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Research Article

Effects on Fiber Quality of Storage Times in Mechanically Harvested Seed Cotton

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Abstract Seed cotton is transferred from the harvesting machinery to the warehouse where it is stored until ginning. During this time, trash and moisture content of seed cotton, and temperature and relative humidity of storage contributed to the deterioration of seed cotton. This study has been carried out in order to find out the impact on fiber quality parameters (length, fineness, strength, uniformity, elongation, short fiber content and yellowness) of different storage times (S_1: Ginning without storage, S_2: Ginning after 30 days stored, S_3: Ginning after 60 days stored, S_4: Ginning after 90 days stored and S_5: Ginning after 120 days stored) in mechanically harvested seed cotton of two cotton (Maras-92 and BA-308) cultivars (*G. hirsutum* L.). There were no differences between cultivars for fiber length, fineness, strength and uniformity. The mean values of fiber length, fineness, strength and uniformity were 30.7 mm, 4.49 micronaire, 30.6 (g tex^{-1}) and 83.52% respectively. BA-308 had higher elongation and yellowness, lower short fiber content than the characters of Maras-92. In the study, it was detected that all characteristics except fineness and uniformity showed significant differences among storage times. Cultivar-storage time interaction was significant only for strength. At the end of experiment, when storage times were delayed from S_1 to S_5 treatment, fiber length, strength, elongation, short fiber content and degree of yellowness were negatively changed.

Keywords Storage period, lint quality, seed cotton

Introduction

Cotton is an industrial cash crop which has an important role in world agriculture and trade. Cotton seed is also an important raw material of the oil and feed industry due to oil content of seeds and oil cake with higher protein. In Turkey, the area of cotton during 2015 was 434 000 hectares with lint production of 738 000 tones and average lint yield of 1700 kg ha^{-1}. Recently, domestic consumption and imports has increased as the result of an improving Turkish textile industry. Currently, over 50% of lint cotton consumed is imported [9]. Turkish textile sector is one of the leading sectors in the Turkish economy providing 17.5 percent of total exports in 2014 [16]. Most of Turkey's cotton is planted in a 60-day period between mid-March and mid-May and harvested from mid-August until November. Cotton is grown in three main regions; Aegean, Cukurova and Southeastern Anatolia region. Until recently, cotton harvest was completely picked by hand in our country cotton fields. In recent years, mechanically cotton harvest has become widespread due to increasing number of harvesters. The total number of cotton harvesters in Turkey has increased rapidly to about 1,100. An important part, about 750, of them are new modern harvesters; about 250 are secondhand, and about 100 are old tractor-pulled harvesters. Presently about 95 percent of Aegean region cotton area is harvested by cotton machine, and 80 percent of Çukurova and 65 percent of South East Anatolian (GAP) cotton. The demand for harvesters has increased in recent years since the high cost and scarcity of labor have caused cotton picking delays and losses [16].

Cotton goes through a series of mechanical processes from being harvested in the field to being pressed into a bale at the gin. At each step of the process cotton fiber quality is affected by interactions between fiber and mechanical actions [10]. Burrs, sticks, and leaves in freshly harvested seed cotton have higher moisture contents than the lint or seed. Humidity can play an important role in the moisture content of seed cotton. Karon and Adams [8] reported that over a 30 day period of exposure to a constant relative humidity of 93%, cottonseed moisture levels increased to 20%. Montgomery and Wooten [12] reported that high seed cotton moisture contents can trigger microbial activity which can have severe, negative effects on fiber quality. Lint moisture content while in the boll was found to vary from a high of 16% to a low of 5% from morning to mid-afternoon of the same day. The authors reported that change in lint color grades resulted in a 7% reduction in lint price between the minimum and maximum moisture contents over the course of 72 hours of storage in cotton trailers. It is evident that excessive moisture in seed cotton is the main factor that starts the deterioration of seed cotton in storage. Possibly the most basic factor contributing to the deterioration of seed cotton in storage is the presence of micro-organisms [14]. The negative impact of weathering on seed cotton is well recognized. Studies have shown changes in color when seed cotton moisture is increased. Curley et al. [1] found that most of the coloring effect was due to yellowing. The yellowing was primarily affected by moisture content, days stored, average air temperature during storage and initial temperature of the cotton module. A recent study [5] has established that increases in cotton yellowness as a result of accelerated ageing at elevated temperatures not only accompanied by decreases in reducing sugars, but also by decreases in pH. This is a strong indication that the color changes produced in cotton under typical storage conditions (at or below 7% moisture content and temperatures not controlled) are due to a non-microbial induced mechanism. A correlation between the increase in cotton yellowness due to warehouse ageing and a decrease in yarn strength has been reported [4]. Furthermore, decreases in reducing sugar levels were significantly correlated with both decreasing yarn strength and increasing fiber yellowness. Previous studies have indicated that HVI +b values of baled Upland cotton increase due to prolonged storage with uncontrolled temperature conditions [6]. Fiber length, average length of the longer one-half of fibers, is dictated by variety, cropping conditions, and ginning practices. Strength reflects the force required breaking the fiber, and micronaire is an indicator of air permeability, indicating both fiber fineness and maturity (degree of cell-wall development) [11]. Micronaire affects processing performance and quality of the end product and it is influenced during the growing season by climatic conditions [19]. Environmental conditions during cotton production, harvest, and pre-ginning storage impact both cotton lint grade and seed aflatoxin content [15].

A more recent study [7] indicated that micronaire, length, strength, elongation, reflectance, yellowness, and free fatty acid content were affected by differing levels of moisture and trash. Moisture content was the most prevalent factor, affecting elongation, free fatty acid content, yellowness, micronaire, length, and reflectance. Moisture content was followed by trash content, which was found to be a significant factor for the responses of yellowness, micronaire, and length.

In Turkey, once the seed cotton is harvested, it is transferred from the harvesting machinery to the warehouse where it is stored until ginning. This could span several days to several weeks. During this time, trash and moisture content of seed cotton, and temperature and relative humidity of storage contributed to the deterioration of seed cotton in storage. Longer stay of the seed cotton in the storage with uncontrolled temperature and moisture conditions may change the color and also effect lint quality parameters such as length, strength, micronaire and elongation. The objective of this study was to establish the influences on fiber quality of storage times in mechanically harvested seed cotton (*G. hirsutum* L.).

Materials and Methods

Seed cotton samples were collected from two farmer fields which was planted Maraş-92 and BA-308 cotton varieties at Kahramanmaras province in the 2009 crop year. These two cotton varieties are cultivated by cotton producers of East Mediterranean region. Kahramanmaras city is located in the East-Mediterranean region of Turkey between 37º 36' north parallel and 46º 56' east meridians. At each field, approximately 50 kg cotton sample was collected from the harvester's basket as the cotton was harvested by a John Deere picker (model 9970). Samples from each variety weighed approximately 2 kg were prepared and placed in cloth bags, and they were stored in the warehouse (moisture and temperature not controlled) according to the subject. Five treatments representing various storing periods of the cotton were used in the study: Treatment 1: Ginning without storage (S_1). Samples were collected from cotton harvested by a cotton picker. These samples were hand ginned without storage. Treatment 2: Ginning after 30 days stored (S_2). Samples were hand ginned after waiting 30 days in the store. Treatment 3: Ginning after 60 days stored (S_3). Samples were hand ginned after waiting 60 days in the store. Treatment 4: Ginning after 90 days stored (S_4). Samples were hand ginned after waiting 90 days in the store. Treatment 5: Ginning after 120 days stored (S_5). Samples were hand ginned after waiting 120 days in the store. Each treatment was replicated four times. In total there were 40 samples (2 varieties x 5 storage periods x 4 replicates). At the end of the storage periods, those samples were hand ginned at the laboratory of KSU Agricultural Faculty, Field Crops Department. After ginning, 50-g lint samples were used for determination of various quality parameters and conditioned at 21 °C and 65% relative humidity for 24 h prior analysis. Lint quality parameters were determined in high volume instruments (HVI-900): 1) fiber length in millimeters measured as 2.5 (2.5% span length); 2) fiber uniformity determined as the ratio of the mean length to upper-half mean length expressed as a percentage; 3) fiber strength as force (g/tex) necessary to break the fiber bundle; 4) micronaire value as fineness of the fiber expressed in standard micronaire units; 5) short fiber content as percentage of fibers less than 12.7 mm long; 6) elongation value as a percentage of fiber elongation at break the fiber bundle; 7) the degree of yellowness is determined by a calculation known as Hunter's +b. All data were analyzed using the SAS statistical software. Significant differences among mean values were compared by protected least significant difference (Protected LSD, $P < 0.05$).

Results and Discussion

From the analysis of variance (Table I), fiber elongation, short fiber content and degree of yellowness showed significant differences between cultivars, and all characteristics except fiber fineness and fiber uniformity showed significant differences among storage times. Cultivar-storage time interactions were not significant for all characteristics except fiber strength, indicating that cultivars responded similarly to the storage periods. Cultivars differed in the fiber elongation and short fiber content with values varying from 6.29 to 7.40% and from 5.60 to 6.12% respectively. BA-308 had a higher percentage (1.11%) of fiber elongation and lower percentage (0.52%) of short fiber content than the value of cotton cultivar Maras-92. In contrast, Maras-92 had a lower degree of yellowness (+b: 7.16) than cotton cultivar BA-308 (+b: 7.37). Differences between cultivars for fiber length, fineness, strength and uniformity were not significant. The mean values of fiber length, fineness, strength and uniformity were 30.7 mm, 4.49 micronaire, 30.6 (g tex^{-1}) and 83.52% respectively. Hake et al. [23] pointed out that variety is the dominant factor controlling fiber quality

Table 1: Mean values of fiber quality parameters for cultivars and storage times.

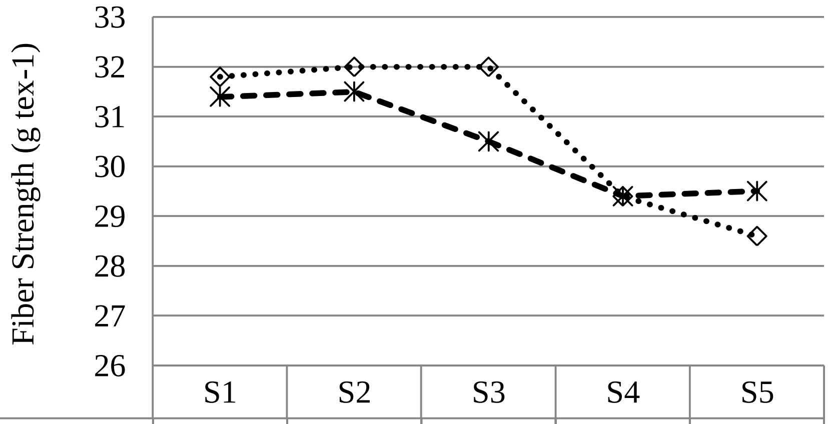
	FL (mm)	FF (mic.)	FS (g tex^{-1})	FU (%)	FE (%)	SFC (%)	DY (+b)
Cultivars							
Maras-92	30.8	4.59	30.8	83.35	6.29 ^{b}	6.12 ^{a}	7.16 ^{b}
BA-308	30.5	4.39	30.4	83.68	7.40 ^{a}	5.60 ^{b}	7.37 ^{a}
Mean	30.7	4.49	30.6	83.52	6.85	5.86	7.27
LSD (0.05)	-	-	-	-	0.42	0.40	0.10
Storage times							
$S_1^{\#}$	31.6 ^{ab}	4.38	31.0 ^{a}	83.71	8.77 ^{a}	4.42 ^{d}	7.02 ^{c}
S_2	31.7 ^{a}	4.21	31.9 ^{a}	83.45	7.52 ^{b}	4.67 ^{cd}	7.17 ^{bc}
S_3	31.2 ^{b}	4.75	31.9 ^{a}	83.98	7.01 ^{b}	5.40 ^{b}	7.28 ^{b}
S_4	29.4 ^{c}	4.78	29.3 ^{b}	83.16	5.83 ^{c}	5.22 ^{bc}	7.50 ^{a}
S_5	29.1 ^{c}	4.32	29.0 ^{b}	83.47	5.10 ^{c}	9.60 ^{a}	7.33 ^{ab}
Mean	30.6	4.49	30.6	83.55	6.85	5.86	7.26
LSD (0.05)	0.37	-	1.50	-	0.75	0.55	0.20
C^{a}	NS^{d}	NS	NS	NS	**	*	**
S^{b}	**	NS	**	NS	**	**	**
CxS^{c}	NS	NS	*	NS	NS	NS	NS

FL: Fiber length, FF: Fiber fineness, FS: Fiber strength, FU: Fiber uniformity, FE: Fiber elongation, SFC: Short fiber content, DY: Degree of yellowness
[#]S_1: ginning without stored; S_2: ginning after 30 days stored; S_3: ginning after 60 days stored, S_4: ginning after 90 days stored; S_5: ginning after 120 days stored
[a]C, cultivars; [b]S, storage times; [c]C x S, cultivar x storage time interactions; [d]Non significant at the 0.05 probability level. *, **Significant at the 0.05 and 0.01 probability level.

parameters, although excessive fiber breakage in the gin can also reduce fiber length and strength. According to storage times (Table I), significant differences in fiber length values were found. The comparison of the fiber length values of five treatments shows that S_1 and S_2 present the higher fiber length values while S_5 presents the lower value. Cotton fiber length values of the five treatments ranged from 29.1 mm (S_5) to 31.7 mm (S_2). The observed values pointed out that ginning after 30 days stored remarkable decreased the fiber length. This conclusion is in keeping with previously reported results [13] indicating that staple length is essentially a function of seed type although (annual) climatic, atmospheric and soil conditions, ginning practices and storage can affect fiber length. Hake et al. [23] found out that a prolonged storage time and increasing storage temperature had adversely affected on the fiber quality.

Storage times had no effect upon fineness and uniformity (Table I). The values of fiber fineness and uniformity in storage periods S_1, S_2, S_3, S_4 and S_5 were 4.38, 4.21, 4.75, 4.78, 4.32 and 4.49 micronaire, and 83.71, 83.45, 83.98, 83.16, 83.47 and 83.55%, respectively. The study results showed that seed cotton can be stored for a long time (until 120 days) without negative effects on fiber uniformity and fineness. These findings are similar to those reported by [17] who detected that had not caused any change in spinning consistency index, micronaire and uniformity in sawgin bales stored in different storing type.

Significant differences were observed among the storage times for fiber strength. In the present study, fiber strength ranged from 29.0 – 31.9 g tex^{-1}. Two groups were occurred among the storage times for the fiber strength values. S_1, S_2 and S_3 times were in the same group and there were no differences among these three storage times. Seed cotton stored more than 60 days had a lower 1.9 g tex^{-1} of strength than cotton stored less than 60 days. The interaction between cultivar and storage time was significant for fiber strength (Figure 1). Response of cultivars to storage times was different. Both cultivars were also negatively affected by the prolonged of storage time. This negative effect was observed after 60 days (S_3) for Maras-92, while it was observed after 30 days (S2) for BA-208. These results are in agreement with the results reported by [4-7-13-17], they reported that storage time was negatively effect on fiber quality.



	S1	S2	S3	S4	S5
Maras-92	31.8	32	32	29.4	28.6
BA-308	31.4	31.5	30.5	29.4	29.5

Figure 1: Cultivar x storage time interaction for fiber strength.

Storage time effect on fiber elongation was significant. The values of fiber elongation among the five storage times ranged from 5.10% (S_5) to 8.77% (S_1). The S_1 had the highest fiber elongation while the two storage times (S_4 and S_5) had similar and the lowest. There was a trend toward reduced fiber strength with prolonged storage times, thus lowering fiber elongation. Fiber elongation at break or the breaking elongation is an important cotton fiber property that directly affects yarn elongation and work-to-break values. A study has shown the importance of fiber elongation and its contribution to yarn quality and specifically to yarn toughness or work-to-break values [20]. Ureyen and Kadıoglu [18] reported that positive correlation between yarn elongation and fiber strength, elongation, length, uniformity and reflectance. Zulkadir and Bolek [22] reported that there was a positive and highly significant relationship (r = 0,820) between fiber strength and elongation. Reduction of fiber strength and elongation has caused the increase of the short fiber content. The highest short fiber content (9.60%) was obtained from the S_5 treatment (120 days stored) while the S_1 treatment (without stored) gave the lowest (4.42%). When storage time was delayed from S_1 to S_2, the short fiber content was dramatically doubled. The higher short fiber content with prolonged storage time can probably be explained by the fact that the cotton kept in storage for a long time was able to exposed different moisture and temperature during the storage times, allowing low strength and elongation. Fiber moisture is important in all aspects of cotton production, from moisture content of the seed cotton during harvesting, storage and ginning through warehousing, shipping and textile processing. Excessively high moisture content can lead to deterioration of seed cotton quality and cause discolored lint and spoiled seed. However, low moisture content of seed cotton can lead to fiber breakage and an overall reduction in fiber quality during harvesting and ginning [2].

The effect of storage times on degree of yellowness (+b) was significant. The highest +b value (7.50) was obtained from the S_4 treatment (90 days stored) and it was followed by S_5 treatment (120 days stored) while the S_1 treatment (without stored) gave the lowest (7.02). When storage time was delayed from S_1 to S_4, the +b value was increased. Fiber color is one of the most important properties of cotton. It can be affected by many factors connected with cotton cultivation: rainfall, freezes, insects, fungi, staining through contact with soil, grass, etc., as well as by the condition of cotton storage: moisture and temperature [3-21]. Our results suggest that under the conditions of this study, the change in +b value may be due to increasing the moisture content and storage temperature. These results are in agreement with the results reported by [4-5-6-7] indicating that HVI +b values of baled Upland cotton increase due to prolonged storage with uncontrolled temperature conditions.

Conclusions

This study has been carried out in order to find out the impact on fiber quality of different storage times (S_1: Ginning without storage, S_2: Ginning after 30 days stored, S_3: Ginning after 60 days stored, S_4: Ginning after 90 days stored and S_5: Ginning after 120 days stored) in mechanically harvested seed cotton of two cotton (Maras-92 and BA-308) cultivars (*G. hirsutum* L.). In the study, it has been detected that fiber elongation, short fiber content and degree of yellowness showed significant differences between the cultivars, and all characteristics except fiber fineness and fiber uniformity showed significant differences among the storage times. Cultivar-storage time interactions were not significant for all characteristics except fiber strength. The results of this research indicate that to avoid adversely affected the cotton fiber quality, seed cotton should be ginned without delay after machine harvest, and not possible it should not be kept for more than 30 days in the storage. When storage times were delayed from S_1 to S_5 treatment, fiber length, strength, elongation, short fiber content and degree of yellowness were negatively changed.

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