Effect of Using a Cleaning Machine on Fiber Quality and Properties of Mechanically Harvested Egyptian Cotton.

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ABSTRACT

Obtaining a good grade and preserving fiber quality are two important phenomena which are playing an essential roll in cotton marketing. The current study was designed to experimentally test, a cleaner machine for separating the foreign materials from seed cotton after two times of mechanical harvesting, and also to evaluate the influence of this process on cotton fiber quality and cleaning efficiency. The results showed that the tested machine separated most of foreign materials like very short immature and low quality fractions, while conserved the fiber quality to a great extent. The impact of tested machine performance on the cotton fiber quality characteristics was discussed. Also, the results indicated that care should be taken in selecting the machine speed and the number of feedings to maximize efficiency at the desired quality levels.

INTRODUCTION

Cotton is considered as one of the most strategic crops in Egypt; it is affecting, up to some extent, the national economics. Egyptian farmers used to harvest cotton manually by hands. This with no doubt resulting in good cotton grades adorned with high quality fibers. Field crops production using mechanical management, however, became essential in Egypt with the advent of technology and increasing the labor cost. In such a research project our team is interested in cotton mechanical harvesting. The published data under Egyptian conditions with this regard are very rare. This technology is brand-new for Egyptian cotton growers and needs a lot of efforts to be evaluated. Mechanical harvesting introducing additional stress on cotton production, because trashier seed cotton was produced. Stems, leaves, hulls, bracts, are common parts found in mechanical harvested cotton. These foreign materials reduce cotton grade and quality as well as create a major concern for cotton

producers and textile mills. This problem can be solved by installing supplementary seed cotton trash removal and lint cleaning before and during ginning. Numerous reviews showed that cotton fiber quality parameters can be affected by many factors such as production practices, variety, and climatic conditions during the growing and harvesting practices, cleaning process and ginning. The current marketing system is dependent on grade and fiber length with grade being composed of color and trash components. Cleaning practices, however, have a major influence on both fiber quality and trash content itself. Cotton cleaning then is very important process; the term "cleaning" usually refers to various types of cleaners designed primarily for removal of dirt, small pieces of leaves, bracts, and other vegetative matter. "Extracting," on the other hand, refers strictly to processes that remove large trash, such as burs, sticks and large pieces of leaves (**Garner and Baker, 1977**). Directly after mechanical harvesting, extracting and cleaning systems will serve a dual purpose. First, large trash such as burs, limbs and branches must be extracted before they are broken up and tightly attached with cotton fibers, and so the gin stands can not operate at maximum efficiency. Second, seed cotton cleaning is necessary to obtain optimum grades and market values, especially when ginning high-trash-content cotton. Moreover, if the improved genotype that may contain both high yielding ability and good quality is the ultimate goal of cotton breeders who is intending to harvest mechanically, the process of mechanical management during and after harvesting will be essential for obtaining a good grade.

Many investigators carried out researches to evaluate the effects of cleaning process on fiber quality. **Williford, et al. (1984)** stated that the amount of extracting and cleaning machinery required to satisfactorily clean cotton varies with the cotton's trash content, which depends in large measure on harvest methods such as manual vs. mechanical, and or (different types of harvesting machines). **Leifeld (1988)** reported that clean ability was a function of the machine and initial trash content and some cotton were more difficult to clean than the others. He considered the number, size and kind of trash particles as three factors related to genetic

background of cottons. Removing trash at the gin is a compromise between braining good grades and preserving fiber quality **(Columbus et al., 1990; Gillium and Armijo, 1997)** with Pima (Egyptian - American cotton) had a crack to determine the optimum amount of overhead cleaning (cleaning after mechanical harvesting and prior to ginning). They found that overhead cleaning efficiency ranged from 54 to 83 % and concluded that no recommendation was made on a particular seed cotton cleaning level based on bale value; instead, general comments concerning cleaning level and color grade were made. **Baker and Barker (1995)** used a conventional two-saw bur and stick extractor. They found that cleaning efficiency and lint wastage percentages increased with increases in grid spacing for both the primary saw and the redaimer saw. **Anthony (1990a)** found that cleaning efficiencies of cotton varieties differ substantially and the impact of varietals differences (Leaf hairiness) on seed cotton cleaning efficiencies is greater than for lint cleaning efficiency. **Anthony (1990b)** reported that removal of foreign matter from cotton during the ginning, process is a complex interaction of genetic traits, moisture differentials and machine performance parameters. He added that the cleaning efficiencies differ for the types of gin cleaning machinery such as seed cotton cleaners and lint cleaners. **Anthony (1989)** found that high-volume instrument (HVI) length, trash and lint visible foreign matter were decreased as moisture decreased, while grade index increased. Several reports showed that repeating cleaning process more than three to four times had drastically affect fiber quality, beside its unreality, of them **Gillium and Armijo (1997); Cho et al. (1996); Rayburn (1988) and Griffin (1984)** reported that improving gin cleaning can improve the resultant product to obtain adequate grade, but some quality is sacrificed.

Therefore, best harvest and ginning procedures are needed to maximize grade and fiber quality for the textile mill. Moreover, the optimum harvest and ginning procedure must be coupled with an acceptable level of machinery. With these criteria as a base, an experiment was designed to evaluate the overhead cleaning process after two times of mechanical picking and assess the influence of this process on cotton fiber quality and cleaning efficiency.

MATERIALS AND METHODS

The cleaning machine:

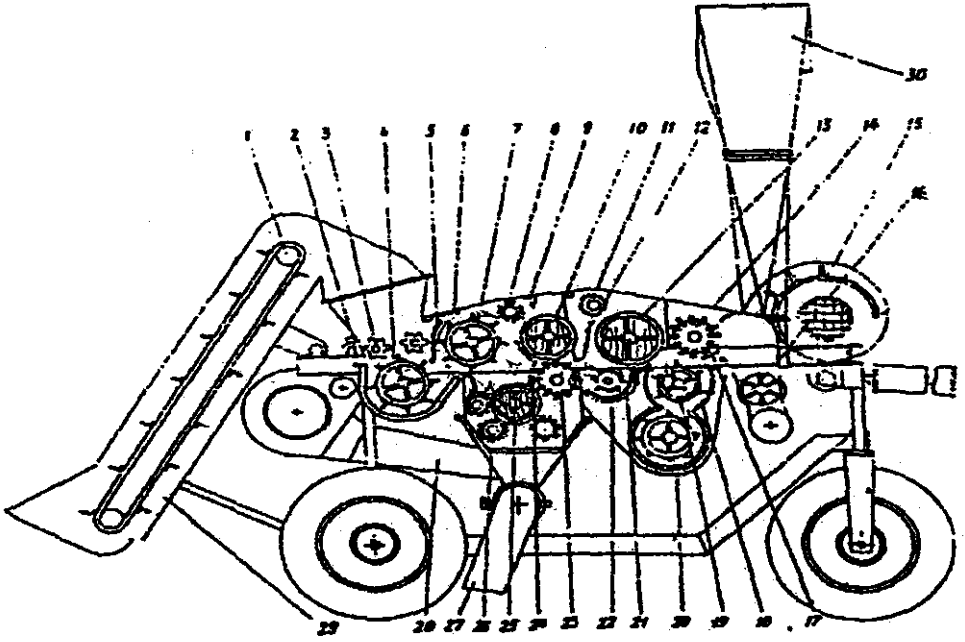
An experimental seed cotton cleaning machine (Figure 1) was used to provide improved methods for removing pieces of limbs and stalks and other foreign stuff from mechanical picked cotton. The machine (cotton feeder extractor) normally operated by Nasr tractor 48.5 kW (65 HP).

The numbers of the figure explain the machine parts. Further design's details for the machine evaluated in this research are given in Table (1). The machine has a saw-devise and transporter feeding that cause more seed cotton to go around the initial saw. The machine splits cotton into three streams: a) cotton and trash that bounce off and is blown over the saw; b) cotton peels that are ejected with the trash between grid rolls below the saw; and c) cotton that remains attached and is recovered from the saw as cleaned seed cotton. The cotton that is lost over or below the saw seems to be the low quality part such as immature bolls. In normal usage of the machine; the separated cotton is reclaimed from the trash and mixed back with the seed cotton recovered from the saw.

The treatments:

Field experiments were carried out in two successive seasons 2002-2003 at Gemmiza Agric. Res. Station, Middle Delta region using cotton variety of Giza 89; grown in randomized complete block design with three replicates. Before mechanical harvesting, cotton leaves were chemically defoliated. Mechanical harvesting was implemented two times; the first pick at 25, 28 September and the second pick at 24, 28 October (2005) for the first and second year, respectively. After mechanical harvesting, seed cotton was transferred to conditioning racks and conditioned at 297°K(24 °C) and 65 % relative humidity for at least 24 h. Prior to operate the extractor, many trails were carried out to adjust the machine bars to avoid loosing excessive amount of seed cotton. Since there is no reference under Egyptian conditions for the machine efficiency, either mechanically or at cleaning levels, different saw speeds with different passage times were used. Saw cylinder speeds were three, viz. 11 m/s (700 rpm), 12.5 m/s (800 rpm), and 14.9 m/s (950 rpm). Feed rate was constant at 20kg/min. The belt conveyor was used to

regulate feed rate at that constant level through the machine. The seed cotton was processed through machine three times.



1- mechanical loader; 2- impurity remover net; 3- feeder roller; 4- impurity remover; 5- net; 6- shelling concave; 7- shelling drum; 8- blade drum; 9-shielding; 10,13,25 – saw drums; 11- repelling drum; 12- shielding ; 14,23- doffing drums; 15- fan; 16- vacuum valve; 17- shielding ; 18- net; 19,20- strip drums; 21- net; 22- small sprocket drum; 24- shielding; 26- rubbing drum; 27- impurity remover hose; 28- air duct; 29- collapsible loader section; and 30- cotton conveyer.

Figure (1) Illustrating schematically the machine configuration.

Table (1) Technical specifications of cotton Extractor

Parameter	Value
Length, m	5.10
Width, m	2.70
Height, m	2.50
Mass, kg	2.500
P.T.O.speed, r.p.m	540
Source of power	Nasr Tractor 48.5 kW (65 HP)
Power consumption, max, HP	23
Output (Mg/hour)	1.5
Efficiency, %	35 – 65 (Anonymous)

Data analysis:

Trash materials that extracted by the machine were collected, weighed and analyzed to obtain an estimate of lint wastage percentage. These data along with the seed cotton trash content determination were used to calculate cleaning efficiency according to the methodology described by **Baker and Barker (1995)**. Twenty five samples (repeated six times to sum of 150 samples) were taken randomly at the trailer to determine the characteristics of the seed cotton as well as the characterizations of the lint cotton. A moisture analysis was performed by the cotton testing laboratory at Gemmiza Agric. Res. Station. High volume instrument (HVI) was carried out by cotton Res. Institute, Agric .Res. Center at Giza. The measurements comprehensively included the following dependent variables: wagon foreign matter (before gin processing), lint moisture, color index, span fiber length, mm, uniformity ratio, strength, micronaire, HVI grayness (Rd), HVI yellowness (+b), HVI trash grade index and Cleaning efficiency, %. A regular analysis of variance of separate years was carried out for each trait. The collected data of initial non-lint before and after extracting were averaged over years and statistically separated for each picking time. A pooled analysis of variance was computed over the two years of experimentation for HVI characters. Bartlett's test, as described by **Cochran and Cox (1957)**, was used to assess homogencity of variances for each year prior to combined analysis. Differences between means were separated by Duncan's Multiple Range Test at 0.05 and 0.01 levels of significance; it will be indicated as needed.

RESULTS AND DISCUSSION

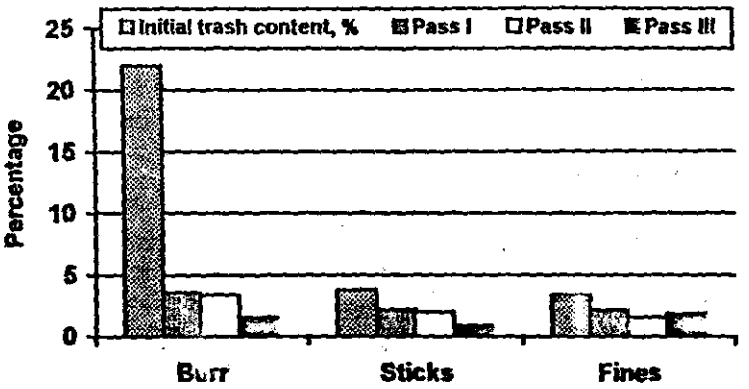
Cleaning performance:

Overhead cleaning and drying are the early steps for preparing the seed cotton for ginning. Afterwards, extractors along with other machines work successively in the cotton ginning factory to complete cotton cleaning. Egyptian cotton, however, necessitated developing and testing this kind of machine as the primarily extracting means. The idea then is to add a field supplementary step to improve the grade of machine-harvested Egyptian cotton. What

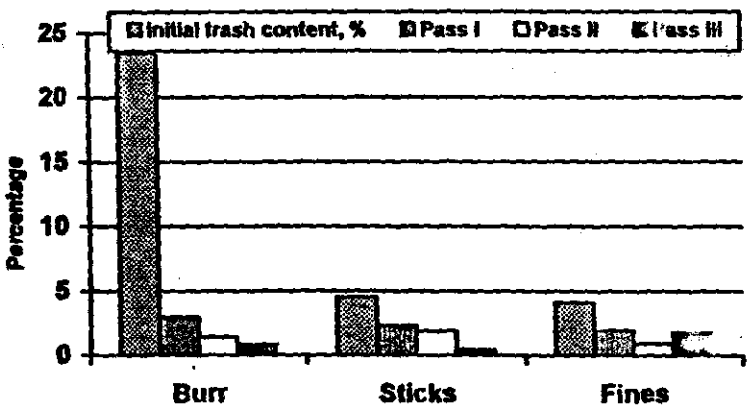
follows are the results of a test which used both the first and the second picks of Egyptian cotton to determine what levels of cleaning give the highest cotton value. The results of initial test for total trash materials and percent fractionation of each pick are presented in Figure (2). Analysis of significance among means of each picking time for initial moisture content revealed insignificant differences. This denoted that no need for adjusting the treatment means to remove moisture effects between these two times of harvesting. A study of Columbus et al. (1990) showed significant differences among different varieties. They indicated that mechanically harvested cotton was associated with high level of foreign matter that ranged significantly from 29.2% to 32% for first and second picking, respectively. These percentages are declined dramatically after cleaning to 4.4 and 3.1 with the third passage for first and second picking, respectively, with significant differences between them. Cleaning effect over speeds for passage time was also reduced significantly with each pass from 8, 7 and 4.4 to 7.3, 5.2 and 3.1, respectively. These results indicated that the dirties cotton was the second pick of cotton. After the third passage of the second pick was cleaned significantly than the first one. This was due to increase the amount of fine content. Total lint waste percentage was affected very little by passes over the machine speed. These differences (almost 0.1%) was too small to be of practical importance. Cleaning efficiency, %, increased by increasing cleaner speed and number of processing through machine for the first and the second pick treatments as shown in Figure (3). At the first pick, it was increased from 35 to 60.6% and from 60.6 to 73.9 % by increasing number of processing cotton through machine at the first and the third speed, respectively. But at the second pick, it was increased from 31 to 37.7 and from 55.1 to 66.3 at the same previous conditions.

Consequently, cotton cleaning is essential treatment for cotton before ginning especially with mechanical harvesting to help to increase the cotton grade and make ginning more efficient. Additional stages of extraction will improve the reduction of final bur and sticks content of seed cotton. Gillium and Armijo (1997), Cho et al., (1996), Rayburn (1988) and Griffin (1984) of the

above mentioned literatures reached these logic conclusions. However, the important question now is about the impact of these treatments on cotton fiber quality.



(a) At the first pick



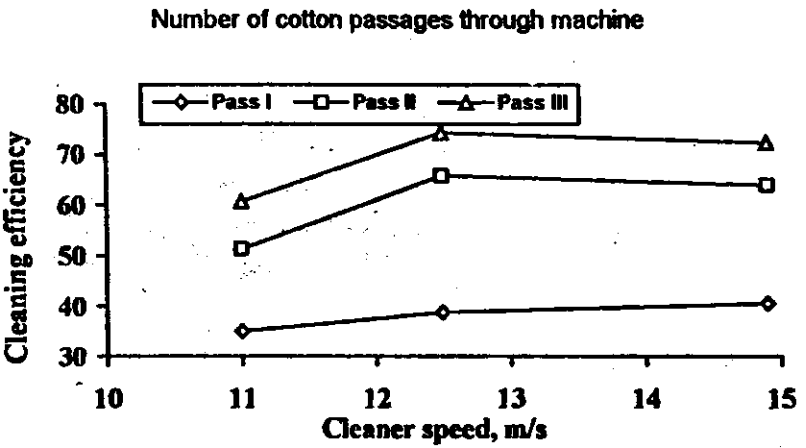
(b) At the second pick

Figure 2: Overhead cleaning performance data for initial test and cleaning treatments at different machine speeds.

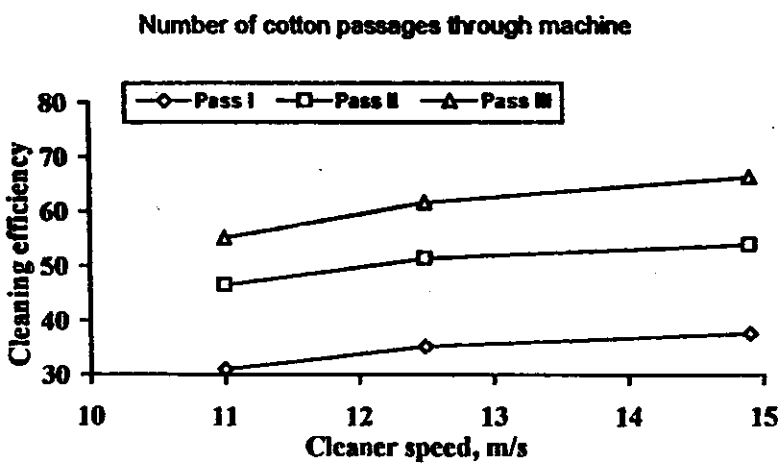
Fiber properties:

Analysis of significance of variable effects and their interactions were recorded. The HVI measurements for picks are affected by harvest date, cleaner speeds and processing through machine (one, two and three times). HVI length was significant for picking time, and passage times and the three way interaction as shown in Table (2). HVI classification means of the two picking times for fiber

quality properties and trash grade are shown in Table (2). Span length 2.5% mm was reduced slightly by both of three stages of saw cleaning and cleaner speed. Highest span length (32 mm) was found at processing through machine one time and at first cleaner speed. Uniformity ratio in general increased as the amount of cleaning increased, but it decreased as linear speed increased (Table 2).



(a) At the first pick



(b)At the second pick

Figure 3: Seed cotton cleaning efficiency (%) at means for the two-harvested times and number of processing cotton through the machine.

Fiber strength took an opposite trend. Micronaire values were stand at approximately 3.5 for all treatments. HVI data collected in Table (2) were somewhat lower than those provided by the **Annual Report of Cotton Research Institute (2003)** for the same variety at the same seasons of experimentation. It would be suggested that too much fiber cleaning may cause the decreased of fiber quality. Similar conclusion was reached by **Mangialardi (1981).** He stated that excessive fiber cleaning can decrease lint quality to an exact not compensated for by the improvements in grade.

Table 2: Mean performance of fiber properties measured by HVI for the first and the second cotton mechanical picking[§].

Variable	Span length, mm		Uniformity, Ratio	Strength, G/tex	Micronaire	Rd	+b	Lint Trash Content
	2.5%	50%						
First Pick[§§]								
Passage time	First cleaner speed of 11 m/s (700 rpm)							
1st time	32.0a[§§]	14.9a	46.5a	31.5a	3.5a	67.8bc	8.0b	6.6b
2nd time	30.8a	14.7a	47.7a	31.2a	3.6a	68.5bc	8.1ab	6.2b
3rd time	29.7a	14.5a	48.9a	30.8a	3.5a	69.2b	8.2a	5.8b
Passage time	Second cleaner speed of 12.5 m/s (800 rpm)							
1st time	31.7a	14.6a	46.0ab	30.1a	3.5a	68.2b	8.7a	5.1cd
2nd time	30.5ab	14.3a	46.8a	29.9ab	3.5a	68.9a	8.3ab	4.8c
3rd time	29.2ab	14.1a	48.2ab	29.4b	3.5a	69.7ab	8.5a	4.3c
Passage time	Third cleaner speed of 14.9 m/s (950 rpm)							
1st time	29.9b	13.9b	45.5b	29.1bc	3.5a	69.9a	8.8a	4.1d
2nd time	25.9c	13.2b	45.6bc	25.6d	3.5a	70.3a	8.6a	4.3c
3 rd time	25.1c	12.8b	45.5c	25.6d	3.6a	70.8a	8.4a	4.9b
Second pick								
Passage time	First cleaner speed of 11 m/s (700 rpm)							
1st time	30.0b	14.2ab	45.7ab	30.1b	3.4a	63.7de	7.5b	8.2a
2nd time	29.7ab	13.8b	46.4b	29.6bc	3.4a	64.3de	7.6b	7.8a
3rd time	29.5a	13.5b	47.3b	29.4b	3.5a	65.1d	7.9a	7.1a
Passage time	Second cleaner speed of 12.5 m/s (800 rpm)							
1st time	29.3b	13.2b	44.4c	29.3bc	3.5a	64.4d	8.2ab	6.8a
2nd time	29.0b	13.0b	44.8c	29.0bc	3.4a	65.8d	7.9b	6.5ab
3 rd time	28.8ab	12.8b	45.2c	28.8bc	3.5a	66.9c	8.4a	6.1a
Passage time	Third cleaner speed of 14.9 m/s (950 rpm)							
1st time	28.6b	12.6c	43.0d	25.0d	3.5a	67.0bc	8.5a	5.8bc
2nd time	28.3b	12.1c	42.7d	28.5c	3.5a	67.8c	8.3ab	5.9bc
3 rd time	27.9b	12.0c	44.0d	28.1c	3.5a	68.3b	8.1a	6.1a

§ Means are tested over Picking time, passage and speed.

§§ Differences inside each picking time and each passage were not significant in most cases.

Means for each cell followed by the same letter are not significantly different at 0.05 level of probability.

Fuel Consumption:

Nasr tractor 47.8 kW was used to operate the extractor machine for cleaning cotton. The analysis of cleaner speeds and number of passages through machine at the first and the second picks on fuel consumption are shown in Figure (4). It is obvious that the fuel consumption increased by increasing cleaner speed, but the depreciation was recorded by increasing number of processing through the machine for the first and the second pick. More details; at the first pick, the fuel consumption increased from 5.11 to 6.3 (l/h), from 4.98 to 6.1 (l/h) and from 4.81 to 5.8 (l/h) at 1st time, 2nd time and 3rd time respectively. However, it decreased from 5.11 to 4.81 (l/h), from 5.41 to 5.18 (l/h) and from 6.3 to 5.8 (l/h) at 700, 800 and 950 rpm cylinder speed, respectively. In spite of the cheap price of fuel and lubricants used for the machine operation, the strict reason for mentioning and discussing the fuel consumptions point is to give a signal to the economical point of view, not only to the current machine performance but also for the whole process of mechanical management and harvesting cotton crop compared to manual processing. Our team in association with economic department is going to evaluate the entire system and will be addressed in a separate study.

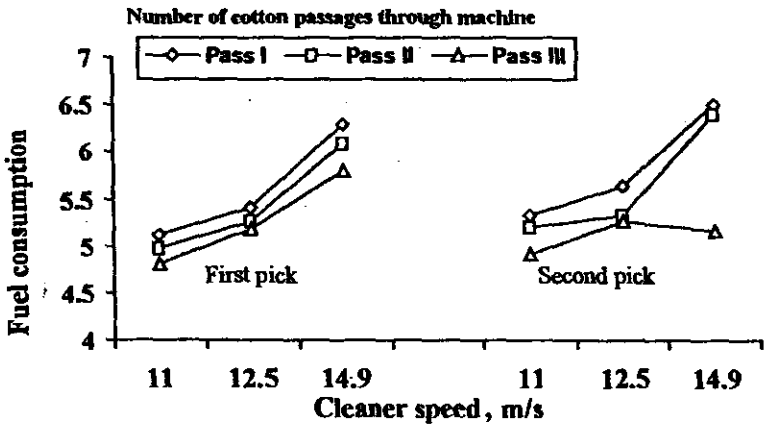


Figure 4: Fuel Consumption l/h at different cylinder speeds at the first and the the second picks.

CONCLUSION

Mechanical harvesting of cotton in Egypt is still in the very early stages. From the agronomist point of view, it is basically standing before several barriers starting from plant genetic background (varieties) up to management passing through experience. Egyptian cotton varieties were not bred for serving this purpose. We have no experience with the

required machinery level either for planting and management or for harvesting. Most important, we almost have no experience with the impact of that technology on the quality of our quality-distinct cottons. The point is that if we can transfer the technology and we can train a new generation of cotton farmers to be familiar with the technology, we are still in need to develop methodologies to maintain our cotton grade and quality until the scientific sectors be able to introduce a new generation of varieties fitted to mechanical harvesting. The main objective of this research was to investigate the influence of cleaning machine performance -combinations on cotton fiber quality. To fulfill this purpose, two mechanically harvested times (pick 1 and pick 2), three numbers of passing through machine and three levels of cleaner speed were used. It appeared that the machine separates the majority of non-lint components. The difference between first and second harvest was significant. The results support the necessity of using machine cleaner after cotton mechanical harvesting and before ginning so that fiber grade will be improved. Since using high machine speed or three time passage lead to sacrifice part of fiber quality, results are likely to recommend the second machine speed with the third passage time.

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الملخص العربى

تأثير استخدام ماكينة تنظيف القطن على جودة وصفات القطن المصرى المجني آليا

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إن الحصول على رتبه عالية مع الإحتفاظ بجودة التيلة هما هدفان هامان لمنتج القطن المصري فضلا عن كونهما ظاهرتين متلازمتين تلعبان دورا هاما في تسويق القطن. صممت الدراسة الحالية لاختبار ماكينة تنظيف حقليًا لفصل المكونات الغريبة (المكونات غير الليفية) من محصول القطن الزهر بعد الجنيه الأولى والجنية الثانية من ا لجني الآلي. وكذلك لدراسة تأثير استخدام تلك الآلة فضلا عن الجني الآلى ذاته على مكونات القطن الزهر وخواص وصفات التيلة. أظهرت نتائج الدراسة تأثير كفاءة استخدام الآلة على صفات التيلة أن الآلة المستخدمة تمكنت من فصل أغلب المواد الغريبة مع الاحتفاظ بجودة التيلة. تشيرا لدراسة بصفة عامة الى أنه يجب أن يكون هناك عناية فائقة عند اختيار سرعة الآلة وعدد مرات التلقيم لكي لا تتأثر صفات جودة التيلة.

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