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Modification of an Air - Carrier Sprayer for Cotton Picking at Small Holdings Area

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ABSTRACT

This study was carried out to modify an air-carrier sprayer as a pneumatic cotton picker to suite the small holdings area. The experiment was designed statistically as a split plots with three replicates. The main plots involved air suction pressure treatment levels of 0.31, 0.38, 0.82 and 0.91 kPa. While, the sub-plots were devoted for defoliant and boll opening spraying treatment levels of applying DROP Ultra + FINISH Pro 15-25 days prior and the bereaved of defoliant and boll opening. these treatments were compared with the manual picking method. The results indicated that the modified cotton picker accomplished higher performance than the manual method. Using the modified cotton picker at 0.91 kPa air suction pressure under defoliant and boll opening achieved the higher actual field capacity value of 14.69 kg/h, the higher picking efficiency value of 97% and the lower specific energy requirements of 19 kJ/kg. While, using the modified cotton picker at 0.31 kPa. air suction pressure under leaves drop accomplished the higher field efficiency values of 83% and the lower criterion costs value of 22.83 LE/h. whilst, there was not a significant difference between the modified cotton picker and the manual method due to the cotton fiber characteristics. Finally, it is recommended to apply the modified cotton picker, especially at 0.91 kPa. air suction pressure using leaves drop.

INTRODUCTION

Egyptian cotton is the best around the world because of its long fiber that makes it softer and stronger. The silky soft cotton once known as "white gold" was so valuable that products made from most of the crop was exported. Egyptians themselves could hardly purchase items that made from its cotton. However, for a long period the business of cotton was not significant for the country, especially since 2011 the production of the cotton has declined sharply. It was time of political turmoil that coincided with looser regulations that ruined the quality of local cotton. Earlier, after 1994, when 'free market' economy started in Egypt, the government made a decision to liberalize the market. That meant Egyptian farmers no longer had direct government subsidies, which discouraged farmers to harvest cotton and they started to cultivate other crops .After years of declining production, Egyptian cotton is again on the rise. A currency devaluation, new policies to increase yields and improve quality, and high farm-gate prices are encouraging farmers to expand cotton area and increase production. Under this new economic environment, cotton exports are expected to rise during the coming years, while imports decrease marginally. During 2018/19, it is expected to increase the cotton harvested area to be 300,000 fed (Egyptian Central Agency for Public Mobilization and Statistics, 2018).

In Egypt, cotton picking is considered as a major problem in cotton production. Cotton is still hand-picked which gives a high quality cotton but requires more time. So, it is a critical time for producers on many fronts. Also, costs associated with hand picking represent a large molecule of the production costs it up to 40% (Abd El-Mageed, 2010).

Cotton mechanical harvest is a relatively new concept with little more than 100 years. Cotton harvester is the single largest cost of production; and the timing and method of harvest can dramatically impact crop quality and yield. Cotton harvesters are of two types, pickers and strippers. The pickers use spindles to remove seed cotton from the boll of the plant, whereas strippers are non-selective, as they strip the entire plant of both opened and unopened bolls using brushes and paddles. Strippers are less expensive and require less maintenance than that required by pickers. However, it harvests cotton contains more foreign matter (burrs, leaves, and many branches from the plant stem, but lower gin turnout is expected, using of additional cleaning machinery at the gin (Faulkner *et al*., 2011; Deshmukh and Mohanty, 2016 and El-Yamani *et al*., 2017).

Also, the use of cotton pickers has no negative effect on traits such as seed cotton yield, lint yield, ginning outturn, fiber length, fiber fineness, fiber strength, elongation, and yellowness. The lint quality of the mechanical picked cotton was not significantly different from those picked by hand (Abd Ullah and Esggici, 2015). Recently, pneumatic cotton picker can be used as a mechanism which would reduce the harvest cost and maintain the cotton fiber quality, comparing with the spindle type (Sharma *et al*., 2011; Selvan *et al*., 2012; Sessiz *et al*., 2012, Nikhil and Mahalle, 2015 and Durgesh *et al*, 2017). Meanwhile, the portable cotton picker is suitable for small farms (Ambati and Majumdar, 2013).

As cited by Ibrahim, *et al*., (2014), the main problem of mechanical picking of Egyptian cotton in the physiological characteristics especially about height of plant, and branching density. Also, the conditions of Egyptian agriculture like small agricultural holding, sporadic fields, and narrow roads between fields that not prepared for passing the machines. In addition, the Egyptian farmers that cannot bear the machine operational costs. Despite of these problems, the recent increased area of the planted Egyptian cotton directed the attention towards applying the mechanical cotton harvest.

This study aimed to modify an air carrier sprayer to be a pneumatic cotton picker to suit the Egyptian conditions.

MATERIALS AND METHODS

Experimental Site and Soil Conditions:

During October 2017, a field experiment of 1 fed (60 x 70 m) was established at a private farm in Kafr El-Hamam village, Zagazig District, El-Sharkia Governorate, Egypt that is located at $30^{\circ}\ 35'\ 15.65''$ N latitude and $31^{\circ}\ 30'\ 7.20''$ E longitude with an altitude of 1550 masl which has an average annual rainfall of 165.00 mm.

As cited by El-Serafy and El-Ghamry (2006), the soil was mechanically analyzed as shown in table (1).

Table 1. Soil mechanical analysis of the experimental site.

Sand, %			Silt, %	Clay, %	Soil texture class
Corse, %	Fine, %	Total, %			
11.05	11.30	21.35	40.30	37.35	Silt clay loam

Agricultural Practices:

Seed bed preparation: The seed bed was prepared using a seven shanks chisel plough in two passes in perpendicular directions at 0.15 m depth. The secondary tillage was performed using a tandem disc harrow. The precision land leveling was conducted using a hydraulic scraper of 1.26 m3 capacity (0.60 x 3.00 x 0.70 m), which is accompanied with a laser control equipment.

Planting: The selected cotton seeds of Giza 94 variety was manually planted at 0.60 m row spacing, 0.20 m spacing apart along the same row and 0.04 m depth.

All other practices were applied as recommended by Darweesh *et al*., 2015.

Cotton Plant Characteristics:

At harvest, some cotton (Giza 94 variety) plant characteristics were determined and presented in table (2).

Table 2. Some cotton (Giza 94 variety) plant characteristics.

Mean boll numbers/ plant	Mean boll weight, gm	Mean plant height, m	Mean plant numbers/ fed	Mean yield, kg/fed
11	2.3	1.55	60000	1570

Air-Carrier Sprayer:

The used air-carrier sprayer has 13 kg mass, and its dimensions are 0.77 m height, 0.55 m length and 0.36 m width. The air-carrier sprayer consists of the following main components:

1. Liquid spraying tank: It has 20 liter capacity. The spraying liquid is fed by gravity through a main plastic tube of 10 mm diameter and 1.50 m length.
2. Fuel tank: It has 1.5 liters capacity. The fuel is fed by gravity through a plastic tube of 4 mm diameter and 0.50 m length. The plastic tube connects with the engine.
3. Engine: It is 3.7 kW power, 2-stroke cycle, Gasoline fuel + 4% oil, and air cooling.
4. Blower: A centrifugal suction blower consists of a casing, blades fixed on motor shaft. The blower rotational speeds are 17.5, 23, 25.9 and 27.5m/s.

Air-Carrier Sprayer Modification:

As indicated in Fig. (1),The used air-carrier sprayer was modified at a private workshop in Kafr El-Hamam village, Zagazig District as follows:

1. The liquid tank was used to collect the picked cotton fibers. The inner tank surface was covered by a soft wire screen of 0.5 mm mesh whole diameter to minimize fiber mechanical damage.
2. To secure the blower, it was covered with a round shape plastic sheet (PVC) of central opening with 0.04 m diameter to prevent the fibers entry.
3. A plastic pipe (PVC) of 0.04 m diameter was fixed and set at the central opening edge by a by a screw nut. The pipe free end was closed with a wire screen of 1 mm mesh whole diameter to prevent the fibers entry. The pipe free end was located at the liquid tank center.
4. A plastic elbow (PVC) was fastened at the inner surface of liquid tank to carry the plastic pipe by a tap bolt.
5. At the sprayer upper surface, an opening of 0.04 m diameter was holed.

A rubber hose of 1.50 m length and 0.04 m diameter was fixed and set at the opening edge by a screw nut.

The air suction pressure was measured at different motor speeds using manometer of 0.1 mbar accuracy.

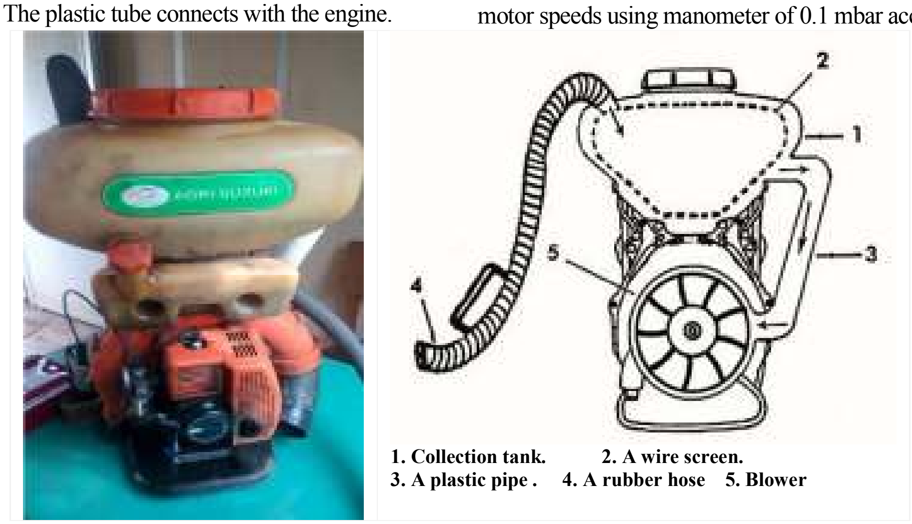

Fig. 1. Modified air-carrier sprayer.

Treatments and Statistical Design:

During the experiment the following treatments were tested:

1. Air suction pressure: It included levels of 0.31, 0.38, 0.82 and 0.91 kPa which were measured at motor rotational speeds are 17.5, 23, 25.9 and 27.5m/s.
2. Spraying of defoliant and boll opening: It included levels of applying DROP Ultra + FINISH Pro 15-25 days prior using hollow cone nozzles and the bereaved of defoliant and boll opening.

These treatments were compared with the manual picking method which consists of 150 labors with average wage of 70 LE/labor.

- The experiment was established as a split plots statistical design with three replications. The main plots were located for the air suction velocity treatment levels and the sub-plots were devoted for the spraying of defoliant and boll opening.

Measurements:

Modified pneumatic cotton picker performance:

The actual field capacity and the Field efficiency were determined as cited by Anonymous (2006 a). The picking efficiency was determined as cited by Anonymous (2006 a). The specific cotton picker energy requirements was calculated according to Kiliçkan *et al*., (2011). While, the specific laborer energy requirements was calculated according to Srivastava *et al*., (2006).

Costs analysis:

As cited by Begum *et al*., (2012), the operational costs are calculated on the basis of fixed costs and variable costs, whereas fixed costs include depreciation, interest, shelter and taxes costs. Depreciation costs are determined by straight line method, described by Zami *et al*. (2014). Variable costs include fuel, lubrication, repairs and maintenance and labor costs. In this study, 3.5% of purchase price is considered as repair costs for every 100 h of effective operation. The equipment salvage value is considered as 10% of purchase value.

Criterion costs = operational costs + unpicked cotton price, LE/kg (1)

Cotton fiber characteristics:

According to Harzallah *et al*., (2010) the cotton fiber characteristics were determined at Cotton Technology Dept., Cotton Res. Inst., Agric. Res. Center, Ministry of Agriculture and Land Reclamation as follows:

1. The digital fiberograph instrument was used to determined fiber length.
2. The pressly tester is used to determine fiber elongation and strength.
3. The micronaire instrument is used to measure micronaire values.

Statistical Analysis:

SPSS (Version 20.0) computer software package is used to employ the analysis of variance test and the LSD test for cotton picking efficiency data. Also, data of the cotton fiber characteristics were analyzed statistically to determine the standard deviation.

Regression and Correlation Analysis:

Microsoft Excel 2016 computer software is used to employ the simple regression and correlation analysis to represent the relation between the cotton picking efficiency and the air suction pressure.

RESULTS AND DISCUSSION

Modified Cotton Picker Performance:

1. Actual field capacity:

Fig. (2) indicates the positive relation between the air suction pressure and the modified cotton picker actual field capacity. The higher field capacity values of 14.69 and 13.85 kg/h were achieved at 0.91 kPa. air suction pressure under leaves drop and bereaved of leaves drop, respectively. This trend is due to the reversible relation between the air suction pressure and the required time for picking cotton bolls. Meanwhile, using the leaves droop increases bolls opening and reduces the bolls rots. Consequently, the quantity of the picked bolls per unit time increases. As indicated in table (3), the labors accomplished cotton picking at area of one feddan during 7 hrs. in other meaning, the manual field capacity recorded 0.43 kg.labor/h. this lower value may be explained that the labors picked only the opened bolls and leaved the others to pick at another harvest.

2. Field efficiency:

Fig. (3) clarifies the reversible relation between the air suction pressure and the modified cotton picker field efficiency. Using 0.31 kPa. air suction pressure accomplished the higher field efficiency values of 83 and 85% under leaves drop and bereaved of leaves drop, respectively. This finding may be explained that the collection tank may be filled at lower time using the higher air suction pressure. Then, the collection tank is emptied more amounts per unit time. Also, using the higher air suction pressure increases the turning amounts per unit time. So, using higher air suction pressure consumes higher squandered time, resulting in lower values of field efficiency. However, table (3) presented that the manual method achieved field efficiency of 65%. It is due to the higher loosen time during fibers collecting and packing,

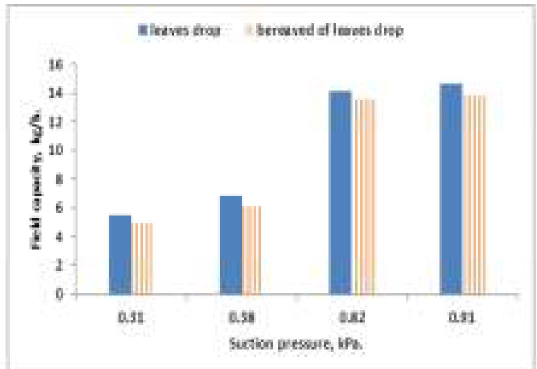

Fig. 2. Effect of air suction pressure on the modified cotton picker actual field capacity.

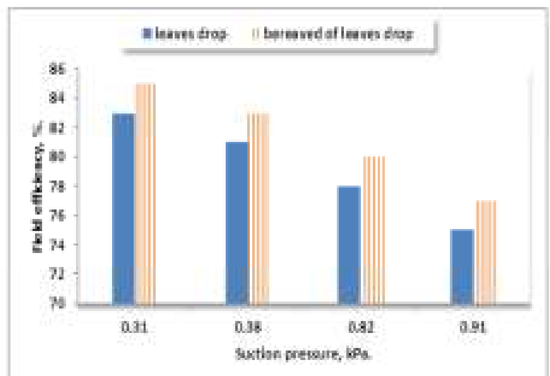

Fig. 3. Effect of air suction pressure on the modified cotton picker field efficiency.

3. Picking efficiency:

Fig. (4) exhibits that the picking efficiency tended to be proportional with the air suction pressure. Adopting 0.91 kPa. air suction pressure recorded the higher picking efficiency values of 97 and 95% under leaves drop and bereaved of leaves drop, respectively. This result is may be illustrated that the higher air suction force increases the probability of bolls picking, leading to lower amount of the unpicked bolls. Whilst, the leaves droop separates the living tissue near the leaf petiole, an area referred to as the abscission zone. Hormones within a plant regulate enzyme activity which causes the cell walls in the abscission zone to dissolve and eventually causes the leaf to drop. As shown in table (3), the manual method recorded 96.54% picking efficiency.

The analysis of variance indicates that, there is a higher significant difference in the modified cotton picker picking efficiency due to the air suction pressure and spraying of defoliant and boll opening. The L.S.D. test at 0.05 level showed that 0.91 kPa. air suction pressure under spraying of defoliant and boll opening achieved the highest picking efficiency among the other treatments.

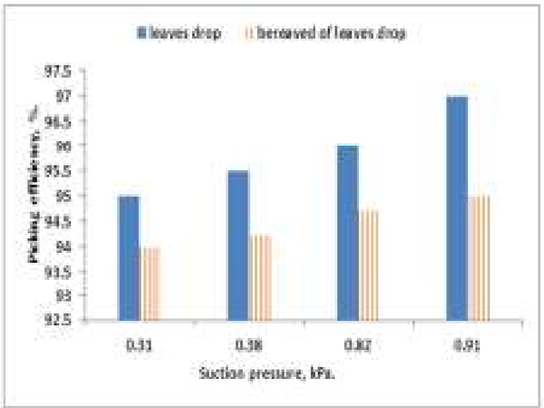

Fig. 4. Effect of air suction pressure on the modified cotton picker picking efficiency.

The regression and correlation analysis reveals that there is a significant highly positive correlation between the modified cotton picker picking efficiency (y) and the air suction pressure (x) as follows:

Leaves drop:

$y = 0.1799\ x + 94.346$ ($R^2 = 0.7732$)

Bereaved of leaves drop:

$y = 0.106\ x +. 93.574$ ($R^2 = 0.9363$)

4. Specific energy requirements:

Fig. (5) demonstrates that the modified cotton picker specific energy requirements tended to be inversely proportional with air suction pressure. The lower specific energy requirements values of 19 and 23 kJ/kg were obtained using 0.91 kPa. air suction pressure under leaves drop and bereaved of leaves drop, respectively. This tendency may be explained that the higher values of air suction pressure require higher blower rotational speed levels, consuming more fuel, expending more energy. This action synchronized with the higher actual field capacity values, resulting in lower values of specific energy requirements. In the meantime, leaves droop may To contribute to facilitate the picking process, expending lower energy. Table (3) indicates that the manual method expended specific energy of 12.55 kJ.labor/kg. this finding attributed to the higher mechanical energy which was required to operate the modified cotton picker.

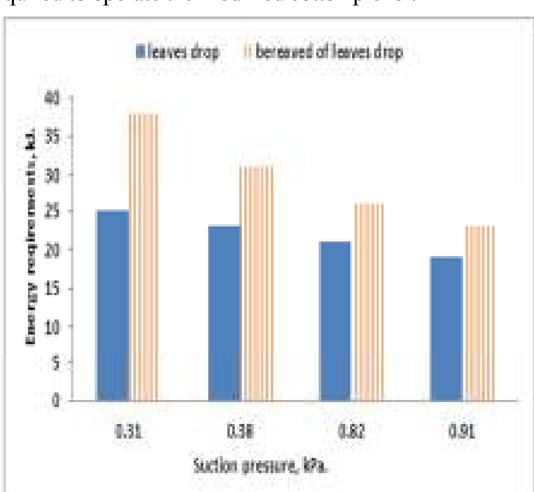

Fig. 5. Effect of air suction pressure on the modified cotton picker specific energy requirements.

Criterion costs:

As presented in Fig. (6), there is a trend towards increasing the modified cotton picker criterion costs with the air suction pressure. Using 0.31 kPa. air suction pressure achieved the lower criterion costs values of 22.83 and 28.46 LE/h under leaves drop and bereaved of leaves drop, respectively. Meanwhile, table (3) shows that the manual method criterion costs was 10 LE.labor/h.

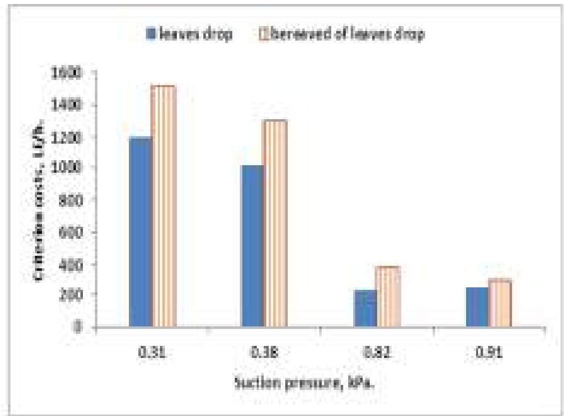

Fig. 6. Effect of air suction pressure on the modified cotton picker criterion costs.

Table 3. Manual picking method performance and criterion costs.

Field capacity, kg.labor/h	Field efficiency, %	Picking efficiency, %	Energy requirements, kJ.labor/kg	Criterion costs, LE.Labor/h
0.43	65	96.54	12.33	10

Cotton Fiber Characteristics:

Table (4) shows that the air suction pressure of the modified cotton picker did not affect significantly on the cotton fiber characteristics. In addition, there was not a significant difference between the effect of both the modified cotton picker and the manual picking method on the cotton fiber characteristics. The statistical analysis showed that the cotton fibers length, elongation, strength and Micronaire recorded the standard deviation of 0.551, 0.453, 0.376 and 0.347%, respectively.

Table 4. Effect of the modified cotton picker and the manual picking method on cotton fiber characteristics.

Suction pressure, kPa.		Length, mm	Elongation, %	Strength, g/tex	Micronaire, %
0.31	A	33.62	6.81	47.48	4.50
	B	33.35	6.74	47.45	4.47
0.38	A	33.21	6.80	47.34	4.48
	B	33.10	6.71	47.30	4.42
0.82	A	33.12	6.77	47.33	4.40
	B	33.04	6.72	47.29	4.36
0.91	A	33.09	6.71	47.25	4.30
	B	33.00	6.69	47.21	4.26
Manual picking		34.00		47.55	4.58

A is leaves drop and B is bereaved of leaves drop.

CONCLUSION

The obtained results could be concluded as follows:

1. The modified cotton picker has higher performance than the manual picking.
2. Applying leaves drop achieved higher performance of the modified cotton picker than bereaved of leaves drop.

3. The modified cotton picker actual field capacity and picking efficiency are proportional with the air suction velocity.
4. The modified cotton picker field efficiency, specific energy requirements and criterion costs are inversely proportional with the air suction velocity.
5. The air suction pressure has non- significant effect on the cotton fiber characteristics.

So, it is recommended to apply the modified cotton picker, especially at higher air suction pressure under leaves drop.

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تعديل آلة الرش ذات الحمل الهوائي لجني القطن في الحيازات ذات المساحة الصغيرة

سها جمال عبد الحميد

معهد بحوث الهندسة الزراعية.مركز البحوث الزراعية

أجريت هذه الدراسة لتعديل آلة الرش ذات الحمل الهوائي لجني محصول القطن في الحيازات ذات المساحة الصغيرة. وقد تم تصميم وتنفيذ التجربة إحصائياً في قطع منشقة في ثلاثة مكررات, وقد تضمنت القطع الرئيسة معاملة ضغط سحب الهواء في مستويات٠.٣١ و٠.٣٨ و٠.٨٢ و٠.٩١ كيلو بسكال بينما إشتملت القطع الشقية على معاملة الرش بمسقطات الأوراق بمستويين هما الرش بمسقطات الأوراق وعدم الرش بمسقطات الأوراق. وقد قورنت هذه المعاملات بطريقة الجني اليدوي. وقد أظهرت النتائج أن أداء آلة جني القطن المعدلة أفضل من طريقة الجني اليدوي. وقد أدى إستخدام الآلة المعدلة عند ضغط سحب الهواء ٠.٩١ كيلو بسكال مع الرش بمسقطات الأوراق إلى تحقيق أعلى سعة حقلية فعلية بمقدار ١٤.٦٩ كجم/ساعة وأعلى كفاءة للجني بمقدار ٩٧% وأقل إحتياجات للطاقة النوعية بمقدار ١٩ ك جول/كجم. بينما أدى إستخدام الآلة المعدلة عند ضغك سحب الهواء ٠.٣١ كيلو بسكال إلى تحقيق أعلى كفاءة حقلية بمقدار ٨٣% وأقل تكاليف حدية بمقدار ٢٢.٨٣ جنيه/ ساعة. وقد وجد أنه لا توجد فروق معنوية بين تأثير كل من آلة جني القطن المعدلة والطريقة اليدوية للجني على خصائص ألياف القطن. ولذا فإنه يوصى باستخدام آلة الرش ذات الحمل الهوائي المعدلة في جني القطن عند ضغط سحب الهواء ٠.٩١ كيلو بسكال مع الرش بمسقطات الأوراق.