out in EL-Gemiza Agricultural Researches Station to study the effect of engineering parameters of the threshing machine used in the study on seed properties of Black Seed, to estimate the power consumed during threshing operation, and to estimate and compare the mechanical threshing costs with the manual method.

• Threshing machine before modification:

The threshing machine used in this study is shown in Fig. (1) , it consists of a steel frame, two drums covered with 2 cm thickness rubber, feeding element consists of a steel rod with radially fixed bars on each of four rows on it, blower which supplies the air used in separating and cleaning processes, and a rectangular straw-walker with 10 degree slope angle with the horizontal. The straw-walker gets its vibratory motion by means of a camshaft.

There are two cylindrical drums, each one takes its motion by two pulleys and a V shape belt. The rotating speeds of these two drums are variable. The upper one rotates in direction of clockwise, while the lower anticlockwise.

The upper drum is supported on a movable frame with a shaft mounted on two bearings on the main frame enables the drum to move in pivotal way to change the clearance between the two drums.

The blower of this machine has a gate that enables to control the air flow. Fig. (2) shows a drawing sketch of the used machine. A 10 Hp (7.5 kW) petrol engine was used as a source of power.

•• Threshing machine after modification :

Some modifications were made on this machine to thresh Black Seed and other similar fine seeds crops as follows:

1- A rectangular steel sheet sieve with 110 cm length, 60 cm width, and 2 mm Φ holes was fixed upon the straw-walker for separation and cleaning process.
2- Four different diameter pulleys were assembled on the upper drum shaft to get four speed levels. Their diameters were (17.2 , 12.5 , 9.8 and 8.01 cm).
3- An adjustable length link consists of two sliding pieces was prepared to adjust the drums clearance.

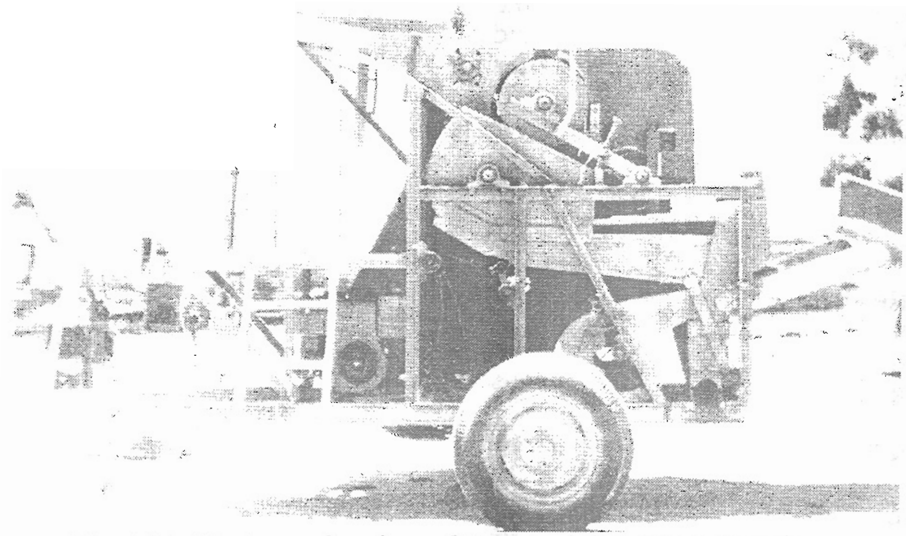

Fig. (1): Photography view of the used threshing machine .

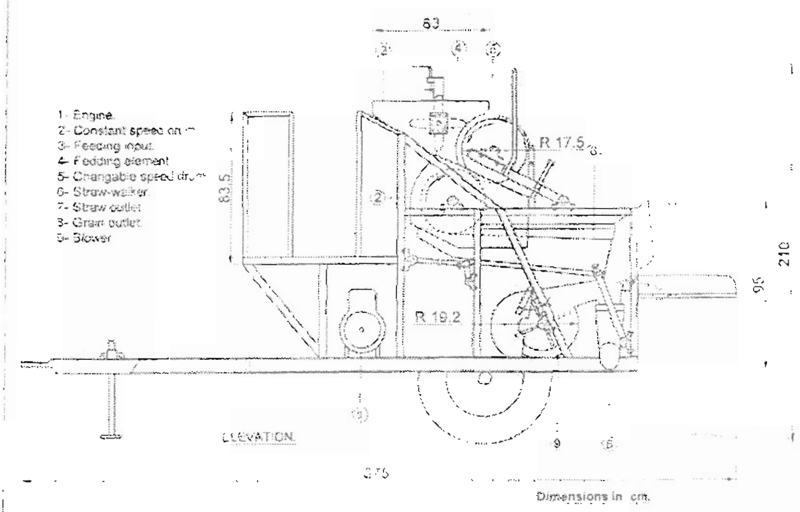

Fig. (2): A drawing sketch of the threshing machine.

- **Treatments:**

The experimental studies were executed to determine the effect of::

1- Relative peripheral drum speed:

The machine used in this study has two drums, the lower drum (driver) was to operate at a constant speed of 100 rpm (1.83 m / sec), while the upper drum (driven) was assembled to operate at four speed levels as follows:

160 (2.93), 220 (4.03), 280 (5.13) and 340 rpm (6.23 m / sec).

To accomplish these speed levels on the upper drum, four different diameter pulleys (17.2 , 12.5 , 9.8 and 8.01 cm) were used.

Finally, the relative peripheral drum speed (the slower one subtracted from the faster) was considered as a variable in this study. It will be referred by symbol (V). These variable levels are as follows:

V_1 = 1.1 , V_2 = 2.2 , V_3 = 3.3 and V_4 = 4.4 m / sec.

2- Drums clearance:

This clearance means the space between the two drums. That clearance can be adjusted by raising the upper drum which was fixed on two steel angles displaced in pivotal way to change the clearance. Four clearances were used C_1(2) , C_2(2.5), C_3(3) and C_4(3.5 mm) .

- **Experimental Procedure:**

The crop of Black Seed was harvested manually and left in the field to reach the suitable grain moisture content of (14 % d.b) average. Then it was collected in form of heaps to start the threshing process. It was divided to bundles, every bundle was of 1 kg mass to be fed in ten seconds to obtain approximately constant feeding rate of (360 Kg / h) in the present study.

During carrying out the experiments, the digital tachometer was used for measuring the cylinder speed. Also, fuel consumption was determined by measuring the quantity of fuel required to refill the full tank after the working period using the graduated glass tumbler. In addition time consumed in threshing process was accounted by means of a stopwatch to estimate the machine capacity. Finally, samples of grain produced and straw were separated after every experiment and taken to estimate the losses, grain damage and grain clean ratio.

- **Measurements:**

Laboratory measurements were carried out in EL-Gemiza Research Station to determine the following:

•• **Total grain input:**

$$A = B + E + F \qquad (1)$$

A : Weight of total grain input per unit time.

B : Weight of threshed grain per unit time collected at the main grain outlet.

E : Weight of threshed grain (escaped grain) per unit time collected at all outlets except from main grain outlet.

F : Weight of unthreshed grain collected from all outlets per unit time.

•• Seed damage percentage:

The damaged grain ratio was calculated as a percentage by the following:

(A) Visible grain damage (external):

Visible grain damage was determined for each conducted treatment by taking randomized sample of about 10 g. The visible damaged grains were separated by hand using a convex lens, and massed. Then the percentage of damaged grains from all outlets can be estimated as follows:

$= (G / A) \times 100$ .... (2)

G : Weight of damaged grains collected from spout per unit time.

A : Total grain input by weight per unit time.

(B) Invisible grain damage (internal):

Invisible grain damage was estimated by using germination test. Supposing that the number of seeds that failed to germinate are considered as seeds with internal damage. To estimate the invisible damaged grain, germination values of seeds exposed to mechanical threshing were subtracted from the ideal value (hand threshed germinated) .

Cracked grain % $= (N / T) \times 100$ .... (3)

Where:

N : No. of cracked grain (failed to germinate and exceeded the ideal value).

T : Total grain number of grain in sample.

•• Grain losses percentage:

Collected losses were carried out to determine their masses.

Percentage of grain losses $= (L / A) \times 100$ .... (4)

L : Weight of grain loosed with the straw and separated using a suitable sieve.

A : Total grain input by weight per unit time.

•• Threshing capacity:

The threshing capacity was calculated by dividing the threshed quantity (kg) by the consumed time (sec) in Kg / sec .

•• Percentage of unthreshed grain:

$= (F / A) \times 100$ .... (5)

F : Weight of unthreshed grain from all outlets per unit time.

A : Weight of total grain input per unite time.

•• Determination of threshing efficiency:

Machine field efficiency was estimated according to the following formula:

Threshing efficiency % = 100 - percent of unthreshed grain .... (6)

•• Cleaning efficiency:

Randomized samples were taken from the main grain outlet and inspected to separate the tarnishes (the strange materials) in grain and weight them individually.

The cleaning efficiency was determined as follows:

Cleaning efficiency % $= 100 - (R / B)$ .... (7)

Where:

R : Weight of tarnishes per unit time collected at the main grain outlet.

B : Weight of threshed grain per unit time collected at the main grain outlet.

- { The equations (1-7) are according to **RNAM, 1995**.}

•• Determination Of Power Required:

The fuel consumption of the engine was taken as a base for estimating the power required (P_r) for each treatment which is given by an equation in the form of **(Embaby, 1985):**

$$P_r = F_c \times [1 / 3600] \times P_f \times 427 \times LCV \times \eta_{th} \times \eta_m \times 1/75 \times 1/1.36 \quad .... \quad (8)$$

Where:

F_c : The fuel consumption, L / h;

P_f : Density of the fuel kg / L (for gasoline fuel = 0.73);

LCV : Lower calorific value of fuel kcal / kg,

LCV of benzene fuel is (10750);

427 : Thermal-mechanical equivalent, W / kcal;

η_{th} : Thermo efficiency of the engine (22 % for benzene engine);

η_m : Mechanical efficiency of the engine (considered to be about 80 % for benzene engine).

•• Threshing Cost Estimation:

An economic comparison was made between the mechanical threshing using this machine and the manual threshing method to thresh one ton of Black Seed grain depending on several supposals as follows:

A - Daily hire of a worker is considered as 20 L.E .

B - Working hours per day is considered as 8 hours .

C - Rental value of the machine without the fuel consumed is considered as 10 L.E per hour.

D- The average price of Black Seed grain is considered as 12000 L.E / ton

E - To calculate the threshing cost of the machine a formula that refers to **(Awady *et al.*, 1982)** was used.

Threshing criterion cost (L.E / ton) = operating cost / ton + grain losses cost / ton.

Operating cost (L.E / ton) = machine cost (L.E / h) / feed rate (ton / h).

F- Grain losses are considered as the sum of damaged grain and total grain losses.

G -The cost of manual threshing is calculated by multiplying the number of workers needed to thresh and clean one ton of Black Seed grains by the daily hire of the worker.

I - The cost of the fuel used (benzene) is 1 L.E per 1 liter.

RESULTS AND DISCUSSION

1- invisible and visible grain damages (total damage):

It is clear that for all drum speeds, increasing the drum speed tends to increase both of the visible and invisible damaged grain for all drum clearances. As shown in Fig. (1) , it was noticed that by increasing the relative peripheral drum speed from 1.1 to 4.4 m / sec , the visible damaged grain increased from 1.32 to 2.21 % at drum clearance of 2 mm. Also at drums clearance of 3.5 mm increasing relative peripheral drum speed from 1.1 to 4.4 m / sec, the visible damaged grain increased from 0.07 to 0.80 % . As shown in Fig. (1), it is clear that increasing relative peripheral drum speed from 1.1 to 4.4 m / sec there was a positive effect on invisible grain damage under different drum clearances. As shown in Fig. (2) it is clear that the total damage decreased by increasing drum clearance for all relative peripheral drum speeds.

The increase in visible and invisible grain damage is due to the high impacting and friction force imposed on the capsules of the Black Seed during the threshing process. This logical increased force was affected by increasing relative peripheral drum speed and so increased the grain damage as a result.

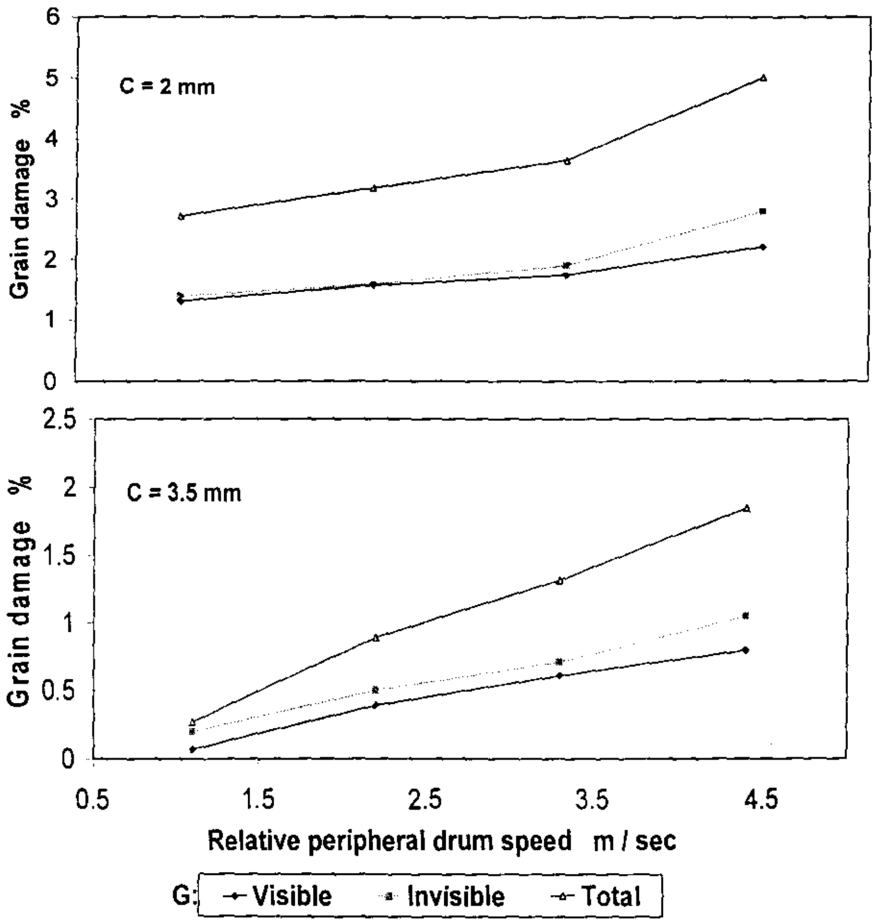

Fig. (1): Relationship between relative peripheral drum speed (V) and grain damage (G)at 2 and 3.5 mm drums clearance (C), air velocity of 1.5 m/sec and feed rate of 0.1 kg/sec.

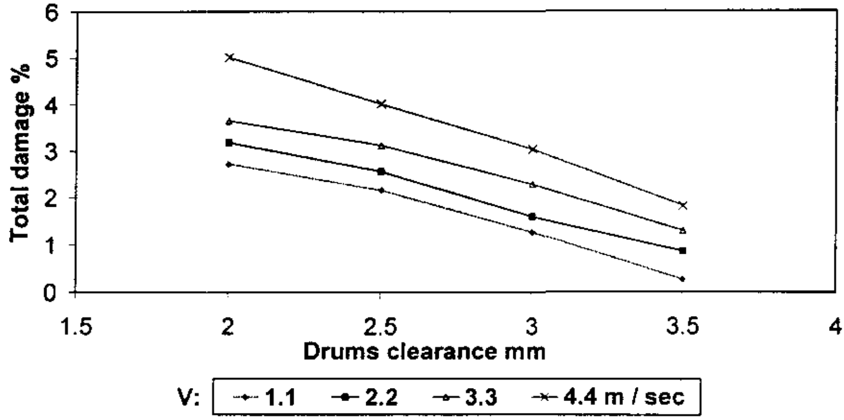

Fig. (2): Relationship between drums clearance and total damage at different relative peripheral drum speeds (V), air velocity of 1.5 m/sec and feed rate of 0.1 kg/sec.

2- germination:

The invisible damage and germination percentage as related to the relative peripheral drum speed and drums clearance are shown in Fig. (3).

It is clear that for all relative peripheral drum speeds, increasing the relative peripheral drum speed tends to decrease the germination percentage due to mechanical damage to the embryo of the seed. Germination percentage decreased from 86.60 to 85.20 % when the relative peripheral drum speed increased from 1.1 to 4.4 m / sec at drums clearance of 2 mm, while it increased from 86.60 to 87.80 % when the drums clearance increased from 2 to 3.5 mm at relative peripheral drum speed of 1.1 m / sec .

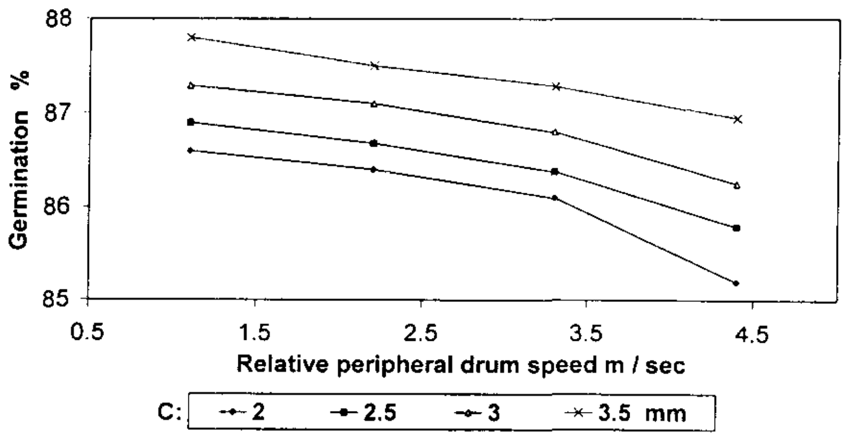

Fig. (3): Relationship between relative peripheral drum speed and germination percentage at different drum clearances (C), air velocity of 1.5 m/sec and feed rate of 0.1 kg/sec.

4- total grain losses:

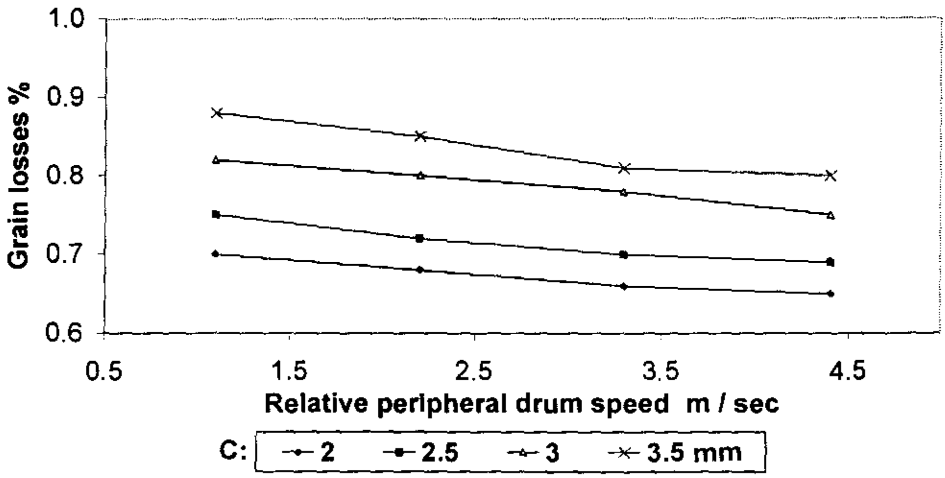

Fig. (4): Relationship between relative peripheral drum speed and grain losses at different drum clearances (C) , air velocity of 1.5 m/sec and feed rate of 0.1 kg/sec.

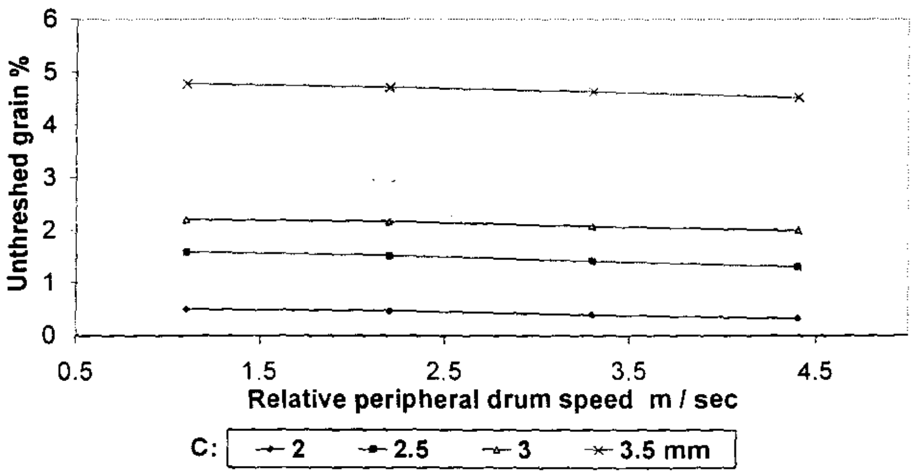

Fig. (5): Relationship between relative peripheral drum speed and unthreshed grain at different drum clearances (C) , air velocity of 1.5 m/sec and feed rate of 0.1 kg/sec.

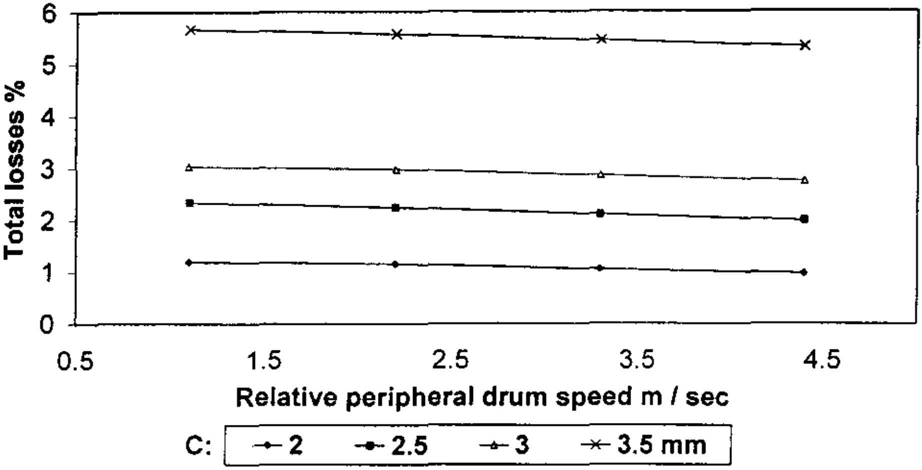

Fig. (6): Relationship between relative peripheral drum speed and total losses at different drum clearances (C) , air velocity of 1.5 m/sec and feed rate of 0.1 kg/sec.

As shown in Fig. (4), it is clear that increasing relative peripheral drum speed tends to decrease the grain losses, which was in this study essentially affected by the blown air velocity of the threshing machine.

This decrease is considered as a slight decrease. When the relative peripheral drum speed increased from 1.1 to 4.4 m / sec, the grain losses decreased slightly from 0.70 to 0.65 % at drums clearance of 2 mm .

This slight decrease of the grain losses with increasing relative peripheral drum speed refers to increasing the amount of threshed grain exposed to the air of the blower by increasing relative peripheral drum speed. On the other hand, increasing the drums clearance leads to increase grain losses at the same relative peripheral drum speed. The grain losses increased from 0.70 to 0.88 % when drums clearance increased from 2 to 3.5 mm at drum speed of 1.1 m / sec, and so on at the other relative peripheral drum speeds. This increase in grain losses by increasing drums clearance referred to decreasing the amount of threshed grain exposed to air of the blower by increasing drum clearance.

As shown in Fig. (5), it was found that with increasing relative peripheral drum speed, the unthreshed grain decreased under different drum clearances. the unthreshed grain decreased from 0.50 to 0.32 % when relative peripheral drum speed increased from 1.1 to 4.4 m / sec at drums clearance of 2 mm . Also, the unthreshed grain decreased from 4.79 to 4.52 % when relative peripheral drum speed increased from 1.1 to 4.4 m / sec at drums clearance of 3.5 mm .

This decrease in unthreshed grain by increasing relative peripheral drum speed is referred to increasing friction force produced by the rubber surface of the drum that leads to increase peeling process of capsules, which finally means less unthreshed grain.

As a natural result, as shown in Fig. (6) it is clear that total losses decreased by increasing relative peripheral drum speed for all drum clearances, while it increased fast by increasing drums clearance for all relative peripheral drum speeds.

5- threshing efficiency:

As shown in Fig. (7) it was noticed that increasing relative peripheral drum speed tends to increase threshing efficiency slightly. The threshing efficiency increased from 99.50 to 99.68 % when the relative peripheral drum speed increased from 1.1to 4.4 m / sec at drums clearance of 2 mm , and so on at the other drum clearances. As shown in Fig. (7) it is clear that the threshing efficiency was affected by drums clearance. Threshing efficiency decreased fast when the drums clearance increased. threshing efficiency decreased from 99.50 to 95.21 % when the drums clearance increased from 2 to 3.5 mm at relative peripheral drum speed of 1.1 m / sec , and decreased from 99.68 to 95.48 % when the drums clearance increased from 2 to 3.5 mm at relative peripheral drum speed of 4.4 m / sec .

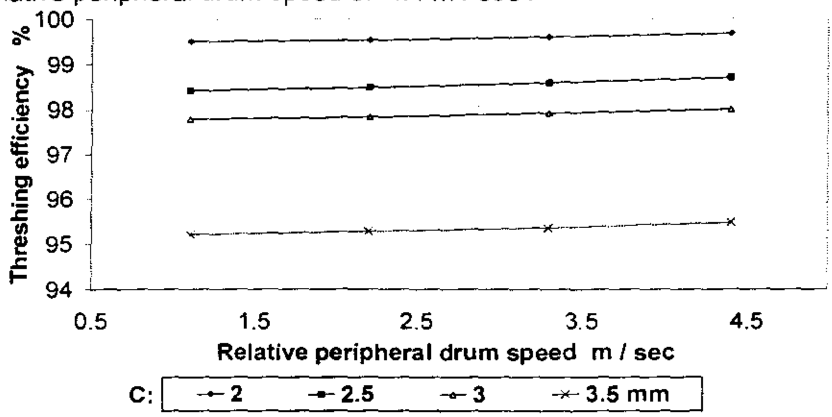

Fig. (7): Relationship between relative peripheral drum speed and threshing efficiency at different drum clearances (C) , air velocity of 1.5 m/sec and feed rate of 0.1 kg/sec.

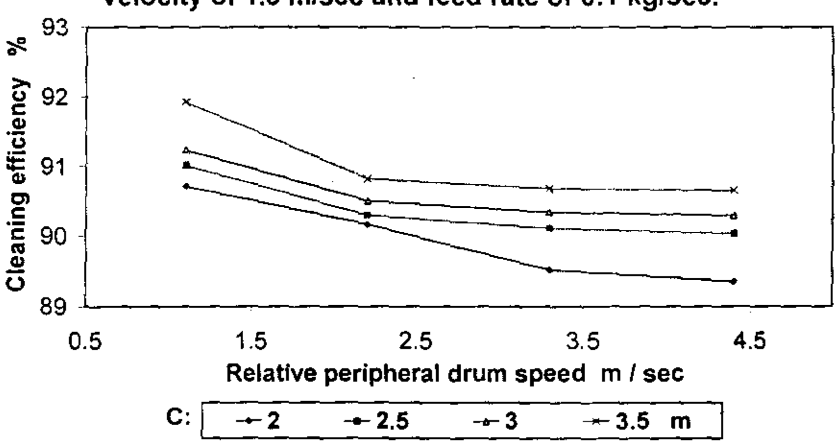

Fig. (8): Relationship between relative peripheral drum speed and cleaning efficiency at different drum clearances (C), air velocity of 1.5 m/sec and feed rate of 0.1 kg/sec.

5- cleaning efficiency:

It was found that increasing relative peripheral drum speed tends to decrease cleaning efficiency at all drum clearances. As shown in Fig. (8) cleaning efficiency decreased from 90.71 to 89.35 % when relative peripheral drum speed increased from 1.1 to 4.4 m / sec at drums clearance of 2 mm , and decreased from 91.92 to 90.65 % at drum clearance of 3.5 mm .This decrease in cleaning efficiency by increasing drum speed is referred to the increase of the soft materials and blotches which increase the load on the sieve during separation process, and increase the liability of passing of these soft material and dust through holes of the sieve with the seeds from the grain outlet. On the other hand, increasing drums clearance led to increase the cleaning efficiency at all relative peripheral drum speeds. When drums clearance increased from 2 to 3.5 mm , cleaning efficiency increased from 90.71 to 91.92 % at relative peripheral drum speed of 1.1 m / sec , and increased from 89.35 to 90.65 % when drums clearance increased from 2 to 3.5 mm at relative peripheral drum speed 4.4 m / sec.

Power Requirement Of Threshing Machine :

The consumed power during the threshing operation for the threshing machine is reported in table (1).

Table (1): Fuel and power requirements under different drum clearances.

Drums clearance mm	Fuel consumption L / h	Power kW	Power kW.h / ton
2	1.44	2.32	26.55
2.5	1.40	2.25	25.12
3	1.31	2.11	23.07
3.5	1.14	1.83	19.90

Threshing Cost Estimation:

An economic comparison was carried out between the mechanical threshing using this machine and the manual threshing method to thresh one ton of Black Seed grain.

1- Manual threshing :

Data gathered from researchers in " the Institute of Horticulture " shows that in order to thresh and clean one ton of Black Seed grain, we need about 60 workers.

As considered before, the daily hire of worker was 20 L.E., we can calculate the cost of manual threshing as follows : (Estimation cost, Awady *et al.*, 1982)

Cost of manual threshing =

= (number of workers needed × daily hire of worker) + grain losses cost

= (60 × 20) + (0 .10 ton × 12000) = 2400 L.E / ton

2- Machine cost :

The operation cost was divided to :

1-	Human cost	= 4 workers	× 20	= 80	L.E / ton
2-	Rental cost	= 12 hour	× 10	= 120	L.E / ton
3-	Fuel cost	= 15.63 liter	× 1	= 15.63	L.E / ton
4-	Grain losses cost	= 0.0 48 ton	× 12000	= 576	L.E / ton
	Total cost	about		= 792	L.E / ton

SUMMARY AND CONCLUSION

- From this study the optimum recommendation values for the following parameters were as follows:
  1-Relative peripheral drum speed was 3.3 - 4.4 m / sec .
  2-Drums clearance was 2.5 - 3 mm .
- The maximum power requirement to produce one ton of Black Seed grain of (26.55 kW.h / ton) was found at the smaller drums clearance of 2 mm , while lower power of (19.90 kW.h / ton) was found at the larger clearance of 3.5 mm .
- It was found that in order to produce one ton of Black Seed grain, using threshing machine costs about 792 L.E , while it costs about 2400 L.E using manual threshing method.

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دراسة على بعض العوامل الهندسية أثناء دراس حبة البركة

محمد أحمد الشيخة * ، حسني الشبراوي المرسي * ، سامي السعيد بدر **و وائل محمد زكي البلكيمي**
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تم تنفيذ هذا البحث في محطة البحوث الزراعية بالجميزة على آلة دراس لها زوج من الدرافيل المغطاة بالمطاط وتم إدخال بعض التعديلات عليها لتناسب دراس محصول حبة البركة وتم دراسة تأثير عاملين أساسين هما : السرعة النسبية لدرفيل الدراس وكذلك مقدار الخلوص بين درفيلي الدراس على خواص بذور حبة البركة الناتجة من عملية الدراس وكذلك كفاءة الدراس، وكذلك تقدير القدرة المستهلكة أثناء عملية الدراس الآلي وحساب ومقارنة التكاليف الكلية لعملية الدراس الآلي بالطريقة اليدوية وكانت أهم النتائج المتحصل عليها كالتالي:

١- **تأثير السرعة الخطية النسبية لدرفيل الدراس :**
زيادتها أدت إلى زيادة نسبة كسر الحبوب وكذلك زيادة كفاءة الدراس، بينما أدت إلى تقليل الفاقد الكلي للحبوب وتقليل كفاءة التنظيف للآلة.

٢- **تأثير الخلوص بين درفيلي الدراس :**
زيادته أدت إلى زيادة الحبوب الغير مدروسة ونسبة الإنبات وكذلك كفاءة التنظيف، بينما أدت إلى خفض كفاءة الدراس وتقليل نسبة الكسر في الحبوب.

٣- **الطاقة المستهلكة :**
قدر أعلى معدل طاقة مستهلكة بالالة موضع الدراسة لإنتاج واحد طن من الحبوب (٢٦,٥٥ كيلووات. ساعة / طن) عند أقل مقدار خلوص بين درفيلي الدراس بلغ ٢ مسم ، في مقابل أقل معدل طاقة (١٩,٩٠ كيلووات. ساعة / طن) عند أكبر مقدار خلوص بين درفيلي الدراس بلغ ٣,٥ مم .

٤- **تكاليف التشغيل :**
قدرت تكاليف تشغيل الألة موضع الدراسة لإنتاج واحد طن من حبوب نبات حبة البركة حوالي ٧٩٢ جنيه مصري مقابل ٢٤٠٠ جنيه مصري للطريقة اليدوية .

●● يوصى عند استخدام آلة الدراس محل الدراسة في دراس محصول حبة البركة أن يتم ضبطها لتعمل على :

١- سرعة خطية نسبية لدرفيل الدراس : ٣,٣ - ٤,٤ م / ث.

٢- خلوص بين درفيلي الدراس : ٢,٥ - ٣ مم .

وذلك للوصول لأفضل النتائج من حيث أقل نسبة كسر وأقل فاقد كلي للحبوب و كذلك كفاءة مناسبة لعملية الدراس