Original research paper

Ginning efficiency and fiber quality properties of cotton as affected by roller gin stand feeding methods and seed cotton grade

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ABSTRACT:

Aims: Attaining the highest ginning efficiency process and fiber quality properties of Egyptian cotton cultivar ' Giza 88' during feeding methods of roller gin stand is the ultimate objective of the community of cotton field industry for local uses, but the productivity of the three feeding methods of conventional roller gin stand used in ginning process still limited

Therefore, the aim of this investigation is to overcome this obstacle.

Study design: This investigation was conducted in a completely randomized design with three replicates and analyzed as a factorial experiment.

Place and Duration of Study: Plant Production Department, the Faculty of Agriculture (Saba Basha), Alexandria University, Egypt during 2017.

Method: Four seed cotton grades; namely, Good to Fully Good (G/FG), Good + ¼ (G + ¼), Good (G) and Good -¼ (G - ¼) belonging to ' Giza 88' cotton cultivar were used in this work. The extra-long staple Egyptian cotton variety with the pedigree and origin of cotton Giza 88 (Giza 77 x Giza 45 B) was used. This work was carried out in 2017. About half cantar (1 cantar = 157.5 kg) of each seed cotton grade as a bulk sample was thoroughly mixed and checked and reclassified by a committee of three expert classers belong to the Cotton Arbitration for Testing General Organization (CATGO), in the gin plan.

Results:

The obtained results indicated that the gin stand's hand feeding method (control treatment); results insignificant increases the highest mean values of the gin stand capacity (0.97 kg lint/inch/h), Lint % (36.59%) and lint grade code (27.33) and the lowest mean value of the ginning time (1.42 h/cantar). Meanwhile, the Belt (2 row) as a mechanical feeding method; gave rise to the lowest mean value of gin stand capacity (0.89 kg lint/inch/h). The differences in fiber length parameters (Upper half mean length and short fiber index), fiber elongation %, micronaire reading, yellowness degree (+b) were not significantly affected. The highest seed cotton grade (Good / Fully Good) gave the better lint cotton grade and the best fiber properties tested by HVI instrument of ' Giza 88' cotton cultivar.

Conclusion:

- The hand feeding method of seed cotton to the gin stand surpassed all studied feeding methods in gin stand productivity, lint % and the most HVI fiber properties are better classer grade. Though, this method is recommended to be used specially with the high levels of the extra-long cottons.
- Cylinder feeding method ranked first in order among studied mechanical method and it could be recommended for ginning medium and low seed cotton level.
- Belt (2 rows) is the preferred feeding method regardless of gin stand productivity.

Keywords: Seed cotton grade, Hand method and Cylinder, feeding method, Fiber quality.

1. INTRODUCTION

Historically, ginning is the process in which seed cotton is subjected to separation of fibers from the seed with conserving its quality characteristics [1]. The roller gin stand was designed by Fones McCarthy in 1840. Ginning efficiency usually evaluated as gin stand capacity, ginning time and ginning out-turn. Generally, the gin stand capacity is influenced by several factors such as gin stand speed and adjustments, feeding method, cotton variety grade, besides its moisture content. Also, the feeder of gin stand regulates the flow of seed cotton

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provided to ginning system according to rate preset by ginner, beside fluffing and cleaning of the fed seed cotton. Historically, the first method for feeding gin stand with seed cotton by using hands was designed by Eli Whitney. In Egypt, the hand feeding remains in use beside two more mechanical feeding methods as the cylinder and belt. The rate of cleaning, fluffing and regulating the flow of seed cotton to the ginning zone greatly varied from one method to another, in addition to the lack of uniformity of seed cotton locks distribution along the ginning roller. On the other hand, some cotton dealers believe that the mechanical feeders in general have a deleterious effect on ginning efficiency and fiber quality.

In 1902 Chessman used a small drum as cleaning feeder to regulate the flow of seed cotton. In 1917 Murray Company invented a draper or a spiked belt as a feeder, a drum type feeder, and saw gin stand, which was usually located between the ginning roller and the overhead cleaning feeder to provide more uniformity and slower feeding at the working zones. The feeder was used at this time with modern roller gin stands. It was a type known as cleaner extractor, it was regulate the feeding the roller gins with suitable amount of seed cotton [2].The seed cotton feeding rate to the gin stand, significantly affected the ginning efficiency (ginning capacity and ginning time), lint grade, non-lint content and lint colour (Rd% and +b). As the feeding rate increased; the amount of seed cotton increased in ginning point, while the extractor of tight locks worked as an opener for the seed cotton before ginning in process. Ginning efficiency increased or decreased owing to the level of feeding rate and the position of the extractor [3]. Feeding rates of seed cotton to roller gin stand, significantly affected gin stand capacity, ginning time, non-lint content, but insignificantly affected lint colour (Rd% and +b) [4]. An extractor feeder led to lint separation from seeds consistently at higher given feed rate. The obtained results showed that the performance and capacity of the cage gin can be increased by improving the separation and distribution of seed cotton on the surface of the roller [5]. Likewise, feeding the gin stand with seed cotton by hand exhibited the highest gin stand capacity (32.76, 38.8 and 38.9 kg/in/h) for the belt, cylinder and hand feeding methods, respectively [6]. A new designed extractor-feeder machine was built to replace both the inefficient belt and cylinder methods that are in use in feeding the gin stand with seed cotton .The obtained results also show that fixing the speed of the extractor feeder at 0.7 rpm, resulted in an increase in the gin stand capacity *ca.* 38.5% higher than using hand, and by about35% and 27% for cylinder and belt methods, consecutively [7]. Furthermore, the seed cotton hand feeding method to the gin stand, surpassed all studied feeding methods in gin stand productivity, ginning out-turn, length uniformity be better classer grade [8]. Gin stand capacity (kg/inch/h) was increased by increasing the seed cotton grade, while, the ginning time varied within the same variety using different grades. This could be explained on the basis that each cotton variety has unique characteristics in terms of staple length, lock size, seed weigh and also the attachment force of the fibers to seeds [9]. Fiber length parameters considerably depending on the used grade of cotton cultivar [10].

The present research was conducted aiming to investigate the effect of feeding method of conventional roller gin stand and seed cotton grade on ginning efficiency, lint grades and fiber properties of the Egyptian extra-long staple cotton variety 'Giza 88'.

2. MATERIAL AND METHODS

This investigation was carried out in the Plant Production Department, the Faculty of Agriculture (Saba Basha), Alexandria University, Egypt to overcome the research statement.

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Two independent variables were under investigation as 1) three feeding methods were used in this research as follows: hand feeding (control), cylinder feeding and belt feeding (2 rows) of tooth spicks, and 2) four seed cotton grades; namely, Good to Fully Good (G/FG), Good + ¼ (G + ¼), Good (G) and Good -¼ (G - ¼) belonging to ' Giza 88' cotton cultivar during the season of 2017. It is an extra-long staple Egyptian cotton variety and its pedigree and origin of cotton Giza 88 (Giza 77 x Giza 45 B). About half cantar (1 cantar = 157.5 kg) of each seed cotton grade as a bulk sample was, thoroughly, mixed and checked or reclassified by a committee of three expert classers belong to the Cotton Arbitration for Testing General Organization (CATGO), in the gin plant. The studied samples were attained from the Arabia Ginning Company, Damanhour, of the commercial cotton received from Shubrakhit region, El-Beheira Governorate, during 2017 season. The bulk sample (27 kg) of each seed cotton grade was divided into nine sub- samples (3 kg/replicate), representing the various combinations of both variables (Twelve treatments representing four seed cotton grades and three feeding methods). The studied sub-samples were ginned using the conventional single roller gin stand [a roll covered with natural leather (McCarthy roller gin)] with the adjustments required for the each grade in the same gin plant.

Studied characteristics

1. Ginning efficiency parameters*:*

These parameters were calculated according to the following equations, proposed by [11]:

1.1. Gin stand capacity (GSC) expressed as the lint weight (kg) per inch per hour, as follows:

$$\text{Gin stand capacity (GSC)} = \frac{60 \times \text{weight of ginned lint (kg)}}{\text{Time (min)} \times \text{Length of roller (inch)}} = (\text{kg lint /inch/h})$$

(Length of roller = 40 inch of the McCarthy roller gin stand)

1.2. Ginning time (GT) was determined according the following equation:

$$\text{Ginning time (GT)} = \frac{\text{Ginning time (minute)} \times 157.5}{\text{Seed cotton weight (kg)} \times 60} = (\text{h/cantar})$$

(1 metric seed-cotton cantar = 157.5 kilograms)

1.3. Lint (%): was expressed as a percentage, and determined according the following equation:

$$\text{Lint \%} = \frac{\text{Lint cotton weight (kg)}}{\text{Seed cotton weight (kg)}} * 100 = \quad \%$$

1.4. Seed index: The average weight of 100 seeds (g) was determined for each replicate.

1.5. Lint grade: The ginned lint of each sample was determined by a three export classers, at (CATGO), Alexandria. For statistical analysis, the grades were converted to code numbers [12] as shown in the following Table (1).

Table (1): Lint cotton grades, their abbreviation and their codes.

Grade	Abbreviation	Code
Extra	Extra	41
Fully good/Extra	FG/Extra	37
Fully good	FG	33
Good/fully good	G/FG	29
Good	G	25
Fully good fair/good	FGF/G	21
Fully good fair	FGF	17
Good fair/fully good fair	GF/FGF	13
Good fair	GF	9
Fully fair/good fair	FF/GF	5
Fully fair	FF	1

Each 1/8 grade is represented by one mark.

3. Determination of fiber properties using HVI instrument:

Description of cotton fiber quality characteristics (USTER® HVI SPECTRUM)

High Volume Instrument (HVI)

In relation to cotton fiber selection, the HVI system is the primary source of fiber information. This is because of the rapid testing and data access associated with the

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system.The introduction of the High Volume Instrument (HVI) has revolutionized the process of fiber selection and bale management. The HVI system provides many measures of fiber characteristics including: Micronaire (Mic), fiber length (FL), length uniformity (LU), fiber strength (FS), fiber elongation (FE), trash area (TA), short fiber index (SFI), color reflectance (Rd), and color yellowness (+b). The HVI system was introduced to provide a rapid and accurate testing of cotton fibers in a way that largely resembles the traditional subjective evaluation of cotton by the classer. In the U.S. market, all upland cotton is classed using the HVI system. The rate of HVI testing is generally determined on the basis of throughput in cycle time for one sample to be measured once on all stations. In modern HVI systems, this amounts to approximately 80 tests per hour or approximately 640 tests per eight-hour shift. This feature is important considering the millions of cotton bales that are classed by the system during the harvest season. The flood of data generated by the HVI system can be managed and manipulated by microcomputers and powerful software programs.

Length: Upper Half Mean Length, Uniformity Index, Short Fiber Index Measured optically in a tapered fiber beard which is automatically prepared, carded, and brushed.

Upper half mean length

UHML is the mean length by the number of fibers in the largest half by weight of fibers in a cotton sample, usually measured from the fibrogram. Upper half mean length is normally equivalent to the staple length. Fiber length which is equivalent to the classer's staple.

Uniformity index: The ratio between mean length (ML) & Upper half quartile length is called uniformity index, express as a percentage. Quality characteristic which is proportional to the variation of the fiber length $\mathrm{UI} = \frac{ML}{UHML} \times 100$

Short fiber index

Short fiber content is the percentage by number or weight of fibers less than a specified length, 0.5 inches (12.7mm) for cotton. Measurement of short fibers <0.5 in/12.7 mm.

Fiber Strength

Fiber strength is measured by breaking the fibers held between clamp jaws. It's reported as grams per tex, which is the force in grams required to break a bundle of fibers one tex unit in size. A tex unit is equal to the weight in grams of 1000 meters of fiber. Fiber strength, measured at the fiber bundle

Strength and elongation

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

Maturity index

Calculated index of the maturity. Maturity Ratio Calculated using a sophisticated algorithm based on several HVI™ measurements. Ratio of mature to immature fibers.

Micronaire value

Indicates fiber fineness. Micronaire reading Measured by relating airflow resistance to the specific surface of fibers. Quality characteristic which is proportional to the fiber fineness. The Micronaire value is taken as an indication of fineness (linear density) and maturity (degree of cell-wall development). For a given cotton type, a relatively low Micronaire reading is a predictor for problems in processing, generation of Neps, and inefficient dyeing.

Fiber brightness or reflectance degree (Rd %)

A measure of the reflected light from the sample and ranges in cotton from (40-90%). The higher the degree of (Rd) the whiter color. Whiteness/grayness of the cotton sample. Rd (Whiteness) Measured optically by different color filters. The higher this value, the better the cotton is rated.

Chroma or degree of yellowness (+b)

A scale that reflects the degree of yellowing in the sample and ranges in cotton from (4 - 18) and the higher the degree of + b the more the sample is yellowing. Yellowness of the cotton sample. +b (Yellowness) Measured optically by different color filters. Assessment of color, degree of yellowness

Trash: Trash content of a measured sample. Particle count, % surface area covered by trash, trash code measured optically by utilizing a digital camera.

Trash count: Number of trash particles per defined area.

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Trash area: Percentage of trash per defined area.
Spinning consistency index (SCI): Calculated index of the spinnability of measured sample. Calculation for predicting the spinnability of the fibers.

4. Statistical procedures

This investigation was conducted in a completely randomized design with three replicates and analyzed as a factorial experiment according to the procedure of [13]. The mean values were computed using the CoStat 6.311 (1998-2005) [14] as a statistical program, to test significant differences among treatments using the least significant difference (L.S.D.) at 0.05 level of probability.

RESULTS AND DISCUSSION

1. Ginning efficiency parameters:

Results presented in Table (2) show the mean values of the ginning efficiency parameters, i.e. gin stand capacity, ginning time, Lint (%), seed index and lint grade code for the cotton cultivar ' Giza 88 ' during the studied season (2017).

The attained results indicated that feeding methods treatments affected significantly the gin stand capacity, ginning time, Lint (%) and lint grade code. Whereas, the differences in seed index were insignificant due to the feeding methods, effect.

It is obvious that the hand method (control treatment) possessed the highest mean values of the gin stand capacity (GSC), lint %, seed index and lint grade code and the lowest mean value of the ginning time (GT). Meanwhile, the Belt (2 row) mechanical feeding method; gave the lowest mean values gin stand capacity (GSC), Lint %, seed index and lint grade code, and the highest mean value of ginning time. It could be proposed that the gin stand capacity increases and the ginning time decreases proportionally as the increase in delivery of cotton locks to the ginning zone in case of the hand feeding method. These results are in accordance with those obtained by [6, 8] they noticed that the feeding rates of seed cotton to roller gin stand significantly affected ginning efficiency (ginning stand capacity and ginning time).

Table (2). Mean values of the ginning efficiency parameters of Giza 88 cotton variety as affected by the feeding method, seed cotton grade and their interaction during season of 2017.

Characters / Treatments	Gin stand capacity (kg lint/inch/h)	Ginning time (h/cantar)	Lint (%)	Seed index (g)	Lint grade code
	Feeding method (A)				
Hand	0.97 a	1.42 b	36.59 a	9.19 a	27.33 a
Cylinder	0.94 b	1.49 ab	36.36 a	8.90 a	26.83 b
Belt (2 row)	0.89 c	1.55 a	35.89 b	8.89 a	26.66 b
L.S.D. $_{0.05}$	0.027	0.076	0.411	0.372	0.397
	Seed cotton grade (B)				
Good / Fully Good	1.03 a	1.38 c	37.33 a	10.48 a	29.00 a
Good + ¼	0.97 b	1.46 bc	37.08 a	9.99 b	28.33 b
Good	0.89 c	1.52 ab	35.98 b	8.98 c	26.33 c
Good - ¼	0.84 d	1.57 a	34.73 c	6.52 d	24.11 d
L.S.D. $_{0.05}$	0.032	0.088	0.474	0.430	0.458
	Interaction				
A × B	Ns	ns	**	*	ns

Means designated by the same letter within each column are not significantly different.
* Significant at 0.05 level of probability. **: Significant at 0.01 level of probability.
NS. : Not significant.

In terms of the main effect of seed cotton grade, results outlined in the same Table, reveal that all studied ginning efficiency parameters were significantly affected by seed cotton grade. It is obvious that the highest seed cotton grade (Good to Fully Good (G/FG)); brought about the lowest mean values of the ginning time and the highest mean values for the rest of the studied ginning efficiency parameters. This result might be because the highest seed cotton grade usually contains the highest proportion of the big fluffy cotton locks, and the lowest proportion of foreign matters or trash content and tight locks. In this connection, [8, 15] reported that the highest seed cotton grade, gave rise to the highest ginning out-turn (%) and gin stand capacity and the lowest value of the ginning time.

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Results tabulated in Table (2) declare that the interaction between the two studied factors, i.e. feeding methods and seed cotton grades (A×B) was significant for lint % and seed index of the cotton cultivar ' Giza 88 '. Mean values of the same traits are presented in Table (3). It is obvious that the hand feeding method of the highest seed cotton grade (G/FG) records the highest mean value of lint %. Otherwise, the lowest mean value of the same trait was recorded from the Belt (2 row) mechanical feeding method with seed cotton grade (G - ¼).

Regarding the seed index, the highest mean value was reached by the cylinder feeding method with the highest seed cotton grade (G /FG) and the Belt (2 row) mechanical feeding method with the same seed cotton grade (G /FG). On the other hand, the lowest mean value of the same trait was obtained using the cylinder feeding method with the lowest seed cotton grade (G - ¼) and the Belt (2 row) mechanical feeding method with the same seed cotton grade (G - ¼).

Table (3). The interaction between feeding method and seed cotton grade (A × B) for the lint (%) and seed index (g) of 'Giza 88' during season of 2017.

Variables		Lint (%)	Seed index (g)
Feeding method (A)	Seed cotton grade (B)		
Hand	G / FG	37.36	10.29
	Good + ¼	37.15	9.99
	Good	36.01	9.00
	Good - ¼	35.86	7.50
Cylinder	G / FG	37.33	10.58
	Good + ¼	37.16	9.99
	Good	36	8.99
	Good - ¼	34.98	6.04
Belt (2row)	G / FG	37.32	10.58
	Good + ¼	36.93	9.99
	Good	35.95	8.96
	Good - ¼	33.36	6.04
L.S.D.$_{(0.05)}$		0.822	0.744

3. Fiber properties tested by H.V.I. instrument:

In general the results outlined in Table (4) indicated that the effect of the feeding method treatments had a highly significant on spinning consistency index (SCI), maturity index, length uniformity index (UI), the fiber bundle strength, fiber reflectance degree (Rd %) and the differences in trash count, and trash area. Whereas, the differences in micronaire value, fiber length parameters, upper half mean length (UHML), and short fiber index (SFI), fiber elongation %, micronaire reading and yellowness degree (+b) were not significantly affected, due to the feeding method effect.

Hand feeding method exhibited the highest mean values for the spinning consistency index (SCI), maturity index, length uniformity index (UI), the fiber bundle strength, fiber reflectance degree (Rd %) and the lowest mean values of trash count and trash area, as shown in Table (4), while the lowest mean values of the same traits and the highest mean value of trash count were possessed by using the Belt (2 rows) mechanical feeding method. Meanwhile, the lowest mean value of the trash area was recorded by cylinder feeding method to the gin stand. These results could be attributed to the little chance for the tight locks to be hanged and ginned, besides the lower rate of flow of seed cotton to the ginning zone in case of the Belt (2 rows) mechanical feeding method.

These results are in agreement with the findings of [7, 8]. They reported that the fiber length parameters as upper half mean length (UHML) and short fiber index (SFI), were insignificantly affected by the seed cotton feeding method to the gin stand. In the same time the attained results disagree with those of [3], who indicated that the length parameters were significantly affected by the different levels of feeding rates.

All studied fiber properties tested by HVI instrument were significantly affected by the seed cotton grade, as presented in Table (4).

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The highest mean values of spinning consistency index (SCI), maturity index, length uniformity index (UI), upper half mean length (UHML), the fiber bundle strength, fiber elongation %, fiber reflectance degree (Rd %) and the lowest mean values of four characters short fiber index (SFI), trash count, trash area and yellowness degree (+b) were reached by the highest seed cotton grade Good / Fully Good (G/FG). On the other exhume, the highest mean value of the micronaire reading was recorded by the seed cotton grade Good + ¼ (G + ¼). Fiber properties tested by HVI instrument of 'Giza 88' cotton cultivar, except short fiber index (SFI), trash count, trash area and yellowness degree (+b) correspondingly decreased as the seed cotton grade decreased. These results were in harmony with those obtained by [8, 15]. They claimed that the HVI fiber properties are in relation with the grade and the high content of mature locks and fibers and low content of trash (non-lint content) and short fibers of the highest seed cotton levels gave the better lint cotton grades.

Likewise, results of Table (4) refer that the interaction (A × B) of both variables under the study i.e. feeding method (A) and seed cotton grade (B) affected insignificantly all studied H.V.I. fiber properties.

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Table (4).Mean values of the H.V.I fiber properties of 'Giza 88' as affected by feeding methods and seed cotton levels during season of 2017.

Characters / Treatments	SCI	UHML (mm)	Uniformity index (%)	Short fiber index (%)	Fiber strength (g/tex)	Fiber elongation (%)	Maturity index (%)	Micronaire reading	Rd (%)	+ b	Trash count	Trash Area (%)
Hand	218.50 a	35.04 a	88.42 a	5.54 a	46.07 a	3.72 a	0.87 a	4.00 a	70.14 a	11.61 a	35.08 b	0.49 b
Cylinder	204.75 b	35.27 a	86.09 b	5.58 a	40.27 b	3.64 a	0.85 b	3.97 a	67.98 b	11.51 a	87.08 a	1.04 a
Belt (2 row)	202.25 b	35.01 a	86.31 b	5.55 a	38.94 b	3.58 a	0.84 b	3.94 a	67.31 c	11.47 a	87.41 a	1.00 a
L.S.D. $_{0.05}$	9.844	ns	1.073	ns	2.292	ns	0.008	ns	0.626	ns	8.857	0.164
Good / Fully Good	219.88 a	35.58 a	88.65 a	5.38 c	45.66 a	3.82 a	0.87 a	4.25 a	70.08 a	11.33 b	39.22 d	0.43 c
Good + ¼	212.77 ab	35.48 a	88.10 a	5.40 c	41.03 b	3.74 a	0.87 a	4.30 a	69.02 b	11.47 ab	58.88 c	0.78 b
Good	204.44 bc	35.10 b	86.78 b	5.58 b	40.08 b	3.63 a	0.84 b	3.88 b	68.47 b	11.63 ab	72.66 b	1.03 a
Good - ¼	196.88 c	34.26 c	85.31 c	5.85 a	40.26 c	3.40 b	0.83 b	3.44 c	66.33 c	11.70 a	108.66 a	1.13 a
L.S.D. $_{0.05}$	11.367	0.369	1.239	0.103	2.646	0.179	0.009	0.113	0.723	0.256	10.227	0.189
A × B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Means designated by the same letter within each column are not significantly different
Ns: Not significant. UHML: Upper Half Mean Length.
SCI: Spinning consistency index

Conclusion

- The hand feeding method of seed cotton to the gin stand surpassed all studied feeding methods in gin stand productivity, lint % and the most HVI fiber properties is the best classer grade. Though, this method is recommended to be used specially with the high levels of the extra-long cottons.
- Cylinder feeding method ranked first in order among studied mechanical method and it could be recommended for ginning medium and low seed cotton level.
- Belt (2 rows) is the preferred feeding method regardless of gin stand productivity.

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