Misr J. Ag. Eng., 22 (2): 555 - 571

DEVELOPMENT AND EVALUATION OF SEED EXTRACTING MACHINE FOR SEED MELONS

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ABSTRACT

The present study was carried out at the Rice mechanization center, Meet EL-Deeba, Kafr EL-Sheikh Govern orate, Egypt during summer season of 2003/2004 using watermelon seed fruit. The objective of this work was to construct and evaluate watermelon seed extracting machine. The studied factor in the present investigation were as follows: Three various drum shapes (Square, triangle and hexagonal); four drum speeds 0.35, 0.52, 0.69 and 0.81 m/s and three feed rate 2.0, 2.857 and 3.714 ton/h.

The results showed that, machine productivity increases by the increase of feeding rate and drum speeds. However the lowest value of specific energy was obtained by using triangle shape. In the same manner the lowest value f speed damage was 1.59% at drum speed of 0.35 m/s and feeding rate of 2.0 ton/h for triangle drum shape. Also, results show a negative relationship between drum speed, feed rate and seed losses. Separating efficiency reached its maximum value of 96.13% at drum speed of 0.81 m/s and feed rate 2.0 ton/h. For triangle drum shape. However, manual separating of watermelon seed costed 5.77 times mechanical separating.

INTRODUCTION

Watermelon (Colocynthis Citrullus) is cultivated in the arid and semi-arid areas. It is believed that the plant is native to Africa middle east and is probably an ancestral type of the watermelon. Watermelon seeds are strategic vegetable products in Egypt that can be exported to several Arab countries.

Recently, watermelon crop has been widely cultivated especially in Northern Nile Delta regions, such as Kafr El-Sheikh Governorate, and newly reclaimed lands. According to, ***Egyptian Ministry of Agriculture and Land Reclamation, (2001)***, the total area of watermelon seed is about 170000 Fed. With an average yield of 470 kg/Fed.

In general watermelon separation machinery are not available in Egypt. In addition the foreign implements, dose not suit most watermelon fruit and seed properties. That requires expensive and complicated operations leads to low efficiency, and high costs ***(Hussan, 1994)***. Hence, the development of a reliable seed separation implement to suit the prevailing Egyptian conditions still needs more attention.

There is considerable interest in cucubita seeds because of their nutrition quality, mainly in terms of protein and oil content. The seed from the mature fruit is used in the from of roasted and salted food items. The kernel, extracted from the seed in the whole form, traditionally called "Azaza". The seed melon

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fruit physically resembles the watermelon in many respects. It is a fleshy fruit which is generally green in color, though some varieties have their green color streaked white. The external surface of the fruits is relatively hard and smooth. The majority of the fruits are nearly spherical in shape, but some are ellipsoids having slightly elongated head-tail axial dimensions. Unlike watermelon, the flesh of the seed melon fruit is bitter and therefore not edible. Seed melon is grow for the seed which are very nutrition, rich in protein. The seeds contain about 53% oil by weight ***(Oyolu, 1977)*** and 32.6 crude protein ***(Oyenuga, 1968)*** and also unsaturated fatty acids. It's amino acid content compares well with those of soybean and whole egg ***(Oyoly, 1977)***. The seed is a major soup ingredient in the most countries of African ***(Oyengua, 1968)***. Watermelon seeds are symmetrically arranged all around the central septum and are concentrated more within the central portion of the fruit than at the ends. On average, the seeds constitute 3.5% of the fruit by weight ***(Nwosu, 1988)***.

Up to date, watermelon seed separation in Egypt is accomplished by manual separation 95%. The traditional method of separating watermelon seeds from the fruit involves manual cracking of the fruit with cutting the head or tail portions of the fruits with a knife. All done in order to separate the seeds from the mesocarp and endocarp at the same time, mainly for seed purposes. The traditional method requires a lot of time and labor. Whereas, 25-30 workers are needed for one feddan which costly about 250-300 LE/Fed.

Construction of a seed-melon separating machine is important for farmer use. This paper discusses some tests which performed to evaluate the performance of the watermelon separating machine in terms of machine productivity, the effectiveness of separating with respect to seed extraction, seed loss energy requirements and cost evaluation.

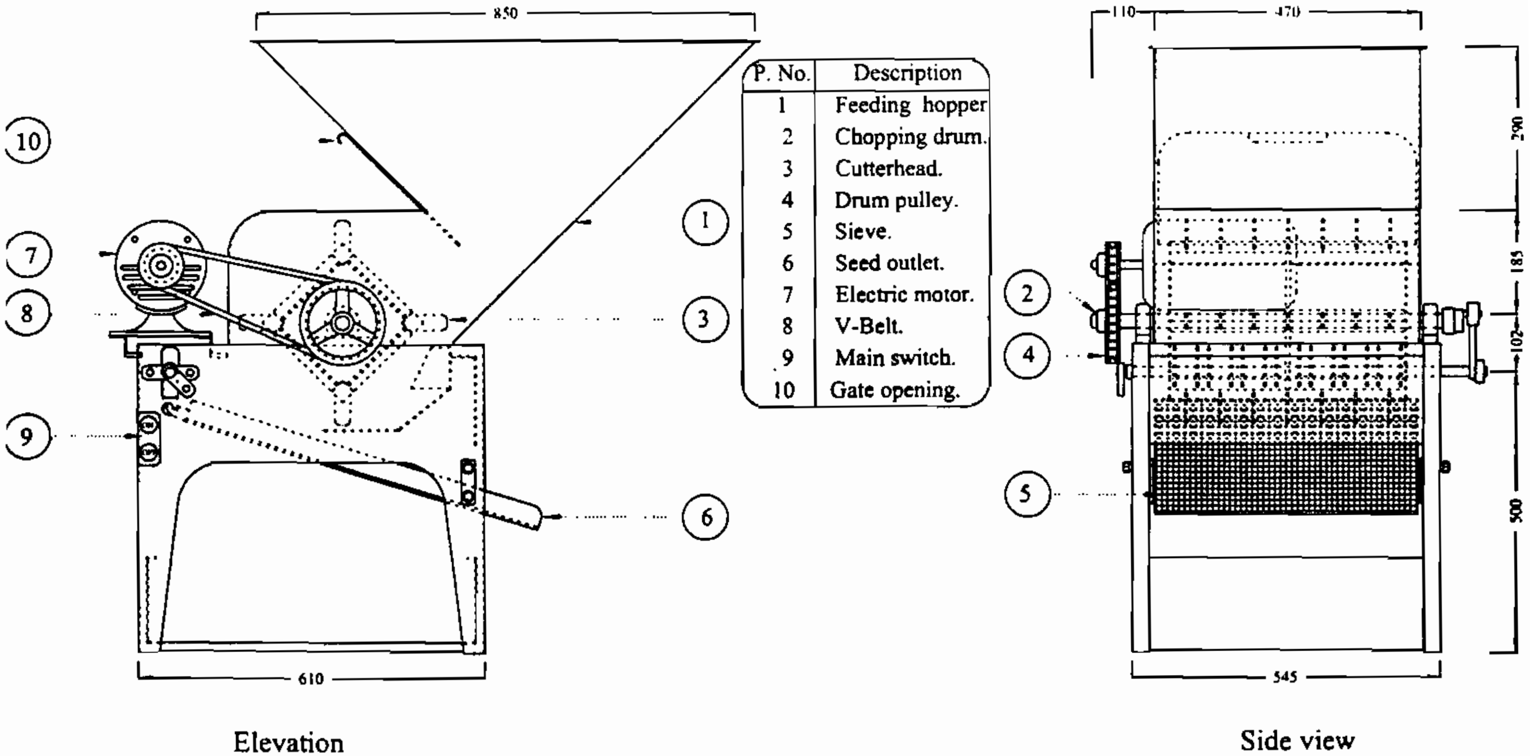
MATERILS AND METHODS

To fulfill the objective of the present study ,watermelon seeds separating machine was constructed at the workshop of Rice Mechanization Center, Meet El- Dyba, kafr El-sheikh, Governorate. Using 1500 W electric motor it has a potential difference (Voltage) of about 220 v powered it. Figure 1 shows the main parts of watermelon seeds separating machine. It has two function units for separating and cleaning the seeds from hull, it contains the following main parts:

a. The main frame (chassis) was constructed from angle bars and galvanized metal sheets 1mm thick.

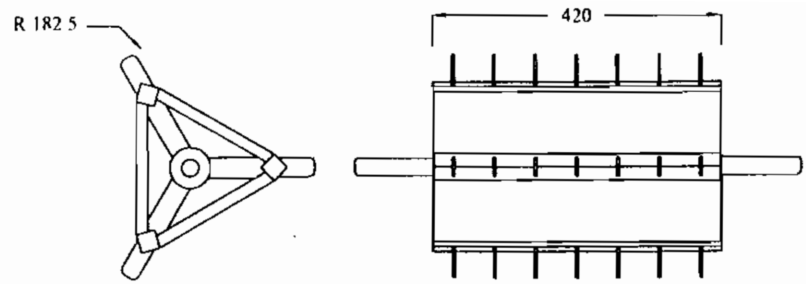
b. Hopper for feeding the watermelon to the seed extraction zone. It was fabricated from galvanized sheet 1mm thick. The size and shape of the hopper as determined from the characteristic dimensions of the watermelon Table 1, facilitates the free flow of watermelon by gravity into the separating section.

c. Seed separating drum (three different drum namely :triangle , square and hexagonal shapes) were fabricated and used in the present investigation Fig. 2 .

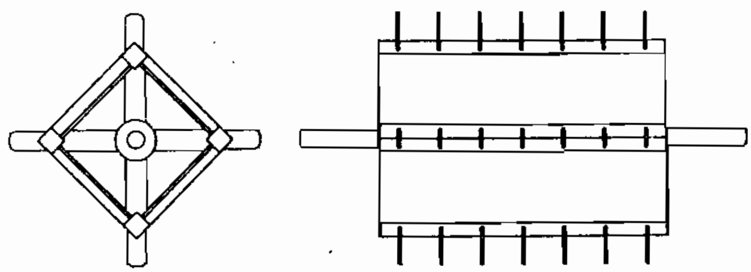


P. No.	Description
1	Feeding hopper
2	Chopping drum.
3	Cutterhead.
4	Drum pulley.
5	Sieve.
6	Seed outlet.
7	Electric motor.
8	V-Belt.
9	Main switch.
10	Gate opening.

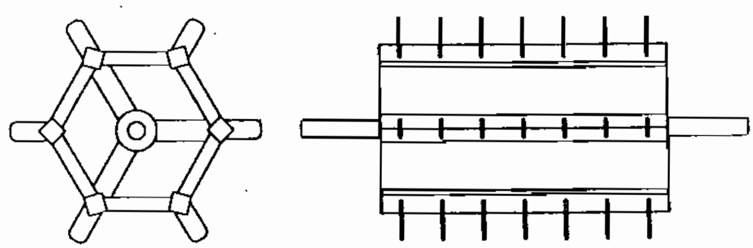
Fig. 1 : An elevation and side view for separating machine.



Triangulcr shape of separating drum.



Square shape of separating drum.



Hexagonal shape of separating drum. Dims. in mm.

Fig. 2 : Three different shapes of separating drum.

d. The separating screen was fixed under the separating drum. The angle of inclination of screen can be adjusted.

Test procedures:

After harvesting watermelon fruit were grouped near the machine. Three various drum shapes were used with four speeds of 0.35, 0.52, 0.69 and 0.81 m/s.. Three feed rate were used of 2.000, 2,857 and 3,714 Mg/h and two labors were operating the machine, the first one was feeding the machine, and the second could be take off the fruit from the land to fruit container to easiness the feeding process. The physical properties determined were: The characteristic dimensions, weight, volume and density.

Table 1: Physical characteristics of watermelon fruit in the three sizes with an average moisture content of 95.9 % wet basis, 8-11 cm, 11-14 cm and 14-17 cm diameter range.

Parameters	Mean values		
	Small size	Medium size	Large size
Major diameter (a), cm	(0.39)* 10.35	(0.51) 12.74	(1.07) 15.09
Intermediate diameter (b),cm	(0.62) 11.15	(0.65) 13.80	(1.12) 15.72
Minor diameter(c), cm	(0.75) 10.76	(0.53) 13.07	(1.47) 16.85
Geometric mean diameter $(a.b.c)^{1/3}$	(0.59) 10.75	(0.59) 13.195	(1.50) 15.78
Sphercity+	(0.05) 1.04	(0.04) 1.04	(0.06) 1.05
Unit volume, cm^3	(1.89) 720.73	(3.18) 1285.29	(4.25) 2317.52
Unit watermelon Mass, g	(3.75) 641.45	(4.85) 1118.20	(5.73) 1969.89
Unit density, g/cm^3	(0.03) 0.89	(0.04) 0.87	(0.05) 0.85
Shear force, N	(0.82) 52.58	(0.75) 83.58	(0.54) 118.7

*Values in the parenthesis are standard deviations;

$$Sphercity = \frac{Geometric\ mean\ diameter}{Major\ diameter}, (Mohsenin\ 1970) \quad .....(1)$$

Fig.3 shows the transverse and longitudinal section of watermelon fruit. The transverse section is obtained by cutting the fruit across the head-tail axis. The epicarp (A) is a thick tough outer coat strongly attached to the much softer fleshy mesocarp (B) to form what the jointly to as the rind ***(Nwosu 1988)*** The epicarp does not decompose easily and cracking is necessary to initiate decomposition. The endocarp (D) is segmented from each other by septum (C). Within the segments are the seeds (F) which lie on their flat sides in planes nearly perpendicular to the head –tail axis, with their heads directed towards the septum and distinctly separated from each other by the flesh component of the endocarp. The longitudinal section is obtained by cutting the fruit along the head –tail axis. The edges of the seeds are displayed and look like thick lines perpendicular to the head –tail axis. The seeds are symmetrically arranged all around the central septum and are concentrated more within the central portion.

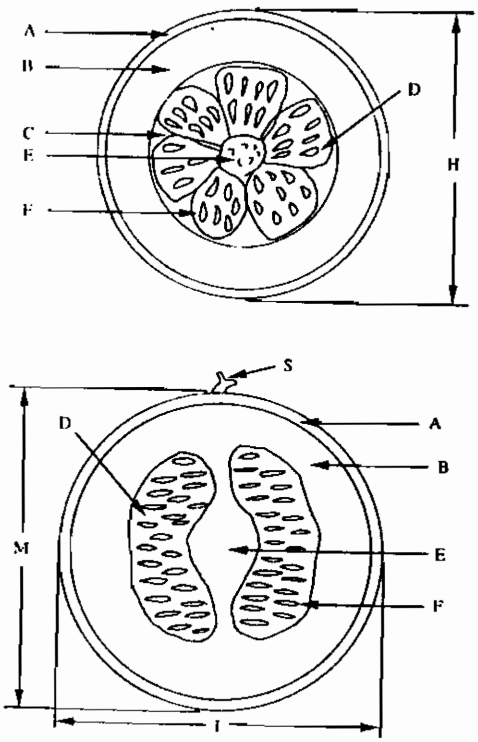


Fig. 3 : Transverse and longitudinal sections of the seed-melon fruit.

The traditional method of seed-melon separating seeds:

It involves manual separating of the fruits from the plnt and grouped it in the field center and cutting off the head or tail portions of the fruits with knife. Then the seed are removed by washing in water. The traditional methods requires about eight labors to one feddan, work eight hours.

Miscellaneous equipment:

a. Digital vernier (with an accuracy of about 0.01milimeter).
b. Mettler balance (accuracy of 0.01g).
c. Stop watch.
d. Tachometer (the rotational speed of seed extraction drum was measured by using digital tachometer. HT-1500,Ono Sokki Co.LTD. Japan make).

Determination of results:

$$Damage\ seeds\ \% = \frac{M_d}{M_t + M_d} \quad \text{.......(2)}$$

Where:

M_d = mass of damage seeds, g. and

M_t = mass of total separating seed, g.

Separating efficiency was determined according to the formula by ***EL-sayed (1992)***:

$$Separating\ efficiency\ \% = \left[1 - \left(\frac{M_{ns}}{M_t + M_{ns}}\right)\right] \quad \text{.......(3)}$$

Where:

M_{ns} = mass of nonseparating seeds, g.

$$Seed\ losses\ \% = \frac{M_l}{M_t + M_l} \quad \text{.......(4)}$$

Where:

M_l = mass of total lost seed either with hull or discharged out of the machine, g.

Estimation of machine productivity:

Machine productivity was calculated by using the following formula:

$$Machine\ productivity\ (Mg/h) = \frac{M_{sp}}{T} \quad \text{.......(5)}$$

Where:

M_{sp} = mass of total separating seeds, (Mg).

T = the time consumed in operation, (h).

Estimation of power and energy requirements:

The consumed power was estimated using clamp meter by measuring the line current and voltage potential difference values. Total consumed power was estimated according to ***(Lockwood and Dustan, 1971)*** as follows:

$$Total\ power\ consumed,\ kW = \frac{I.V.\cos\theta.\eta}{1000} \quad \text{.......(6)}$$

Where:

I = line current strength in Ampers;

V = potential difference (Voltage) being equal 220 V,

$\cos\theta$ = power factor (was taken 0.7) and

η = machine efficiency assumed (0.90).

The energy requirements was calculated by using the following equation:

$$Energy\ requirements,\ kWh/Mg = \frac{P}{M_p} \quad ......(7)$$

Where:

P = power consumed for seed separating, kW and

M_p = machine productivity, Mg/h.

Machine operation cost:

The machine operation cost were calculated according to ***(Younis,1997)*** as follow:

Fixed costs:

$$-Depreciation = \frac{Original\ cost - Salvage\ value}{Machine\ life} \quad ......(8)$$

Salvage value 10% of original cost. L.E/ year.

$$-Interest,\ LE/year = Interest\ rate \left[\frac{Original\ cost + Salvage\ value}{2}\right] \quad ......(9)$$

$$-Shelter,\ taxes\ and\ insurance = 0.04 (Original\ cost) \quad ......(10)$$

$$-Total\ cost = \left[\frac{(Depreciation + interest + Shelter,\ Taxes\ and\ insurance)}{Hours\ of\ use\ per\ year}\right] \quad ......(11)$$

Variable cost:

$$-Repair\ and\ maintenance,\ LE/h = 0.0577 \left(\frac{Original\ cost}{Hours\ of\ use\ per\ year}\right), (Bowers, 1987) \quad ......(12)$$

$$-Electricity\ cost,\ LE/h = Maximum\ power\ consumed (Electricity\ price) \quad ......(13)$$

- *Greasing, LE/h.*
- *Labor cost, , LE/h.*

$$-Total\ variable\ cost = (Repair + Electricity + Lubrication + Labor) \quad ......(14)$$

The cost of production (Cp) was calculated by the following formula:

$$Cp,\ LE/Mg = \frac{Total\ cost}{Productivity} \quad ......(15)$$

RESULTS AND DISCUTION

Separating machine productivity:

The observations indicated in Table 2 and Fig. 4 show the effect of drum speeds, drum shape and the feeding rate on machine productivity. The data reveal that increasing drum speeds and feeding rate increases the machine productivity. The highest values of machine productivity was obtained by

Table 2: Effect of drum shape, feeding rate and drum speed on separating machine performance.

Drum shape	Feeding rate ,kg/h	Drum seed, m/s	Seed prod. kg/h	Power, kW	Uint cost, LE/ton	Seed damage , %	Seed losses , %	Sep. eff %
Triangle	2000	0.35	46.33	0.811	130.43	2.18	12.93	87.29
		0.52	47.27	0.852	127.66	2.37	12.70	87.50
		0.69	48.67	0.847	125.00	2.56	12.43	87.85
		0.81	50.08	0.869	120.00	2.71	12.25	88.34
	2857	0.35	70.15	0.858	85.71	1.84	13.29	86.78
		0.52	72.59	0.884	83.33	2.08	12.97	87.17
		0.69	73.70	0.897	82.19	2.31	12.75	87.43
		0.81	76.15	0.923	78.95	2.58	12.51	87.60
	3714	0.35	93.06	0.874	64.52	1.59	13.62	86.59
		0.52	95.37	0.891	63.16	1.78	13.26	86.92
		0.69	98.55	0.918	61.22	1.99	13.05	78.15
		0.81	100.28	0.933	60.00	2.27	12.78	78.46
Square	2000	0.35	56.94	0.957	107.14	2.50	8.83	91.35
		0.52	58.34	0.978	103.45	2.82	8.49	91.74
		0.69	59.75	0.998	101.69	3.07	8.34	92.10
		0.81	61.78	1.035	98.36	3.34	8.12	92.59
	2857	0.35	84.14	0.986	71.43	2.21	9.17	91.07
		0.52	86.14	1.007	69.77	2.50	9.01	91.49
		0.69	88.36	1.029	68.18	2.79	8.83	91.85
		0.81	90.58	1.053	66.67	3.02	8.65	92.14
	3714	0.35	113.58	1.021	53.10	2.05	9.54	90.77
		0.52	115.89	1.038	52.17	2.32	9.31	91.05
		0.69	119.07	1.062	50.42	2.59	9.05	91.32
		0.81	122.25	1.086	49.18	2.80	8.81	91.58
Hexagonal	2000	0.35	71.92	1.113	84.51	3.11	5.55	94.70
		0.52	74.88	1.154	81.08	3.46	5.27	95.27
		0.69	77.84	1.196	77.92	3.74	4.95	95.85
		0.81	79.56	1.217	75.95	4.02	4.73	96.13
	2857	0.35	111.89	1.209	54.05	2.85	5.98	94.22
		0.52	116.11	1.247	51.72	3.14	5.54	94.84
		0.69	118.33	1.268	50.85	3.45	5.17	95.36
		0.81	121.21	1.292	49.59	3.69	4.91	95.59
	3714	0.35	164.15	1.290	36.59	2.60	6.68	93.27
		0.52	17196	1.347	35.09	2.87	6.55	93.60
		0.69	176.58	1.379	34.09	3.15	6.13	94.09
		0.81	179.76	1.396	33.52	3.43	5.62	94.31

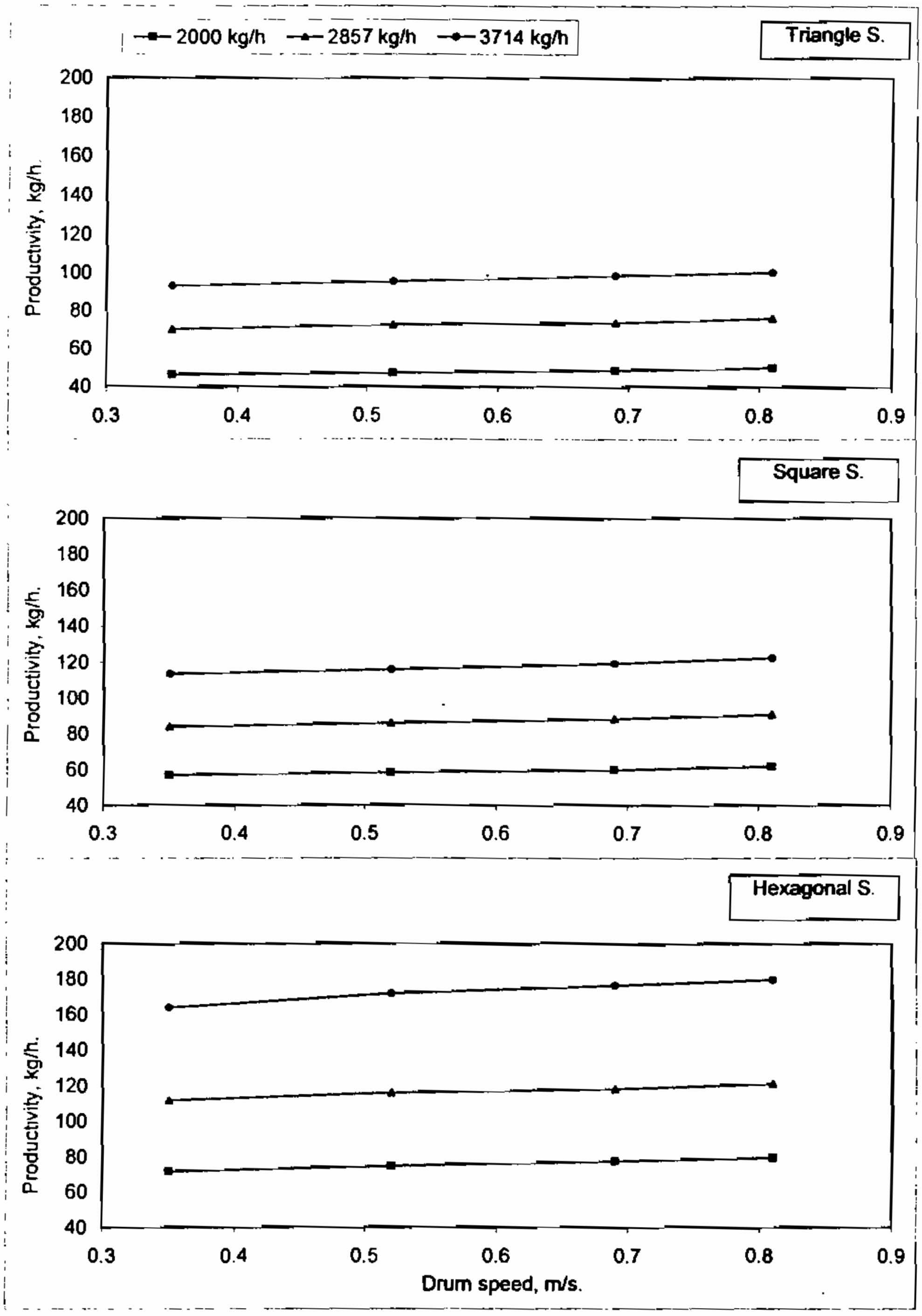


Fig. 4: Effect of drum speed, feeding rate and drum shape on machine productivity.

using drum the hexagonal shape whereas, the increase of drum speeds from 0.35 to 0.81 m/s cause a corresponding increase in machine productivity of seed from 71.92 to 79.56 , 11.89 to 121.21 and 164.15to 179.76 kg\h at watermelon rate 2.0, 2.857 and 3.714 Mg\h.

Power and energy requirements:

Table 2 and Fig. 5 show the power and energy requirements as affected by three different drum shape, feed rate and drum speed. It is noticeable that the power requirement of separating operation increases with the increase of both drum speeds and watermelon feed rate. Meanwhile, there is a reverse proportion between the unit energy and feed rate and these due to the increase machine productivity. The results clearly showed that the hexagonal drum shape having six bars gave the highest values of power requirement however, it was gave lowest values of unit energy at the same operating parameters. The increase of drum speed from 0.35 to 0 .81m/s increases the power required for seed separating from 1.113 to 1.217,from 1.209 to 1.292and 1.290to 1.396 kW.h at watermelon feed rate of about 2.0, 2.857 and 3.714 Mg\h ,respectively. On the other hand, drum shape triangle gave the lowest values of unit energy and these may be due to the reduce of the power requirement of machine by using this drum shape. The same increase in drum speeds increases the unit energy from 0.406 to 0.435, from 0.30 to 0.323 and 0.235 to 0.251 kW.h/ton at the same mentioned above feed rate, respectively and drum shape, triangle.

Seed damage:

Table 2 shows the relation between drum speed and seed damage for three various drum shape and three levels of watermelon feed rates. The results clearly showed that, the increase of drum speeds tend to increase the seed damage and these may be due to the increase of impact during the separation of seed from hull. The highest values of seed damage were obtained by using hexagonal drum shape and reached 4.02 at drum speed of 0.81 m/s and feed rate of 2.00 Mg/h meanwhile, drum shape triangle gave the lowest values of seed damage where it reached 1.59 % at drum speed of 0.35 m/s and feed rate of 3.71 Mg/h. However, the increase of feeding rates tend to decrease the seed damage under the various operating parameters. The reason is due to the more dense of material passing through the extracting zone at high feed rate which provide more protection and reducing the repeated of impact by the cylinder bars.

Seed losses:

Data presented in Table 2 and Fig .6 obvious the effect of four various drum speeds, three different levels of feed rates and four various drum shape. The results illustrated that, the increase of drum speed decreases the seed losses and these due the increase in separating efficiency which otherwise decrease the amount of seed discharged with hull at the higher

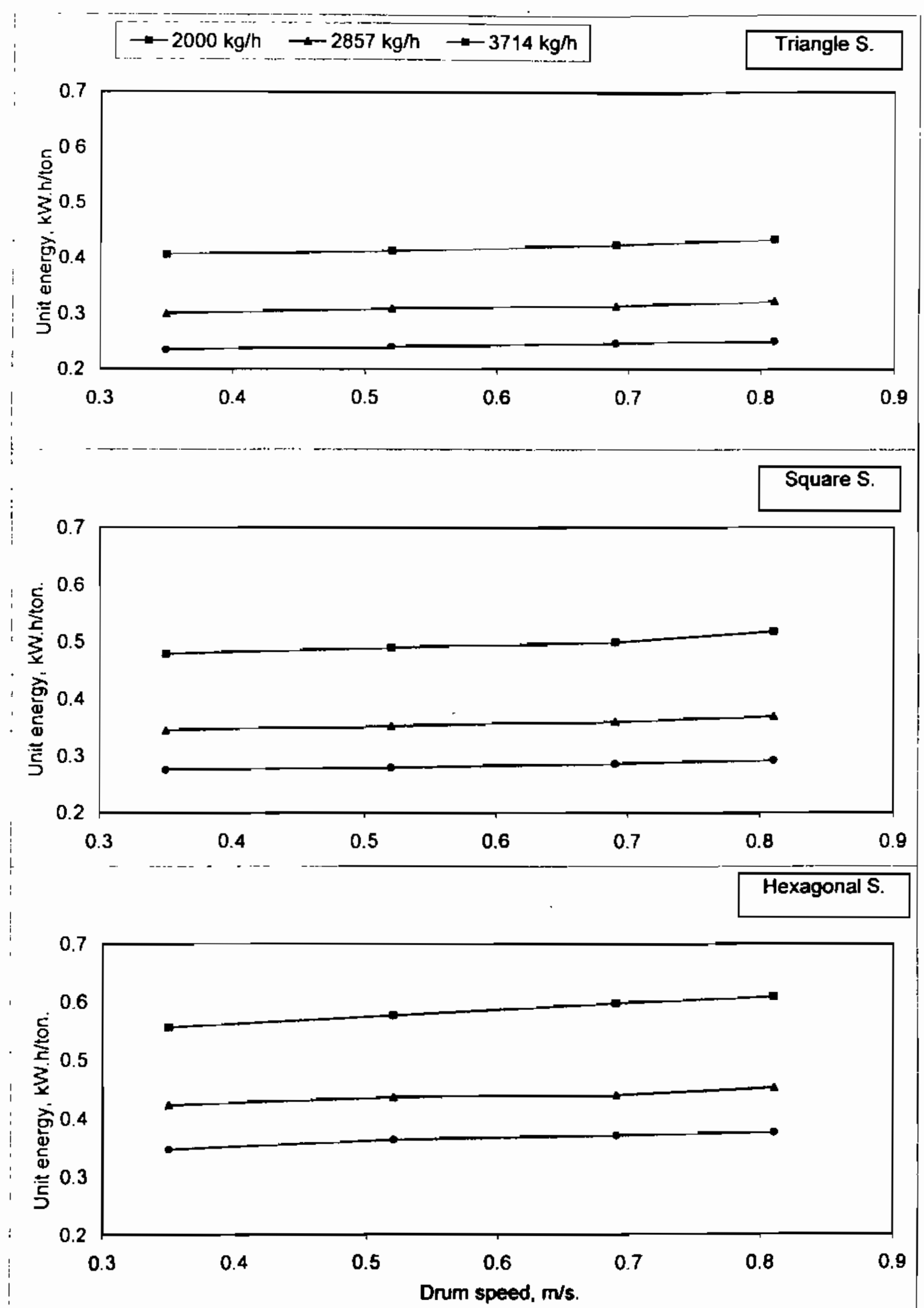


Fig. 5: Effect of drum speed, feeding rate and drum shape on unit energy.

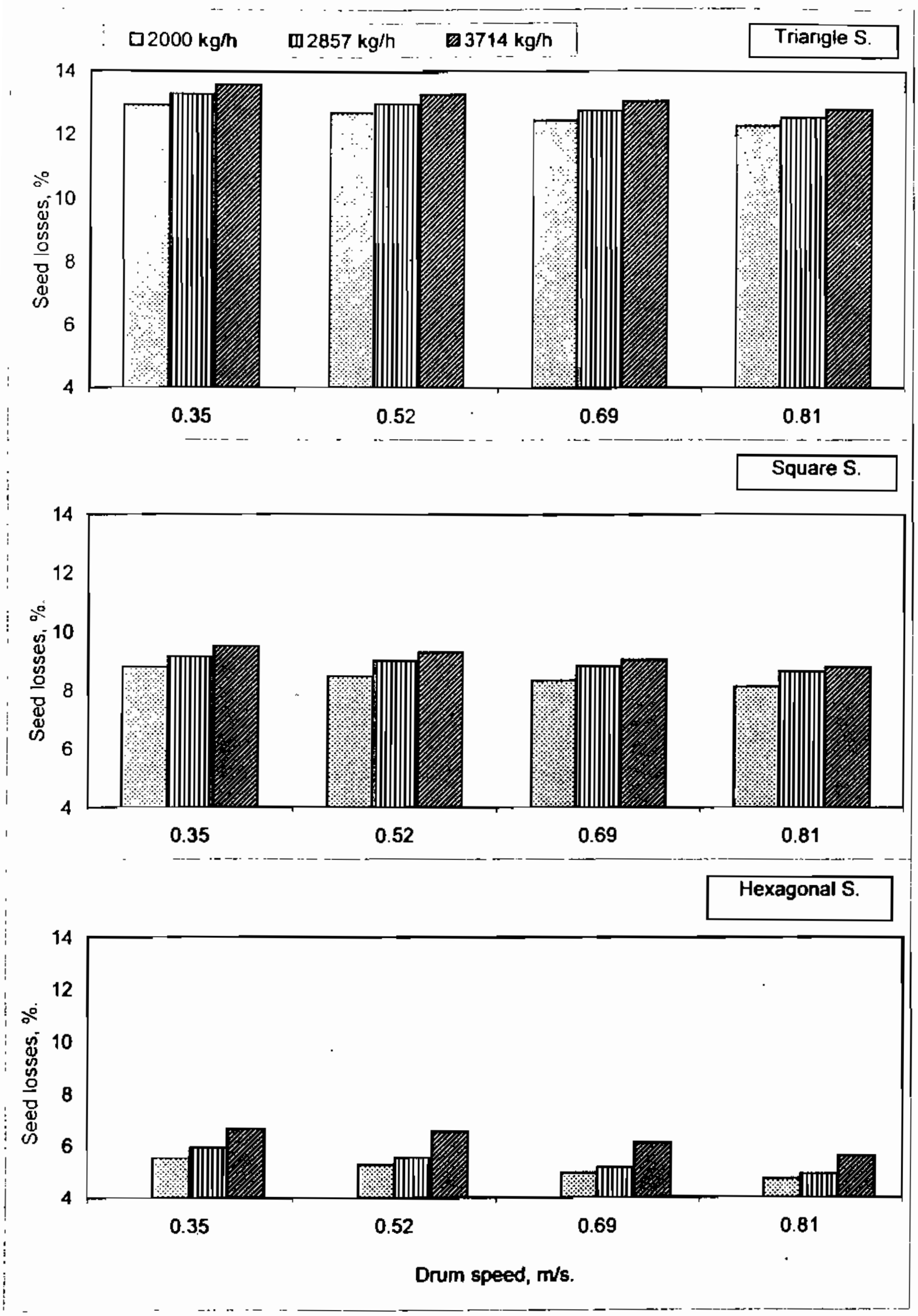


Fig. 6: Effect of drum speed, feeding rate and drum shape on seed losses.

speed. Also, the increase of feed rates increases the seed losses due to the same reason mentioned above. However, the highest values of seed losses were 13.62, 9.54, and 6.68 % at drum speed of 0.35 m/s and feeding rate of 3.714 mg/h for the drum shapes triangle, square and hexagonal respectively. The data also, showed that drum speed triangle gave the highest amount of seed losses and these may be due the reduce of separating efficiency of this drum shape.

Seed separating efficiency:

Dealing with the effect of drum speeds, drum shape and the feeding rate of watermelon on seed separating efficiency as shown in Table 2 and Fig. 7.It was found that the drum speed increase tends to increase the seed extracting efficiency. Increasing the drum speed from 0.35 to 0.81 m/s tends to increase the seed extracting efficiency from 87.29 to 88.34, 91.35 to 92.59 and 94.70 to 96.13 % at the same feeding rate of 2.0 Mg\h and drum shape triangle, square and hexagonal, respectively. On the other hand increasing the feed rate from 2.0 to 3.714 Mg/h tends to decrease the seed separating efficiency from 87.29 to 86.59, 91.35 to 90.77 and 94.7 to 93.27 % at drum speed of 0.35 m/s and drum shape triangle, square and hexagonal, respectively

Cost evaluation:

Table 2 summarizes the effect of drum speeds, feed rate and drum shape on unit cost. It can be stated that, hexagonal drum shape with drum speed 0.81 m/s and feed rate 3.714 Mg/h gave the lowest cost where, it reached 33.52 L.E/ton. Whilst the maximum value of total cost was 130.34 L.E/ton for drum shape triangle and drum speed 0.35 m/s and feed rate of 2.0 Mg/h.

CONCLUSIONS

From the obtained results the following Conclusions are derived:

1- The data revealed that, increasing both drum speeds and feeding rate increases drum speeds and feeding rate increases the machine productivity at three various shape of separating.

2- It can be stated that, the highest value of specific energy requirements was 0.61 kW.h/ton at drum speed of 0.81 m/s and feeding rate of 2000 ton/h for hexagonal drum shape.

3- The lowest value of seed damage was 1.59% at drum speed of 0.35m/s and feeding rate of 3.714 ton/h for triangle drum shape.

4- The results illustrated that, the increase of drum speed decreases seed losses whereas, the increase the feeding rate increases seed losses.

5- It can be reported that, the separating efficiency reached to 96.13% at drum speed of 0.81m/s and feeding rate of 2000 ton/h for triangle drum shape.

6- Manual separating cost is about 5.77 times mechanical separating.

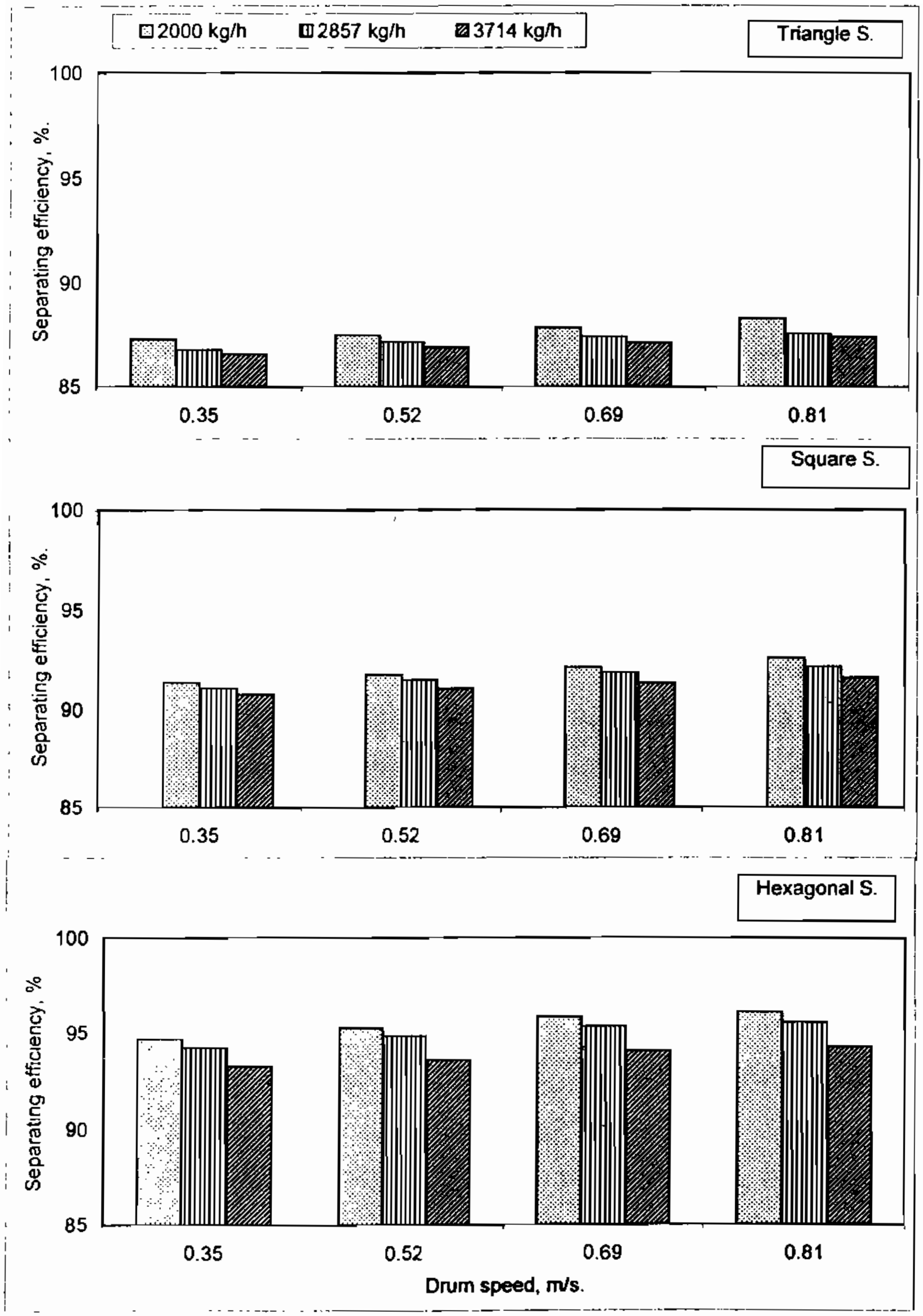


Fig. 7: Effect of drum speed, feeding rate and drum shape on separating efficiency.

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الملخص العربي

تطـــــــوير وتقيم آلة لفصل لب البطيخ

د. رزق خليف* د. رفاعى أبو شعيشع* د. علاء المسيرى***

تعتبر عملية حصاد وفصل بذور الخضر آليا من أهم العمليات الزراعية التي تستحوذ على اهتمام المزارع المصري لما يجده من عناء وجهد كبيرين فى الحصول على البذور بطريقة يدوية. وحيث أن محصول بطيخ اللب من محاصيل الخضر التي تتبع العائلة القرعية والذي انتشرت زراعته في الاونه الأخيرة وخصوصا فى منطقة شمال الدلتا والأراضي الجديدة حيث يزرع فى شهر مايو ويحصد فى أغسطس بغرض الحصول على البذور والتى تدر دخلا كبيرا على المزارع المصري ومن ثم تساهم فى زيادة الدخل القومي حيث أنها تصدر إلى الخارج.

وتبلغ مساحة بطيخ اللب فى مصر حوالي 170000فدان وبإجمالي إنتاج سنوى قدره 79.900طن بمتوسط 470كجم/فدان (كتاب الإحصاء الزراعية - وزارة الزراعة 2001م) وبمتوسط سعر 8 جنيهات لكل كجم بذور.ولما كانت عملية ميكنة إنتاج هذا المحصول من الوسائل التي تساهم فى زيادة جودته ومن ثم رفع أسعار تصديره فضلا عن التغلب عل مشكلة نقص الأيدي العاملة اللازمة للقيام بمعظم العمليات وخاصة عملية فصل البذور والتى تحتاج إلى وقت وجهد كبيرين، حيث يحتاج الفدان الواحد ما بين 25-30عامل بتكلفة كلية تصل إلى 250-300جنية/فدان.

ولقد اتجهت أنظار الباحثين إلى التوقف عند حل مشكله فصل واستخلاص بذور بطيخ اللب فى مصر وذلك من خلال تصنيع واختبار آلة محلية صغيره لفصل بذور البطيخ تعمل بموتور كهربي قدرته 1500وات سهلة التنقل بحيث تلائم المزارع المصري.

ولقد تناول البحث دراسة تأثير كل من شكل الدرفيل(مثلث- مربع- سداسي) وسرعة الدرفيل (من 0.35 إلى 0.81 م/ث) ومعدل التغذية (ص2.000 إلى 3.714 طن/ساعة) وذلك على معدل أداء الآلة من خلال إنتاجية الآلة، كفاءة الفصل، فواقد البذور، تلف البذور وكذا القدرة اللازمة لفصل البذور والتكلفة الكلية لعملية الفصل.

ويمكن تلخيص النتائج المحصل عليها كما يلي:-

1- أوضحت النتائج أنه بزيادة كل من سرعة الدرفيل ومعدل التغذية تؤدى إلى زيادة إنتاجية الآلة عند الثلاث تصميمات المختلفة لدرفيل الفصل.
2- وصلت الطاقة المستخدمة لعملية فصل البذور إلى أعلى قيمة لها 0.61كيلووات ساعة/طن لسرعة درفيل 0.81م/ث ومعدل تغذية 2.00طن/ساعة عند استخدام درفيل الفصل السداسي.
3- تم الوصول إلى أدنى قيمة لتلف البذور 1.59% عند سرعة درفيل 0.35م/ث ومعدل تغذية 3.714طن/ساعة لشكل درفيل الفصل المثلث.
4- بينت النتائج أن زيادة سرعة درفيل الفصل تؤدى إلى تقليل نسبة الفاقد من بذور بطيخ اللب ، بينما زيادة معدل التغذية تؤدى إلى زيادة نسبة الفاقد من بذور بطيخ اللب.
5- تم الوصول إلى أعلى كفاءة فصل لبذور بطيخ اللب 96.13% عند سرعة درفيل 0.81م/ث ومعدل تغذية 2.000طن/ساعة لشكل درفيل الفصل المثلث.
6- انخفضت التكاليف اللازمة لعملية فصل بذور بطيخ اللب آليا بمقدار 82% بالمقارنة بطريقة الفصل اليدوي.

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