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# ENGINEERING PARAMETERS REQUIRED FOR THE DESIGN AND DEVELOPMENT OF CLEANING MACHINE FOR MEDICINAL AND AROMATIC SEED CROPS

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**ABSTRACT: The main experiments were carried out at Department of Agricultural engineering, Faculty of Agriculture, Zagazig University to develop and evaluate the performance of a threshing and cleaning machine to be suitable for medicinal and aromatic seeds plants (Fennel, Caraway and Coriander Plants).**

**The performance of the developed machine was measured under the following parameters: Four different sieve speeds, four different sieve tilt angles, four different seed moisture contents and four different feed rates. The performance of the developed machine was evaluated taking into consideration: overall machine efficiency, energy requirements and Criterion cost.**

**The experimental results reveal that seed losses as well as criterion costs were minimum while overall machine efficiency was maximum under the following conditions:**

**Operate the developed machine at a sieve speed of about 3.17 Hz for the three crops,**

**Operate the developed machine at a sieve tilt angle of about 2.0 deg. For the three crops,**

**Threshing and cleaning fennel, caraway and coriander at seed moisture contents of about 11.38, 7.50 and 10.26% respectively**

**Operate the developed machine at a feed rates of about 1.03, 1.64 and 1.20 Mg/h for fennel, caraway and coriander respectively.**

**Key words: Machine, threshing, cleaning, fennel, caraway, coriander.**

## INTRODUCTION

In Egypt, the medicinal and aromatic plants have an important export value. Medicinal and aromatic plants come in the forth order. Fennel, Caraway and Coriander are considered of the most important medicinal and aromatic plants.

The academic and applied researches indicated that total seed losses occurring through different stages of plant production, is a vital problem to be solved. One of these stages is threshing and cleaning. Medicinal and aromatic plants are too sensitive to threshing and cleaning operation due to the high percentage of seed losses affecting on the total yield.

Suliman (1987) studied the technical parameters of flat sieve such as dimensions of sieve, the speed of crankshaft of screening unit, ideal distribution of the holes on the sieve sheet. These information are very important in designing and developing the specific cleaning machines suitable for Egypt.

El-Sheikha *et al.*, (1988) developed and tested a simple, cheap and easily operated cleaning machine using horizontal airflow. Then to optimize the operating conditions to achieve higher cleaning efficiency with wheat grain from light impurities, chaff and fine straw. They tested the performance of the machine under different air velocities, feed rates, total impurities and different proportions of chaff and straw, where that, these factors affect significantly on the separation effectiveness, grain recovery and the degree of cleanliness. They added that the highest separation effectiveness, cleanliness with minimum grain losses and no obvious seed damage were recorded at 7.8 m/s air velocity and 32 r.p.m. feeder speed at (8, 10 and 12%) total impurities. The best degree of cleanliness obtained at the best separation effectiveness ranged from (99.46 to 100%); (99.12 to 100%) and (98.77 to 100%) for (8, 10 and 12%) total impurities respectively. The maximum feed rate was 450 kg/h.

Korayem *et al.*, (1988) developed and tested a winnowing machine for using with a threshed wheat crop (Giza 157) by the locally made stationary thresher. They found that 80% of straw associated with the grain output of local threshers can be separated by an air stream of a velocity of about 6.25 m/s. The remaining 20% can be effectively separated by a conventional sieve system.

Hexing, (1989) mentioned that although many kinds of cleaning systems have been developed most of the field harvesting machinery (e.g. combine harvesters, threshers and cleaners) still employ the conventional cleaning system, that is the oscillating screen with blower. This kind of cleaning system is important and widely used. The basic advantage of the oscillating screen-blower cleaning unit for grain cleaning is the resulting machine compactness, low cost, easy fabrication and easy operation. It can be used for separating and cleaning many different agricultural products with high reliability, stability and adaptability.

Ismail *et al.* (1994) designed and tested a pneumatic separating and cleaning machine to clean wheat grains from light impurities. Investigation was carried out on the obtained model to get the optimal operating conditions for achieving a high degree of cleaning wheat grains from impurities. The machine was tested under different combination of the following factors: air stream velocity, specific feeding rate, the total impurities and sample moisture content. The performance of the machine was evaluated by its cleaning efficiency and percentage of grain losses. They illustrated that the combination of air stream velocity, specific feeding rate, percentage of total impurities and samples moisture content affected significantly on the cleaning efficiency and grain losses. Air stream velocity of 6 m/s combined with 10 kg/h. specific feeding rate can be considered the most favorable combination of all these variables. It gives the highest grades of cleaning efficiency and minimum percentage of grain losses.

El-Raie *et al.*, (1996) studied some physical characteristics for various varieties of wheat, rice and barley such as volume, average diameters, percent of sphericity and frontal area as following 28.05 $mm^3$, 3.90 mm, 58.80% and 14.90 $mm^2$ for wheat; 23.04 $mm^3$, 4.36 mm, 44.29% and 17.41 $mm^2$ for rice and 62.34 $mm^3$ , 5.77 mm, 49.30% and 25.56 $mm^2$ for barley. Also studied some mechanical properties of grains such as natural angle of repose, solid friction, hardness, average speeds of grain movement over a flat swing screen. They also studied some aerodynamic properties of grains and straw such as drag coefficient, drag force, terminal velocity, Reynolds's number and moisture of grain. They were either measured or calculated for various varieties of wheat, rice and barley. They determined the terminal velocity of wheat, rice and barley. They found that the terminal velocity ranged from 5.85 to 9.71 m/s for wheat varieties; from 7.89 to 8.55 m/s for rice varieties; and 7.49 to 9.95 m/s for barley varieties.

Awady *et al.* (2003) developed and tested a winnowing and cleaning machine for winnowing rice crop for better efficiency and reduced losses. The cleaning machine consists of frame, grain hopper, oscillating dual-screen assembly, a centrifugal blower and electric motor. The optimum performance was at air speed of 4 m/s, moisture content of 18 %, sieve tilt angle of 2 degree, round shaped sieve and feed rate 1200 kg/h .Purity of these condition was 98.98% and total losses of 0.21%.

Sahrigi *et al.* (2004) designed and constructed a cleaning unit able to various types of medicinal and aromatic seeds and their associated foreign matter by making simple adjustments according to the type of seeds, its physical properties and associated impurities. Also they tested the performance of a cleaning unit under the following main factors: the frequency of the sieve unit, feed rate, air velocity and slope of the sieve unit. The maximum seed cleanliness and separation effectiveness were 99.01 and 89.75% respectively and obtained at frequency of 10.50 Hz, feed rate of 300 kg/h, slope of 13 deg. and air velocity of 3.2 m/s.

Many factors control the performance of the cleaning machine. These factors can be divided into two sections: machine and plant, machine variables include peripheral speeds of machine devices and feeding rate. Moreover, the plant variables are considered critical factors. These variables are variety, moisture content and degree of maturity.

## The Main Objectives of this Study

Develop a local threshing and cleaning machine to be suitable for medicinal and aromatic plants.

Optimize some operating parameters (sieve speed, sieve tilt angle, seed moisture content and feed rate).

Evaluate the developed machine from the economic point of view.

## MATERIALS AND METHODS

The main experiments were carried out at Department of Agricultural engineering, Faculty of Agriculture, Zagazig University to develop and evaluate the performance of a threshing and cleaning machine to be suitable for medicinal and aromatic seeds plants (Fennel, Caraway and Coriander Plants). Field experiments for seed bed preparation, planting, fertilizing and harvesting of the three investigated crops were carried out during two growing seasons of (2005– 2006) and (2006 – 2007).

### The Developed Machine

A threshing and cleaning machine, suitable for medicinal and aromatic crops, was developed and manufactured from low cost, local material to overcome the problems of high power and high cost requirements under the use of the imported machines. The developed machine was manufactured specially for this work and constructed at a private workshop in Sharkia Governorate. Fig.1.

The developed machine consists mainly of power source, transmission system, frame, threshing unit and cleaning unit (separating and cleaning).

#### The power source

The developed machine was powered by an electric motor 3.68 Kw (5.00 hp) at a rated speed of 3000 rpm.

#### The transmission system

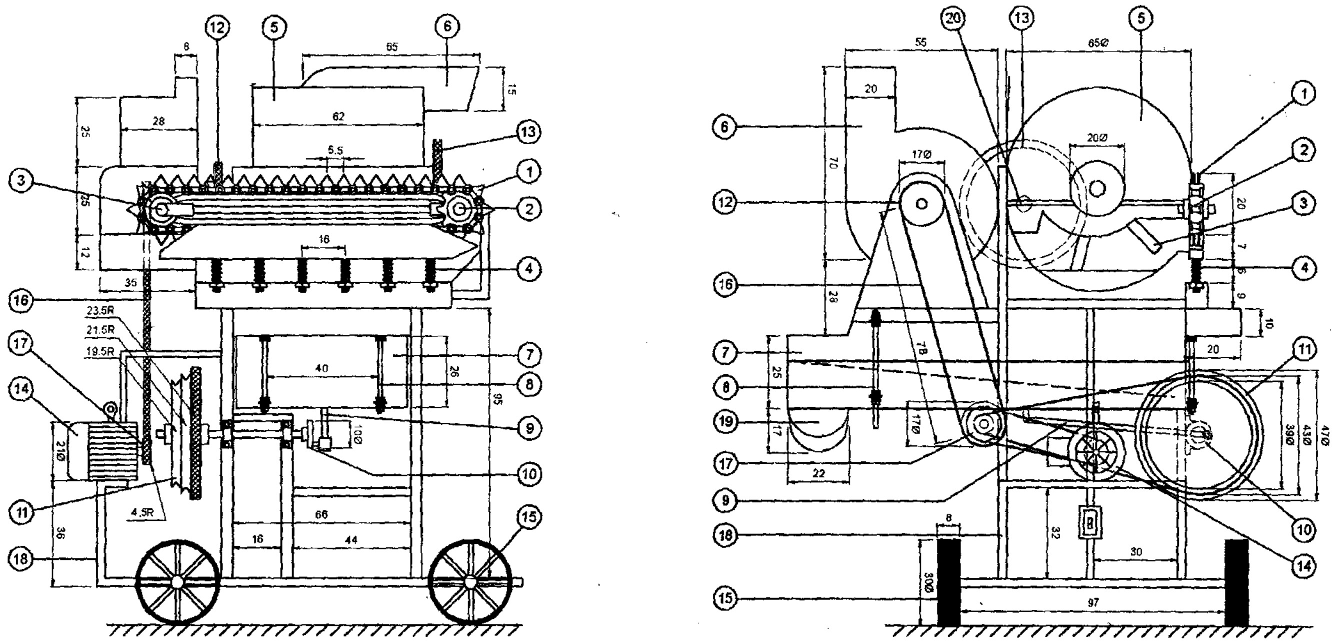
The machine is operated by means of machine pulley (170 mm diameter) and belt powered from the electric motor pulley (90 mm diameter). The power is transmitted from the machine pulley to the other moving parts by means of pulleys and belts with different speed ratios.

#### The frame

The frame is made of rectangular iron sheet steel. It includes elements to fix the motor, the transmission system, the threshing and cleaning units. It was carried by four ground wheels of 300 mm diameter.

#### The threshing unit

The threshing unit consists of a drum and concave with holes. Specifications of the threshing unit were as follows:




All Dimensions in, mm

| No. | Part name | No. off | No. | Part name | No. off |
|---|---|---|---|---|---|
| 1 | Feed chain | 1 | 10 | Crank pulley | 1 |
| 2 | Drive sprocket | 1 | 11 | Change pulley | 3 |
| 3 | Driven pulley | 1 | 12 | Fan pulley | 1 |
| 4 | Spring | 6 | 13 | Feed pulley | 1 |
| 5 | Threshing chamber | 1 | 14 | Electric engine | 1 |
| 6 | Suction fan | 1 | 15 | Machine wheel | 4 |
| 7 | Sieve chamber | 1 | 16 | V-Belt | 5 |
| 8 | Sieve support | 4 | 17 | Engine pulley | 1 |
| 9 | Pitman | 1 | 18 | Machine frame | 1 |

**Fig. 1. Elevation and right side view of the developed aromatic threshing machine.**

The threshing drum is of a spiked type, Threshing drum length: 600mm, Threshing drum diameter: 550 mm, Number of spikes rows 8, Number of drum spikes 48, threshing drum rotating speed (370 rpm), Concave length: 620 mm, Concave cells have a circle shape, Concave cells diameter:6mm, clearance between drum and concave: 10 mm .

**The cleaning system**

The cleaning system consists of a suction fan, two sieves (upper and lower) and inclination pan.

**The Main Dimensions of the Developed Machine were as Follows**

Overall length, 1750 mm, overall width, 1650 mm, overall height, mm2000 and Total weight, 250 kg.

**Table 1. The main specifications of the used crops were as follows.**

| Crops properties | Fennel | Caraway | Coriander |
|---|---|---|---|
| Plant height, mm | 160 | 130 | 130 |
| Plant diameter mm | 1.50 | 1.00 | 0.80 |
| Plant population,plant/m$^2$ | 5 | 5 | 5 |

**Table 2. The performance of the developed machine was measured under the following parameters .**

| Variable | Values | | | | Crops |
|---|---|---|---|---|---|
| Sieve speeds, Hz. | 2.78 | 3.17 | 3.45 | 4.02 | For three crops |
| Sieve tilt angles, deg. | 1.5 | 2.0 | 2.5 | 3.0 | For three crops |
| Seed moisture contents. | 6.47 | 8.91 | 11.38 | 13.93 | For fennel crop |
| | 5.05 | 7.50 | 10.12 | 11.50 | For caraway crop |
| | 5.35 | 7.32 | 10.26 | 12.16 | For coriander crop |
| Feed rats, Mg/h. | 0.80 | 0.90 | 1.03 | 1.20 | For fennel crop |
| | 1.06 | 1.29 | 1.64 | 2.25 | For caraway crop |
| | 0.82 | 0.90 | 1.20 | 1.50 | For coriander crop |

### The Performance of the Developed Machine was Evaluated Taking into Consideration the Following Indicators

#### Overall machine efficiency

$$\text{Overall machine efficiency} = \frac{\text{output seeds from cleaning unit}}{\text{input seeds on threshing unit}} \times 100$$

#### Energy requirements

$$\text{Energy requirement} = \frac{\text{Motor power}}{\text{Machine productivity}}, \text{kw.h/kg}$$

#### Criterion cost

Criterion cost = operating cost + seed losses cost, L.E./Mg,

$$\text{Operating cost} = \frac{\text{Machine cost}}{\text{Machine productivity}}$$

Hourly cost= $P/h\ (1/a+i/2+t+r) + (w.e) + m/144$,L.E./h

Where: P = price of machine, h = yearly working hour, a = life expected of machine, i = interest rate /year, t = taxes and overhead ratio, w = power of motor in Kw, e = hourly cost / Kw.h, and m /144 monthly wage ratio.

## RESULTS AND DISCUSSION

The performance of the developed machine is affected by many parameters. These parameters can be arranged into three groups. The first group is concerned with the overall machine efficiency; the second group is related to energy requirements and the third to criterion cost.

The obtained results will be discussed under the following items:

### Overall Machine Efficiency

Overall machine efficiency at different feed rates is affected by sieve speed, sieve tilt angle and seed moisture content.

#### Influence of sieve speed on overall machine efficiency at different feed rates

Results show that increasing sieve speed increased overall machine efficiency up to 3.17 Hz any further increase in sieve speed up to 4.02 Hz overall machine efficiency will decrease Fig. 2.

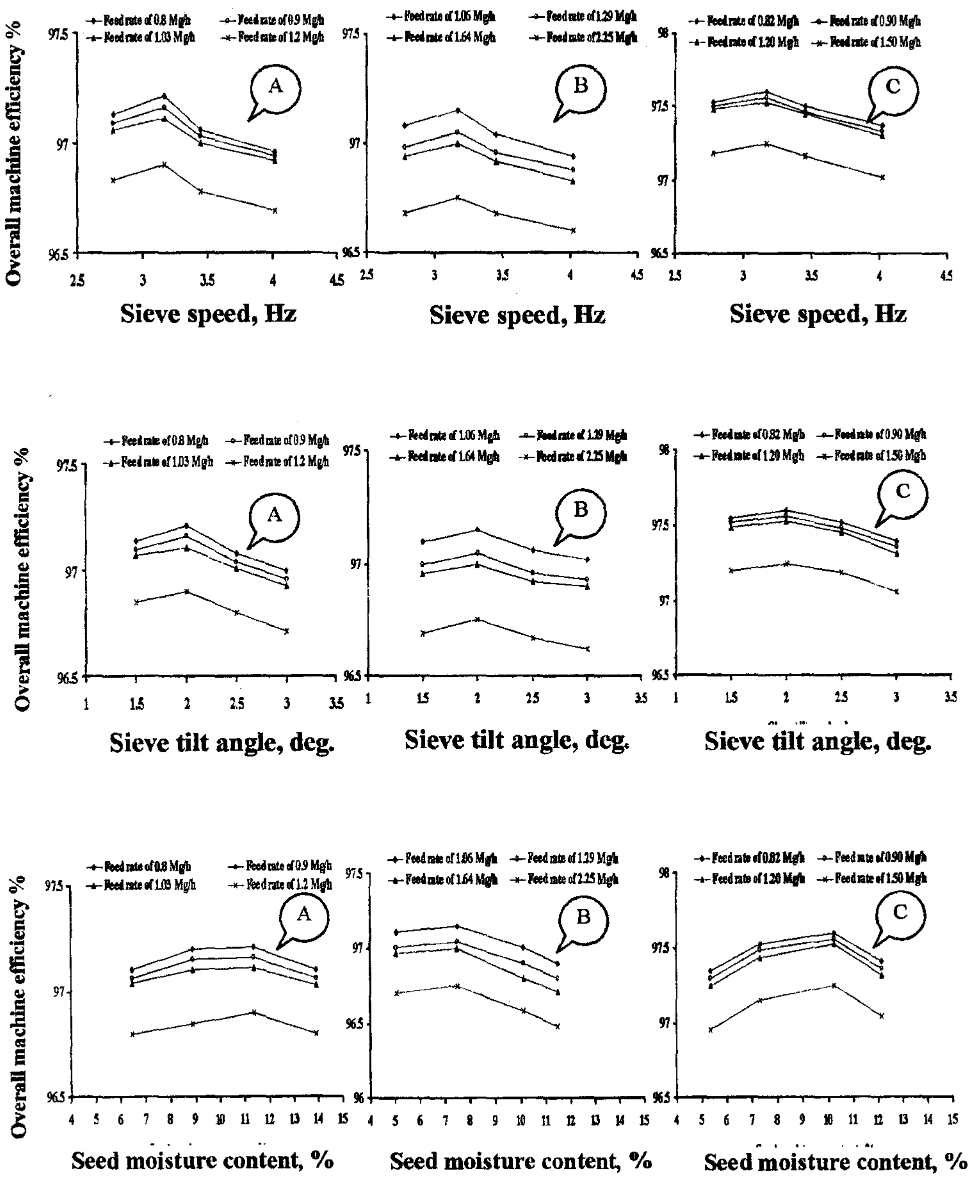



**Fig. 2. Effect of sieve speed, sieve tilt angle and seed moisture content on overall machine efficiency at different feed rates for fennel (A), caraway (B) and coriander (C) crop**

Considering fennel crop, obtained results show that increasing sieve speed from 2.78 to 3.17 Hz measured at different feed rates of 0.80, 0.90, 1.03 and 1.20 Mg/h increased overall machine efficiency from 97.13 to 97.21, from 97.07 to 97.16, from 97.06 to 97.11 and from 96.83 to 96.90% respectively. The further increase in sieve speed more than 3.17 up to 4.02 Hz decreased overall machine efficiency from 91.21 to 96.96, from 97.16 to 96.94, from 97.11 to 96.92, and from 96.90 to 96.69% respectively at constant sieve tilt angle of 2.0 deg. and constant seed moisture content of 11.38%.

As to caraway crop, results show that increasing sieve speed from 2.78 to 3.17 Hz measured at different feed rates of about 1.06, 1.29, 1.64 and 2.25 Mg/h, increased overall machine efficiency from 97.08 to 97.15, from 96.98 to 97.05, from 96.94 to 97.00 and from 96.68 to 96.75% respectively. Any further increase in sieve speed more than 3.17 up to 4.02 Hz measured at the same previous feed rates decreased overall machine efficiency from 97.15 to 96.94, from 97.05 to 96.88, from 97.00 to 96.83 and from 96.75 to 96.60% respectively at constant sieve tilt angle of 2.0 deg. and constant seed moisture content of 7.50%.

Concerning coriander crop, obtained data show that increasing sieve speed from 2.78 to 3.17 Hz measured at different feed rates about 0.82, 0.90, 1.20 and 1.50 Mg/h increased overall machine efficiency from 97.53 to 97.60, from 97.50 to 97.56, from 97.48 to 97.53 and from 97.18 to 97.25% respectively. Any further increase in sieve speed more than 3.17up to 4.02 Hz measured at the same previous feed rates decreased overall machine efficiency from 97.60 to 97.37, from 97.56 to 97.33, from 97.53 to 97.30 and from 97.25 to 97.02% respectively at constant sieve tilt angle of 2.0 deg. and constant seed moisture content of 10.26%.

Higher values of sieve speed more than the optimum value tend to decrease overall machine efficiency because the forward motion of seeds towards the straw exit is greater than that in reverse. Furthermore, seeds will jump off the sieve surface and thus losses contact; While Lower values of sieve speed less than the optimum value tend to decrease overall machine efficiency because of the increase of cleaning materials thickness on the sieve surface, so most of seeds will leave the sieve with the straw from the straw exit without well cleaning.

**Influence of sieve tilt angle on overall machine efficiency at different feed rates**

Results obtained show that increasing sieve tilt angle increased overall machine efficiency up to 2.0 deg. any further increase in sieve tilt angle up to 3.0 deg. overall machine efficiency will decrease Fig. 2.

Concerning fennel crop, results show that increasing sieve tilt angle from 1.5 to 2.0 deg. measured at different feed rates of about 0.80, 0.90, 1.03 and 1.20 t/h increased overall machine efficiency from 97.14 to 97.21, from 97.10 to 97.16, from 97.07 to 97.11 and from 96.85 to 96.90% respectively. The further increase in sieve tilt angle more than 2.0 up to 3.0 deg. measured at the same previous feed rates decreased overall machine efficiency from 97.21 to 97.00, from 97.16 to 96.96, from 97.11 to 96.93 and from 96.90 to 96.71% respectively at constant sieve speed of 3.17 Hz and constant seed moisture content of about 11.38%.

Relating to caraway crop, obtained data show that increasing sieve tilt angle from 1.5 to 3.0 deg. measured at different feed rates of about 1.06, 1.29, 1.64 and 2.25 t/h increased overall machine efficiency from 97.10 to 97.15, from 97.00 to 97.05, from 96.96 to 97.00 and from 96.69 to 96.75% respectively. The further increase in sieve tilt angle more than 2.0 up to 3.0 deg. decreased overall machine efficiency from 97.15 to 97.02, from 97.05 to 96.93, from 97.00 to 96.90 and from 96.75 to 96.62% respectively at constant sieve speed of 3.17 Hz and constant seed moisture content of about 7.50%.

As to coriander crop, obtained results show that increasing sieve tilt angle from 1.5 to 2.0 degree measured at different feed rates of about 0.82, 0.90, 1.20 and 1.50 t/h increased overall machine efficiency from 97.55 to 97.60, from 97.52 to 97.56, from 97.49 to 97.53 and from 97.20 to 97.25% respectively. The further increase in sieve tilt angle more than 2.0 up to 3.0 deg. measured at the same previous feed rates decreased overall machine efficiency from 97.60 to 97.40, from 97.56 to 97.36, from 97.36, from 97.53 to 97.32 and from 97.25 to 97.06% respectively at constant sieve speed of 3.17 Hz and constant seed moisture content of about 10.26%.

Higher values of sieve tilt angle more than the optimum value tend to decreased overall machine efficiency because the increase in sieve tilt angle forced the seeds to move along the sieve faster toward the straw exit. Lower values of sieve tilt angle less than the optimum value tend to decreased overall machine efficiency because seeds move slowly which subject the small size seeds to the flow of air in the vertical direction for long time that tends to increase losses.

**Influence of seed moisture content on overall machine efficiency at different feed rates**

The obtained results show that increasing seed moisture content increased overall machine efficiency up to 11.38, 10.12 and 10.26% for fennel crop, caraway crop and coriander crop respectively. Any further increase in seed moisture contents up to 13.93, 11.50 and 12.16% for the same previous crops overall machine efficiency will decrease Fig. 2.

Regarding fennel crop, results show that increasing seed moisture content from 6.47 to 11.38% measured at different feed rates of about 0.80, 0.90, 1.03 and 1.20 t/h increased overall machine efficiency from 97.10 to 97.21, from 97.06 to 97.16, from 97.04 to 97.11 and from 96.80 to 96.90% respectively. Any further increase in seed moisture content more than 11.38 up to 13.93% measured at the same previous feed rates decreased overall machine efficiency from 97.21 to 97.10, from 97.16 to 97.06, from 97.11 to 97.03 and from 96.90 to 96.80% respectively at constant sieve tilt angle of 2.0 deg. and constant sieve speed of 3.17 Hz.

Relating to caraway crop, obtained data show that increasing seed moisture content from 5.05 to 7.50% measured at different feed rates of about 1.06, 1.29, 1.64 and 2.25 t/h increased overall machine efficiency from 97.11 to 98.15, from 97.01 to 97.05, from 96.97 to 97.00 and from 96.70 to 96.75% respectively. The further increase in seed moisture content more than 7.50 up to 11.50% measured at the same previous feed rates decreased overall machine efficiency from 97.15 to 96.90, from 97.05 to 96.80, from 97.00 to 96.71 and from 96.75 to 96.48% respectively at constant sieve tilt angle of 2.0 deg. and constant sieve speed of 3.17 Hz.

With regard to coriander crop, results show that increasing seed moisture content from 5.35 to 10.26% measured at different feed rates about 0.82, 0.90, 1.20 and 1.50 t/h increased overall machine efficiency from 97.35 to 97.60, from 97.30 to 97.56, from 97.25 to 97.53 and from 96.95 to 97.25% respectively. The further increase in seed moisture content more than 10.26 up to 12.16% measured at the same previous feed rates decreased overall machine efficiency from 97.60 to 97.41, from 97.56 to 97.36, from 97.53 to 97.32 and from 97.25 to 97.04% respectively at constant sieve tilt angle of 2.0 deg. and constant sieve speed of 3.17 Hz.

Higher values of seed moisture content more than the optimum value tend to decrease machine efficiency because of the increase in both weight and size of seeds, which forced them to move toward the straw exit without complete cleaning. On the other side, the lower values of seed moisture content less than the optimum value tend to decrease machine efficiency due to the decrease in both weight and size of seeds, which throw them out toward chaff exit with suction air direction causing more total losses.

## Energy Requirements

Energy requirements are more sensitive to different factors such as feed rate, sieve speed, sieve tilt angle, and seed moisture content.

### Influence of sieve speed on energy requirements at different feed rates

Results obtained show that increasing sieve speed increased energy requirements Fig. 3.

Considering fennel crop, obtained results show that increasing sieve speed from 2.78 to 4.02 Hz measured at different feed rates of about 0.80, 0.90, 1.03 and 1.20 Mg/h increased energy requirements from 4.20 to 5.50, from 4.18 to 5.19, from 3.95 to 4.83 and from 3.59 to 4.29 Kw.h/t respectively at constant seed moisture of about 11.38% and constant sieve tilt angle of 2.0 deg.

Concerning caraway crop, results show that increasing sieve speed from 2.78 to 4.02 Hz measured at different feed rates of about 1.06, 1.29, 1.64 and 2.25 Mg/h increased energy requirements from 4.13 to 4.90, from 3.70 to 4.29, from 3.09 to

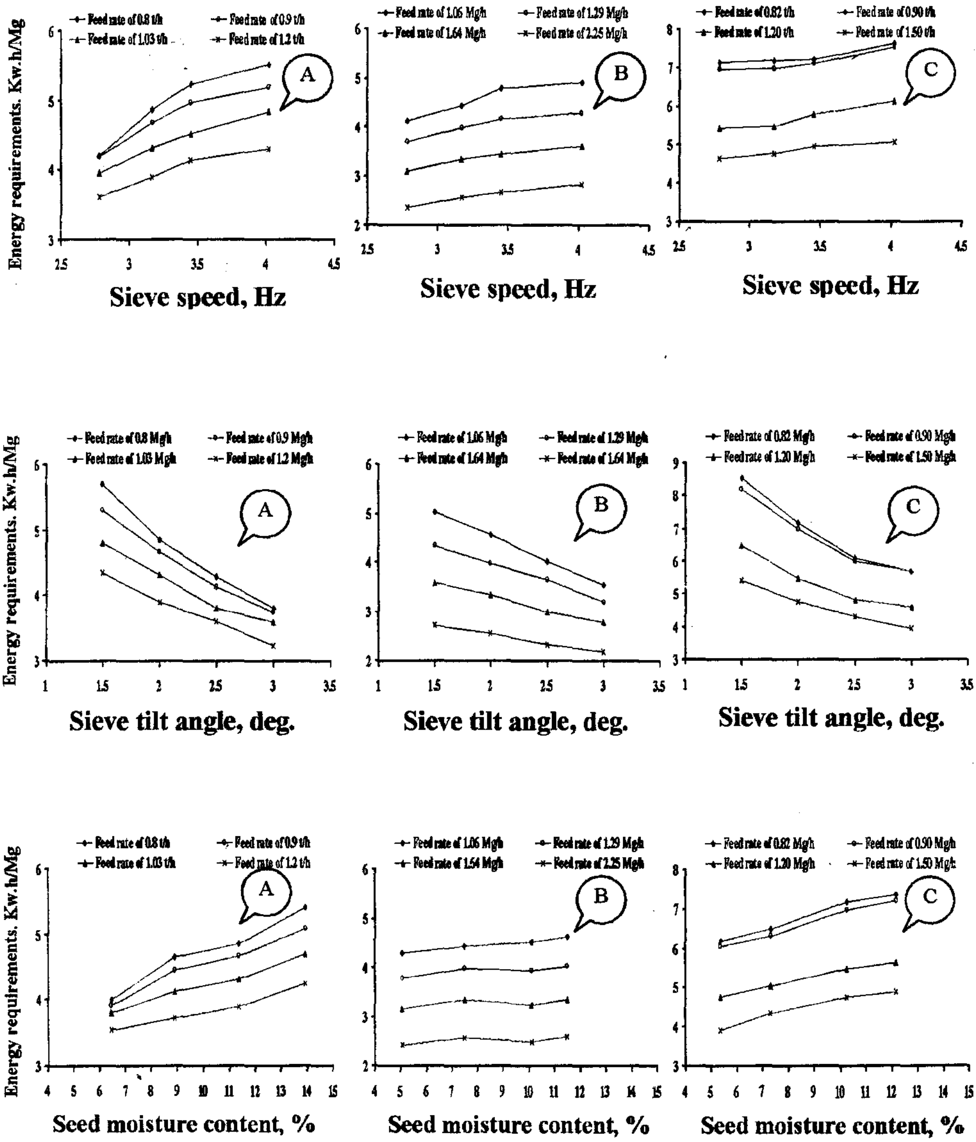



**Fig. 3. Effect of sieve speed, sieve tilt angle and seed moisture content on energy requirements at different feed rates for fennel (A), caraway (B) and coriander (C) crop**

3.61, and from 2.35 to 2.82 Kw.h/t respectively at constant seed moisture content of about 7.50% and constant sieve tilt angle of 2.0 deg.

Relating to coriander crop, obtained data show that increasing sieve speed from 2.78 to 4.02 Hz measured at different feed rates of about 0.82, 0.90, 1.20 and 1.50 t/h, increased energy requirement from 7.12 to 7.64, from 6.94 to 7.53, from 5.43 to 6.12 and from 4.62 to 5.05 Kw.h/t respectively at constant seed moisture content of about 10.26% and constant sieve tilt angle of 2.0 deg.

Energy requirements increased by increasing sieve speed because of the increase of seeds flow on the sieve surface at the same time unit.

**Influence of sieve tilt angle on energy requirements at different feed rates**

The obtained results show that increasing sieve tilt angle decreased energy requirements Fig. 3.

Concerning fennel crop, results show that increasing sieve tilt angle from 1.5 to 3.0 degrees measured at different feed rates of about 0.80, 0.90, 1.03 and 1.20 Mg/h, decreased energy requirements from 5.71 to 3.81, from 5.30 to 3.75, from 4.81 to 3.58 and from 4.35 to 3.23 Kw.h/t respectively at constant speed moisture content of about 11.38% and constant sieve speed of 3.17 Hz.

Relating to caraway crop, obtained data show that increasing sieve tilt angle from 1.5 to 3.0 degrees measured at different feed rates of about 1.06, 1.29, 1.64 and 2.25 Mg/h, decreased energy requirements from 5.04 to 3.54, from 4.36 to 3.19, from 3.58 to 2.78 and from 2.72 to 2.18 Kw.h/t respectively at constant seed moisture content of about 7.50% and constant sieve speed of 3.17 Hz.

As to coriander crop, obtained results show that increasing sieve tilt angle from 1.5 to 3.0 degrees measured at different feed rates of about 0.82, 0.90, 1.20 and 1.5 Mg/h, decreased energy requirements from 855 to 570, from 8.20 to 5.68, from 6.51 to 4.60 and from 5.40 to 3.92 Kw.h/t respectively at constant seed moisture content of about 10.26% and constant sieve speed of 3.17 Hz.

The decrease in energy by increasing sieve tilt angle was attributed to the decrease in plant material on the sieve surface and suction fan leads to smoothly seed flow that reduces power and energy.

### Influence of seed moisture content on energy requirements at different feed rates

Results show that increasing seed moisture content increased energy requirements Fig. 3.

Regarding fennel crop, results show that increasing seed moisture content from 6.47 to 13.93% measured at different feed rates of about 0.80, 0.90, 1.03 and 1.20 Mg/h increased energy requirements from 4.00 to 5.41, from 3.92 to 5.08, from 3.80 to 4.70 and from 3.54 to 4.26 Kw.h/t respectively at constant sieve tilt angle of 2.0 deg. In addition, constant sieve speed of 3.17 Hz.

Relating to caraway crop, results show that increasing seed moisture content from 5.05 to 11.50% measured at different feed rates of about 1.06, 1.29, 1.64 and 2.25 Mg/h increased energy requirements from 4.29 to 4.61, from 3.78 to 4.02, from 3.16 to 3.33 and from 2.41 to 2.58 Kw.h/t respectively at constant sieve tilt angle of 2.0 deg. In addition, constant sieve speed of 3.17 Hz.

Regarding coriander crop, results show that increasing seed moisture content from 5.35 to 12.16% measured at different feed rates of about 0.82, 0.90, 1.20 and 1.50 Mg/h increased energy requirements from 6.18 to 7.36, from 6.04 to 7.19, from 4.75 to 5.62 and from 3.90 to 4.89 Kw.h/t respectively at constant sieve tilt angle of 2.0 deg. In addition, constant sieve speed of 3.17 Hz.

Energy increased by increasing seed moisture content due to the excessive load of plants on the machine devices, which consumed more power and energy.

## Criterion Cost

A complete cost analysis was made at different operating conditions and related with machine productivity. The resulting operating cost was found to be affected significantly by both feed rate, sieve speed, sieve tilt angle seed moisture content .

### Influence of sieve speed on criterion cost at different feed rates

Sieve speed is considered on important factor, which affects criterion cost Fig. 4.

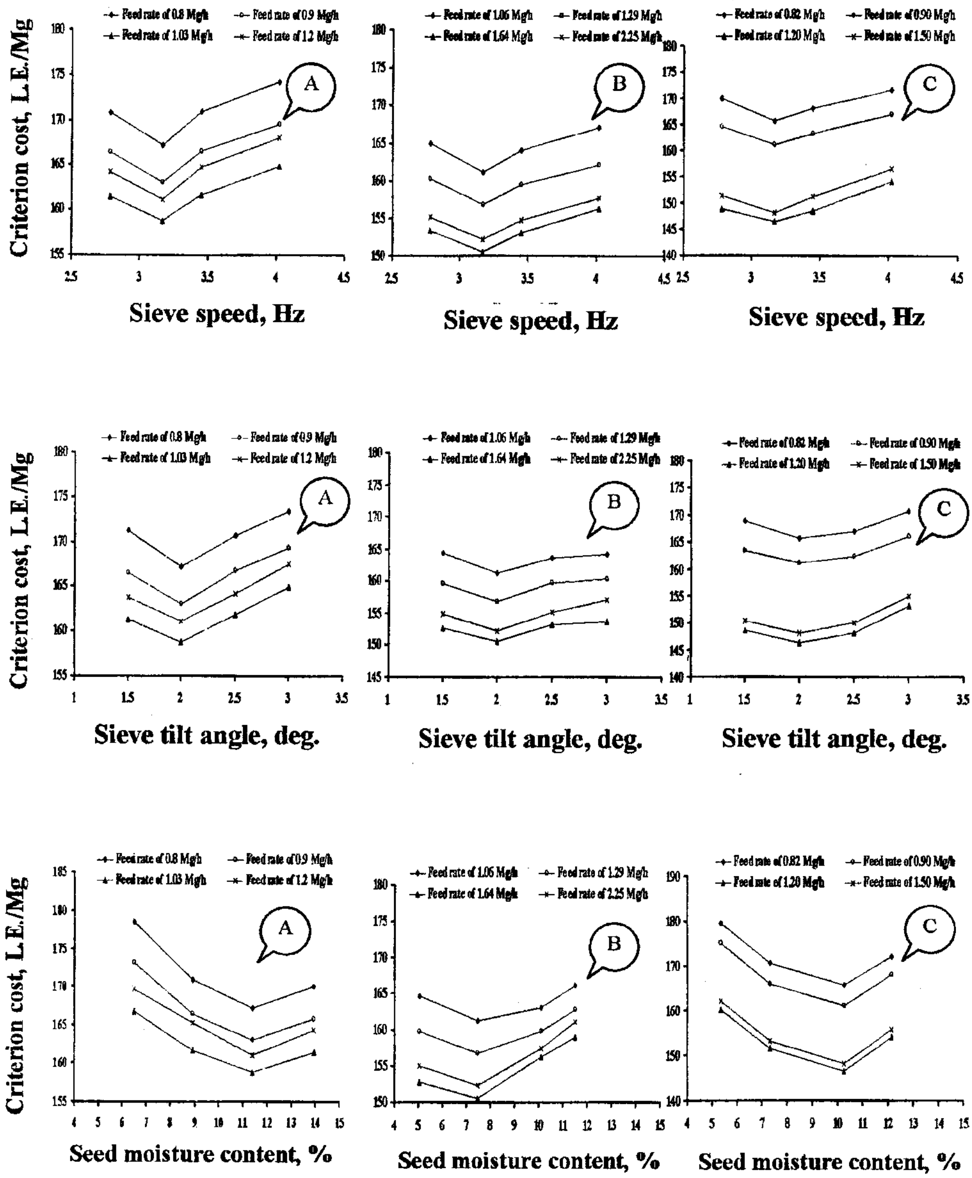



**Fig. 4. Effect of sieve speed, sieve tilt angle and seed moisture content on criterion cost at different feed rates for fennel (A), caraway (B) and coriander (C) crop**

As to fennel crop, results show that increasing sieve speed from 2.78 to 3.17 Hz measured at different feed rates of about 0.80, 0.90, 1.03 and 1.20 Mg/h, decreased criterion cost from 170.82 to 167.16, from 166.40 to 162.98, from 161.46 to 158.75 and from 164.18 to 161.40 L.E/Mg respectively at constant seed moisture content of about 11.38% In addition, constant sieve tilt angle of 2.0 deg. Any further increase in sieve speed from 3.17 to 4.02 Hz, criterion cost will increase from 167.16 to 174.23, from 162.98 to 169.57, from 158.75 to 164.87 and from 161.40 to 167.99 L.E./Mg under the same previous conditions.

Relating to caraway crop, obtained data show that increasing sieve speed from 2.78 to 3.17 Hz measured at different feed rates of about 1.06, 1.29, 1.64 and 2.25 Mg/h, decreased criterion cost from 164.88 to 161.17, from 160.17 to 156.76, from 153.26 to 150.49 and from 155.17 to 152.22 L.E./Mg respectively at constant seed moisture content of about 7.50% In addition, constant sieve tilt angle of 2.0 deg. Any further increase in sieve speed from 3.17 to 4.02 Hz, criterion cost will increase from 161.17 to 167.14, from 156.76 to 162.11, from 150.49 to 156.26 and from 152.22 to 157.72 L.E./Mg under the same previous conditions.

Regarding coriander crop, results show that increasing sieve speed from 2.78 to 3.17 Hz measured at different feed rates of about 0.82, 0.90, 1.20 and 1.50 Mg/h, decreased criterion cost from 169.97 to 165.69, from 164.52 to 161.09, from 148.88 to 146.42 and from 151.34 to 148.10 L.E./Mg respectively at constant seed moisture content of about 10.26% and constant sieve tilt angle of 2.0 deg. Any further increase in sieve speed from 3.17 to 4.02 Hz, criterion cost will increase from 165.69 to 171.65, from 161.09 to 167.04, from 146.42 to 154.19 and from 148.10 to 156.58 L.E./Mg under the same previous conditions.

**Influence of sieve tilt angle on criterion cost at different feed rates**

Threshing and cleaning costs are greatly affected by sieve tilt angle. This relation as the following Fig. 4.

As to fennel crop, obtained results show that increasing sieve tilt angle from 1.5 to 2.0 deg. measured at different feed rates of about 0.80, 0.90, 1.03 and 1.20 Mg/h, decreased criterion cost from 171.22 to 167.16, from 166.51 to 162.98, from 161.35 to 158.75 and from 163.81 to 161.40 L.E./Mg, respectively at constant seed moisture content of about 11.38% in addition, constant sieve speed of 3.17 Hz. Any further increase in sieve tilt angle from 2.0 to 3.0 deg. criterion cost will increase from 167.16 to 173.33, from 162.98 to 169.33, from 158.75 to 164.92 and from 161.40 to 167.51 L.E./Mg under the same previous conditions.

Considering caraway crop, obtained results show that increasing sieve tilt angle from 1.5 to 2.0 deg. measured at different feed rates of about 1.06, 1.29, 1.64 and 2.25 Mg/h decreased criterion cost from 164.43 to 161.17, from 159.60 to 156.76, from 152.61 to 150.49 and from 154.87 to 152.22 L.E./Mg respectively at constant seed moisture content of about 7.50% and constant sieve speed of 3.17 Hz. Any further increase in sieve tilt angle from 2.0 to 3.0 deg. criterion cost will increase from 161.17 to 164.25, from 156.76 to 160.32, from 150.49 to 153.59 and from 152.22 to 156.99 L.E./Mg under the same previous conditions.

Concerning coriander crop, results show that increasing sieve tilt angle from 1.5 to 2.0 deg. measured at different feed rates of about 0.82, 0.90, 1.20 and 1.50 Mg/h, decreased criterion cost from 168.92 to 165.69, from 163.51 to 161.09, from 148.59 to 146.42 and from 150.46 to 148.10 L.E./Mg at constant seed moisture content of about 10.26% and constant sieve speed of 3.17 Hz. Any further increase in sieve tilt angle from 2.0 to 3.0 deg. criterion cost will increase from 165.69 to 170.67, from 161.09 to 166.02, from 146.42 to 153.18 and from 148.10 to 154.91 L.E./Mg under the same previous condition.

**Influence of seed moisture content on criterion costs at different feed rates**

The relation between seed moisture content and criterion cost is illustrated as the following Fig. 4.

With regard to fennel crop, results show that increasing seed moisture content from 6.47 to 11.38% measured at different feed rates of about 0.80, 0.90, 1.03 and 1.20 Mg/h decreased criterion cost from 178.50 to 167.16, from 173.16 to 162.98, from 166.77 to 158.75 and from 169.67 to 161.04

L.E./Mg respectively at constant sieve tilt angle of 2.0 deg. and constant sieve speed of 3.17 Hz. Any further increase in seed moisture content from about 11.38 to 13.93%, criterion cost will increase from 167.16 to 170.05, from 162.98 to 165.79, from 158.75 to 161.35 and from 161.04 to 164.23 L.E./Mg under the same previous conditions.

Considering caraway crop, obtained results show that increasing seed moisture content from 5.05 to 7.50% measured at different feed rates of about 1.06, 1.29, 1.64 and 2.25 Mg/h decreased criterion cost from 164.62 to 161.17, from 159.76 to 156.76, from 152.80 to 150.49 and from 154.90 to 152.22 L.E./Mg respectively at constant sieve tilt angle of 2.0 deg. and constant sieve speed of 3.17 Hz. Any further increase in seed moisture content from about 7.50 to 11.50%, criterion cost will increase from 161.17 to 166.11, from 156.76 to 162.78, from 150.49 to 159.00 and from 152.22 to 161.00 L.E./Mg under the same previous conditions.

Concerning coriander crop, results show that increasing seed moisture content from about 5.35 to 10.26% measured at different feed rates of about 0.82, 0.90, 1.20 and 1.50 Mg/h decreased criterion cost from 179.53 to 165.69, from 175.11 to 161.09, from 160.25 to 146.42 and from 162.16 to 148.10 L.E./Mg respectively at constant sieve tilt angle of 2.0 deg. and constant sieve speed of 3.17 Hz. Any further increase in seed moisture content from about 10.26 to 12.16%, criterion cost will increase from 165.69 to 172.09, from 161.09 to 168.10, from 146.42 to 154.04 and from 148.10 to 155.85 L.E./Mg under the same previous conditions.

Both higher and lower values of sieve speed, sieve tilt angle, and seed moisture content more or less than the optimum value tend to increase criterion cost because of the increase in total losses.

## Conclusions

The experimental results recommended the following:

- Operate the developed machine at a sieve speed of about 3.17 Hz for the three crops.
- Operate the developed machine at a sieve tilt angle of about 2.0 deg. for the three crops.
- Threshing and cleaning fennel, caraway and coriander at seed moisture contents of about 11.38, 7.50 and 10.26% respectively.

- Operate the developed machine at feed rates of about 1.03, 1.64 and 1.20 Mg/h for fennel, caraway and coriander respectively.

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# العوامل الهندسية اللازمة لتصميم وتطوير آلة تنظيف بذور المحاصيل الطبية والعطرية

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تم تنفيذ التجارب الحقلية بقسم الهندسة الزراعية – كلية الزراعة– جامعة الزقازيق لتطوير وتقييم أداء آلة الدراس والتذرية مع بعض النباتات الطبية والعطرية وهما (الشمر– الكراوية– الكزبرة ).

وفيما يلي الأهداف الخاصة بهذا العمل:

١. تطوير آلة الدراس والتذرية المحلية لتناسب بعض النباتات الطبية والعطرية.

٢. تحديد القيم التشغيلية المثلي لكل من سرعة تردد الغربال وزاوية ميل الغربال والمحتوى الرطوبى للبذور ومعدلات التلقيم.

٣. تقييم الآلة المطورة من الناحية الاقتصادية.

ولتقييم أداء الآلة تم أخذ بعض المعا ملات التالية: أربع قيم مختلفة من (سرعة تردد الغربال – زاوية ميل الغربال – المحتوى الرطوبى للبذور – معدلات التلقيم). وتم أخذ القياسات التالية : (الكفاءة الكلية للآلة – الطاقة المستهلكة – التكاليف الكلية).

أظهرت النتائج التجريبية الآتي :

١. يوصى باستخدام آلة الدراس والتذرية عند سرعة تردد للغربال قدرها (٣,١٧ هرتز) للثلاثة محاصيل موضع الدراسة.

٢. يوصى باستخدام آلة الدراس والتذرية عند زاوية ميل للغربال قدرها (٢ درجة) للثلاثة محاصيل موضع الدراسة.

٣. يوصى باستخدام الآلة لدراس وتذرية محصول (الشمر – الكراوية – الكسبرة) عند محتوى رطوبى قدرة (١١,٣٨– ٧,٥٠ – ١٠,٢٦) للثلاثة محاصيل على الترتيب.

٤. يوصى باستخدام الآلة لدراس وتذرية محصول (الشمر – الكراوية – الكسبرة) عند معدلات تلقييم قدرها حوالي (١,٠٣ – ١,٦٤ – ١,٢٠ ميجا جرام/ س) للثلاثة محاصيل على الترتيب.