J. Agric. Sci. Mansoura Univ., 32 (2): 1129 - 1144, 2007

TESTING RESULTS OF A LOCALLY THRESHING AND CLEANING MACHINE FOR SOYBEAN CROP

El-Gayar, Safya M.
Agric. Eng. Res. Inst., (AEnRI). Giza.

ABSTRACT

This study was carried out during 2005 season at El-Gemmeza Agricultural Research Station, El-Garbia Governorate. The study aimed to identify the energy requirements for threshing and cleaning soybean. Factors studied were: three drum speeds (15.36, 17.49 and 19.63 m/s), three soybean plant feed rates (500, 660 and 825 kg/h) and two plant moisture contents (11.59 and 14.91% (W.b)). The effect of these factors on the machine capacity, machine productivity (cleaned seeds per hour), total energy requirements, specific energy requirements for threshing soybean plants (S_{EP}), specific energy requirements for threshing and cleaning soybean seeds (S_{ES}), threshing efficiency, cleaning efficiency, seed damage, thrown seeds with straw, total seed losses and specific threshing and cleaning costs were investigated.

The obtained results may be summarized as follows:

1- The highest machine capacity and machine productivity were 824.18 and 357.17 kg/h, respectively obtained under 19.63 m/s drum speed, 825kg/h feed rate and 11.59% plant moisture content.
2- The lowest total energy requirements of 19.68MJ was achieved using 15.36 m/s drum speed, 500 kg/h feed rate and 11.59% plant moisture content.
3- The lowest S_{EP} and S_{ES} were 30.7 and 72 MJ/ton for plants and cleaned seeds, respectively recorded at 15.36 m/s drum speed, 825 kg/h feed rate and 11.59% plant moisture content.
4- There were high significant differences between the drum speeds, the crop feed rates, plant moisture contents and interaction between these factors due to machine capacity, machine productivity, total energy requirements, S_{EP} and S_{ES}.
5- The highest threshing efficiency and cleaning efficiency of 98.37 and 98.59%, respectively reached using 19.63 m/s drum speed, 500 kg/h feed rate and 11.59% plant moisture content.
6- The lowest seed damage of 1.23%, thrown seeds with straw of 0.17%, and total seed losses of 4.13% were obtained using 15.36 m/s drum speed, 825 kg/h feed rate and 14.91% plant moisture content.
7- The lowest specific threshing and cleaning costs of 115.44 LE/ton was achieved using 19.63 m/s drum speed, 500 kg/h feed rate and 11.59% plant moisture content.

Finally, it is recommended to use this local machine to thresh and clean soybean plants because of its high productivity, low energy requirements, high seed quality and low specific threshing and cleaning costs.

INTRODUCTION

Soybean is a highly nutrition seed which was used as oil seed as well as a pro-teineous seed. It contents 13.5 - 24.2 % for oil and 29.6 - 50.3 % for protein (Aviara et al., 2004). In Egypt, the annual soybean cultivated area is about 34181 feddan that produced approximately 43.47 thousand tons of seeds (Ministry of Agriculture, 2005). The increase in soybean production is considered necessary in Egypt because it can participate in solving food and oil shortage production. While, it serves as an oil crop, artificial milk, soyflour and source of protein for human feeding. As well as animal feeding (Orthoefer and Liu, 1995 and Wilson, 1995).

The purpose of threshing is to recover the seeds free from residues with minimum losses. In Egypt, the traditional soybean threshing method is still carried out manually using simple tools. This method consumes more time and human energy, and costs higher labour wages. Mechanization of threshing is important because of saving the labour energy, operational time and seed losses. The Egyptian farmers use widely the conventional thresher for soybean. It produces high seed damage and seed losses.

There are some factors that affect the mechanical seed damage during threshing such as drum speed, feed rate and moisture content. Threshing and separation losses are usually nil if the thresher is adjusted properly. Threshing loss constitute un-threshed beans remaining in pods, damaged seeds and seed losses from straw outlet. Franceneto *et al.* (1985) recommended that the maximum acceptable soybean damage is 7 %.

The seed losses and mechanical damage is directly proportional to the drum speed (Mesquita, 1990; Mesquita and Hanna, 1993 II; Joshi et al., 1998 and Wright *et al.* 2002). Bartsch *et al.* (1986) indicated that soybean threshing at 15m/s produced seed damage. Moreover, Baiomy *et al.* (1999) found that as the drum speed increased from 10 to 16 m/s, the seed damage increased from 0.23 to 2.93 % and the total losses increased from 0.23 to 4.88%. While, Vejasit and Salokhe (2004) indicated that seed damage and seed loss at 15.4 m/s drum speed were 0.22 % and 0.80 %, respectively.

The seed feed rate affects seed damage and losses negatively. While, it is directly proportional to un-threshed seed (Joshi et al., 1998). Moreover, Vejasit and Salokhe (2004) indicated that the seed damage was 0.22% at 720 kg/h feed rate.

The average moisture content of fresh soybean is about 20-30%. Usually drying of harvested soybean is done naturally before threshing. The subsequent moisture content is reduced to about 12-15% (Tippayawong et al., 2003 and Lexion 2005). Mesquita 1990, Mesquita and Hanna 1993 I and Mesquita *et al*., 1999) concluded that seed damage and loss increased significantly as seed moisture content dropped from 13 to 8%. Abou El-Kheir (1991) indicated that the un-threshed seed losses was proportional with the increase of the seed moisture content. Wright *et al.* (2002) indicated that the drier the beans should keep bean damage to a minimum. As well as Fernado *et al.* (2004) observed that seed breakages of 0.35 to 1.11 % and seed coat damages of 11.8 % to 16.6 %. The mechanical damage increases drastically when the moisture content falls below 13.0 %.

However, there is a lack in the information about required threshing and cleaning energy for producing high soybean seed quality. On the other hand, many researches worked on threshing soybean concerning energy requirements such as Sharma and Devnani (1980); El-Behery (1995); Baiomy *et al.* (1999); and Mousa (2006). While, Vejasit and Salokhe (2004) estimated the power consumption for threshing soybean without estimating threshing and cleaning energy requirements.

The previous researchers estimated only energy requirements for threshing soybean not including cleaning energy requirements. Then, the present study aimed to determine the effect of machine operational parameters on machine performance, energy requirements, seeds quality and specific threshing and cleaning costs.

MATERIAL AND METHODS

Experimental procedure:

To fulfill the objective of this study, the experiments were carried out at the agricultural experimental farm of El-Gemmeza, during 2005 season. Soybean plants (Variety SAKHA 111) were harvested manually and dried naturally to moisture content of (11.59 and 14.91% w.b.).

A- Physical properties of soybean:

Five randomized samples were taken to determine some soybean seed physical properties in order to select concave holes as given in table (1):

1- Measuring the dimensions of three principal axes, namely: length (L), width (W) and thickness (T) in mm, was carried out using a micrometer reading to 0.01 mm.
2- Arithmetic mean diameter (D_a), calculated according to Mohsenin (1986) as follows:

$$D_a = (L + W + T)/3 \qquad mm \qquad (1)$$

3- Geometric mean diameter (D_g), calculated according to Mohsenin (1986) as follows:

$$D_g = (L * W * T)^{1/3} \qquad mm \qquad (2)$$

4- Surface area (S_a), calculated according to Mccabe *et al.* (1986) as follows:

$$S_a = \pi\ D_g^2 \qquad mm^2 \qquad (3)$$

5- Sphericity percent (S_p), calculated according to El-Raei *et al.* (1996) as follows:

$$S_p = (L * W * T)^{1/3}/L \times 100 \qquad \% \qquad (4)$$

6- Bulk density (B_d), calculated to classify the seeds according to quality by the ratio of weight to volume. The weight of seeds was obtained using an electric balance reading to 0.001 g. While, the volume of seeds was calculated according to El-Raei *et al.* (1996) as follows:

$$V = \pi/6\ (L * W * T) \qquad mm^3 \qquad (5)$$

Table1: some physical properties of soybean seeds (variety SAKHA 111):

Moisture content (%)	Length (mm)	Width (mm)	Thickness (mm)	Arithmetic diameter (mm)	Geometric diameter (mm)	Surface area (mm^2)	Sphericity percent (%)	1000 seed mass (g)	1000 seed specific weight kg.m/sec^2	Volume (mm^3)	Bulk density (g/cm^3)
11.59	6.42	5.31	4.24	5.32	5.25	86.59	81.78	119.25	1.17	75.68	1.58
14.91	6.64	5.47	4.35	5.49	5.41	91.95	81.48	121.59	1.19	82.73	1.47

B- Threshing and cleaning machine:

All experiments were conducted using local manufactured threshing and cleaning machine (ERDIREN-9) (figure1). T was selected depending on the physical seed properties as given in table (1). Nasr tractor 48.51 kW was used to operate the thresher. The thresher is overall dimensions 2.60 m length, 1.39 m width and 2.23 m height. Crop feeding is done manually through opening of 1.20 × 0.30 m. The thresher consists of:

1- Threshing unit: It consists of: Threshing drum of 1.12 m length and 0.38 m diameter is fitted with 36 trapezoidal flat knives shape, arranged in 9 lines and 0.13 m row spacing. The knives are: 0.45 m length, 0.06 m lower width, 0.14 m upper width and 0.009 m thickness. The drum rotates inside a perforated sheet concave of 0.003 m thick. It has round holes (0.015 m hole diameter). The drum – concave clearance was fixed to be 0.04 m.

2- Cleaning unit: It consists of: a sheet metal fan of 0.83 m diameter, 0.53 m width and 0.001 m thickness with six radial blades, the fan discharges air blast through the sieves. The peripheral fan speed is transmitted from the machine drum through belt with a reduction ratio 1: 2.5. A screen oscillating perforated metal sheet of 0.005 m thick hang on four adjustable link rods consists of two parallel screens, with a vertical spacing of 0.10 m. The upper screen for separating the impurities. The lower screen has two parts: the first part with 0.001 m diameter holes is for removing fine dust particles, and the second with 0.009 m diameter circular holes to pass the seed to spout.

Fig. 1: Threshing machine.

Studied factors:

In this research, the following factors were studied:

1- Thresher drum speed: the studied of drum speed were 720, 820 and 920 rpm (15.36, 17.49 and 19.36 m/s), respectively. It was measured using speedometer (accuracy 1 rpm).
2- Crop feed rate: the studied feed rates were 500, 660 and 825 kg/h.

3- Plant moisture content: The studied plant moisture contents were 11.59 and 14.91% (w.b.). It was determined according to AOAC (1990).

Measurements:

The required threshing and cleaning energy was estimated as follows:

A- Machine performance:

1- Machine capacity (M_c): It was calculated as follows:

$$M_c = W_t / T \qquad \text{kg/h} \qquad (6)$$

Where:

W_t = weight of total sample before threshing, kg.

T = the time consumed in the operation, h.

The sample was weighed using a spring balance 100 kg limit and 0.1 kg accuracy and the time elapsed was measured using a stopwatch (0.01 sec. accuracy).

2- Machine productivity (cleaned seeds per hour) (M_p): It was calculated as follows:

$$M_p = W_c / T \qquad \text{kg/h} \qquad (7)$$

Where:

W_c = weight of the cleaned seeds output, kg

B- Energy requirements:

1- Fuel consumption (F_c), during the operations was determined by measuring the consumed diesel fuel by refueling the tractor tank using a graduated cylinder.

2- Mechanical power requirements (P_r): the fuel consumption was converted to power by using the following equations:

$$Pr = (F_c \times \frac{1}{60 \times 60}) \times \rho_f \times L.C.V. \times 427 \times \eta_{th} \times \eta_m \times \frac{1}{75} \times \frac{1}{1.36} \text{ kW} \qquad (8)$$

$$= 3.163 \times F_c$$

Where:

F_c = fuel consumption rate, L/h

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

L.C.V. = Lower calorific value of fuel, kcal/kg (10000 kcal/kg)

427 = Thermo – mechanical equivalent (kg.m/kcal).

η_{th} = Thermal efficiency of the engine (40% for diesel engine)

η_m = Mechanical efficiency of the engine (80% for diesel engine).

3- Human power requirements. (H_E): According to chancellor (1981), the human power, was estimated based on the power of one labor, which was considered to be about 0.0746 kW.

Then, the human power is determined using the following equation:

$$H_E = 0.0746 \times N_L \qquad \text{kW} \qquad (9)$$

Where:

N_L = number of laborers, man

The power requirements for threshing and cleaning operations (P_T) were estimated by adding the mechanical power requirements and human power requirements.

4- Total energy requirements (T_E): it was estimated as follows:

$$T_E = 3.61 \times P_T \times T \qquad \text{MJ} \qquad (10)$$

Where:

3.61 = coefficient for changing from kW.h to MJ.

5- Specific energy requirements for threshing soybean plants (S_{EP}): It was estimated as follows:

$$S_{EP} = 3.61 \times P_T/M_C \qquad \text{MJ/ton plants} \qquad (11)$$

6- Specific energy requirements for threshing and cleaning soybean seed (S_{ES}): It was estimated as follows:

$$S_{ES} = 3.61 \times P_T/M_P \qquad \text{MJ/ton cleaned seeds} \qquad (12)$$

C- Seed qualities:

The following measurements were carried out to determine the threshed and cleaned seeds quality:

1- Seed damage (S_d): it was sorted manually and weighed. S_d was measured by the following formula:

$$S_d = W_b/ W_s \times 100 \qquad \% \qquad (13)$$

Where:

W_b = weight of the seed damage in the sample, kg.

W_s = weight of the total seeds, kg

2- Un-threshed seed (U_s): It was measured by the following formula.

$$U_s = W_U / W_s \times 100 \qquad \% \qquad (14)$$

Where:

W_u = Weight of un-threshed seed in the sample, kg

3- Threshing efficiency (η_{th}): It was calculated as follows:

$$\eta_{th} = 1 - U_s \qquad \% \qquad (15)$$

4- Thrown seeds with straw (T_s): It was measured by the following formula:

$$T_s = W_{th} / W_s \times 100 \qquad \% \qquad (16)$$

Where:

W_{th} = weight of thrown seeds with straw, kg

5- Total seed losses (T_L): It consists of seed damaged, un-threshed seed and thrown seeds with straw. It was measured by the following formula:

$$T_L = S_d + U_s + T_s \qquad \% \qquad (17)$$

6- Cleaning efficiency (η_{cl}): It was measured as follows:

$$\eta_{cl} = (W_c / W_s) \times 100 \qquad \% \qquad (18)$$

D- Specific threshing and cleaning costs (S_c)

1- Total cost (T_c): it was performed considering conventional method of estimating both fixed and variable costs, according to price of 2005. The fixed cost was calculated according to ASAE (1998) as follows:

$$F_c = (P - 0.1\,P) / E + [(P + 0.1P)/2]\,(i) / E + 0.2P \qquad \text{LE/h} \qquad (19)$$

Where:

F_c = fixed cost, LE/h; P = purchase price, LE; E = machine life, years; i = interest rate, %.

The variable cost including repair and maintenance; fuel cost, labor cost and grease and daily services were calculated using the following assumptions:

Repair and maintenance cost = 90% of depreciation, fuel cost (LE/h) = fuel consumption (L/h) × price (LE), labor cost (LE/h) = wage × number of labor; grease and daily services = 1% of the (P).

2- The specific threshing and cleaning cost (S_c): it was calculated according to the following formula:

$$S_c = T_c / M_p \qquad \text{LE/ton} \qquad (20)$$

Statistical analysis:

The obtained data of machine capacity, machine productivity, total energy requirements, S_{EP} and S_{ES} were analyzed statistically as factorial experimental design in 3 replicates. L.S.D. test at 0.10 was carried out to compare the difference between the mean of the treatments.

Regression and correlation analysis:

For each one of the moisture contents, the multiple regression and correlation analysis was carried out using microstate computer program to represent the relations between threshing drum speed and crop feed rate and machine capacity, machine productivity, total energy requirements, S_{EP} and S_{ES}.

RESULTS AND DISCUSSION

The obtained data of machine performance, energy requirements, seeds quality and specific threshing and cleaning costs were presented and discussed as follows:

1- Machine performance:

a- Machine capacity:

Figure (2) Shows that the machine capacity is positively proportional with the drum speed and plant feed rates. While, it is negatively proportional with plant moisture contents. From the figure, it was found that the higher machine capacity of 824.18 kg/h was obtained with drum speed of 19.63 m/s under feed rate of 825 kg/h at moisture content of 11.59%. While, the lower machine capacity of 454.54 kg/h was obtained with drum speed of 15.36 m/s under feed rate of 500 kg/h at moisture content of 14.91%. It can be concluded that the machine capacity increases with increase drum speed. It is due to the increased amount of the threshed material per unit time as the higher drum speed. Moreover, increasing the feed rate increases machine capacity, that's due to increase the layer thickness of soybean plants, resulting in threshing more amount of soybean plants per unit time. While, decreasing the moisture content increases machine capacity, that's due to decreasing elasticity for the threshed material and consequently decreases the friction coefficient which causes easy motion in threshing chamber.

The analysis of variance indicated that there were high significant differences between the drum speeds, the crop feed rates, the plant moisture contents, and the interaction between these factors due to machine capacity. The L.S.D. test revealed that 19.63 m/s drum speed, 825 kg/h feed rate and 11.59 % plant moisture content gave the highest machine capacity among the other treatments.

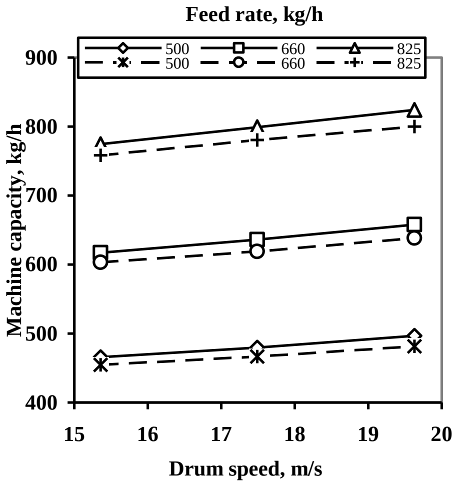
The multiple regression and correlation analysis show that the relation between machine capacity (y), drum speed (x_1) and crop feed rate (x_2) may be represented as follows:

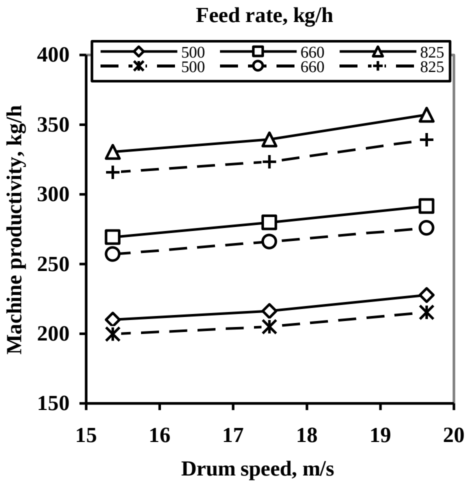
$Y = 9.48\ x_1 + 0.98\ x_2 – 173.09 \quad R^2_{yx1x2} = 0.9997$ at 11.59% m.c. (21)

$Y = 8.15\ x_1 + 0.96x_2 – 155.41 \quad R^2_{yx1x2} = 0.9998$ at 14.91% m.c. (22)

b- Machine productivity (cleaned seeds per hour):

It is considered a very important indicator for threshing and cleaning operation. The presented data in figure (3) clear that there is a positive relation between the machine productivity and both the drum speed and feed rate. While, there is a negative relation between the machine productivity and plant moisture content. As the drum speed increased from 15.36 to 19.63 m/s, the machine productivity increased to 8.32, 8.22 and 8.08% using feed rates of 500, 660 and 825 kg/h, respectively at a moisture content of 11.59%. While, the corresponding values of the increase in the machine productivity were 7.82, 7.30 and 7.42% at the previous feed rates with the moisture content of 14.91%. It can be indicated that the machine productivity increases with the increase in drum speed.





N.B. —— = Mc 11.59 % ----- = Mc 14.91 %

Fig. 2: Effect of drum speed on machine capacity under different feed rates at different moisture contents.

Fig 3: Effect of drum speed on machine productivity under different feed rates at different moisture contents.

This is because the knives impact action is directly proportional to drum speed, which subsequently reduces consumed time for threshing and increased the amount of threshed seeds. In case of the increased feeding rate, more amount of the pods was subjected to the knife action per unit time. So, it is logic that the increased pods feeding rate produce more amount of seeds per unit time. While, machine productivity decreased by increasing moisture contents which leads to increasing the friction resistance between the pods and threshing chamber. This effect retards its movement in the threshing chamber and increase the repose time.

The analysis of variance indicated that there were high significant differences between the drum speeds; the crop feed rates, the moisture contents and the interaction between these factors due to machine productivity. The L.S.D. test showed that 19.63 m/s drum speed, 825 kg/h feed rate and 11.59% moisture content gave the highest machine productivity among the other treatments.

The multiple regression and correlation analysis show that the relation between machine productivity (y), drum speed (x_1) and crop feed rate (x_2) may be represented as follows:

$Y = 5.18 x_1 + 0.39 x_2 – 66.31$ $R^2_{yx1x2} = 0.9992$ at 11.59% m.c. (23)

$Y = 4.52 x_1 + 0.37 x_2 – 55.73$ $R^2_{yx1x2} = 0.9993$ at 14.91% m.c. (24)

2- Energy requirements:

a- Total energy requirements:

Figure (4) reveals that the total energy requirements are directly proportional with the drum speed, feed rate and plant moisture content. As the drum speed increased from 15.36 to 19.63 m/s the total energy requirements increased with 22.05 , 19.51 and 16.81 % and 22.63, 19.91 and 17.18 % using feed rates of 500, 660 and 825 kg/h at 11.59 and 14.91 % moisture contents, respectively. On the other hand, as the feed rate increased from 500 to 825 kg/h the total energy requirements increased with 20.88, 22.56 and 15.70 % and 22.63, 24.05 and 17.18 % using drum speeds of 15.36, 17.49 and 19.63 m/s at the previous moisture contents. From the data, the effect of the increase in knives speeds regarding its impact action must either cut the pods or move it on the concave circular path. This movement must charge the threshed pods with a centrifugal force proportional to the peripheral speed. This effect will increase the frictional resistant of the pods against both the knives and the concave surface. This effect will result in higher energy requirements. In addition the increase of the material in the threshing chamber, which may increase the load on the thresher due to increase in the feeding rate. Then, more energy will be needed to overcome friction between pods and both the knives and the concave surface. Moreover, increasing the plant moisture content increase energy requirements, that's due to increase plant surface moisture content would increase material coefficient of kinetic friction on metal surface of threshing chamber and among particles.

The analysis of variance indicated that there were high significant differences between the drum speeds, the crop feed rates, the moisture contents and the interaction between these factors due to total energy requirements. The L.S.D. test showed that 19.63 m/s drum speed, 825 kg/h feed rate and 14.91% moisture content gave the highest total energy requirements among the other treatments.

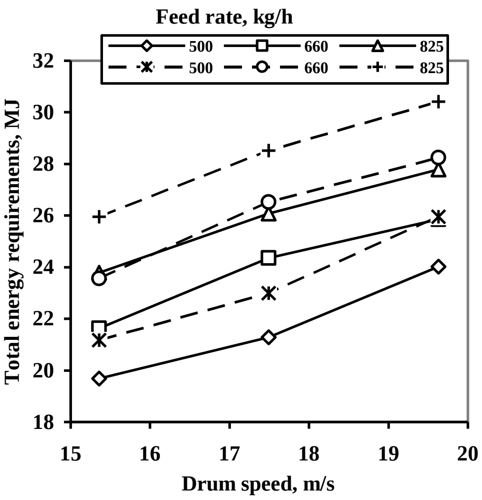
The multiple regression and correlation analysis show that the relation between total energy requirement (y), drum speed (x_1) and crop feed rate (x_2) may be represented as follows:

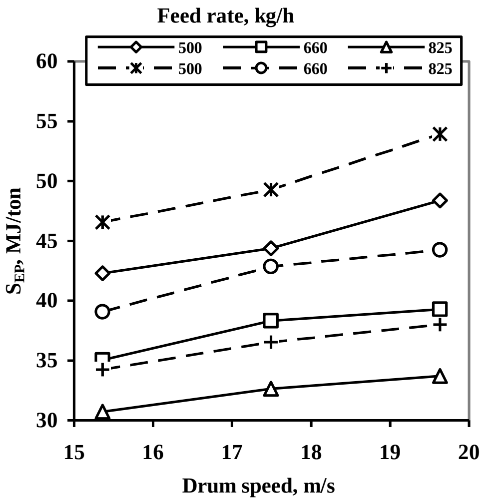
$Y=0.98x_1 + 0.013 x_2 -1.92$ $R^2_{yx1x2} = 0.9940$ at 11.59% m.c. (25)

$Y=1.09x_1 + 0.015 x_2 -3.14$ $R^2_{yx1x2} = 0.9943$ at 14.91% m.c. (26)

b- Specific energy requirements for threshing soybean plants (S_{EP}):

Figure (5) shows that S_{EP} is directly proportional to the drum speed. This may be mainly due to the increased knife impacts per unit time, resulting in: greater force for striking pods and may increase friction coefficient of pods against the metal surface of threshing chamber. Also, the plant moisture content related positively with S_{EP}. This may be due to the rate of increasing the total energy requirements is higher than that of machine capacity when increasing the plant moisture content from 11.59 to 14.91%. While, S_{EP} is inversely proportional with the feed rate where, at the higher feeding rate, the required energy for threshing a unit plant weight was less than the corresponding one of the low feeding rate due to the rate of increase of the total energy requirements is lower than that of machine capacity when increasing the feed rate from 500 to 825 kg/h. As the drum speed increased from 15.36 to 19.63 m/s the S_{EP} increased with 14.43, 12.10 and 9.80 % and15.78, 13.23 and 11.01% using feed rates of 500, 660 and 825 kg at 11.59 and 14.91% moisture contents, respectively. On the other hand, as the feed rate increased from 500 to 825 kg/h the S_{EP} decreased with 27.37, 26.46 and 30.30% and 26.48, 25.85 and 29.51% using drum speeds of 15.36, 17.49 and 19.63 m/s at the previous moisture contents.





N.B. —— = Mc 11.59 % ----- = Mc 14.91 %

Fig. 4: Effect of drum speed on total energy requirements under different feed rates at different moisture contents.

Fig 5: Effect of drum speed on S_{EP} under different feed rates at different moisture contents.

The analysis of variance indicated that there were high significant differences between the drum speeds, the crop feed rates, the plant moisture contents and the interaction between these factors due to specific energy requirements for threshing soybean plants. The L.S.D. test revealed that 19.63 m/s drum speed, 500 kg/h feed rate and 14.91% plant moisture content gave the highest S_{EP} among the other treatments.

The multiple regression and correlation analysis show that the relation between S_{EP} (y), drum speed (x_1) and crop feed rate (x_2) may be represented as follows:

$Y=1.04x_1 - 0.039\ x_2 +45.81$ $R^2_{yx1x2} = 0.9871$ at 11.59% m.c. (27)

$Y=1.27x_1 - 0.042\ x_2 +48.28$ $R^2_{yx1x2} = 0.9885$ at 14.91% m.c. (28)

C- Specific energy requirements for threshing and cleaning soybean seeds (S_{ES}):

Figure (6) reveals S_{ES} is directly proportional to the drum speed and plant moisture content. The total energy requirements is higher than that of machine productivity when increasing the drum speed from 15.36 to 19.63 m/s and the plant moisture content from 11.59 to 14.91%. While, S_{ES} is inversely proportional to the feed rate due to the rate of increase of the total energy requirements is lower than that of machine productivity when increasing the feed rate from 500 to 825 kg/h as indicated in figures 3 and 4. As the drum speed increased from 15.36 to 19.63 m/s the S_{ES} increased with 12.66, 10.46 and 8.07% and 13.76, 11.71 and 9.06% using feed rates of 500, 660 and 825 kg/h at 11.59 and 14.91% moisture contents, respectively. On the other hand, as the feed rate increased from 500 to 825 kg/h the S_{ES} decreased with 23.13, 21.93 and 26.26% and 22.44, 21.35 and 25.64% using drum speeds of 15.36, 17.49 and 19.63 m/s at the previous moisture contents.

The analysis of variance indicated that there were high significant differences between the drum speeds, the crop feed rates, the plant moisture contents and the interaction between these factors due to specific energy requirements for threshing and cleaning soybean seeds. The L.S.D. test revealed that 19.63 m/s drum speed, 500 kg/h feed rate and 14.91% plant moisture content gave the highest S_{ES} among the other treatments.

The multiple regression and correlation analysis show that the relation between S_{ES} (Y), drum speed (x_1) and crop feed rate (x_2) may be represented as follows:

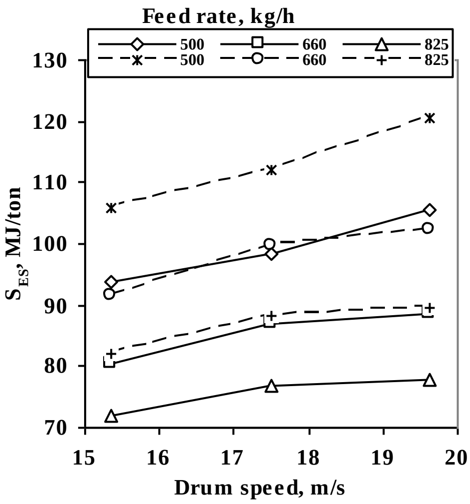
$Y=2.03x_1 - 0.073\,x_2 +99.02$ $\quad R^2_{yx1x2} = 0.9863$ $\quad$ at 11.59% m.c. (29)

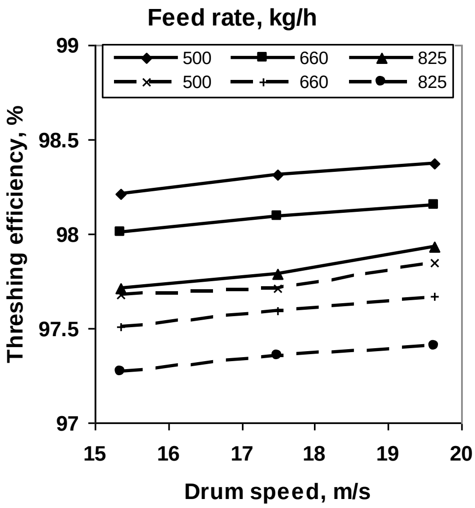
$Y=2.53x_1 - 0.081\,x_2 +107.73$ $\quad R^2_{yx1x2} = 0.9876$ $\quad$ at 14.91% m.c. (30)

3- Seed quality:

a- Threshing efficiency:

Figure (7) shows the effect of drum speed on threshing efficiency. As the drum speed increased the threshing efficiency increased. This was logic because of the increased impact action of the knives on the threshed material which acts the pods of the soybean and charge the seeds.





N.B. —— = Mc 11.59 % ----- = Mc 14.91 %

Fig 6: Effect of drum speed on S_{ES} under different feed rates at different moisture contents.

Fig 7: Effect of drum speed on threshing efficiency under different feed rates at different moisture contents.

The high threshing efficiency of 98.37% was reached at 19.63 m/s drum speed, 500 kg/h feed rate and 11.59% moisture content. While, a low threshing efficiency of 97.27% was recorded using 15.36 m/s drum speed, 825 kg/h feed rate and 14.91% moisture content. From the results, there are inversely relation between threshing efficiency and feed rate. It is due to the crop thin layer at the low feed rate which increased the probability of threshing more seeds in time unit.

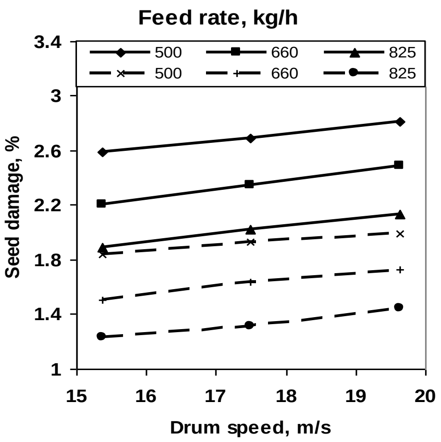
Moreover, the threshing efficiency decreased with increasing moisture content. It is because decreasing the moisture content leads to minimize the layer thickness and the log of pods to the impact action decreased.

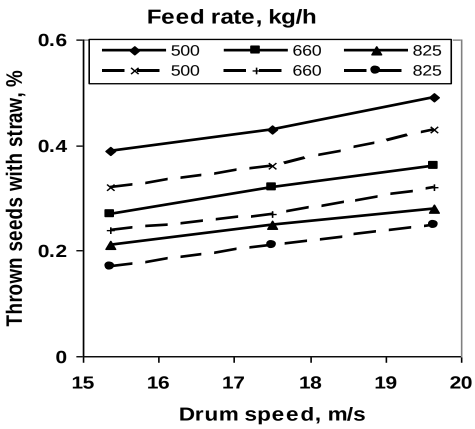
b- Seed damage:

Figure (8) reveals that the seed damage is directly proportional with the drum speed. It is due to the higher knife impacts, consequently, increased the damaged seeds. In addition, the seed damage relate positively to feed rate. It is due to the increased crop layer thickness which leads to the excessive plants in the threshing chamber which saves seeds from impacting forces. Moreover, the seed damage is inversely proportional with the moisture content. At the high seed moisture content, the cohesive forces between the seed molecules and together the probability for damage during threshing. From the figure, it was found that the high seed damage of 2.81 % reached using 19.63 m/s drum speed, 500 kg/h feed rate and 11.59 % moisture content. While, the low seed damage of 1.23% was noticed using 15.36 m/s drum speed, 825 kg/h feed rate and 14.91% moisture content.

c- Thrown seeds with straw:

Figure (9) indicates that thrown seeds with straw is related positively to the drum speed. This is due to increased fan air speed, which was related to drum speed and that increase thrown seed with straw.





N.B. —— = Mc 11.59 % ----- = Mc 14.91 %

Fig 8: Effect of drum speed on seed damage under different feed rates at different moisture contents.

Fig 9: Effect of drum speed on thrown seeds with straw under different feed rates at different moisture contents.

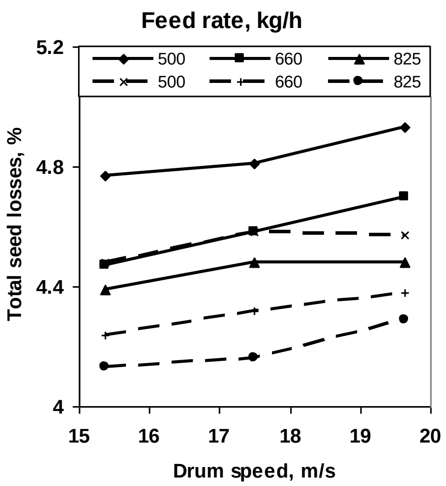
Data in the figure indicate the low threshed seeds per unit time which have lower specific weight, consequently the probability of thrown seeds increased. From the results, it was found that the high thrown seeds with straw of 0.49% was reached at 19.63 m/s drum speed, 500 kg/h feed rate and 11.59% moisture content. While, the low thrown seeds with straw of 0.17% at 15.36 m/s drum speed, 825 kg/h feed rate and 11.59% moisture content.

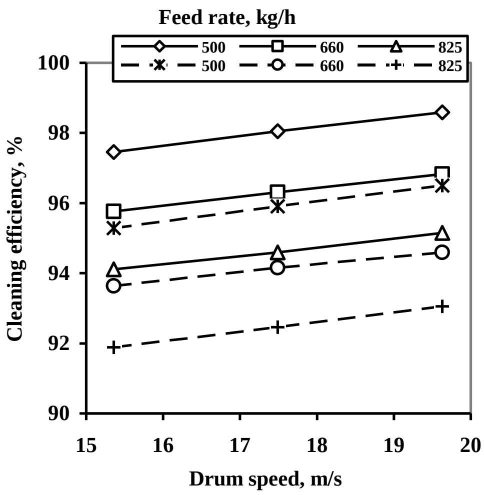
d- Total seed losses:

The most critical indicator in selecting optimum operating parameters is total seed losses. Test results indicated total seed losses was from 4.13 to 4.93% for the range of variables studied (figure 10). It is clear that total seed losses consist of seed damage, un-threshed seeds and thrown seeds with straw, with any change in them causing change in total seed losses. It was resulted to the excessive load of plant on the knives and the high impact of knives with plants, lead to increase the percentage of seed damage and decrease the percentage of un-threshed seeds, subsequently increase drum loss.

e- Cleaning efficiency:

Figure (11) indicates that the cleaning efficiency is related positively to the drum speed. Since, increased fan speed is related to drum speed that causes, increase in the amount of air to give more chance to discharge the straw and impurities from the threshed seeds. Whereas, the cleaning efficiency is inversely proportional with the feed rate. This attributed to the excessive threshed seeds which is objective to fan air that is not enough to separate straw and impurities from the threshed seeds.





N.B. —— = Mc 11.59 % ----- = Mc 14.91 %

Fig 10: Effect of drum speed on total seed losses under different feed rates at different moisture contents.

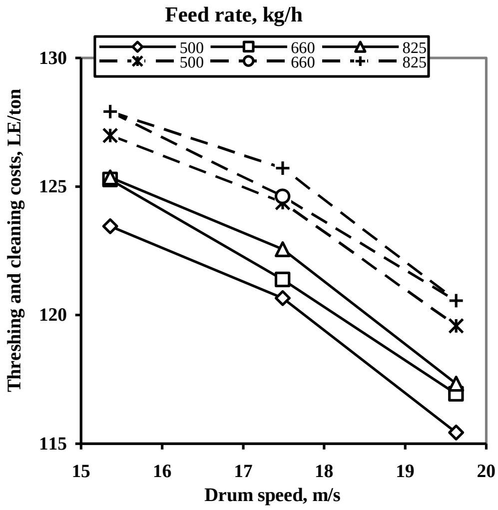
Fig 11: Effect of drum speed on cleaning efficiency under different feed rates different moisture contents.

Moreover, the increase of the moisture content, the cleaning efficiency decrease due to high moisture content of pods which will increase holding of seeds. From the figure, the high cleaning efficiency of 98.59% was obtained at

19.63 m/s drum speed, 500 kg/h feed rate and 11.59% moisture content. While, the least cleaning efficiency of 91.89% was reached using 15.36 m/s drum speed, 825 kg/h feed rate at 14.91% moisture content.

4- Specific threshing and cleaning costs:

This is an important indicator for selecting the optimum system for soybean threshing and cleaning. Figure (12) reveals the effect of the drum speed on the specific threshing and cleaning costs. It is due to the high values of machine productivity which are accompanied with low values of specific threshing and cleaning costs per unit weight of soybean plants. From the results, it was found that the high specific threshing and cleaning costs of 127.91 LE/ton was obtained with drum speed of 15.36 m/s using feed rate of 825 kg/h at plant moisture content of 14.91%. Meanwhile, the lower specific threshing and cleaning costs of 115.44 LE/ton was reached with drum speed of 19.63 m/s using feed rate of 500 kg/h at plant moisture content of 11.59%.



N.B. —— = Mc 11.59 % ----- = Mc 14.91 %

Fig 12: Effect of drum speed on specific threshing and cleaning costs under different feed rates at different moisture contents.

CONCLUSION

A local machine was used to thresh and clean soybean plants. The machine performance, energy requirements, seeds quality and specific threshing and cleaning costs were evaluated. The tested parameters were drum speed, feed rate and plant moisture content. The obtained results could be concluded as follows:

1- The threshing drum speed related positively with machine capacity, machine productivity (cleaned seed per hour), total energy requirements specific energy requirements for threshing soybean plants, (S_{EP}), specific energy requirements for threshing and cleaning soybean seeds (S_{ES}), threshing efficiency, cleaning efficiency, seed damage, thrown seeds with straw and total seed losses. While, it is affected inversely with the specific threshing and cleaning costs.

2- The crop feed rate affected positively the machine capacity, machine productivity, total energy requirements and specific threshing and cleaning costs. While, it is related negatively with S_{EP}, S_{ES}, , threshing efficiency, seed damage, thrown seeds with straw, total seed losses and cleaning efficiency.
3- The plant moisture content affected inversely the machine capacity, machine productivity, , threshing efficiency, seed damage, thrown seeds with straw, total seed losses and cleaning efficiency. While, it is related positively with the total energy requirements, S_{EP}, S_{ES} and specific threshing and cleaning costs.

REFERENCES

Abo EL-Kheir, M.M. (1991) "Effect of Some Factors on Threshing Performance of Soybean" Misr. J. Ag. Eng., 8 (3): 172 – 181.

AOAC, (1990) "Official Methods of Analysis" (15th Ed.), Association of Official Analytical Chemists, Washiungton, DC.

ASAE, (1998) "Thermal Properties of Grain and Grain Products" ASAE standards, 62th Ed. D262. I. St. Joseph, MI.

Aviara, N.A.; O.O. Ajibola and S.A. Oni (2004) "Sorption Equlibrium and Thermodynamic Characteristics of Soybean" Biosystems Engi. 87 (2) 179-190.

Baiomy, M.A.; H.A. Alaa; I. Yehia and E.M. Arif (1999) "Performance of AMRI and Gabr Threshers for Soybean" Misr, J. Ag. Eng., 16 (4): 340-350.

Bartsch, J.A., C.G. Haugh, K.L. Athow and R.M. peart (1986) "Impact Damage to Soybean seed" Trans; of the ASAE 29 (2): 582 – 586.

Chancellor, W.J. (1981) "Substituting Information for Energy in Agriculture" Trans. of the ASAE, (5): 802 – 807.

El-Behery, A.A. (1995) "Development and Evaluation of Multi – Crop Thresher" thesis of Ph D. Agronomy and Agric. Mech. Dept. Fac. Of Agric. Moshtohoy, Zagazig Univ.

El-Raie, A.E., N.A. Hendawy and A.Z. Taib (1996) "A study of Physical and Engineering Properties for Some Agricultural products. Misr, J. Ag. Eng., 13 (1): 211-236.

Fernando, S.; M. Hanna and C. Mesquita (2004) "Soybean Threshing Mechanism Development and Testing" Trans of the ASAE 47 (3): 599 – 605.

Francanets, J.B.; L.A.G Pereia and N.P. Costa (1985) "Diagnostico Completo da qualidade da semente de saja" EMBRAPA. Londrina, Brazil: Natl. Center for soybean Research.

Joshi, A.; T. Guruswamy; S.R. Deasi and T. Basavaraj (1998) "Effect of cylinder Speed and Feed Rate on the Performance of Thresher" J. of Agric. Sci. 11 (4) 1120 – 1123.

Lexion, T.M. (2005) "Soybean harvesting" Univ. of Arkansas Cooperative Extension service 2301, USA.

Mccabe, W.L.; J.C. Smith and P. Harriott (1986) "Unit Operations of Chemical Engineering" Mc Graw-Hill Bock company, New York.

Mesquita, C. M. (1990) "Mechanics of soybean threshing nul. edu/diss., Nebraska Univ., Lincoln.

Mesquita, C.M. and M.A Hanna (1993 I) "Soybean Threshing Mechanics: I Frictional Rubbing by Flat Belts" Tran. of the ASAE Vol. 36 (2). 275 – 279.

Mesguita, C.M. and M.A. Hanna (1993 II) "Soybean Threshing Mechanics: II Impact" Trans. of The ASAE vol. 36 (2) 281-284.

Mesquite, C.M.; N.P Costa; J.E. Pereira; A.C. Maurina and J.G.M. Andrade (1999) "Mechanical Harvesting of Soybeans: Evaluation of Losses and Grain Physical Quality" Engenharia Agricola 18 (3) 44-53.

Ministry of Agric. and Land Reclamation (2005) "Economic Affairs sector (EAS)" Agric. Statistics vol. 2 147 – 148.
Mohsenin, N.N. (1986) "Physical Properties of Plant and Animal Materials" Gordan and Beach science publishers, New York.
Mousa, A.L. (2006) "The Effect of Selected Mechanical Threshing Parameters on Threchability of Some Legume Crops" J of Agric. Sci. Mansoura Univ., 31 (7) 223 – 242.
Orthoefer, F. and K.S. Liu (1995) "Soybeans for food uses" Int/ food Marketing & Technol. 9 (4) : 4 – 8.
Sharma, K.D. and R.S. Devnani (1980) "Threshing Studies on Soybean and Cowpea" AMA 33 (2) 65 – 68.
Tippayawong, N.; A. Pittayapak and W. Jompackdee (2003) "Analysis of Energy Requirement for vegetable oil production in Northern Thailand's farms" chiang Mai Univ., J. vol 2 (1) 37 – 47.
Vejasit, A. and V.M. Salokhe (2004) "Studies on Machine – crop parameters of an Axial flow thresher for threshing soybean" Agric. Eng. Int. J. of Scientific Res. And Development.
Wilson, L.A. (1995) "Soy foods" In Practical Hand Book of Soybean Processing and Utilization. D.R. Erickson (Ed.) AOAC press, champaign, IL., PP. 428 – 459.
Wright, D.L.; J.R. Rich; J.J. Marois and R.K. Sprenkel (2002) "Soybean production in Florida" Institute of Food and Agric. Scin. Univ. of Florida, Gainesville, Florida, 32611, 1 : 10.

نتائج إختبار آلة محلية لدراس وتذرية محصول فول الصويا

صفية مصطفى أحمد الجيار
معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – الجيزة.

أجريت هذه الدراسة بمحطة البحوث الزراعية بالجميزة – مركز البحوث الزراعية – محافظة الغربية خلال موسم 2005م وذلك لتقدير طاقة الدراس والتذرية اللازمة لإنتاج بذور فول الصويا عالية الجودة، وقد استخدمت آلة محلية الصنع لدراس وتذرية فول الصويا وتم تقييم معدل إنتاجيتها واحتياجات الطاقة لتلك الآلة وجودة البذور المدروسة والتكلفة النوعية للدراس والتذرية وكانت عوامل الدراسة: سرعة إسطوانة الدراس (15.36، 17.49، 19.63 م/ث) ومعدل تغذية المحصول (500، 660، 825 كجم/س) والمحتوى الرطوبي للنبات (11.59 %،14.91 %) وتتلخص أهم النتائج فيما يلي:

1- كانت أعلى سعة لآلة الدراس والتذرية 824.18 كجم/س وأعلى إنتاجية للآلة 357.17 كجم/س عند سرعة إسطوانة دراس 19.63 م/ث ومعدل تغذية 825 كجم/س ومحتوى رطوبي 11.59%.
2- كانت أقل طاقة كلية لازمة 19.68 ميجا جول عند سرعة إسطوانة دراس 15.36 م/ث ومعدل تغذية 500 كجم/س ومحتوى رطوبي 11.59%.
3- كانت أقل طاقة لازمة لدراس فول الصويا 30.71 ميجا جول/طن وأقل طاقة لازمة لإنتاج البذور 72 ميجا جول/ طن عند سرعة إسطوانة دراس 15.36م/ث ومعدل تغذية 825 كجم/س ومحتوى رطوبي 11.59%.
4- توجد فروق معنوية عالية لتأثير كلا من سرعة إسطوانة الدراس ومعدلات التغذية والمحتوى الرطوبي للنبات والتفاعل بين هذه العوامل مع سعة آلة الدراس والتذرية وإنتاجية الآلة واحتياجات الطاقة الكلية والطاقة اللازمة لدراس محصول فول الصويا والطاقة اللازمة لإنتاج البذور.
5- كانت أعلى كفاءة دراس 98.37% وأعلى كفاءة تذرية 98.59% عند سرعة أسطوانة دراس 19.63 م/ث ومعدل تغذية 500كجم/س ومحتوى رطوبي 11.59%.
6- كانت أقل نسبة بذور تالفة 1.23% وأقل نسبة بذور متناثرة مع القش 0.17% وأقل نسبة للفواقد الكلية للبذور 4.13% عند سرعة أسطوانة دراس 15.36 م/ث ومعدل تغذية 825كجم/س ومحتوى رطوبي 14.91%.
7- كانت أقل تكلفة نوعية للدراس والتذرية 115.44 جنيه/طن عند سرعة أسطوانة دراس 19.63م/ث ومعدل تغذية 500 كجم/س ومحتوى رطوبي 11.59%.

وأخيراً، يوصى باستخدام تلك الآلة المحلية كوسيلة فعالة لدراس وتذرية محصول فول الصويا تحت ظروف التشغيل سالفة الذكر لما تحققه من معدل إنتاجية مرتفع واحتياجات طاقة منخفضة وجودة عالية للبذور بأقل تكلفة.