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DEVELOPMENT OF A SIMPLE MACHINE FOR THRESHING COWPEA AND KIDNEY BEAN CROPS.

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ABSTRACT

The objective of the present investigation is to develop, manufacture and evaluate a machine for threshing Cowpea and Kidney bean crops. The thresher was evaluated and tested at El- Serw Agricultural Research Station, Domietta Governorate under different screen holes, drum speeds, number of spike tooths and concave clearances at four different levels of grain moisture contents for Cowpea and Kidney bean crops. The performance of the thresher machine was evaluated under the following parameters :-

Three different number of spike tooths of 10,20 and 30 are distributed on the drum through 2, 4 and 6 lines, four different drum speeds (5.5 , 7.9 , 10.6 and 14.4 m/s) , four different drum-concave clearances (9 , 11 , 14 and 16 mm) and (16,18,20 and 22mm) for cowpea and kidney bean crops respectively and four levels of seed moisture contents (10.09 , 13.48 , 15.22 and 18.94 %) and (10.43, 12.90,15,21 and 17.85 %) (d.b.) for cowpea and kidney bean crops respectively. The optimum results of total grain damage, unthreshed and losses percentages were obtained by using thresher drum with 30 spike tooths arranged in six lines and drum speed 7.9 m/s for cowpea and kidney bean crops. At the same time, the concave clearance of threshing machine 11 and 18 mm at grain moisture content of 13.48 % and 15.21 % for cowpea and kidney bean crops respectively gave the acceptable values of total grain damage, unthreshed and losses. Also, the results indicated that the modified threshing machine reduced the

operation cost of threshing cowpea and kidney bean crops per fed. by 63.01 and 62.08 % when compared with the use of traditional manual system.

INTRODUCTION

The Egyptian Government is planning to increase the human food productivity through planting newly reclaimed lands and using modern technology in agriculture . Leguminous crops such as cowpea and Kidney bean are considered an important popular food and the most economical crops . The successful production and good marketability of these crops depend on both quantity and quality of seeds. Many scientists studied physical , mechanical and chemical properties of the seeds. Zaalouk and Ghanem (2003) reported that, the specific weight and rigidity force of cowpea seeds were7-8.71 kN/m^3 and 80.82-91.38 N respectively . Friction angle less than 24° was recommended for chutes conveying of the cowpea seed varieties studied . For belt conveying an angle of less than 22° was recommended for Kreeam-7 and Dokki-331 varieties and an angle of less than 28° was also recommended for the Balady type respectively. The terminal velocities of cowpea seeds were ranged between 6.8-8.9 cm/s . So, a vertical air stream of 2.3 m/s is successfully sufficient to separate straw, fine particles and dust from cowpea seeds for all varieties studied . Allen and watts (1997) , reported that for cowpeas (var.Minice Beans) vertical air stream of 6m/s was sufficient to completely separate the threshed buds from the beans. They also stated that this velocity was lower than terminal velocity

of beans, which was approximately 8m/s on average also threshing effectiveness is significantly better with the crop at moisture levels below 13% (w.b). Therefore , pre-drying the crop enhances threshing. Mosa et al (2003) reported that, the effect of some parameters such as, drum peripheral speeds 4.6 , 6.3 , 7.1 and 7.9 m/s (350 , 400 , 450 and 500 r.p.m.) , concave clearance (8 , 9 and 10 mm) and average moisture contents of pea plants (11 , 13 and 15 % dry basis) on machine productivity (output) (kg/h), and energy requirements (kW.h/Mg.) were studied. Also, the effect of machine parameters on the seed losses and seed quality (mechanical damage) during the threshing operation was considered .The results revealed that , optimum operations conditions were obtained at 6.3 m/s drum peripheral seed ; concave clearance of 10 mm and 13 % average moisture content At this level the machine productivity of 0.266 (Mg./h), energy consumption (16.2 kW.h/Mg.), total seed losses (2.74 %) and the total mechanical damage of (2.38 %) were obtained. Sharma and Devnani (1980) stated that ; cylinder tip speed and concave clearance for soybean and cowpea threshing were 413 r.p.m. at 12 mm and 496 r.p.m. at 8 mm clearance for consumption purpose , and 330 r.p.m. at 12 mm and 288 r.p.m. at 8 mm clearance for seed purpose, respectively. Dauda(2001) evaluated a manually operated Cowpea thresher for small scale farmers in Northen Nigeria. The threshing efficiency was from 1.8 to 2.3%.

The main objectives are:

-Develop and manufacture a suitable small Cowpea and Kidney bean thresher.

-Evaluate and determine the performance characteristics of threshing efficiency.

MATERIAL AND METHODS

The experiments were conducted at El-Serw Agricultural Research Station, Damietta Governorate for threshing Cowpea variety (Dokki-331) and Kidney bean varity (Contender) crops by using a simple thresher machine . Evaluation the developed machine concerning capacity , threshing efficiency, grain losses and damage for both crops. The technical specifications of the developed machine are shown in table (1) and Fig.(1).

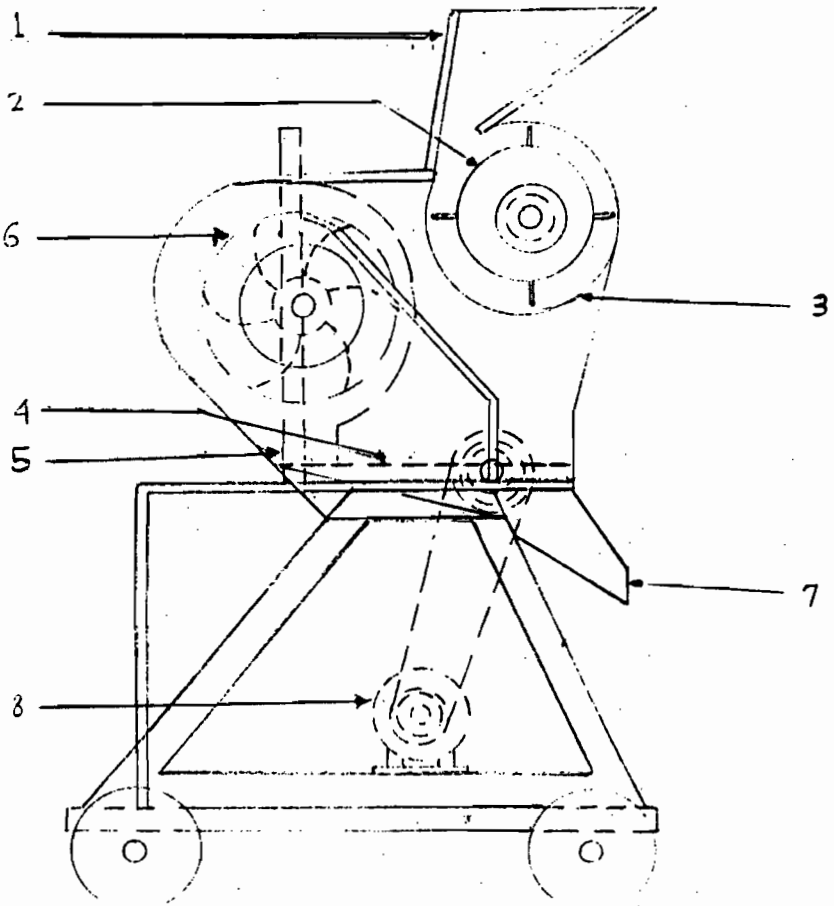
Concave clearance is varied by a hand wheel. The spike tooths are distributed on the drum with 2,4and 6 lines each having 5 spike tooths (total = 10,20 and 30 spike tooths respectively).

Experimental treatments:

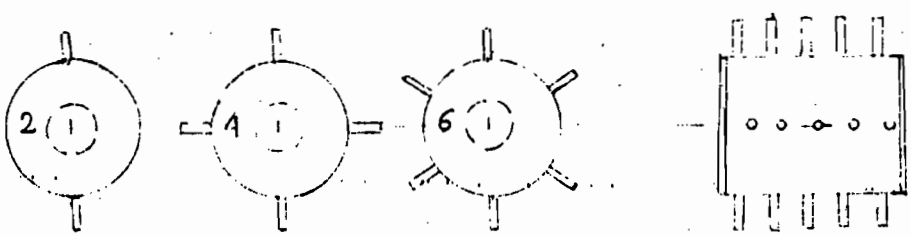
Different levels of screen holes, grain moisture content, drum speed, number of spike tooths and concave clearance were used in this investigation and are as follows:

1-Two different screen holes of circle hole (11 and 16 mm. diameter) and rectangle holes [(11and 7mm.) and (16and 8mm.) for length and width hole]

2-Four levels of grain moisture contents of (10.09,13.48,15.22 and 18.94%) and (10.43, 12.90, 15.21,and 17.85%)(d.b.) for Cowpea and Kidney bean crops respectively.



1- Feed tray 2-Threshing drum 3- Concave
4- Oscillating screen 5-Outlet. 6- Blower
7- Grain discharge outlet. 8- Engine.



Distribution of the spike tooths on the threshing drum.

Fig. 1: A Schematic Diagram for the modifed threshing machine.

3-Three number of spike tooths of 10,20 and 30.
4-Four drum speeds of 5.5, 7.9, 10.5 and 14.4 m/s.(320,460,610and 840 r.p.m.).
5-Four concave clearances 9,11,14and 16 mm. and 16,18,20 and 22 mm. for threshing Cowpea and Kidney bean crops respectively.

Table(1): The technical specifications of the developed machine.

Item	Before modification	After modification
Total length, (mm)	2000	2000
Total height, (mm)	2100	2100
Total width, (mm)	1000	1000
Ac motor power,(kW).	3.75	3.75
Rotor shaft speed (r.p.m.)	1400	1400
Type of the drum	Spike tooth	Spike tooth
Length of the drum, (mm).	500	500
Diameter of the drum, (mm)	350	350
No. of the spike tooths	20	10 , 20 , 30
Length of drum spiders, (mm)	5	9
Diameter of the drum spiders, (mm)	10	15
Concave type	Perforated sheet metal of 3 mm thickness.	Perforated sheet metal of 3 mm thickness.
Hole diameter for screen: - Circle hole, mm -Rectangle holes, mm	11 ----------	11 cowpea 16 kidney bean crop. (11 and 7) cowpea (16 and 8) kidney bean crop.
Screen	Perforated sheet metal of 3 mm thickness.	Perforated sheet metal of 5 mm thickness.

Instruments and Measuring:

Speedometer was used to measure the threshing drum speed of the threshing machine. A stopwatch was used to measure the time required to any operation.

Three principal dimension of grains Cowpea and kidney bean (length, width and thickness) were measured by using the digital vernire caliper (according to Pappas et.al. 1988) for limited screen holes diameter were required to clean Cowpea and bean grains.

A germination test was carried out to determine the invisible damage in Cowpea and Kidney bean grains. Ten replicates of 50 grains of Cowpea and Kidney bean crops were germinated at Petri dishes on a paper filter covered with water and incubated at 20°C for 8 days. The obtained data was expressed as percentage of the original number of grains.

Machine performance:

Machine performance was estimated according to (Singh and Joshi 1980) as follow:

Unthreshed grains = (M_1/M_t) *100, %

Where: M_1= mass of unthreshed grains, Mg/m^2.

M_t = total mass of grains, Mg/m^2

Grain damage = (M_2/M_t) *100, %

Where: M_2 = mass of undamaged grains, Mg/m^2.

Grain losses = $(M_l / M_t) * 100$, %

Where: M_l =mass of losses, Mg/m^2.

Threshing efficiency = $(M_{th} / M_t) * 100$,%.

Where: M_{th} = mass of threshing grains(grain out put), Mg/m^2.

Quality of grains = (100 – visible damage) * 100, %.

Machine capacity = $(M_t / T) * 100$, Mg / h.

Where : T = the time consumed during threshing operation, h.

RESULTS AND DISCUSSION

A laboratory experimental was carried out on winnowing the Cowpea and Kidney bean grains to select the suitable holes for sieves . The rectangle holes[(11and 7 mm.) and (16and 8 mm.)for length and width] for the Cowpea and Kidney bean crops respectively were the preferable more than the circle holes.

The rectangular holes of concave (11 and 7 mm) and (16 and 8 mm) for cowpea and kidney bean crops were more effective on cleaning efficiency resulting values of 92.5, 94 % where under the circular holes (11 and 16 mm) for the two studied crops the cleaning efficiency not exceed than 80.2,85.6 %.

Influence of threshing parameters on the modified thresher performance:

The effect of drum speed, number of spike tooth and concave clearances on the total grain damage percentage (y_1)and unthreshed percentage (y_2) for the Cowpea and Kidney bean crops by using threshing machine are shown in Figs. 2 and 3.

It is clear that increasing drum speed and the number of spike tooth increase the total grain damage percentage (y_1) and decrease unthreshed grain percentage (y_2) under different concave clearances for Cowpea and Kidney bean crops.

The resultes indicated that the percentage of the total grain damage (Y1) decreased from 5.2 to 3.8 % and 4.1 to 2.3 % as the concave clearance increased from 9 to 16 mm and from 16 to 22 mm for cowpea and kidney bean crops respectively, at the drum speed 14.4 m/s and the number of spike tooths 30. However, unthresed grain percentages (Y2) increased from 1.91 to 5.24 % and from 2.21 to 4.94 %, as previous concave clearance increased for cowpea and kidney bean crops respectively, at the drum speed 5.5 m/s and the number of spike tooths 10.

At the same time, increasing drum speed from 5.5 to 14.4 m/s, increasd the total grain damage percentages of Cowpea crop by 28.85, 45.45, 47.62 and 50 % for concave clearances of 9,11,14and 16 mm, respectively, at the number of spike tooth 30, and increased the total grain damge percentages of Kidney bean crop by 26.83,36.84,46.88 and 60.87 % for concave clearances 16, 18,20 and 22 mm. respectively, at the same number of spike tooth 30.This may be attributed to high and more impact force applied to the pods on the stalks.

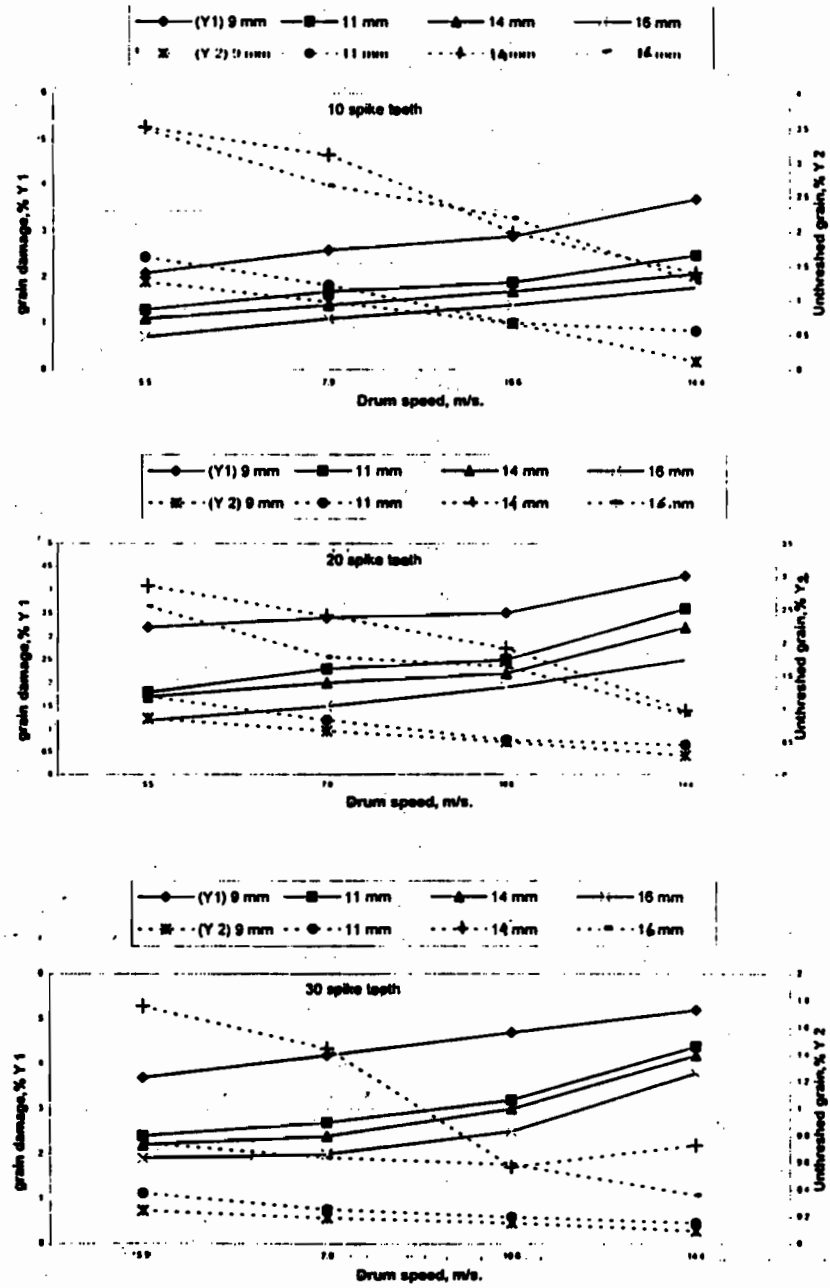


Fig.2: Effect of drum speed ,concave clearance and the number of spike teeth on the grain damage (Y1) and unthreshed grain (Y2) of Cowpea crop

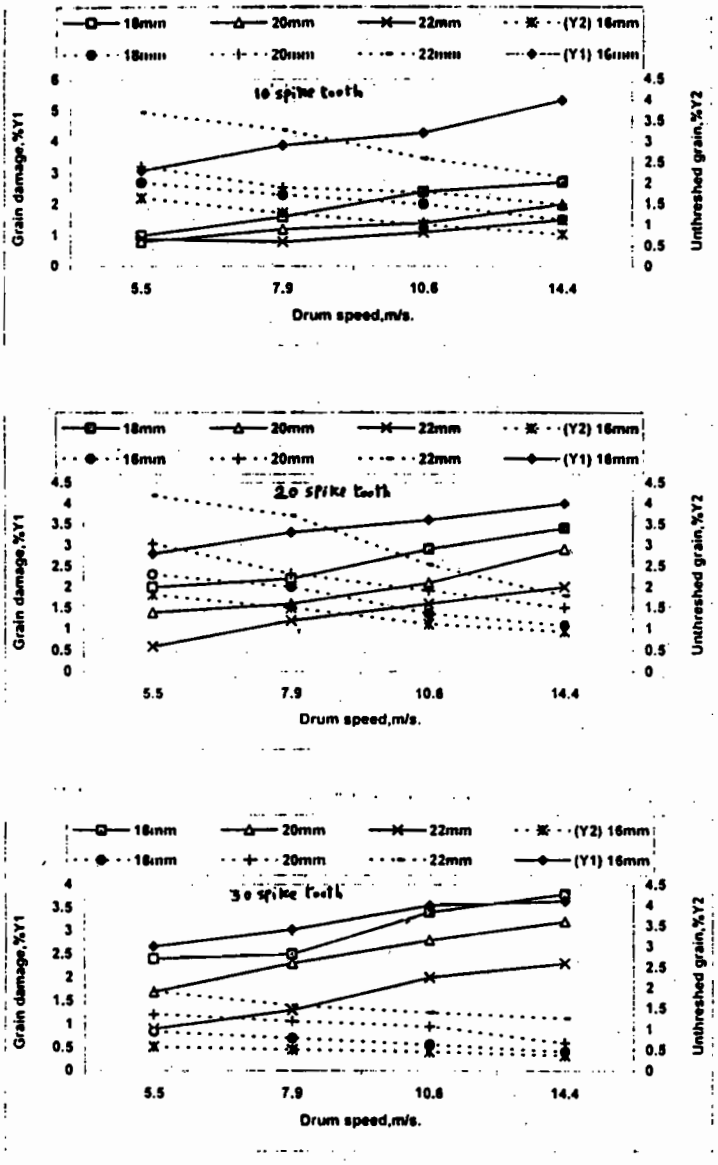


Fig.3: Effect of drum speed ,concave clearance and the number of spike teeth on the grain damage (Y1) and unthreshed grain (Y2) of kidney bean crop.

On the other hand, the number of spike tooths 30 gave the lowest values of the unthreshed grains (y_2) than that given by the other numbers of spike tooths. This tends to increase of impact forces imparted to the Cowpea and Kidney bean pods by the spike tooths of drum during threshing process.

Fig.4 shows the effects of drum speed and grain moisture content on the total grain damage (y_1) and grain losses percentage (y_2) for Cowpea and Kidney bean crops. The results indicated that increasing drum speed tends to increase the total grain damage percentage (y_1),whilst decrease the total grain losses percentage (y_2) for all grain moisture contents for Cowpea and Kidney bean crops.

The optimum drum speed was fall around 7.9 m/s at the best results of total grain damage (Y1) of (3.75 and 6.23 %) and losses percentage (Y2) of (2.45 and 4.58 %) for threshing cowpea and kidney bean crops respectively.

On the other hand, increasing drum speed from 5.5 to 14.4 m/s for grain moisture contents of 13.48 and 12.9% increased the total grain damage percentage (y_1)by 40.91 and 48.39% for threshing Cowpea and Kidney bean crops respectively and decreased the total grain losses percentage (y_2) by 26.32 and 27.27 %at the two above mentioned crops respectively.

The optimum grain moisture content was fall around 13.48 % and 15.21 % at the best results of the total grain damage (Y1) of (3.3 and 2.58 %) and losses percentage (Y2) of (4.78 and 4.38 %) for cowpea and kidney bean crops respectively.

The observations reported in Fig. 5 show the effect of drum speed and concave clearance on the machine capacity for threshing Cowpea and Kidney bean crops. The data revealed that increasing drum speed and concave clearance tends to increase the machine capacity for all treatments.

On the other words, the results indicated that increasing drum speeds from 5.5 to 14.4 m/s cause a corresponding increase in the machine capacity by 17.21, 16.09, 15.24 and 14.59 % at concave clearance of 9, 11, 14 and 16 mm respectively for Cowpea crop and by 23.29, 24.1, 20.54 and 23.83 % at concave clearance of 16,18,20 and 22 mm respectively for Kidney bean crop.

The highest threshing efficiency was 98.82 and 96.39 % at drum speed of 7.9 m/s and the number of spike tooths 30 for cowpea and kidney bean crops respectively. At the same time, the results indicated that the highest values of grain losses from straw outlet (0.47 and 0.39 %) was obtained at a drum peripheral speed of 5.5 m/s and (18.94 and 17.85 %)average moisture content for cowpea and kidney bean crops respectively.

At the same time, the data showed that increasing concave clearance form 9 to 16 mm cause a corresponding increase in the machine capacity by 15.83, 13.9, 12.88 and 13.17 % at the drum speed of 5.5, 7.9, 10.6 and 14.4 m/s respectively for Cowpea crop and by 20.32, 20.93, 15.86 and 20.88 % at the four above mentioned the threshing drum speeds respectively for Kidney bean crop.

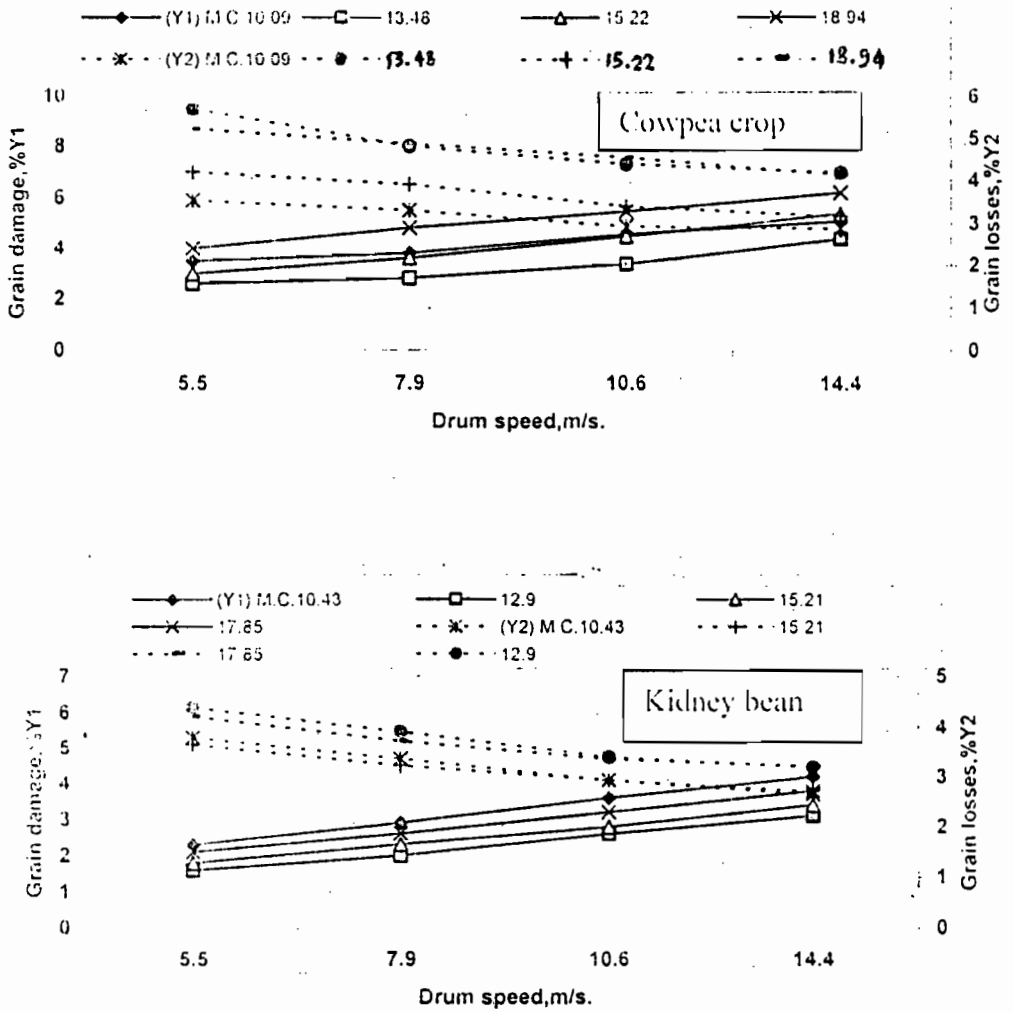


Fig.4: Effect of drum speed and grain moisture content on the grain damage (Y1) and grain losses (Y2) for cowpea and kidney bean crops.

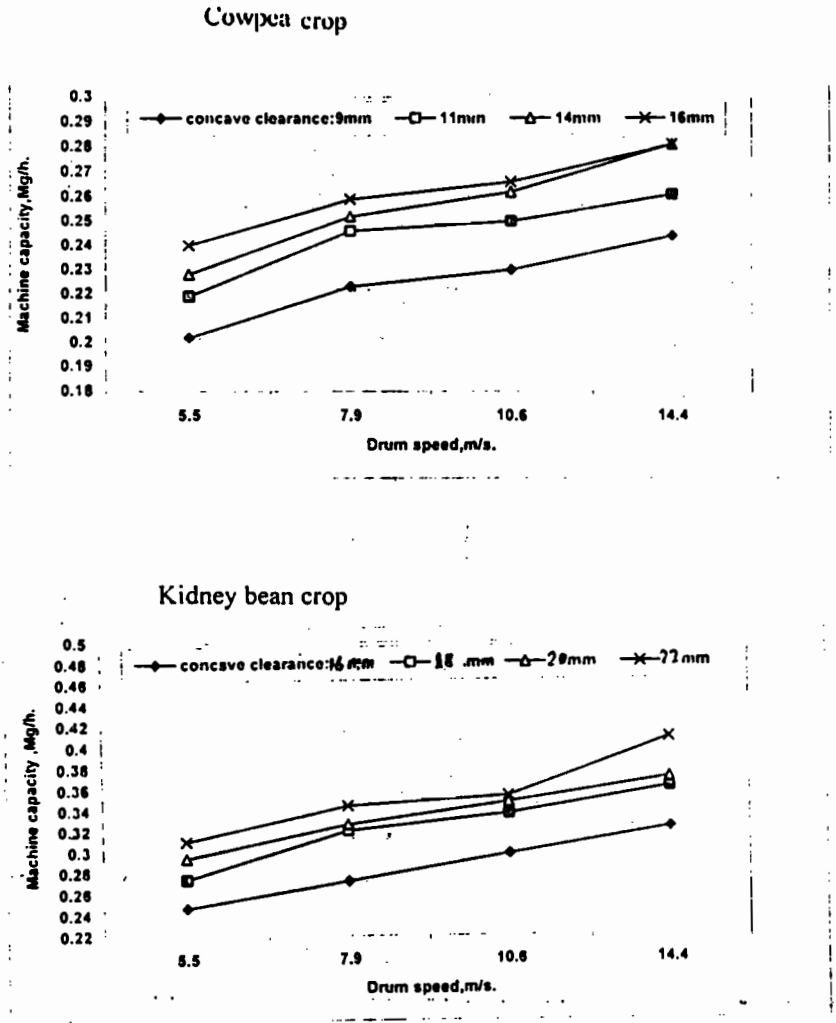


Fig.5: Effect of drum speed and concave clearance on the machine capacity for cowpea and kidney bean crops.

Threshing cost :-

The cost of threshing Cowpea and Kidny bean grains calculated according to declining - balance deprecation method (Metwalli,1984). At the best results by using 30 spike- tooths and 7.9 m/s drum speed at 13.48 and 12.9 % grain moisture content for Cowpea and Kidney bean crops respectively are presented (Table 2).

Table (2) : The cost of cowpea and kidney bean threshing.

		Cowpea crop	Kidney bean crop
Machine capacity	Mg./h	0.246	0.320
Total yield	Mg./fed.	1.5	2.0
Machine + labor cost	l.E./h.	9.1	9.1
Machine threshing cost	l.E./Mg.	36.99	28.44
Machine threshing cost	l.E./fed.	55.49	56.88
No. of labor needed for threshing /fed.		15	15
Labor cost l.E./fed.		10	10
Total manual threshing cost l.E./fed.		150	150

CONCULTION

The main results can be summarized as follows:-

* Using the rectangle holes of sieve [(11 and 7 mm) and (16 and 8 mm) for length and width] respectively gave the best results of cleaning efficiency compared with the circle holes (11and 16 mm) for cowpea and kidney bean crops respectively.

- Drum speed of threshing machine 7.9m/s and the number of spike tooths 30 gave the best results of total grain damage, unthreshed and losses percentages.

- The concave clearance 11 and 18 mm for cowpea and kidney bean crops respectively gave the best values of total grain damage, unthreshed and losses.

- Grain moisture content range of 10.09 to 13.48 % and 12.9 to 15.21 % for cowpea and kidney bean crops respectively gave the best results of total grain damage, unthreshed and losses.

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تطوير آلة بسيطة لدراس اللوبيا والفاصوليا

عبد المحسن لطفي – إبراهيم صلاح الدين يوسف وعصام واصف

باحث اول بمعهد بحوث الهندسة الزراعية – الدقى – الجيزة – مصر.

يعتبر محصولى اللوبيا والفاصوليا من أهم محاصيل الخضر في مصر . وتعتبر عملية الدراس لهذين المحصولين من أهم العمليات الزراعية التى تؤثر بشكل كبير على الانتاجية. وعلى الرغم من هذه الأهمية الا أن عملية الدراس تتم بطرق يدوية تتطلب الكثير من العمالة اليدوية المرتفعة الثمن وكذلك لفترة زمنية كبيرة مع زيادة نسبة الكسر والفقد فى المحصول.

لذا اللوبيا من أهم العمليات الزراعية والتي تؤثر بشكل كبير على إنتاجية المحصول والتي تتم عادة بالطرق اليدوية وهذه العملية تتطلب عدد كبير من العمال وفترة زمنية طويلة لإنجازها بالإضافة إلى زيادة الفاقد في المحصول . لذا كان الهدف من هذا البحث هو تطوير آلة دراس محصول اللوبيا وما يشابهها من محاصيل أخرى تناسب المزارع الصغيرة وتصنع من خامات محلية بسيطة وتكون قدرة تشغيلها قليلة بقدر الإمكان وبأقل معدل من الفاقد والتكاليف وتم إجراء البحث في مزرعة محطة البحوث الزراعية بالسرو – دمياط في نهاية الموسم الصيفي ٢٠٠٥ .

عوامل الدراسة :-

١- عدد أسنان درفيل الدراس (١٠ ،٢٠، ٣٠ سنة) وهى مرتبة على الدرفيل فى صفوف (٢،٤،٦) على التوالى بكل صف عدد ٥ أسنان .

٢- سرعة درفيل الدراس هى: ٤،٤،٦،١٠،٧،٩،٥م/ث (٨٤٠،٦١٠،٤٦٠،٣٢٠ لفة /دقيقة).

٣- خلوص الدراس لمحصول اللوبيا هى ١٦،١٤،١١،٩ مم ولمحصول الفاصولياهى ٢٢،٢٠،١٨،١٦:مم.

٤- نسبة الرطوبة بالحبوب لمحصول اللوبيا هى : ١٠,٠٩،١٣,٤٨،١٥,٢٢،١٨,٩٤ % ولمحصول الفاصولياهى : ١٠,٤٣،١٢,٩٠،١٥,٢١،١٧,٨٥ %

وقدأوضحت النتائج أن أفضل ظروف لتشغيل هذه الآلة فى دراس محصول اللوبيا هى استخدام درفيل دراس ذو عدد اسنان ٣٠ سنة فى ٦ صفوف مع خلوص الصدر ١١مم وسرعة درفيل الدراس ٧,٩ م/ث (٤٦٠ لفة /دقيقة) وذلك عند متوسط نسبة الرطوبة بالحبوب ١٣,٤٨%اما بالنسبة لمحصول الفاصوليا كانت افضل ظروف تشغيل لآلة الدراس المعدلة هى استخدام درفيل الدراس ذو عدد اسنان ٣٠ سنة فى ٦ صفوف مع خلوص الصدر ١٨ مم وسرعة درفيل الدراس ٧,٩ م/ث (٤٦٠ لفة/دقيقة) وذلك عند متوسط نسبة رطوبة بالحبوب ١٥,٢١ % حيث سجلت اقل نسبة فقد وكسر فى حبوب محصولى اللوبيا والفاصوليا وكذلك افضل استخدام للطاقة المستهلكة.

استخدام الآلة المعدلة خفضت التكاليف بنسبة ٦٣,٠١، ٦٢,٠٨ % بالنسبة لدراس محصولى اللبيا والفاصوليا على التوالى مقارنة بالطريقة التقليدية.