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Development Seed Cotton Feeder-Cleaner Suit for Small Gins

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ABSTRACT

This research aims to develop and evaluate the performance and efficiency of the seed cotton feeder-cleaner suit for small gins to reduce maintenance & downtime of the gin. The studied factors were four different feed rates ranged from 0.5, 0.75, 1.0 and 1.25 kg/min; Four different speeds of saw cleaning drum ranged from 3.32, 4.27, 5.22 and 6.17.m/s; Four different speeds of brush cleaning drum ranged from 5.32, 6.83, 8.39 and 9.87.m/s using seed cotton varieties of Giza 86 and Giza 94. The obtained results concluded that: The maximum productivity of the developed feeder /cleaner was 1.075 kg/h for cleaning Giza 86 variety compared to 1.115 kg/h for Giza 94 variety at the saw drum speed of 3.32 m/s, brush drum speed of 5.32 m/s and feed rate of 1.25 kg/min . The maximum values of cleaning efficiency of 89.60 and 94.30 % were obtained at the feed rate of 0.5 kg/min; saw drum speed of 6.17 m/s and brush speed of 9.87 m/s during cleaning seed cotton Giza 86 and Giza 94, respectively. The developed seed cotton feeder/cleaner produced better values of 2.5 and 50% span fiber length, uniformity ratio of length, reflectance of color and cotton fiber strength with seed cotton variety of Giza 94 compared to Giza 86.

Keywords: brush dram, saw dram, productivity, reflectance of color

INTRODUCTION

Egyptian cotton has an excellent international reputation and still meets the strong demand in the hand-harvest market for ultra-long staple cotton to achieve a higher degree of seed cotton from the point of view of containing foreign materials. Nowadays, the high cost of cotton manually harvesting will soon force farmers to mechanically harvest. The cotton mechanically harvested contains large amounts of waste and trash material such as stems, leaves, body of plants and fractures that must be removed in the early stages before ginning. Therefore the primary cotton cleaning must be done to reduce the unwanted impurity content of cotton before sending to gin stands.

Anthony (1994) reported that cleaning equipment is used to extract the trash objects and is used in combination with gin stands to separate usable fiber from the cotton seeds. The optimum amount of cleaning equipment is selected to maximize lint quality and yield. The selection of the amount of cleaning equipment is based on the amount of trash present in the incoming seed cotton. Trash meters are used to measure the amount of trash present in cotton based on the percentage of the surface area covered by trash particles on the surface of the sample. However, Baker *et al.*(1994) cleared that, feed rate, combing ratio and saw speed are the most important operating variables that affect the performance of the saw lint cleaner in terms of fiber quality. They added to that, foreign matter is removed by centrifugal force as seed cotton is pulled across a series of grid bars by a rotating saw cylinder. Sticks, and other heavy foreign matter are removed from seed cotton with greater efficiency than leaf or fine trash in extractor cleaners as a result of the inertia-based cleaning method. Cylinder type cleaners are generally employed for removal of leaf material and other fine particulate, while extractor-type machine is employed for the removal of large trash such as burs and stick. However, the field cleaner should be used as a first step of cleaning to get the least cost cleaning configuration across the harvesting, ginning, and textile mill stages. Also, they found that field cleaning did not affect the quality parameters measured in cotton classification (Bennett and Misra, 1996 , Gillum and Armijo, 1997).

Gillum *et al.* (2001) indicated that as the speed of the cleaning cylinder on the foreign materials loss lint cleaner increased, lint trash content decreased, opening and cleaning waste decreased, lint loss increased and cleaning efficiency increased. Based on the results of the experiment, the optimum speed of the cleaning cylinder was found to be between 750 and 900 rpm (9.8 and 11.8 m/s). The lint cleaner increased as the speed of the cleaning cylinder increased, and the lint cleaning efficiency ranged from 39.9% to 67.7 %.(Foreign matter in seed cotton may include sticks, burrs, leaf, grass, or other objects. Trash particles originate from the cotton plant including different parts of the leaf, stem bark, seed and hull or from the local environmental including grass, sand, dust and other contamination. Cotton contamination including large trash and small pepper trash is commonly referred to as visible foreign matter (Foulk *et al* ., 2006).)

Wanjura *et al.* (2009) examined the effect of processing rate from 52 to 156 kg min-1 m-1 to optimize performance of a stripper-harvester field cleaner. Their results showed that lower rates resulted in a greater reduction in foreign matter content, while processing rate

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was not a significant variable in the lint loss model. This foreign matter content is much larger than typically found in picker-harvested cotton. Removing foreign matter before ginning is necessary to maximize lint value for the cotton producer and reduce maintenance and downtime at the gin especially with the mechanized cotton picking because the machine-picked cotton contains approximately 7% foreign matter, while the machine-stripped cotton typically has a foreign matter content of 32.5%, (Hardin *et al*., 2011).

Wanjura *et al*. (2011) investigated the influence of harvest method, number of seed cotton extractor cleaners (e.g. stick machines), and seed cotton cleaning rate on foreign matter content, lint turnout and bale value. The use of two stick machines removed more foreign material from seed cotton than using only one and more foreign material was removed by the stick machines at slower seed cotton cleaning rates. Total seed cotton loss was higher for seed cotton cleaning systems utilizing two stick machines but was unaffected by harvest method or seed cotton cleaning rate. Seed cotton cleaning system efficiency was greater for stripper harvested cotton and when two stick machines were used the seed cotton cleaning rate had no effect. The use of two stick machines improved fiber reflectance and yellowness properties and reduced lint foreign matter content. Seed cotton cleaning rate had a minimal effect on fiber quality.

Wanjura *et al*. (2012) indicated that lower seed cotton cleaning rates resulted in more foreign matter removed by the stick machines, while no differences were observed for other tests. No differences in stick machine fiber loss were observed between processing rates. The maximum processing rate was still less than the rates used at some commercial gins. Marey *et al*. (2012) studied the effect of using locally manufactured seed cotton trash extractor compared with Russian type extractor model YIIX-I, on the quality of cotton fiber properties under four feed rates (10, 12.5, 15 and 17.5 kg/min). They reported that the span fiber length at 2.5 and 50% and the uniformity ratio were found to be proportional to the feed rate at all levels of drum speeds and fiber moisture contents in both extractors. However, the maximum color reflectance, color yellowness and seed cotton grade could be achieved at feed rat of 10 kg/min in both extractors and all values of moisture contents and drum speeds.

Cleaning machinery improves the composite grade of lint cotton by removing foreign matter and by blending the cotton. Cotton gins typically use two kinds of machines to remove foreign matter from seed cotton. The first one is called cylinder cleaners which utilize rotating cylinders with spikes to convey seed cotton across grid rods, allowing small foreign matter (primarily leaf and soil particles) to be removed. While the second is called extractor cleaners, such as stick machines have rotating saws that hold seed cotton while larger foreign matter particles (burrs and sticks) are removed by centrifugal force. Their results showed that the lower processing rates increased the amount of material removed by the first stage cylinder cleaner and stick machine. Extractor-feeders, used for cleaning and regulating the flow of cotton to the gin stand. Lower foreign matter removal and increased fiber loss with higher seed cotton processing rates (Hardin and Byler 2013). Many factors influence the performance of extractors including machine design, cotton moisture content, processing rate, adjustments, speed and condition of the machine, the amount and nature of trash in the cotton, distribution of seed cotton across the machine, and the cotton cultivar. The moisture content was the most prevalent factor, affecting elongation, free fatty acid content, yellowness, micronaire, length, and reflectance. Lint cleaners significantly decreased fiber and reduce availably the foreign matter content of machine-harvested cotton while improve color grade but damage fiber (Hamann, 2011; Li *et al*., 2012 and Xu *et al*., 2014).

Ahmed (2016) investigated the effect of trash content on fiber quality using six of the commercial varieties of Egyptian cotton. All the characters were significant, and correlated negatively to the increment of trash content accepted the reflectance degree, span length at 2.5%, fiber strength in gram/tex. (g/tex), micronaire reading characters which, correlated positively with trash content at the yellowness degree.

From this standpoint of view, the pervious study results concluded that, not controlling the uniformity of the feeding rate of the gin, lead to an increase in the work stopping times, an increase in the percentage of losses, lower ginning efficiency and productivity of the gin, plus the direct negative impact on the quality characteristics of ginned fiber. Consequently, they recommended to use cotton mechanical harvesters followed by pre-cleaning decreased the total cost cotton production, encourage the Egyptian farmers to increase the cultivated cotton area again and overcome the main cotton production problems in Egypt. In addition to conduct more research studies on the factors affecting on ginning performance and quality of cotton fiber properties. Therefore, the main objective of this study is to develop and evaluate the performance of seed cotton feeder/cleaner as a dual-purpose device suit for small seed cotton gins. The seed cotton feeder/cleaner was developed to regulate the flow to the gin and perform an additional secondary cleaning of the foreign materials in the seed cotton to be ginned. However, the specific objectives are:

1. Reduce gin stand maintenance and downtime, consequently, improve the gin productivity and ginning efficiency;
2. Improve the quality characteristics of cotton lint which maximize lint value for the cotton producer;
3. Reduce the health risks of the feeding labors and save human power.

MATERIALS AND METHODS

1- The developed seed cotton feeder/cleaner

The seed cotton feeder/cleaner was developed to suit seed cotton small gins and fabricated using local materials in the Rice Mechanization Center (RMC) Workshop; Agricultural Engineering Research Institute (AEnRI); Meet El-Deeba, Kafr El-Sheikh Governorate; Agricultural Research Center (ARC). The fabrication process of developed seed cotton feeder/cleaner and other experimental tests were done during years of 2018 and 2019. The overall dimensions of the developed seed cotton feeder/cleaner are 100 cm length, 75 cm width and 218 cm height. However, the main components of developed seed

cotton feeder/cleaner were main frame, feeding unit, cleaning unit cleaning concave, covering parts and power source transmission as shown in Figs. (1 and 2) and could be explained as follows:

Main frame

The main frame was constructed from iron angle with cross section of 50 x 50 x 3 mm to assemble of feeding unit, cleaning unit and power source units with its gears, pulleys and belts on it. The overall dimensions of assembling frame were taken under consideration during designed and fabricated it to suit combining the developed seed cotton feeder/cleaner with the cotton gin stand under study. The overall length, width and height of main frame are 1000, 750 and 1820 mm respectively.

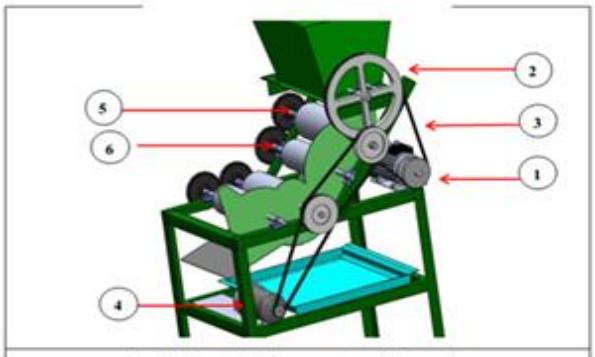

Fig. (1): Isometric of the power transmission-units.
(1)Feeding unit power motor, (2) Feeding drum pulley, (3) V belt (4) Cleaning unit power motor, (5) Saw drum gear, (6) Brush drum gear

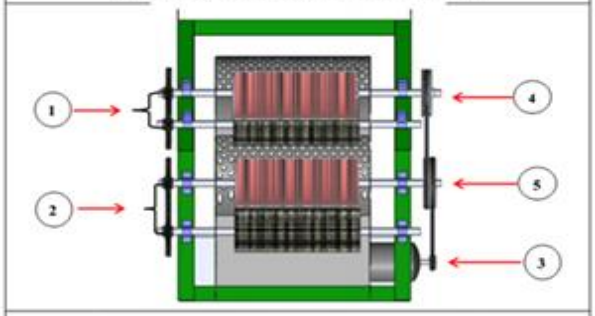

Fig. (2): Plan view of the cleaning power transmission-unit.
(1) First cleaning-unit, (2) Second cleaning-unit, (3) Cleaning motor pulley, (4) Saw-drum pulley of the first cleaning stage, (5) Saw-drum pulley of the second cleaning stage

Feeding unit:

The feeding unit consists of seed cotton hoper and feeding mechanism. A seed cotton hopper was fabricated from steel sheet (2 mm thickness) with dimensions of, 470, 600 and 390 mm for width, length and height, respectively. However, the feeding mechanism consists of two feeding shafts 25 mm in diameter, 820 mm in length and 90 mm spacing between them. The feeding shafts were fixed in the bottom of the seed cotton hopper. Each shaft was assisted with three grids (18mm in width, and 4 mm in thickness) on the outer diameter to facilitate and moving down seed cotton to the hopper exit opening.

Cleaning unit:

The cleaning unit contains two stages of cleaning drums, cleaning concave and cleaning covering parts. Each stage consists of saw drum and brush drum. The main components of saw drum were drum shaft (25 mm diameter), iron rotor (170 mm diameter, 400 mm length and 3 mm thickness), steel saw snail tape (2 mm thickness and 5 mm tooth height) fitted around the outer diameter of the iron rotor. However, the main components of brush drum were drum shaft (25 mm diameter), wooden rotor (100 mm diameter and 400 mm length), and plastic hairs (100 mm length) which was arranged in rows and fixed on the circumference of the wooden rotor. The cleaning concave was made of steel sheet with 2 mm thickness, 500 mm width and 1500 mm length. The clearance between drums and concave can be adjusted from 5 to 15 mm. The cleaning concave was perforated in hales rows with a diameter of 30 mm under each cleaning part to get out the foreign matter during the cleaning process. The covering parts include side covering-part for covering left and right sides of cleaning unit and top covering part which used for covering top end of cleaning unit. In general, easy assembling and disassembling for maintenance were taken in design consideration of cleaning unit during fabrication it.

Power unit and its power transmission

Two electrical motors of three phases and 1 hp (0.75kW) for each were used as the power source to drive both feeding and cleaning units. Arrangement of gears and two groups of different diameter pulleys/belts were used to transfer power from the motors to the feeding and cleaning units as shown in Figs. (1 and 2) and summarized in Tabs. (1and 2).

Table 1. The technical specification data of feeder power transmission.

Feeding speed level	Feeding motor			Feeding shaft				Feeding rate,
	Pulley φ mm	Speed rpm	Speed m/s	Pulley φ mm	rpm	Shaft φ mm	m/s	kg/min
Level 1	105	80	0.44	420	20.0	51	0.053	0.50
Level 2	120		0.50	320	30.0		0.080	0.75
Level 3	135		0.56	270	40.0		0.107	1.00
Level 4	150		0.63	240	50.0		0.133	1.25

Table 2. The technical specification data of cleaner power transmission.

Cleaning speed levels	Cleaning motor			Saw drum				Brush drum			
	Pulley ϕ mm	Speed rpm	Speed m/s	Pulley ϕ mm.	Drum ϕ mm	Speed rpm	Speed m/s	Gear ratio.	Drum ϕ mm	Speed rpm	Speed m/s
Level 1	50	1450	3.79	20.5	180	350	3.32	1.6	180	560	5.32
Level 2				16.0		450	4.27			720	6.83
Level 3				13.1		550	5.22			880	8.35
Level 4				11.1		650	6.17			1040	9.87

2- Study parameters

To realize the main purpose from this study, a series of laboratory experiments were carried out on two stages. First stage to test and evaluate the productivity and cleaning efficiency of the developed design of seed cotton feeder/cleaner. While, the second stage of experiments was to evaluate the effect of the developed seed cotton feeder/cleaner on the quality of the cotton fiber properties. Two stages of experiments were done under the following study parameters:

- Four different feed rates of 0.5, 0.75, 1.0 and 1.25 kg/min;
- Four different speeds of saw cleaning drum, namely 3.32, 4.27, 5.22 and 6.17.m/s. (350, 450, 550, and 650.rpm, respectively).
- Four different speeds of brush cleaning drum, namely; 5.32, 6.83, 8.35 and 9.87.m/s. (560, 720, 880 and 1040 rpm, respectively).
- Two different seed cotton varieties of Giza 86 and Giza 94

3- Measurements

The measurements of productivity and cleaning efficiency were taken into consideration as performance measurements of the developed seed cotton feeder/cleaner. However the fiber length at 2.5 and 50%, uniformity ratio, reflectance color grade and fiber strength were taken into consideration as a quality of cotton fiber properties using the High Volume Instrument (HVI) Spectrum II system at the cotton technology research laboratories; Cotton Research Institute (CRI); Agricultural Research Center (ARC); Giza; Egypt.

Productivity

The productivity of the developed seed cotton feeder/cleaner (P_c, kg/h) was calculated under study parameters using the following formula:

$$P_c = \frac{M_b}{T} \quad \text{.....} \quad (1)$$

Where: P_c **= productivity of cleaning unit, kg/h**
M_b **= mass of seed cotton sample before cleaning, kg**
T **= time consummation for sample cleaning, h**

Cleaning efficiency

The total foreign matter content (F_m , kg) such as burrs, sticks, motes, leaf, fine trash, lint, and seeds was manually sorted and weighed from each test sample of seed cotton before cleaning process immediately. The total foreign material removed by the seed cotton cleaning unit was also weighed and calculated (F_c, kg). The cleaning efficiency were calculated using the following formulas:

$$CE = \frac{F_m - F_c}{F_c} \times 100 \quad \text{.....} \quad (2)$$

Where:
CE **= cleaning efficiency, %**
F_m **= mass of total foreign matter manually sorted from seed cotton sample, kg**
F_c **= mass of foreign matters collected during sample cleaning, kg**

Fiber length:

A computerized type instrument of fibro-graph, model 630 (ASTM., designation D-1447-63T, 1984) was used to determine fiber length parameters. The fiber length parameters were determined directly and expressed as 2.5 & 50% span length (mm) according to May and Bridges (1995).

2.5% span length (2.5% SL) = Length (millimeters) at which 2.5% of the fibers are ≥ this length
50% span length (50% SL) = Length (millimeters) at which 50% of the fibers are ≥ this length.

Uniformity ratio

The ratio between two span lengths expressed as a percentage of the longer span length accordance with (ASTM, designated D-1445-95, 1984). It was determined by using the following formula:

$$Uniformity\ ratio, \% = \frac{50\%\ span\ fiber\ length}{2.5\%\ span\ fiber\ length} \times 100 \quad \text{.....} \quad (3)$$

Reflectance color grade:

The Color grade measures in terms of two components namely, Fiber brightness or reflectance degree (Rd, %) and degree of yellowness (+b). The Fiber brightness or reflectance degree (Rd %) is measuring the reflected light from the sample and ranges in cotton from (40-90%) optically by different color filters. The higher the degree of reflectance the whiter color, the better the cotton is rated. It was determining by using High Volume Instrument (HVI) classing lines within USDA's Agricultural Marketing Service (AMS) (1995) at fiber testing laboratory, CRI, ARC.

Fiber strength:

Fiber strength is measured at the fiber bundle. Breaking tenacity measured on fiber bundle. Strength is measured physically by clamping a fiber bundle between 2 pairs of clamps at known distance. The second pair of clamps pulls away from the first pair at a constant speed until the fiber bundle breaks. The distance it travels, extending the fiber bundle before breakage, is reported as elongation. The stelometer instrument was used to determine the fiber strength and elongation at fiber testing laboratory, CRI, ARC according to (ASTM, designated D-1445-75, 1984). The cotton fiber strength value can be determined using the following formula:

$$Fiber\ strength, (g/tex) = \frac{Breaking\ load\ (g)}{Bundle\ mass\ (tex)} \quad \text{.....} \quad (4)$$

Where: Tex = number of grams which weighted from 1 km length from fiber (One mass of 1 cm length from fiber = 150×10^{-8} g)

RESULTS AND DISCUSSION

Productivity:

The obtained results of the developed feeder/cleaner productivity which affected by saw and brush drums speed, feed rate and seed cotton variety are illustrated in Fig. (3). These results observed that the productivity of developed feeder/cleaner was decreased as the saw and brush drums speed increased and feed rate decreased for both cotton varieties of Giza 86 and Giza 94.

There is a positive correlation between the feeding rate and the productivity at any given saw drum speed, brush drum speed and seed cotton variety. Increasing feed rate from 0.5 to 1.25 kg/min increased the productivity from 0.391 to 1.075 kg/h at 3.32 and 5.32 m/s saw and brush drum speed, respectively, for Giza 86 seed cotton.

As shown in Fig. (3), it could be noticed that, the productivity decreased due to increasing the saw and brush drums speed. Increasing saw drum speed from 3.32 to 6.17 m/s decreased the productivity from 0.391 to 0.348 kg/h in case of cleaning seed cotton of Giza 86 variety compared to 0.667 to 0.635 kg/h for cleaning Giza 94 variety at the 5.32 m/s brush drum speed and 0.5 kg/min feed rate. The corresponding values were decreased from 1.075 to 0.925 kg/h and from 1.115 to 0.931 kg/h for cleaning seed cotton Giza 86 and Giza 94 varieties, respectively, at 5.32 m/s brush drum speed and feeding rate of 1.25 kg/min. Increasing brush drum speed from 5.32 to 9.89 m/s decreased the productivity from 0.391 to 0.362 and from 0.445 to 0.411 kg/h during cleaning seed cotton Giza 86 and Giza 94 varieties, respectively at saw drum speed of 3.32 m/s and feed rate of 0.5 kg/min.

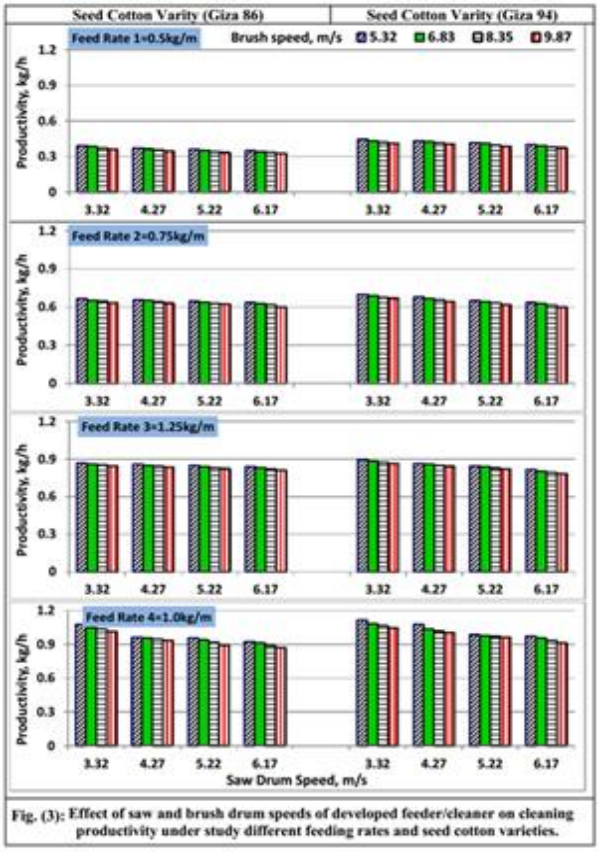

Fig. (3): Effect of saw and brush drum speeds of developed feeder/cleaner on cleaning productivity under study different feeding rates and seed cotton varieties.

The seed cotton variety of Giza 94 gave the higher values of productivity than that obtained with seed cotton variety of Giza 86 variety, at any given study parameters. The maximum productivity of the developed feeder /cleaner was 1.075 kg/h obtained when cleaning Giza 86 variety compared to 1.115 kg/h for Giza 94 variety at the lowest saw drum speed of 3.32 m/s, brush drum speed of 5.32 m/s and highest feed rate of 1.25 kg/min.

Cleaning efficiency:

The effect of feed rate; saw drum speed, brush drum speed and seed cotton variety and the interactions between them on the cleaning efficiency is shown in Fig. (4). This figure indicates that, the higher feed rate values led to decrease the percentage of cleaning efficiency than the lower feed rate values at any given saw drum speed, brush drum speed and seed cotton variety. This increasing the feed rate from 0.5 to 1.25 kg/min decreased the cleaning efficiency of the developed feeder/cleaner from 80.50 to 75.8 % and from 85.83 to 84.55 % during cleaning seed cotton Giza 86 and Giza 94 varieties, respectively, at 3.32m/s saw speed and 5.32 m/s brush drums speeds.

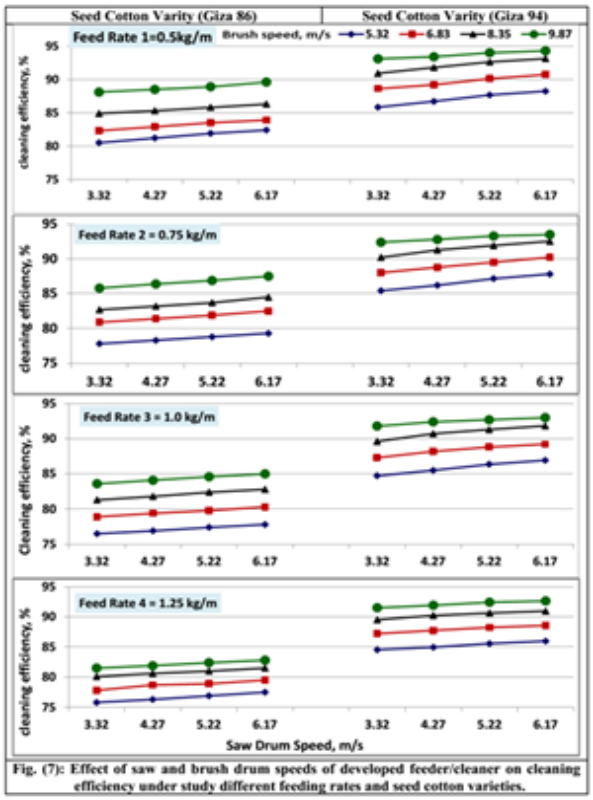

Fig. (7): Effect of saw and brush drum speeds of developed feeder/cleaner on cleaning efficiency under study different feeding rates and seed cotton varieties.

There is a positive correlation between cleaning efficiency and saw drum speed. The same cleaning efficiency trend of the developed feeder/cleaner was obtained with brush drum speed. Increasing the saw speed from 3.32 to 6.17 m/s increased the cleaning efficiency of the feeder/cleaner from 80.50 to 82.40 % for Giza 86 seed cotton variety compared to from 85.83 to 88.23 % for Giza 94 seed cotton variety, at 5.32 m/s brush drum speed and 0.5 kg/min feed rate. However, increasing, the brush drum speed from 5.32 to 9.87 m/s increased the cleaning efficiency from 80.50 to 88.10 and from 85.83 to 93.10 % during cleaning seed cotton of Giza 86 and Giza 94 varieties, respectively, at saw speed of 3.32 m/s and feed rate of 0.5 kg/min. The effect of seed cotton variety on the cleaning efficiency of the developed feeder/cleaner , cleared that the obtained values of cleaning efficiency were higher with seed cotton Giza 94 than that obtained with Giza 86 at any given study parameters. The maximum values of cleaning efficiency of 89.60 and 94.30 % were found at the feed rate of 0.5 kg/min; saw drum speed of 6.17 m/s and brush speed of 9.87 m/s during cleaning seed cotton Giza 86 and Giza 94, respectively

Cotton fiber length:

The obtained data of study parameters effect on the fiber length as one of the quality of cotton fiber are tabulated in Table (3). These data indicated that, the fiber length at 2.5% and 50% was highly affected by study parameter such as feed rate, saw drum speed, brush drum speed and seed cotton variety. The fiber length at 2.5% and 50% increased by increasing the feed rate at any given saw

drum speed, brush drum speed and seed cotton variety. The fiber length at 2.5% was increased from 36.5 to 38.1mm due to increasing the feed rate from 0.5 to 1.25 kg/min at saw drum speed of 3.32 m/s and brush drum speed of 5.32 m/s for seed cotton variety of Giza 86. However, the corresponding values obtained for Giza 94 seed cotton variety were increased from 42.7 to 48.1mm at the same pervious mentioned parameters for Giza 86 seed cotton variety. On the other hand, the obtained values for fiber length at 50% were increased from 18.3 to 21.4mm due to increasing the feed rate from 0.5 to 1.25 kg/min at saw drum speed of 3.32 m/s and brush drum speed of 5.32 m/s for Giza 86 seed cotton variety compared to from 22.4 to 25.4 mm for Giza 94 seed cotton variety 3.32 m/s saw drum speed and 5.32 m/s brush drum speed when increasing feed rate from 0.5 to 1.25 kg/min.

Also, an increase in both saw or brush drum speeds gave decrement percentages in cotton fiber length at 2.5% and 50% at any given feed rate for Giza 86 and Giza 94 seed cotton varieties. The cotton fiber length at 2.5% decreased from 36.5 to 35.3 mm and from 42.7 to 41.6 mm by increasing saw drum speed from 3.32 to 6.17 m/s for Giza 86 and Giza 94 seed cotton varieties, respectively, at lowest brush drum speed of 5.32 and feed rate 0.5 kg/min. While, the cotton fiber length at 50% was decreased from 18.3 to 17.6 mm and from 22.4 to 21.5 mm. for Giza 86 and Giza 94, respectively when increasing the saw drum speed from 3.32 to 6.17 m/s at brush speed of 5.32 and feed rate of 0.5 kg/min. On the other side, increasing brush drum speed from 5.32 to 9.87 m/s decreased the cotton fiber length at 25% from 36.5 to 35.2 mm and from 42.7 to 41.6 mm for seed cotton varieties of Giza 86 and Giza 94, respectively, in case of using 3.32 m/s saw drum speed and 0.5 kg/min feed rate. While, the cotton fiber length at 50% was decreased from 18.3 to 17.5 mm and from 22.4 to 21.7 mm for Giza 86 and Giza 94 seed cotton varieties, respectively, due to increasing brush drum speed from 5.32 to 9.87 m/s under the same pervious mentioned saw drum speed (3.32 m/s) and feed rate (0.5 kg/min).

Table 3. Quality of cotton fiber properties under different study parameters.

Measurements Items		2.5% span fiber length, mm				50% span fiber length, mm				Uniformity ratio, %				Reflectance, unit				Strength, g/tex			
Saw speed, m/s		3.32	4.27	5.22	6.17	3.32	4.27	5.22	6.17	3.32	4.27	5.22	6.17	3.32	4.27	5.22	6.17	3.32	4.27	5.22	6.17
Brush speed, m/s		Seed cotton, Giza 86																			
Feed rate 0.5 kg/min	5.32	36.5	36.1	35.7	35.3	18.3	18.1	17.9	17.6	50.2	50	49.9	49.8	69.3	69.6	70.1	70.3	29.5	29.3	29	28.7
	6.83	36.1	35.7	35.3	35	18	17.8	17.5	17.1	49.9	49.8	49.7	49.6	69.5	69.8	70.3	70.5	29.2	29	28.8	28.5
	8.35	35.6	35.3	34.9	34.6	17.7	17.4	17.1	16.8	49.7	49.6	49.4	49.3	69.7	70	70.5	70.7	28.9	28.7	28.5	28.2
	9.87	35.2	34.8	34.4	34	17.5	17.1	16.7	16.5	49.5	49.4	49.2	49.1	69.8	70.2	70.6	70.8	28.7	28.5	28.2	27.9
Feed rate 0.75 kg/min	5.32	36.9	36.6	36.2	35.8	19.2	18.8	18.3	17.8	51.9	51.6	51.4	51.1	67.8	68.1	68.5	68.7	30.6	30.2	29.8	29.5
	6.83	36.5	36.1	35.7	35.3	18.8	18.4	18	17.5	51.5	51.3	51.1	50.9	67.9	68.3	68.7	68.9	30.3	29.9	29.5	29.1
	8.35	36.1	35.7	35.3	35	18.4	18	17.6	17.1	51	50.8	50.7	50.5	68.2	68.5	68.9	69.2	30	29.6	29.2	28.8
	9.87	35.7	35.2	34.8	34.5	17.9	17.6	17.2	16.7	50.7	50.5	50.4	50.2	68.4	68.7	69.1	69.4	29.7	29.3	28.9	28.5
Feed rate 1.00 kg/min	5.32	37.4	37	36.6	36.2	20.1	19.6	19.2	18.8	53.7	53.3	53	52.7	66.7	67.1	67.4	67.8	31.1	30.7	30.3	30
	6.83	37	36.7	36.2	35.9	19.7	19.1	18.8	18.5	53.2	52.9	52.6	52.4	66.9	67.3	67.7	68	30.8	30.5	30	29.7
	8.35	36.7	36.3	35.9	35.6	19.3	18.7	18.3	18	52.8	52.5	52.2	51.9	67.1	67.5	67.9	68.2	30.5	30.1	29.8	29.5
	9.87	36.3	36	35.6	35.3	18.9	18.3	17.9	17.6	52.3	52.1	51.8	51.6	67.3	67.7	68.1	68.4	30.2	29.7	29.5	29.2
Feed rate 1.25 kg/min	5.32	38.1	37.8	37.5	37.1	21.4	21.1	20.7	20.3	56.1	55.8	55.5	55.2	65.4	65.7	65.9	66.3	31.9	31.2	30.8	30.5
	6.83	37.7	37.3	37	36.7	21	20.6	20.3	19.9	55.7	55.2	54.8	54.5	65.6	65.9	66.2	66.5	31.3	31	30.5	30.2
	8.35	37.3	36.8	36.6	36.2	20.7	20.2	19.8	19.4	55.3	54.9	54.5	54.1	65.8	66.2	66.4	66.8	31	30.7	30.2	29.8
	9.87	36.9	36.5	36.2	35.9	20.4	19.9	19.5	19.1	55	54.7	54.2	53.7	66	66.4	66.6	67	30.7	30.3	29.9	29.5
		Seed cotton, Giza 94																			
Feed rate 0.5 kg/min	5.32	42.7	42.2	41.8	41.6	22.4	22.2	21.8	21.5	55.1	54.7	54.5	54.3	73.1	73.3	73.5	73.7	31.2	30.9	30.5	30.2
	6.83	42.3	41.9	41.5	41.3	22.1	21.8	21.6	21.3	54.8	54.4	54.2	54	73.4	73.6	73.8	73.9	31	30.7	30.3	30
	8.35	42	41.6	41.3	41	21.9	21.6	21.2	21	54.6	54.1	53.9	53.7	73.6	73.8	73.9	74.1	30.8	30.6	30.1	29.8
	9.87	41.6	41.3	41.1	40.8	21.7	21.3	21	20.8	54.3	53.8	53.6	53.4	73.9	74.1	74.3	74.4	30.5	30.3	29.9	29.7
Feed rate 0.75 kg/min	5.32	45.3	44.8	44.4	44.1	23.6	23.4	23.1	22.8	57.3	57.1	56.8	56.6	71.8	72.9	72.4	72.7	32.8	32.5	32.2	32
	6.83	44.9	44.6	44.1	43.7	23.3	23.1	22.7	22.5	57	56.7	56.5	56.3	72	72.6	72.7	72.9	32.6	32.3	32	31.7
	8.35	44.7	44.3	43.8	43.5	23	22.8	22.5	22.2	56.8	56.5	56.2	56	72.2	72.3	72.9	73.3	32.4	32.1	31.8	31.5
	9.87	44.4	44	43.6	43.3	22.7	22.5	22.3	21.9	56.5	56.2	55.9	55.7	72.4	72.1	73.2	73.6	32.1	31.8	31.6	31.3
Feed rate 1.00 kg/min	5.32	46.2	45.8	45.5	45.1	24.3	24.1	23.7	23.5	58.1	57.8	57.6	57.2	70.9	71.4	71.7	72.1	33.2	33	32.7	32.5
	6.83	45.9	45.5	45.3	44.7	24	23.8	23.4	23.3	57.9	57.6	57.3	57	71.2	71.7	72	72.4	33	32.8	32.5	32.3
	8.35	45.6	45.2	45	44.5	23.7	23.5	23.1	23	57.7	57.3	56.9	56.7	71.5	71.9	72.4	72.8	32.8	32.6	32.3	32.1
	9.87	45.3	44.9	44.7	44.3	23.5	23.3	22.9	22.7	57.4	57.1	56.7	56.5	71.7	72.2	72.6	73.2	32.7	32.4	32.1	31.8
Feed rate 1.25 kg/min	5.32	48.1	47.7	47.2	46.8	25.4	25.1	24.9	24.7	59.2	58.9	58.6	58.4	69.5	70	70.5	70.9	34.4	34.2	33.9	33.7
	6.83	47.8	47.3	46.9	46.5	25.1	24.8	24.6	24.4	59	58.7	58.3	58.1	69.8	70.3	70.8	71.3	34.2	34	33.7	33.5
	8.35	47.6	47	46.6	46.3	24.8	24.5	24.3	24.1	58.7	58.5	58	57.8	70.1	70.6	71.3	71.7	34	33.8	33.5	33.3
	9.87	47.3	46.8	46.5	46.1	24.6	24.2	24.1	23.8	58.5	58.3	57.7	57.5	70.4	70.9	71.6	72.1	33.8	33.6	33.3	33.1

The higher values of cotton fiber length at 2.5% and 50% were obtained with Giza 94 seed cotton variety in comparison with that obtained with Giza 86 seed cotton variety. The maximum values of cotton fiber length at 2.5 were 36.5, 36.9, 37.4 and 38.1mm for Giza 86 cotton variety compared to 42.7, 45.3, 46.2 and 48.1mm for Giza 94 cotton variety under feed rate of 0.5, 0.75, 1.0 and 1.25 kg/min, respectively and the lowest levels of saw and brush drum speeds. However, the maximum values of cotton fiber length at 50% were 18.3, 14.2, 20.1 and 21.4 mm for Giza 86 seed cotton variety compeered to 22.4, 23.6, 24.3 and 25.4 mm for Giza 94 seed cotton in case of using feed

rate of 0.5, 0.75, 1.0 and 1.25 kg/min, respectively under 3.32 and 5.32 m/s saw and brush drum speed, respectively.

Uniformity ratio:

The obtained results of cotton fiber length uniformity ratio % (Tab. 3) indicated that, there is a positive correlation between feed rate and uniformity ratio of cotton fiber length, and a negative correlation between saw or brush drum speeds and cotton fiber length uniformity ratio for both varieties under study. Increasing feed rate level from 0.5 to 1.25 kg/min increased the cotton fiber length uniformity ratio from 50.2 to 56.1 and from 55.1 to 59.2 for Giza 86 and Giza 94 seed cotton varieties, respectively at 3.32 m/s saw drum speed and 5.32 m/s brush drum speed.

The obtained values of fiber length uniformity ratio decreased from 50.2 to 49.8 % and from 55.1to 54.3 % due to using 6.17 m/s saw drum speed level instead of 3.32 m/s for Giza 86 and Giza 94 seed cotton varieties, respectively at 5.32 m/s brush drum speed and 0.5 kg/min feed rate. However, by increasing brush drum speed from 3.32 to 9.87 m/s the fiber length uniformity ratio decreased from 50.2 to 49.5 and from 55.1 to 54.3 for Giza 86 and Giza 94 seed cotton varieties, respectively at saw drum speed of 3.32 m/s and feed rate of 0.5 kg/min. Also, the obtained values of cotton fiber length uniformity ratio were higher for Giza 94 seed cotton variety than that obtained for Giza 86 cotton variety at any given feed rate, saw drum speed and brush drum speed, The highest values of uniformity ratio (56.5 and 59.2) were obtained when using 3.32m/s saw drum speed, 5.32 m/s brush drum speed and feed rate 0.5 kg/min for Giza 86 and Giza 94, respectively.

Color grade (Reflectance Rd %):

The obtained results listed in Table (3) showed the effect of the study parameters (feed rate, saw drum speed, brush drum speed and seed cotton variety) on the reflectance fiber color, % as one of the color grade items. These results indicated that the reflectance fiber color values were increased by any increase in saw drum and brush drum speeds and any decrease in feed rate for any given seed cotton variety. The reflectance fiber color was decreased from 69.3 to 65.4% due to increasing feed rate from 0.5 to 1.25 kg/min for Giza 86 seed cotton variety at saw speed of 3.32 m/s and brush drum speed of 5.32 m/s. While, the corresponding values for Giza 94 seed cotton variety were from 73.1 to 69.5% by increasing the feed rate 0.5 to 1.25 kg/min at saw drum speed of 3.32 m/s and brush drum speed of 5.32 m/s.

Increasing any seed level of saw drum and brush drum increase the reflectance color grade at any feeding rate and seed cotton variety. The seed cotton of Giza 94 give the higher values of the reflectance fiber color than that recorded with Giza 86 seed cotton variety at any given study parameters. The maximum values (69.3 and 73.1%) of reflectance fiber color were obtained for Giza 86 and Giza 94 seed cotton varieties, respectively at 3.32 m/s saw drum speed and 5.32 m/s brush drums.

Fiber strength:

The obtained results of the cotton fiber strength under different levels of study parameters are summarized in Tab (3). These results indicated that the cotton fiber strength is highly affected by any given level of study parameters. Increasing feed rate from 0.5 to 0.75, from 0.75 to 1.0 and from 1.0 to 1.25 kg/min increased the cotton fiber strength from 29.5 to 30.6, from 30.6 to 31.1 and from 31.1 to 31.6 g/tex, respectively when using 3.32 m/s saw drum speed and 5.32 brush drum speed for Giza 86 seed cotton variety. However, the corresponding values of cotton fiber strength for Giza 94 seed cotton were from 31.2 to 32.8, from 32.8 to 33.2 and 33.2 to 34.4 g/tex due increasing feed rate from 0.5to 0.75, from 0.75 to 1.0 and from 1.0 to 1.25 kg/min, respectively at saw drum speed of 3.32 m/s and brush drum speed of 5.32 m/s. Also, there is a negative correlation between cotton fiber strength and saw or brush drums speeds for any given feed rate and seed cotton varieties under study.

The cotton fiber strength was decreased by about 2.71, 3.59, 3.53 and 3.48 % for Giza 86 seed cotton variety compared with 3.20, 2.43, 2.10 and 2.03 % for Giza 94 seed cotton variety due to increasing the saw drum speed from 3.32 to 6.17 m/s at feed rate 0.5, 0.75, 1.0 and 1.25 kg/min, respectively at brush drum speed of 5.32 m/s. However, increase brush drums speed from. 5.32 to 9.87m/s decreased the cotton fiber strength by about 2.71, 2.94, 2.89 and 2.84 % for Giza 86 seed cotton variety in comparison with 2.24, 2.13, 1.50 and1.74 % for Giza 94 seed cotton variety of feed rate of 0.5, 0.75, 1.0 and 1.25 kg/min, respectively and saw drum speed of 3.32 m/s. The seed cotton variety of Giza 94 gave the higher values of cotton fiber strength than that obtained when using seed cotton variety of Giza 86 at any given study parameters. The highest values (29.7, 31.3, 31.8 and 33.1 g/tex) of cotton fiber strength were obtained for Giza 94 seed cotton variety at feed rate of 0.5, 0.75, 1.0 and 1.25 kg/min respectively, saw drum speed of 6.17 m/s and brush drum speed of 9.87 m/s.

CONCLUSION

The obtained results could be concluded as follows:

- The cleaning productivity of developed feeder/cleaner was decreased as the saw and brush drums speed increased and feed rate decreased for both cotton varieties of Giza 86 and Giza 94. The maximum productivity of the developed feeder /cleaner was 1.075 kg/h obtained when cleaning Giza 86 variety compared with 1.115 kg/h for Giza 94 variety at the lowest saw drum speed of 3.32 m/s, brush drum speed of 5.32 m/s and highest feed rate of 1.25 kg/min.
- The higher feed rate values led to decrease the percentage of cleaning efficiency than the lower feed rate values at any given saw drum speed, brush drum speed and seed cotton variety. There is a positive correlation between cleaning efficiency and saw drum speed. The maximum values of cleaning efficiency of 89.60 and 94.30 % were found at the feed rate of 0.5 kg/min; saw drum speed of 6.17 m/s and brush speed of 9.87 m/s during cleaning seed cotton Giza 86 and Giza 94, respectively
- The results indicated that the developed seed cotton feeder/cleaner produced better values of 2.5 and 50% span fiber length, uniformity ratio of length, reflectance of color (Rd) and cotton fiber strength with Giza 94 variety compared with Giza 86 variety at any given study parameter's.

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تطوير مُغذي / مُنظف للقطن الزهر يناسب الحلاجات الصغيرة

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الهدف الرئيسي من هذه الدراسة هو تطوير وتقييم أداء وكفاءة مُغذي / مُنظف للقطن الزهر ليناسب الحلاجات الصغيرة وتنظيم معدل تغذيتها بالقطن مع إجراء تنظيف ثانوي إضافي للمواد الغريبة في القطن الزهر المراد حلجه للحد من الصيانة ومرات التوقف عن العمل بسب الاعطال ، وبالتالي تحسين إنتاجية الحلاجة وكفاءة الحلج لها بالإضافة الى تحسين خصائص جودة الياف القطن الشعر الناتج من عملية الحلج وبالتالى زيادة قيمة القطن التسويقية لمنتجى القطن والحد من المخاطر الصحية للعاملين في تغذية الحلاجات وتوفير الطاقة البشرية. ولتحقيق هذا الهدف تم تصنيع مُغذي / مُنظف القطن الزهر المُطور باستخدام مواد محلية في ورشة مركز ميكنة الأرز (RMC) ؛ معهد بحوث الهندسة الزراعية (AEnRI) ؛ ميت الديبة ، محافظة كفر الشيخ ؛ مركز البحوث الزراعية (ARC). حيث تم إجراء عملية تصنيع مُغذي / مُنظف القطن الزهر المُطور واختباره خلال سنوات 2018 و 2019. وذلك بتقدير وقياس إنتاجية وحدة التنظيف وكفاءة التنظيف وجودة خصائص ألياف القطن الناتجة منها (مثل طول الألياف عند 2.5 و 50٪ ، نسبة الانتظامية فى طول الليفة ، درجة الانعكاس للون ومتانة الألياف) لمُغذي / مُنظف القطن الزهر المُطور والذى تم تقييمه تحت تأثير أربعة معدلات تغذية مختلفة تراوحت من 0.5، 0.75، 1.0، 1.25 كجم / دقيقة ؛ أربع سرعات مختلفة للدرفيل المنشاري تراوحت من 3.32،4.27،5.22 ، 6.17 م / ث ؛ أربع سرعات مختلفة للدرفيل الفرشى تراوحت من 5.32 ، 6.83، 8.35، 9.87 م / ث باستخدام صنفى القطن الزهر جيزة 86 وجيزة 94. أشارت النتائج ان أقصى إنتاجية لمُغذي / مُنظف القطن الزهر المُطور 1.075 كجم / ساعة تم الحصول عليها عند تنظيف صنف جيزة 86 مقارنة بـ 1.115 كجم / ساعة لصنف جيزة 94 بأقل سرعة للدرفيل المنشارى 3.32 م / ث ، والدرفيل الفرشى 5.32 م / ث وأعلى معدل تغذية 1.25 كجم / دقيقة. بينما أدت قيم معدل التغذية الأعلى إلى تقليل النسبة المئوية لكفاءة التنظيف مقارنة بقيم معدل التغذية الأقل عند أي سرعة للدرفيل المنشارى أوالفرشى وكل من صنفى القطن تحت الدراسة. كما وجد ان هناك ارتباط إيجابي بين كفاءة التنظيف وسرعة للدرفيل المنشارى أوالفرشى. وكانت القيم القصوى لكفاءة التنظيف 89.60 و 94.30٪ بمعدل تغذية 0.5 كجم / دقيقة ؛ سرعة درفيل منشارى 6.17 م / ث سرعة درفيل فرشى 9.87 م / ث أثناء تنظيف صنفى القطن جيزة 86 وجيزة 94 على التوالي. كما أوضحت النتائج أن مُغذي / مُنظف القطن الزهر المُطور قد أنتج قيمًا أفضل من 2.5 إلى 50٪ من طول الألياف ، ونسبة الانتظامية في الطول ، ودرجة الانعكاس فى اللون ومتانة الألياف القطنية مع صنف القطن جيزة 94 مقارنةً بصنف القطن جيزة 86 عند أي مستوى لعوامل الدراسة.