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

ABSTRACT:

Aims: Investigate the relationships between the three different methods of roller gin stand type, i.e., hand feeding (control), cylinder feeding and belt feeding (2 rows) of tooth spicks on four seed cotton grades of Giza 88 cotton variety; namely, Good to fully good (G/FG), Good + ¼ (G + ¼), Good (G) and Good + ¼ (G + ¼) to estimate their effects on ginning efficiency, lint grade and the quality of fiber properties.

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.

Methodology: Four seed cotton grades; namely, Good to Fully Good (G/FG), Good + ¼ (G + ¼), Good (G) and Good -¼ (G - ¼) belonging to ˊ Giza 88ˋ cotton cultivar during the season of 2017, it is the extra-long staple Egyptian cotton variety were used in this work and the 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 plan.

Results: The obtained results indicated that the gin stand's hand feeding method (control treatment); results in, significantly ($p \leq 0.05$) the highest mean values of the gin stand capacity (G.S.C.), Lint percentage, seed index and lint grade code and the lowest mean value of the ginning time (G.T.). Meanwhile, the Belt (2 row) as a mechanical feeding method; gave rise to the lowest mean value of gin stand capacity (G.S.C.). The differences in fiber length parameters (Upper half mean length and short fiber index), fiber elongation percentage, micronaire reading, yellowness degree (+b) were not significantly ($p \leq 0.05$) affected due to the feeding methods to the gin stand. The highest seed cotton grade (Good / Fully Good) gave the better lint cotton grade and the best fiber properties tested by H.V.I. instrument of ˊ Giza 88ˋ cotton variety.

Conclusion:

- The hand feeding method of seed cotton to the gin stand surpassed all studied feeding methods in gin stand productivity, lint percentage and the most H.V.I. fiber properties be 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 preferred feeding method regardless 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. Meanwhile, the first gin plant was constructed in Egypt at Talkha by the Nile Rever- side in 1859, and then twenty gin plants were founded by the end of 1870. 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 speed and adjustments of the gin stand, feeding method, cotton variety and grade besides the moisture content.

The feeder of gin stand regulates the flow of seed cotton into ginning system according to rate preset by ginner, beside fluffing and cleaning of the fed seed cotton. The first method used in feeding the first gin stand with seed cotton in history, designed by Eli Whitney, was the hand feeding method. The hand feeding is still in use in Egypt beside two more mechanical feeding methods, the cylinder feeding method and the belt feeding method. The rate of cleaning, fluffing and regulating the flow of seed cotton to the ginning zone greatly

varied from one method to another. Besides, the variation in seed cotton locks distribution along the ginning roller. Some cotton dealers belief that the mechanical feeders in general had a deleterious effect on ginning efficiency and fiber quality.

In 1902 Chessman used a small drum cleaning feeder with regulated flow of seed cotton. In 1917 Murray Company invented a draper or a spiked belt feeder and a drum type feeder and saw gin stand, that was usually located between the ginning roller and the overhead cleaning feeder to provide more uniform and shower feeding at the working zones. Draper or spiked belt feeder that was usually located between the ginning roller and the overhead cleaning feeder to give more uniform and slower feeding at the working zones. The feeder was used at this time with modern roller gins. It was a type known as cleaner extractor feeder that was provided with feed regulation suitable to roller gins [2].The seed cotton feeding rate to the gin stand, significantly ($p \leq 0.05$), 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 did as an opener for the seed cotton before ginning. 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 ($p \leq 0.05$), affected capacity, ginning time and non-line content and insignificantly affected lint colour [Rd% and +b] [4]. An extractor feeder, lint removal was consistently higher for a given feed rate: the results of the tests 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 cage [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/hr.) 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 to about 38.5% higher than manual, cylinder and belt methods 35% and 27%, consecutively [7]. Nevertheless, 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].

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 ʻGiza 88ʼ.

2. MATERIAL AND METHODS

This investigation was carried out in the Plant Production Department, the Faculty of Agriculture (Saba Basha), Alexandria University, Egypt. Four seed cotton grades; namely, Good to Fully Good (G/FG), Good + ¼ (G + ¼), Good (G) and Good -¼ (G - ¼) belonging to ʻ Giza 88ʼ cotton cultivar during the season of 2017, it is the extra-long staple Egyptian cotton variety were used in this work and the 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 of each seed cotton grade was divided into nine sub- samples (3 kilograms each), representing three feeding methods with three replicates. 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. Twelve treatments representing four seed cotton levels and three feeding methods were used in this research as follows: Hand feeding (control), cylinder feeding and belt feeding (2 rows) of tooth spicks.

Studied characteristics

1. Ginning efficiency parameters*:*

These parameters were calculated according to the following equations, proposed by [9]:

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

$$\text{Gin stand capacity (G.S.C)} = \frac{60 \times \text{weight of ginned lint (kg)}}{\text{Time (min)} \times \text{Length of roller (inch)}} = \text{(kg lint /inch/hr)}$$

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

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

$$\text{Ginning time (G.T.)} = \frac{\text{Ginning time (minute)} \times 157.5}{\text{Seed cotton weight (Kg)} \times 60} = \text{(hr. / cantar)}$$

(1 metric seed-cotton cantar = 157.5 kilograms)

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

$$\text{Lint percentage (L.P.)} = \frac{\text{Lint cotton weight (kg)}}{\text{Seed cotton weight (kg)}} \times 100 = \text{(\%)}$$

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 [10] 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 H.V.I. instrument:

Representative sample of lint cotton (about 200 grams) was drawn for determining the fiber properties. The High Volume Instrument (HVI) Spectrum II system was used to determine the fiber properties at the Laboratories of Cotton Arbitration for Testing General Organization (C.A.T.G.O.), Alexandria, Egypt.

All samples were opened and left for 24 hours at least under the standard conditions of 65 ± 2% relative humidity and 21 ± 1°C temperature before being tested, and the following properties were determined:

3.1. Fiber upper half mean length (U.H.M.L.; mm.).
3.2. Length uniformity index (%).
3.3. Short fiber index (%).
3.4. Fiber bundle strength (g/tex).
3.5. Fiber elongation (%).
3.6. Micronaire value.

3.7. Maturity index (%).
3.8. Fiber brightness or reflectance degree (Rd %).
3.9. Chroma or degree of yellowness (+b).
3.10. Trash area (%).
3.11. Trash count.
3.12. Spinning consistency index (SCI).

4. Statistical procedures

This investigation was conducted in a completely randomized design with three replicates and analyzed as a factorial experiment according the procedure of [11]. The mean values were computed using the CoStat 6.311 (1998-2005) [12] 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 percentage (%), seed index and lint grade code for the cotton cultivar ˊGiza 88ˋ during the studied season (2017).

The attained results indicated that feeding methods treatments affected significantly ($p \leq 0.05$) the gin stand capacity, ginning time, Lint percentage (%) 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 (G.S.C.), lint percentage, seed index and lint grade code and the lowest mean value of the ginning time (G.T.). Meanwhile, the Belt (2 row) mechanical feeding method; gave the lowest mean values gin stand capacity (G.S.C.), Lint percentage, 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/hr.)	Ginning time (hr./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 ($p \leq 0.05$) 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 studied ginning efficiency parameters. This result was taken place because of 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, 13]. [14] 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.

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 ($p \leq 0.05$) for lint percentage and seed index of the cotton cultivar ʹGiza 88ʹ. 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 percentage. 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 percentage (%) and seed index (g) of ʹGiza 88ʹ during season of 2017.

Variables		Lint percentage (%)	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 ($p \leq 0.01$) on spinning consistency index (SCI), maturity index, length uniformity index (U.I.), 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 (U.H.M.L.), and short fiber index (SFI), fiber elongation percentage, 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 (U.I.), 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 (U.H.M.L.) 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 H.V.I. instrument were significantly ($p \leq 0.05$) affected by the seed cotton grade, as presented in Table (4).

The highest mean values of spinning consistency index (SCI), maturity index, length uniformity index (U.I.), upper half mean length (U.H.M.L.), the fiber bundle strength, fiber elongation percentage, 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 H.V.I. 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 ,13]. They claimed that the H.V.I. 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.

Table (4).Mean values of the H.V.I fiber properties of ʼGiza 88ʼ 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 percentage and the most H.V.I. fiber properties be 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 preferred feeding method regardless gin stand productivity.

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