DEVELOPMENT OF A HARVESTING MACHINE FOR FABA BEAN (*Vicia faba* L.) CROP

El-Shal, M.S[1] **M.K. Abd El-Wahab[1]**
M.A.Tawfik[2] **K A. Metwally[3]**

ABSTRACT

The aim of this study is fabricating and developing a local mower with windrowing mechanism for harvesting faba bean (Vicia faba L.) crop in small holdings. The practical experiments were divided into two groups. The first one is the preliminary experiment to choose the proper crop conveyor angle and the horizontal distance between cutter bar and crop conveyor. The second one is the main experiment that conducted to evaluate the performance of the developed mower under four average forward speeds of 1.80, 3.00, 4.30 and 5.80 km/h, four stem moisture contents of 24.20, 30.30, 35.80 and 41.70 % (w.b), three cutter bar speeds of 1.44, 1.96 and 2.38 m/s and three conveying fingers speeds of 1.63, 2.23 and 2.70 m/s under three planting methods of manual planting, seed drill and pneumatic planter taking into consideration the actual field capacity, field efficiency, total seed losses, required power and specific energy requirements From the obtained results, it is recommended to use the pneumatic planter and operate the developed mower at average forward speed of 4.30 km/h, stem moisture content of 30.30%, conveying fingers speed of 2.23 m/s, crop conveyor angle of 60° and cutter bar speed of 1.96 m/s with horizontal distance between the cutter bar and conveyor of 7 cm to achieve the lowest values of total seed losses(0.23%), criterion costs (41.8 L.E/fed) and specific energy requirement (6.92 kW.h/fed) at actual field capacity of 1.64 fed/h and field efficiency of 79.10%.

INTRODUCTION

Recently, faba bean (*Vicia faba* L.) comes in the first rank of legume crops in Egypt in terms of the cultivated area and total production and consumption where green and dry seeds consume in the human diets or as a processed food because it contains

[1] **Prof. Emeritus, Agric. Eng. Dept., Fac. of Agric., Zagazig Univ., Egypt**
[2]**Associate Prof., Agric. Eng. Dept., Fac. of Agric., Zagazig Univ., Egypt.**
[3] **Assistant lecturers, Agric. Eng. Dept., Fac. of Agric., Zagazig Univ., Egypt.**

percentage of a high-quality protein up to 28% and the carbohydrates 58% in addition to many of vitamins and other nutrients so, it is as agronomical viable alternative to cereal seeds The faba bean productivity in Egypt is the highest in Mediterranean region where the average cultivated area is about 204,800 fed/ year with medium yield around of 1.88 Mg/fed, **(Ministry of Agriculture, 2012).** Despite of the good coverage of the crop in Egypt, very limited efforts have been done to use and improve the mechanical harvesting methods, where using the conventional mechanical harvesters such as; reaper and reciprocating mower may cause crop losses and reduce quality of seeds because the fruiting zone occupies most of the plant stem so, the lowest pods become very close to the ground and consequently low height for cutting that needs a proper technique and good management during faba bean harvesting operation, especially when the plants maturing unevenly, so the manual harvesting is very common in Egypt. **GRDC (2008)** reported that late sown or drought seed legume crops may carry pods very close to the ground, especially if seeding rates were low, also the excessive harvester speeds will cause large seed losses **Abo Elnaga (1995)** concluded that the mechanical planting using the seed drill and the mechanical harvesting using the mounted mower followed by the threshing machine is the recommended system for producing the balady bean (*Vicia faba* L.) crop under the Egyptian conditions as it requires minimum cost. He added that the seed moisture content of 14.36% is recommended for harvesting and threshing the balady bean crop as it recorded minimum seed losses **Trevor *et al.* (2003)** mentioned that to prevent yield and quality losses of faba bean crop, windrowing needed to take place when the seed in the top pods had a complete black hilum.. Thus, such care should be given to establish a simple technique for harvesting faba bean to suit the small holdings with maintaining the seed quality and saving time, labor, energy and operational costs Hence, the objectives of this study are:

1. Developing and constructing a local made mower with proper mechanism for harvesting faba bean crop in the small holdings

2. Evaluating some operational parameters affecting the performance of the developed mower.
3. Comparing the developed mower with the manual harvesting method from the economic point of view.

MATERIALS AND METHODS

The field experiments of this study were carried out during agricultural seasons of 2010/2011 and 2011/2012 at a private farm in Diarb Negm District, Sharkia Governorate to fabricate a local mower with windrowing mechanism for harvesting faba bean (*Vicia faba* L.) crop. The experimental area was about 5 faddans which divided into three equal plots having dimensions about (122 x 56 m) per each and each plot divided into subplots.Table (1) depict the mechanical analysis of the experimental soil.

Table (1): Soil mechanical analysis

Soil depth, cm	Clay (%)	Silt (%)	Coarse sand (%)	Fine sand (%)	Texture class
0 - 30	54.28	13.9	8.32	23.50	clay

A-Materials

1-Faba Bean Variety: One variety of faba bean (Improved Giza 103) was used in this study.

2-Machines and Equipment

-Tractors: Three types of four wheel tractors were used in the crop mechanization system, the first one is the Universal 650-M (77 hp, 57.40kW), the second is Kubota M110 (110 hp, 82 kW) that used with the pneumatic planter, while the third is the reversible Kubota L1- R26 (26 hp, 19kW) that used in the mechanical harvesting.

-Planting machines: Two types of mounted planting machines were used in this study, the first one is the seed drill (Colorado) with working width of 210 cm while, the second one is the pneumatic planter (SFOGGIA) with working width of 280 cm.

-The developed mower: The development depending upon converting of the cutting and conveying mechanism of a reciprocating mower (star wheel mower) to cutting and windrowing mechanism that suit the faba bean crop as depicted in Fig.(1).

The developed windrowing mower mainly consists of the following parts:

-The cutter bar: It is a single action cutter bar with length of 180 cm which contains 26 trapezoidal shape knives that located above the fixed knives

.**The crop conveyor**: A sloped rectangular steel sheet conveyor was fixed behind the cutter bar to receive the cutting plants slightly to windrow the crop on the right side of mower. The conveyor is composed of two chains; the upper one has twenty fingers, while the lower one has seventeen fingers with noting that all fingers were covered by rubber.

The transmission system: The transmission system is shown in Fig.(2) The drive pulley (1) which installed on the end of universal joint of the tractor P.T.O. transmit the motion to the driven pulley (2) by V-belt (3) and subsequently to the gear box (4) thereafter, the motion will transmit in two ways, the first one is to the shaft (5) ended of connecting rod then to the cutter bar (6) , the second one is to the crop conveying shaft (7) that transmit the motion to the upper (8) and lower (9) conveying fingers by two gears installed on it (10).The mower parts were carried on a frame.

Stationary thresher: A Turkish threshing machine was used to determine the seed yield of faba bean.

.**B-Methods**

-Treatments: The field experiments were performed through six treatments as follows:

A- Manual planting + manual harvesting.

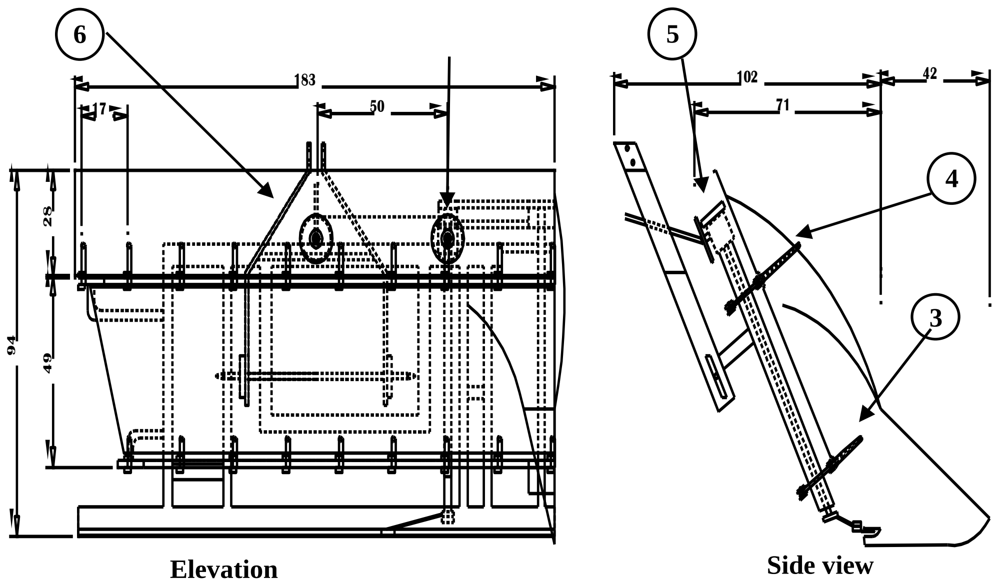
B- Manual planting + developed mower.

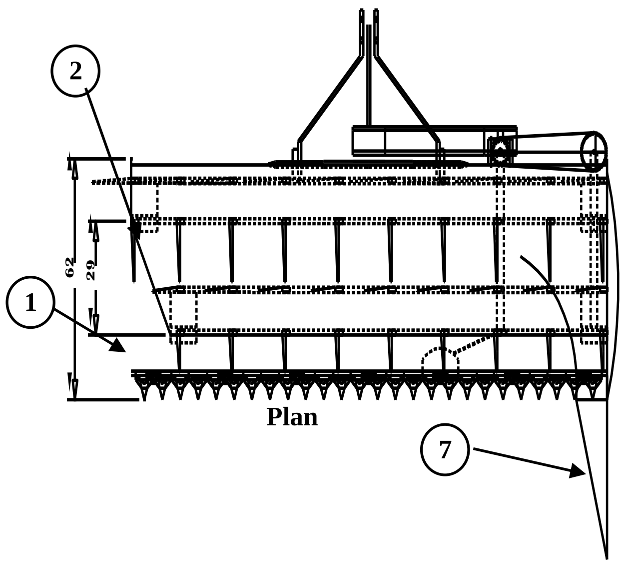
C- Seed drilling + manual harvesting.

D- Seed drilling + developed mower.

E- Pneumatic planter + manual harvesting.

F- Pneumatic planter + developed mower.





No.	Part name	No. of parts
1	Cutter bar	1
2	Crop conveyor	1
3	Lower fingers of conveyor	20
4	Upper fingers of conveyor	17
5	Gear box	6
6	Frame	1
7	Plants divider	1

All dimentions in cm.

Fig. (1): Elevation, plan and side view of the developed mower.

- Planting methods

Two methods of planting were used, the manual and mechanical method. The mechanical planting including the seed drill and the pneumatic planter with average forward speed of about 4.5 km/h.

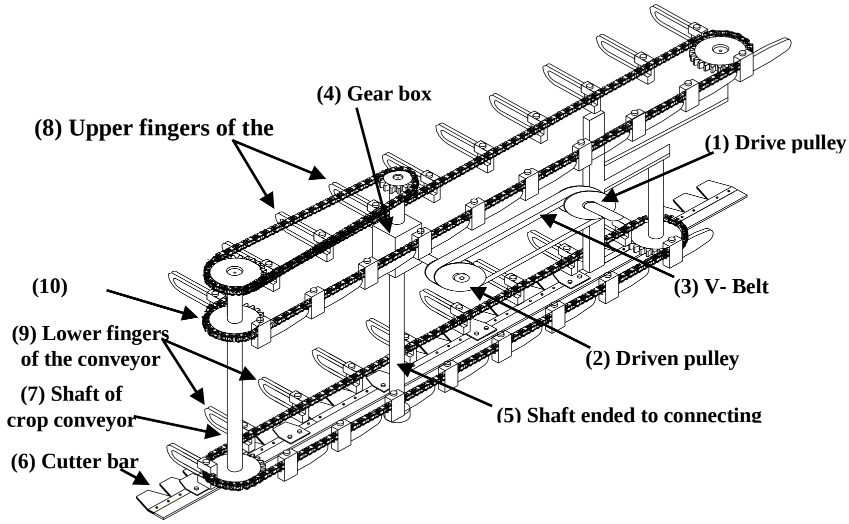
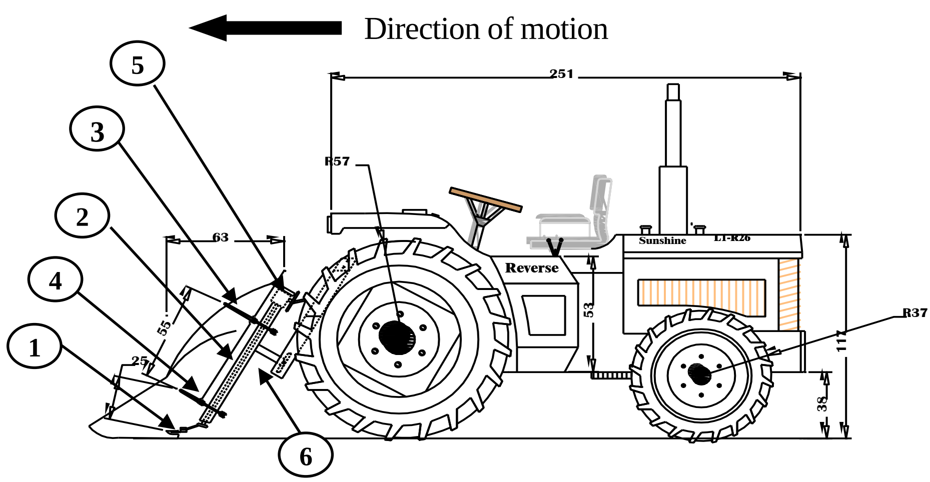


Fig.(2): The transmission system of the developed mower.

-Harvesting methods

The manual harvesting was performed by using the sickle, while the developed mower was used for harvesting faba bean that equipped to a reversible tractor as shown in Fig.(3)



(1) cutter bar (2) crop conveyor (3) upper fingers of conveyor (4) lower fingers of conveyor (5) gear box (6) frame (All dimentions in cm.)

Fig.(3):Schematic diagram of the reversible tractor and the mower.

The evaluation of the developed mower was carried out through two experiments as follows:

-The Preliminary Experiment

It was conducted to determine the proper parameters affecting the cutting and conveying of plants as follows:

1. Using the vertical conveying reaper (star wheel reaper).
2. Three different crop conveyor angles of 30, 60 and 90°.
3. Three different horizontal distances of 0, 7 and 15 cm between cutter bar and the crop conveyor.

-The Main Experiment

It was performed at the field to optimize the parameters affecting the performance of the developed mower, these parameters are:

1. Three planting methods of manual, seed drill and pneumatic planter.
2. Average forward speeds of 1.80, 3.00, 4.30 and 5.80 km/h.
3. Average stem moisture contents of 24.2, 30.3, 35.8 and 41.7 % (w.b.).
4. Cutter bar speeds of 1.44, 1.96 and 2.38 m/s.
5. Conveying fingers speeds of 1.63, 2.23 and 2.70 m/s.

-Measurements

The performance of the developed mower was evaluated taking into consideration the following indicators:

- Field efficiency

The theoretical and the actual field capacity was calculated .then **t**he field efficiency.

-Harvesting losses

The harvesting losses including the pre-harvest, header and manual harvesting losses as follows:

-Pre-harvest losses

The pre-harvest losses were determined by locating a square meter frame in the un-harvested area and the seeds losses in the frame were counted.

The percentage of pre-harvesting losses was calculated by using the following equation:

$$\text{Pre}-\text{harvesting losses}\,(\%)=\frac{\text{Pre}-\text{harvesting losses, kg/fed.}}{\text{Total yield, kg/fed.}}\,x100$$

-Header losses

The header losses were obtained by locating a frame of one square meter on the ground after the harvesting operation and slowly clearing of harvested crop (windrowed) from the same area where the seeds in the frame represent the pre- harvest and header losses together. Then, for indicating the header losses only, the pre- harvest losses must be subtracted. The percentage of header losses was calculated by using the following equation:

$$\text{Header losses}\,(\%)=\frac{\text{Header losses, kg/fed.}}{\text{Total yield, kg/fed.}}\,x\,100$$

- Manual harvesting losses

The manual harvesting losses including both of the pre-harvest and manual losses

-Power and specific energy requirement

The required power was calculated by using the following formula:

$$P\,(kW)=Fc_h\,x\,\rho\,x\,C.V.\;x\,\eta_{thb}x\,\frac{427}{75}\,x\,\frac{1}{1.36}$$ **(Embaby,1985)**

Where:

Fc_h : Rate of fuel consumption, L/s

ρ : Density of fuel (for solar =0.85 kg/L).

$C.V.$: The average calorific value of fuel, (For solar = 11000 kcal/kg).

427:Thermo-mechanical equivalent, kg.m/kcal.

η_{thb}: The thermal brake efficiency of engine (Considered to be about 30 - 35% for diesel engines).

-Specific energy requirements

Energy requirements can be calculated by the following equation:

$$\text{Energy requirement}=\frac{\text{Required power, (kW)}}{\text{AFC, (fed/h)}}$$

-Economical evaluation

The machine cost was determined by using the following equation **(Awady, 2003):**

$$C = \frac{p}{h}\left(\frac{1}{e} + \frac{i}{2} + t + r\right) + (0.9W.S.F) + \frac{m}{144}$$

Where:

C: Machine hourly cost, L.E/h.

P: Price of machine, L.E.

h: Yearly working hours, h/year.

e: Life expectancy of the machine, year.

i: Annual interest rate ,(%).

t: Annual taxes, over heads rate, (%).

r: Annual repairs and maintenance rate, (%).

0.9: Factor accounting for ratio of rated power and lubrications

W: Power, kW.

S: Specific fuel consumption, L/kW.h.

F: Fuel price, L.E/L.

m: Operator monthly salary, L.E.

144: The monthly average working hours

The tractor and mower operating costs were calculated from following equation:

$$Operational\ \ \text{cost(LE/fed)} = \frac{\text{Hourly cost,(L.E./h)}}{\text{Actual field capacity,(fed./h)}}$$

The criterion cost of mechanical harvesting = operational cost of machines (L.E/fed) + cost of crop losses (LE/fed).

RESULTS AND DISCUSSION

-Results of the Preliminary Experiment

The practical test of the vertical conveying reaper (star wheel reaper) revealed that the star wheel caused a high impact in faba bean stems at fruiting zone and the small clearance between star wheels and crop conveyor caused high crop losses due to crushing the stems with pods It is obvious that, the star wheel reaper is not suitable to harvest faba bean crop. Regarding to the developed mower, the results of the preliminary experiment indicated that when crop conveyor angle with horizontal level was 60°, the horizontal distance between the cutter bar and the conveyor was 7 cm, and harvesting moisture content was about 30% under the manual planting gave the lowest value of total seed losses (3.31%) comparing with the other angles and distances as shown in Fig.(4).

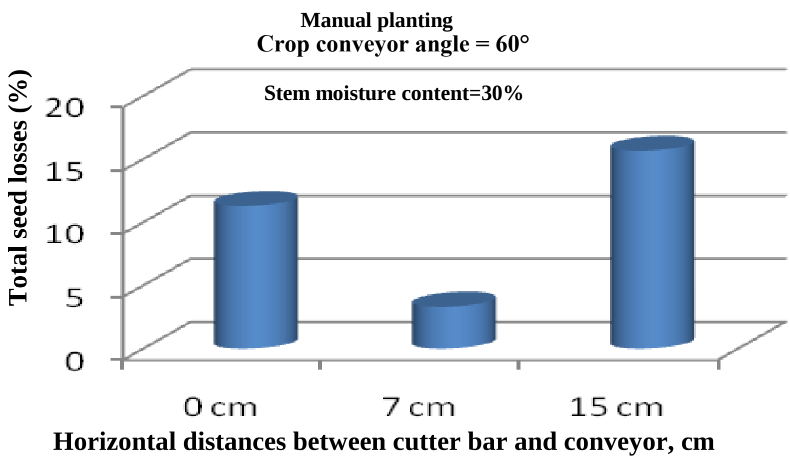


Fig.(4):Effect of the horizontal distances between the cutter bar and crop conveyor on total seed losses.

<u>-Results of the main Experiment</u>

1- Effect of some operational factors on the actual field capacity and field efficiency under different planting methods and forward speeds

-Planting method

Fig.(5-a) depict that, as machine forward speed increases from 1.80 to 5.80 km/h, the actual field capacity increases, but the field efficiency would decrease rapidly. The obtained results revealed that the stem moisture content of 30.30%, conveying fingers speed of 2.23 m/s and cutter bar speed of 1.96 m/s gave the highest value of the actual field capacity of 1.63 fed/h and field efficiency of 91.63% at machine forward speed of 5.30 and 1.80 km/h, respectively, using the pneumatic planter. For the manual harvesting, the highest value of field capacity of 0.042 fed/h was recorded under pneumatic planter treatment while, the lowest value was 0.031 fed/h using the manual planting at stem moisture content of about 30.30%, as shown in Fig. (5-e).

- Stem moisture content

Fig.(5-b) show that by decreasing the stem moisture content from 41.70 to 30.30%, both the actual field capacity and field efficiency increased from 1.35 to 1.45 fed/h and 73.78 to 79.10% respectively, but reducing the stem moisture content to 24.4%, the actual field capacity and field efficiency decreased rapidly to 1.33 fed/h and 72.40% respectively, at machine forward speed of 4.30 km/h cutter bar speed of 1.96 m/s and conveying fingers speed of 2.23 m/s using the pneumatic planter. These results may be referred to that both cutting and windrowing the plant stems that having low moisture content may block out the cutter bar and the crop conveyor components.

- Cutter bar speed

Fig.(5-c) display that the increase of cutter bar speed from 1.44 to 1.96 m/s, was followed by a low increase in actual field capacity from 1.44 to 1.45 fed/h, then it decreases to 1.38 fed/h by increasing the cutter bar speed to 2.38 m/s at plant moisture content of 30.30%, machine forward speed of 4.30 km/h and conveyor speed of 2.23 m/s Generally, the increase of cutting bar speed would increase the field capacity but the excessive speed my cause blocking out the space between the adjacent guards by the plant stems clump. The same trend was observed with the field efficiency.

- Conveying fingers speed

Fig. (5-d) illustrate that it was a low increase in actual field capacity when the conveying fingers speed increased from 1.63 to 2.23 m/s, but the actual field capacity decreased to 1.38 fed/ h, once conveying fingers speed increased to 2.7 m/s at plant moisture content of 30.30%, machine forward speed of 4.30 km/h and cutter bar speed of 1.96 m/s under pneumatic planter treatment, also, the same trend was occurred at the field efficiency. It is clear that forward speed of 4.30km/h, stem moisture content of 30.30%, cutter bar speed of 1.96 m/s and conveying fingers speed of 2.23 m/s and cutter bar speed of 1.96 m/s using the pneumatic planter gave acceptable values of actual field capacity (1.40 fed/h) and field efficiency (79.10%).

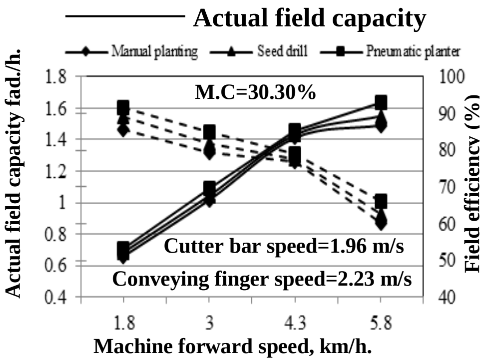


Fig. (5-a): Effect of planting method and forward speed on field capacity and field efficiency.

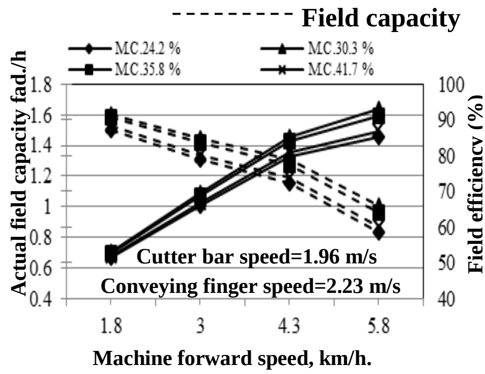


Fig.(5-b): Effect of stem moisture content and forward speed on field capacity and field efficiency using pneumatic planter.

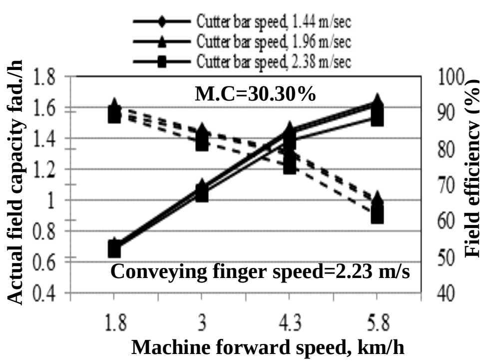


Fig.(5-c): Effect of cutter bar speed and forward speed on field capacity and field efficiency using pneumatic planter.

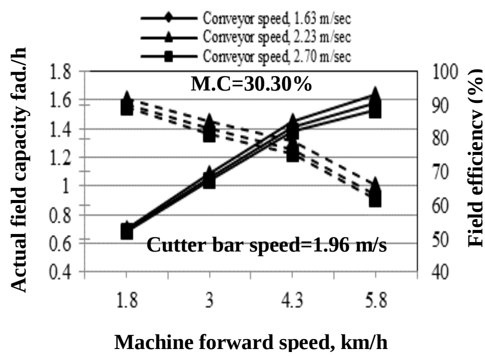


Fig.(5-d): Effect of conveying fingers speed and forward speed on field capacity and field efficiency using pneumatic planter.

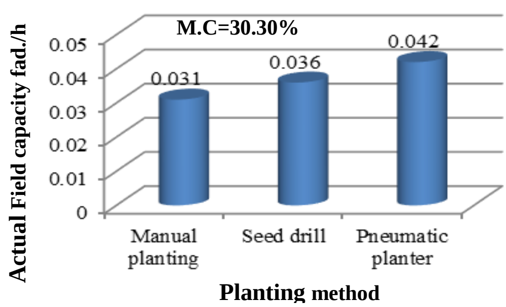


Fig.(5-e): Effect of planting method on field capacity using manual harvesting.

2- Effect of some operational factors on total seed losses under different planting methods and forward speeds

- Planting method

Figs.(6- a to 6- d) display that, by increasing the machine forward speed from 1.80 to 4.30 km/h, the total seed losses decreased from 0.37 to 0.23% then total losses increased to 0.72% as the machine forward speed increased to 5.80 km/h, at stem moisture content of 30.30%, conveyor speed of 2.23 m/s and cutter bar speed of 1.96 m/s using the pneumatic planter. The high machine speeds may cause a great variation in the cutting height resulting in shattering the lower pods to the paddock which would lead to increase the header losses. Fig. (6–a) depicts that the lowest seed losses of 0.23% was recorded at machine forward speed of 4.30 km/h, stem moisture content of 30.30%, conveying fingers speed of 2.23 m/s and cutter bar speed of 1.96 m/s using pneumatic planter. Regarding to the manual harvesting, the highest total seed losses of 3.17% was recorded under manual planting at stem moisture content of 30.30%, as shown in (Fig. 6-e).

- Stem moisture conten

Fig.(6-b) shows that the total seed losses decreased clearly from 1.31 to 0.23% as the stem moisture content decreased from 41.70 to 30.30%, then total losses start to increase slightly when stem moisture content decreased to 24.4% at machine forward speed of 4.30 km/h, cutter bar speed of 1.96 m/s and conveying fingers speed of 2.23 m/s under pneumatic planter treatment. The harvesting at low level of stem moisture content may shatter the bottom and middle pods that are over ripe.

- Cutter bar speed

Fig.(6-c) display that total seed losses decreased from 0.28 to 0.23% when cutter bar increased from 1.44 to 1.96 m/s but, the opposite trend was noticed by increasing the cutter bar speed to 2.38 m/s at stem moisture content of 30.30%, machine forward speed of 4.30 km/h and conveying fingers speed of 2.23 m/s using pneumatic planter. This may be attributed to the high vibration of the cutter bar which may shatter the mature lower and the middle pods which leads to reduce the quantity and quality of seeds.

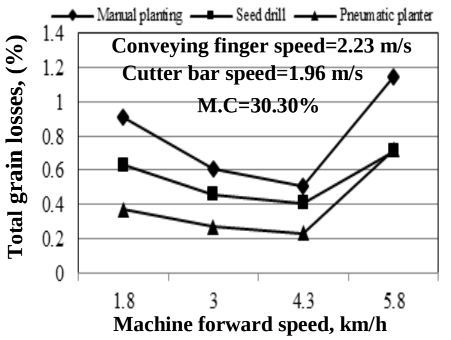


Fig.(6-a):Effect of planting method and forward speed on total seed losses.

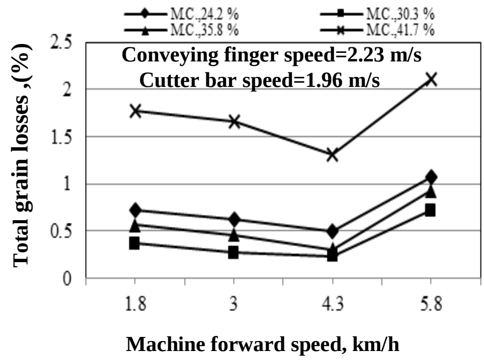


Fig.(6-b): Effect of stem moisture content and forward speed on total seed losses using pneumatic planter.

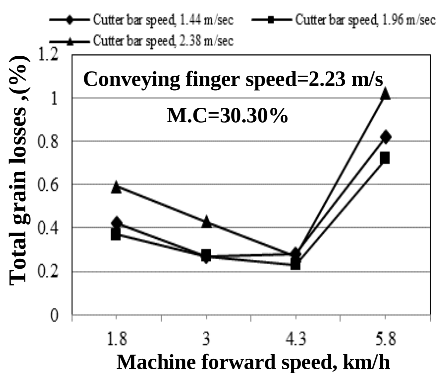


Fig.(6-c):Effect of cutter bar speed and forward speed on total seed losses using pneumatic planter.

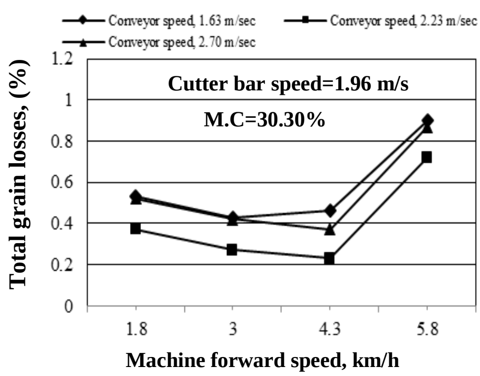


Fig.(6-d):Effect of conveying fingers speed and forward speed on total seed losses using pneumatic planter.

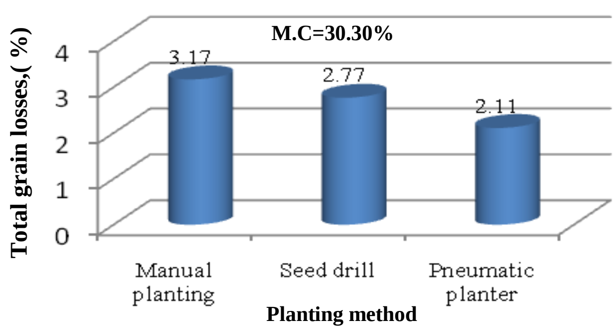


Fig.(6-e):Effect of the planting method on total seed losses under manual harvesting.

- Conveying fingers speed

Fig.(6-d) show that the total seed losses decreased from 0.46 to 0.23% as conveying fingers speed increased from 1.63 to 2.23 m/s, but the opposite trend was noticed for any further increase in the conveying fingers speed at plant moisture content of 30.30%, machine forward speed of 4.3 km/h and cutter bar speed of 1.96 m/s using the pneumatic planter. This due to the high impact of conveying fingers with stem clump at high conveying speed.

3-Effect of some operational factors on specific energy requirements under different planting methods and forward speeds

-Planting method

Figs.(7–a to d) illustrate that the specific energy consumption decreases by increasing the forward speed and the contrarily was occurred with the consumed power. This decrease can be attributed to the increase of the actual field capacity compared with the increase of the consumed power when the forward speed increased from 1.80 to 5.80 km/h. The obtained results indicated that the lowest value of specific energy requirement of 6.58 kW.h/fed was achieved at machine forward speed of 5.80 km/h, stem moisture content of 30.30 %, cutter bar speed of 1.96 m/s and conveying fingers speed of 2.23 m/s under pneumatic planter treatment, Fig. (7-e) display that the specific energy values of the manual harvesting are still very low due to the little values of both the actual field capacity and the required power under all planting methods ,that means consuming more time and costs

-Stem moisture content

Fig.(7-b) show that the specific energy requirements decreased from 8.71 to 6.92 kW.h/fed, when plant moisture content decreased from 41.70 to 30.30% then the specific energy requirements tend to increase until it reach 8.0 kW h/fed, when plant moisture content decreased to 24.4% at machine forward speed of 4.3 km/h, conveyor speed of 2.23 m/s and cutter bar speed of 1.96m/s under the pneumatic planter treatment. This may be referred to the decrease occurred in the actual capacity at low stem moisture content.

Power requirement   Specific energy requirement

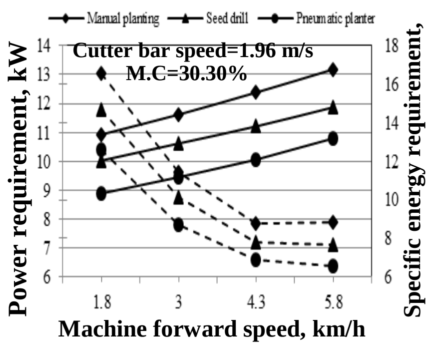


Fig.(7-a):Effect of planting method and forward speed on power and specific energy requirement at conveying fingers speed of 2.23 m/s.

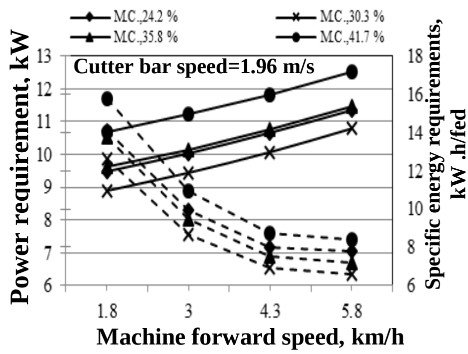


Fig.(7-b):Effect of stem moisture content and forward speed on power and specific energy requirement at conveying fingers speed of 2.23 m/s using pneumatic planter.

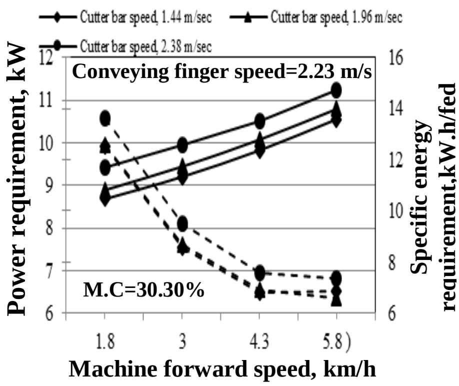


Fig.(7–c): Effect of cutter bar speed and forward speed on power and specific energy requirement using pneumatic planter.

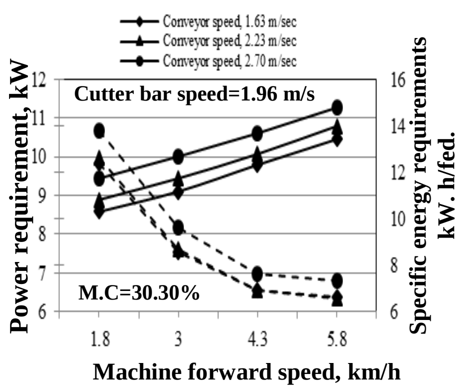


Fig.(7-d):Effect of conveying finger speed and forward speed on power and specific energy requirement using pneumatic planter.

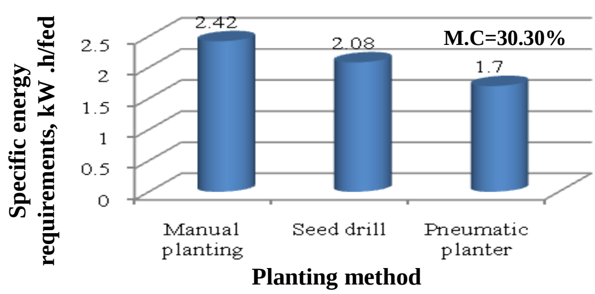


Fig.(7-e):Effect of the planting method on specific energy requirement using the manual harvesting.

-Cutter bar speed

Fig.(7-c) show that, as the cutter bar speed increases from 1.44 to 2.38 m/s the specific energy requirements increases from 6.82 to 7.60 kW.h/fed., at machine forward speed of 4.30 km/h, plant moisture content of 30.30%, cutter bar speed of 1.96 m/s and conveying fingers speed of 2.23 m/s using the pneumatic planter. This may be referred to the excessive stress on cutting knives at the high speeds of cutter bar that may consume more power.

-Conveying fingers speed

Under the previous operating conditions, it is noticed that a low decrease was occurred in specific energy requirements as the conveying fingers speed increased from 1.63 to 2.23 m/s but once the conveying finger speed increased to 2.7m/s, the specific energy requirements increased to 7.62 kW.h/fed, as shown in Fig.(7–d). The optimum operating conditions of the developed mower were the machine forward speed of 4.30 km/h, plant moisture content of 30.30%, cutter bar speed of 1.96 m/s and conveying fingers speed of 2.23 m/s using the pneumatic planter which consumed power of 10.07 kW and specific energy of 6.92 kW.h/fed.

4-Effect of some operational factors on criterion cost under different planting methods and forward speeds

Figs.(8-a to d) indicate that the value of criterion cost decreases from 76.00 to 41.80 L.E./fed., as the machine forward speed increases from 1.80 to 4.30 km/h, but any further increase in forward speed, the criterion cost will increase rapidly at stem moisture content of 30.30%, cutter bar speed of 1.96 m/s and conveying fingers speed of 2.23 m/s under pneumatic planter. This decrease can be attributed to the increase of actual field capacity of machine in rang of 1.80 to 4.30 km/h and any increase in forward speed will increase the total seed losses cost. Under the same operating conditions, the criterion cost reduced by decreasing the stem moisture content from 41.7 to 30.30% and increasing both of cutter bar speed from 1.44 to 1.96 m/s and the conveying fingers speed from 1.63 to 2.23 m/s, but any further decrease in stem moisture content

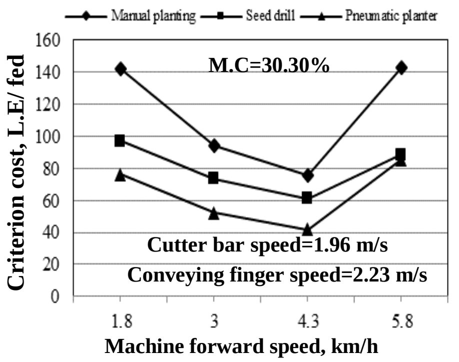


Fig.(8-a): Effect of planting method and machine forward speed on criterion cost.

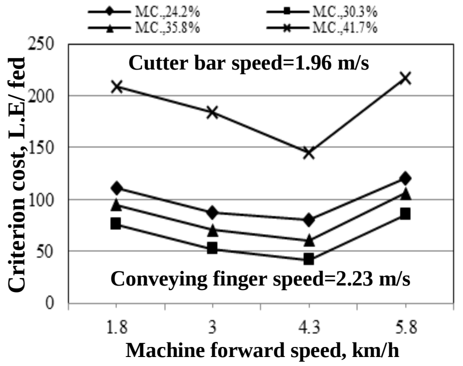


Fig.(8-b): Effect of stem moisture content on criterion cost using pneumatic planter.

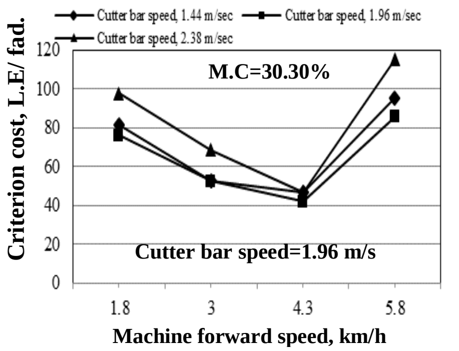


Fig.(8-c): Effect of conveying fingers speed on criterion cost using pneumatic planter.

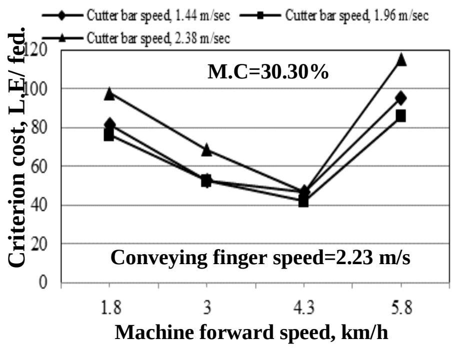


Fig.(8-d): Effect of cutter bar speed on criterion cost using pneumatic planter.

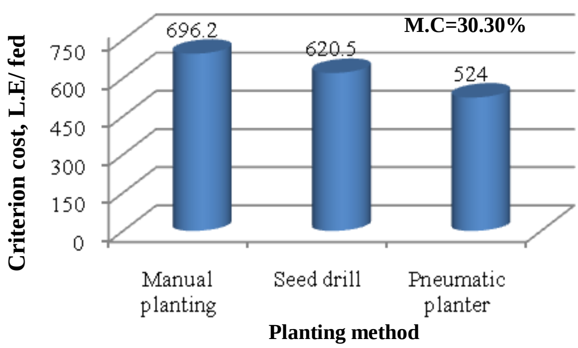


Fig.(8-e):Effect of the planting method on creterion cost using manual harvesting.

or increase of both the conveying fingers speed and cutter bar speed, the opposite trend would occur. Fig.(8-e) show that the criterion cost under the manual harvesting is very high under all planting methods at stem moisture content of 30.30%. Ultimately, it can be concluded that the lowest value of criterion cost of 41.80 L.E./fed was achieved at machine forward speed of 4.30 km/h, plant moisture content of 30.30%, cutter bar speed of 1.96 m/s and conveying fingers speed of 2.23 m/s using pneumatic planter.

CONCLUSION

According to the obtained results, it is recommended to use the developed mower for harvesting faba bean crop with crop conveyor angle of 60° and horizontal distance between cutter bar and the conveyor of 7 cm at average machine forward speed of 4.30 km/h, stem moisture content of 30.30%, cutter bar speed of 1.96 m/s and conveying fingers speed of 2.23 m/s to achieve the lowest values of total seed losses(0.23%), criterion costs (41.8 L.E/fed) and specific energy requirement (6.92 kW.h/fed) at actual field capacity of 1.64 fed/h and field efficiency of 79.10%.

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الملخص العربي

تطـوير آلة لحصاد محصول الفول البلدى

أ.د. محمد سعد الدين الشال[1] أ.د. محمد قدرى عبدالوهاب[1]
د.محمد على توفيق[2] م. خالد عبد السلام متولي[3]

الهدف من هذه الدراسة هو تصنيع وتطوير محشة ترددية لتعمل بآلية تصفيف النباتات علي جانب الآلة لحصاد محصول الفول البلدى في الحيازات الصغيرة، وتم إجراء الدراسة من خلال تجربتين هما التجربة الأولية وهي بغرض تحديد أهم العوامل المؤثرة علي عملية قطع وصف النباتات وتشمل ثلاث زوايا مختلفة لناقل المحصول مع المستوى الأفقى (٣٠، ٦٠ ،٩٠°) وثلاث مسافات أفقية بين قضيب القطع وناقل المحصول (صفر، ٧ ،١٥سم)، أما التجربة الأساسية فكانت بغرض تقييم أداء المحشة المطورة والتي تشمل ثلاث طرق مختلفة للزراعة وهى الزراعة اليدوية، آلة التسطير وآلة الزراعة في الخطوط الهوائية وكذلك أربع سرعات أمامية للمحشة (١,٨، ٣، ٤,٣ و٥,٨ كم/ساعة)، أربع نسب لرطوبة السيقان (٢٤,٢، ٣٠,٣٠، ٣٥,٨ و ٤١,٧% علي أساس رطب)، ثلاث سرعات لقضيب القطع (١,٤٤، ١,٩٦ و ٢,٣٨ م/ث) وثلاث سرعات لأصابع نقل المحصول (١,٦٣، ٢,٢٣ و ٢,٧٠ م/ث) حيث تم تقييم أداء المحشة مع الأخذ في الاعتبار تأثير جميع العوامل السابقة علي كل من السعة الحقلية الفعلية للآلة ، الكفاءة الحقلية، فواقد الحصاد، الطاقة المستهلكة وتكاليف حصاد المحصول، وقد أوصت الدراسة بإستخدام آلة الزراعة الهوائية وتشغيل المحشة المطورة لحصاد الفول البلدى عند سرعة أمامية ٣,٤ كم/ساعة ورطوبة لسيقان النبات ٣٠,٣٠% وسرعة لأصابع نقل المحصول ٢,٢٣ م/ث وسرعة لقضيب القطع ١,٩٦ م/ث و ذلك باستخدام زاوية لناقل المحصول مع المستوى الأفقى ٦٠° ومسافة أفقية بين قضيب القطع وناقل المحصول مقدارها ٧ سم للحصول على أقل قيم لكل من فواقد المحصول(٠,٢٣%) والطاقة المستهلكة (٦,٩٢ كيلووات.ساعة/ فدان) وتكاليف الحصاد(٤١,٨٠ جنيه/فدان) عند سعة حقلية فعلية للآلة حوالي١,٦٤ فدان/ ساعة وكفاءة حقلية مقدارها٧٩,١٠%.

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[1] أستاذ الهندسة الزراعية المتفرغ – كلية الزراعة – جامعة الزقازيق- مصر.
[2] أستاذ الهندسة الزراعية المساعد – كلية الزراعة - جامعة الزقازيق – مصر.
[3] مدرس مساعد الهندسة الزراعية– كلية الزراعة - جامعة الزقازيق – مصر.