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TESTERELİ ÇIRÇIRLAMANIN (SAWGIN) Bt VE Bt OLMAYAN PAMUKLARIN LİF KALİTESİ ÜZERİNDEKİ ETKİSİ

EFFECT OF SAW GINNING ON THE FIBRE QUALITY OF Bt AND NON-Bt COTTON

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EFFECT OF SAW GINNING ON THE FIBRE QUALITY OF *Bt* AND NON-*Bt* COTTON

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ABSTRACT: Bt cotton refers to a plant which has Bacillus thuringiensis (Bt) toxins in many of its cells. This naturally occurring soil bacterium will be used to reduce insect damage from bollworm, pink bollworm, and budworm. Therefore, farmers who are cultivating the Bt cotton variety will not be subjected to spray pesticides to control these worms. Whereas in this study, the non-Bt cotton (DP-90) refers to the commercially known variety which have no Bacillus thuringiensis (Bt) toxins in its cells. During the cultivation of non-Bt cotton varieties, the control of bollworms is done through the application of pesticides, which is a costly exercise in terms of cost of pesticides, spray equipment and labour. Along with the cost of cultivation, the best index to cotton quality is the performance of the fibres during spinning at the textile mill. In the present study the effect of saw ginning to the quality of both varieties was studied. The result could help the spinners to predict the preperformance of both varieties when subjected to the mechanical action of modern high rotating spinning machines parts. Ginning results a significant effect (at 0.05 level of significance) in all other measured fibre quality properties (upper half mean length, length uniformity index, short fibre content by number and by weight, level of neps, single fibre tenacity and elongation) of both Bt and non-Bt (DP-90) cotton varieties. The impact of ginning on the studied fibre quality properties was relatively severer on Bt cotton varieties than non-Bt (DP-90) varieties.

Keywords: Saw Ginning, Bt-cotton, non-Bt cotton, Single fibre, Bundle fibre

TESTERELİ ÇIRÇIRLAMANIN (SAWGIN) *Bt* VE *Bt* OLMAYAN PAMUKLARIN LİF KALİTESİ ÜZERİNDEKİ ETKİSİ

ÖZ: Bt pamuk, hücrelerinin çoğunda *Bacillus thuringiensis (Bt)* toksinleri bulunan bir bitkiyi ifade eder. Bu doğal olarak oluşan toprak bakterisi, yeşil kurt, pembe kurt ve tomurcuk kurdundan kaynaklanan böcek hasarını azaltmak için kullanılır. Bu nedenle, Bt pamuk çeşidini yetiştiren çiftçiler, bu kurtları kontrol etmek için püskürtme ilaç (pestisit) kullanmaya ihtiyaç duymayacaklardır. Bu çalışmada kullanılan Bt olmayan pamuk (DP-90) ise hücrelerinde *Bacillus thuringiensis (Bt)* toksini içermeyen, ticari olarak bilinen çeşidi ifade etmektedir. Bt olmayan pamuk çeşitlerinin yetiştirilmesi sırasında, böcek ilacı, ilaçlama ekipmanı ve işçilik maliyeti açısından maliyetli bir uygulama yoluyla yeşil kurt kontrolü yapılır. Yetiştirme maliyetinin yanı sıra, pamuğun kalitesinin en iyi göstergesi, tekstil fabrikasında iplik eğirme sırasında liflerin gösterdiği performansıdır. Bu çalışmada sawgin ile çırçırlamanın her iki çeşidin kalitesine etkisi incelenmiştir. Sonuçlar, iplikçilerin, modern yüksek devirli iplik makina parçalarının mekanik etkisine maruz kaldıklarında her iki çeşidin ön performansını tahmin etmelerine yardımcı olabilir. Çırçırlama, her iki örneğinde (Bt ve Bt olamayan pamuk) ölçülen tüm lif kalite özellikleri (ortalama üst yarı uzunluk, uzunluk homojenlik indeksi, sayıya ve ağırlığa göre kısa lif içeriği, neps seviyesi, tek lif mukavemeti ve uzaması) açısından anlamlı etkiye (0, 05 anlamlılık düzeyinde) sahip olduğunu göstermiştir. Çırçırlamanın incelenen lif kalitesi özellikleri üzerindeki etkisi, Bt olmayan (DP-90) çeşitlere göre Bt pamuk çeşitlerinde nispeten daha belirgindir.

Anahtar Kelimeler: Testereli Çırçırlama (sawgin), Bt pamuk, Bt olmayan pamuk, tek lif, demet halinde lif

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1. INTRODUCTION

Fibre quality can be attributed by set of measurable properties that affect the spinning performance of a given cotton variety. Palve [1] stated that fibre strength, fibre length and fibre fineness are the primary quality parameters that influence the textile processing.

Since ginning is the first process after the harvesting of genotypes, it can be used as a means for evaluating the performance of new gens against the mechanical action of modern rapidly rotating machine parts. Controlling the quality of raw cotton (for example percentage of short fibres and level of neps) at the starting point can have tremendous benefit for all parties in the cotton value chain.

The purpose of ginning is to convert seed cotton into lint cotton fibre, which is a saleable and processable commodity. The process of ginning involves separating the fibre from the seed, which was historically done by hand. As this was laborious and slow the process has been replaced by machines, with the modern ginning process a combination of thermal, pneumatic and mechanical processes Anthony and Bragg [2]. The layout, size, type and technology of the gin may take on a number of forms, which depends mainly on the type of cotton grown, the production and harvesting conditions and the economic factors, as well as consumer requirements [3]. There are essentially two ginning methods, namely saw and roller. Saw gins are generally used to process Upland cotton (*Gossypium hirsutum L.*) with short to medium staple length (25.4 mm to 29.5 mm), whereas roller gins are used to process Extra Long Staple (ELS) cottons (*Gossypium barbadence L.*) with longer staple length (≥ 35.6 mm), [3], [4]. The production of ELS cottons as compared to Upland cotton is relatively small, making up just 3% of the world supply [5], [6] and, consequently, saw ginning is the most prevalent gin technology in the world. Among the major cotton producing countries of the world, both saw and roller ginning are popular in Turkey and India. Turkey uses 25-30% saw ginning and 70-75% roller ginning [7].

1.1. Mechanism of saw ginning

Saw-type lint cleaners are used in saw-type cotton gins to remove leaf particles, bract, seed-coat fragments, motes grass and bark; comb the fibres to produce a “smooth” appearance; and to blend colour spots. Most gins in the world have lint-cleaning facilities, and most saw-type gins have two or more stages of lint cleaning. The number of stages of saw cleaning refers to the number of saws over which the fibres pass.

Lint cleaning generally improves the colour and leaf grade classifications of the lint. As the number of lint cleaners increases, classer grade tends to improve. However, as grades improve, bale weights are reduced and staple length may decrease. These opposing factors affect bale value. Occasionally, such offsetting losses may cause the bale value to be reduced by lint cleaning. When price spreads between grades are small, the grower can obtain maximum bale value most often on upland variety cottons by using one saw lint cleaner on early-season clean cottons and two stages of saw lint cleaning on late-season, trashier, or light spotted cottons [8], [9].

Saw-type lint cleaners could blend light spotted with non-light spotted cottons and upgrade the bales into white grades. The lint cleaners also appear to improve the colour factor by removing background trashes.

The use of two stages saw cylinder lint cleaners also facilities the removal of some amount of stickiness present in the cotton. This is because of the ejection of sticky cotton through the grid bars into the waste box of saw type lint cleaners [10].

The ginning process scatters the honeydew, making it more difficult to be detected by visual inspection [11].

Perhaps the best index to cotton quality is the performance of the fibres during spinning at the textile mill. Increasing the number of saw lint cleaners at the gin decreases the manufacturing waste during spinning, but often has the adverse effects of increasing neps in the card web and lowering yarn strength, appearance, and processing efficiency. A decline in appearance is greater for the finer count carded yarns. From a spinning standpoint, the use of more than two saw lint cleaners in series has been strongly discouraged [12], [13].

In the present study since, both Bt and non-Bt (DP-90) varieties are Upland type cottons (*Gossypium hirsutum L.*), saw type of ginning is preferred to evaluate their performance to the mechanical action of ginning machine parts.

1.2 Bt and non-Bt cotton varieties

Bt cotton is a plant which has Bacillus thuringiensis (Bt) toxins in many of its cells. This naturally occurring soil bacterium will be used to reduce insect damage from bollworm, pink bollworm, and budworm (Figure 1). This technology may sharply reduce conventional insecticide use. However, because the Bt toxin is highly effective, insect resistance may develop in a short period, rendering Bt less useful for some insect species of cotton [14].

Transgenic crop technology promises to revolutionize crop production. Cotton with the Bt (Bacillus thuringiensis) gene expressed in it was marketed commercially for the first time in 1996.

Figure 1 Source: USDA Agricultural Research service (ARS – 154), 2001 (Mature cotton boll at left was protected by a gene for Bt; Other bolls show damage from cotton pests).

Although Bt cotton has proven effective as a means of controlling tobacco budworm and bollworm, producers are concerned about the costs and returns of Bt in relation to non-Bt varieties. Many estimates have been made as to how much Bt cotton will save producers in insecticide costs by controlling budworm and bollworm. One Bt cotton field trial in Tallahatchie and Washington counties in Mississippi found savings in insecticide costs to be $82.25 per 4,047 m^2 in Washington county and $73.63 per 4,047m^2 in Tallahatchie county [15]. Another study concluded Bt cotton could increase profits by $12.53, $41.01, or $79.12 per 4,047 m^2 given low, normal, or high budworm/bollworm infestation levels [16].

However, spraying for late season pests such as budworm and bollworm also inadvertently controls other pests such as boll weevil and plant bugs [17]. Therefore, complete economic analysis of Bt cotton is necessary to determine the true economic benefit, if any, to producers.

In the Mississippi of USA researches was conducted in the years 1995 and 1996 to encompass all practices involved in producing cotton including tillage, insecticide and herbicide applications, harvest cost, and labour costs as well as any yield advantages Bt cotton may offer [18]. The results of those researches showed that in the year 1995 a saving in the cost of insecticide applications including the $32 charges for Bt technology. Plus, the added benefit of increased yields was observed. Total insect control costs for Bt cotton averaged $32.58 per 4,047 m^2. non-Bt plots averaged $91.13 per 4,047 m^2 for total insect control costs, a difference of $58.55 per 4,047 m^2 in favour of Bt cotton. Since Bt technology is an insect control measure and $32 is charged to producers specifically for Bt technology, it is necessary to include the technology charge in analysis of insect control cost. The true savings in insect control cost was $26.55 per 4,047 m^2 in 1995 test plots where the technology charge is included. The results of the 1996 survey also showed Bt cotton to hold an economic advantage over the non-Bt varieties. However, some of the savings in insecticide costs observed in the 1995 field test plots were not observed from the 1996 survey. Per 4,047 m^2 net returns from surveyed 1996 Bt fields ranged from $7.81 to $561.83 per 4,047 m^2. The average net return for surveyed Bt fields was $246.30 per 4,047 m^2 in 1996. Per 4,047 m^2 net returns for surveyed non-Bt fields ranged from a loss of $53.38 to a positive return of $628.87 in 1996. The average net return per 4,047 m^2 of surveyed non-Bt fields was $230.08 for 1996. In 1996, average net returns for Bt cotton were $16.23 per 4,047 m^2 higher than non-Bt fields. The 1996 survey average total income per 4,047 m^2 for Bt cotton was $686.95 and $653.65 per 4,047 m^2 for non-Bt cotton varieties, $33.30 per 4,047 m^2 less than Bt cotton varieties. When the charge for technology is added to the average insect control cost for Bt cotton in 1996, the total cost for insect control is $63.13 per 4,047 m^2, which is $13.84 per 4,047 m^2 more than insect control costs for non-Bt cotton varieties. However, this increased cost is compensated for by increased yields in Bt cotton. Surveyed non-Bt fields has an average yield of 430,006 kg. of lint per 4,047 m^2. Surveyed 1996 Bt fields had an average yield of 451,324 kg on lint per 4,047 m^2, 21,318 kg of lint more than non-Bt fields. On average, higher yields from Bt cotton in the 1996 survey increased per 4,047 m^2 revenue of Bt cotton by $28.20.

As a conclusion the Mississippi Economic analysis of complete enterprise budgets for Bt cotton and non-Bt cotton indicate, for crop years 1995 and 1996, Bt cotton had higher returns per 4,047 m^2 than non-Bt cotton. The actual savings for Bt cotton will vary from year to year depending on the level of insect infestation and the number of sprays required in a given year.

A recent research work on variation in plant injury and yield by Lepidopterous pests in selected cultivars of Bt cotton in New Mexico showed that the non-Bt cotton had 36-40% boll damage and the yield of the non-Bt cotton was 10-34% less that the Bt cotton varieties [19].

The new Bt-cotton variety is introduced in Ethiopia and Common Market for Eastern and Southern Africa (COMESA) region which necessitates a need to continuously evaluate their cost-effectiveness, fibre quality performance and develop efficient plans for their deployment.

Cotton production in the COMESA region is dominated by smallholder farmers (Table 1). For instance, the cotton sector in Ethiopia comprises about 53,000 smallholder cotton farmers with areas ranging from 0.25 to 0.75 ha [20], while in Tanzania there are about 350,000-500,000 smallholder producers. A substantial 70-80% of all cotton production in the country takes place on small farms averaging only 0.4-0.8 ha. Medium farms up to 20 ha make up the remaining 20-30% of production [21]. Gordon and Goodland [22] and Baffes [23] reported that there are approximately 250,000 to 400,000 low-income cotton households in Uganda. In Zambia, it is `estimated that more than 200,000 farmers grow cotton, with about 90% of these farmers growing cotton on areas ranging between 0.5-2.5 ha [21].

Table 1. Production, yields, area and number of cotton farmers in COMESA countries [24].

Country	Ethiopia	Kenya	Tanzania	Uganda	Zambia	Egypt
Production (MT)	82,500	30,000	337,500	78,000	180,000	325,000
Seed cotton yield (MT/ha)	0.75	0.65	0.75	0.75	0.8	2.5
Area under cotton (ha)	110,000	46,000	450,000	105,000	225,000	130,000
Number of farmers	53,000	200,000	350,000-500,000	250,000	200,000	750,000

Source: FAOSTAT [25]; Mekuria [20]; International Trade Centre [26]; TCB [27]; Gitonga et al. [28]; Abdel-Selam and El-Sayed [29]; Chitah [30].

These smallholder farmers as well as mechanized farms in Ethiopia and other COMESA countries face several challenges including the high cost of labor; minimal use of necessary inputs for intensification (e.g., fertilizer, herbicides, etc.); inadequate availability of quality seed; and unstable and low seed cotton prices paid to farmers [30], [28]. In addition, the farmers face pest challenges, with the most destructive being the cotton bollworm (Helicoverpa armigera). Currently, the control of these bollworms is done through application pesticides, which is a costly exercise in terms of cost of pesticides, spray equipment, and labor [31].

Table 2 presents production costs in five COMESA region countries [24]. From this table, the cost of pesticides and pesticide application labor ranges from 10.5% in Kenya to 50% in Zambia. In Ethiopia, where pesticide and pesticide application costs are about 22.6% and most farmers in Ethiopia do not spray enough to control bollworms. This situation leads to a dilemma where, to improve on cotton yields, small house hold farmers with limited incomes are required to use a lot of resources to control bollworms. Alternatively, they could maintain the status quo where little or no pesticides are applied in some farms and get little or no yields. Whereas, reduction in these pest infestations can lead to an increase in yields that can provide several benefits, including welfare gains to cotton producers and consumers in COMESA region.

Research studies are conducted to find a solution to overcome the COMESA countries pest infestations so that to improve the quality and productivity of cottons produced in these regions.

Some of these research studies recommended that a more effective and less costly way to control damage from bollworms and other insects that frequently damage cotton in Africa is by adopting Bt cotton. They claimed that, this is because it has benefits to both producers and spinners. For producers, Bt cotton provides improved control of insects and weeds, reduced input costs such as labor and chemical application costs, increased yields, reduced exposure to chemical, and increased incomes [24]. For the spinners the increased production (yields per hectare) of Bt cotton can ensure continuity of supply in sufficient quantity of the same type of cotton over a period. This will minimize possible change of variety in a given mix which will benefit not to have appreciable change in yarn character.

Other research studies states that although the use of genetically modified cotton, the so called Bt-cotton, which is a gene of the bacterium Bacillus thuringiensis, supposed to become resistant to the cotton boll worm and one of the most relevant pests for cotton [32], but it can only be used for a short-term reduction in pesticide. Because, they stated that after sometime there will be a renewed increase, problems with secondary pests occur and the cotton bollworm develops resistance over time [33]. Furthermore, they found that genetically modified cotton consumes at least three times more water than conventional cotton [34]. At the same time, the use of genetically modified species always carries the risk of invasive species formation [32].

So far, genetically modified cotton is not commercially used in Ethiopia, but its introduction is discussed controversially on a national level. An increased competitiveness on the world market share is named as main argument in favour of Bt-cotton, while the high costs for corresponding cotton seeds are also seen as a major obstacle. Furthermore, the necessity to buy new genetically modified seeds every year and the resulting dependency are evaluated negatively [35].

Therefore, farmers are subjected to select which one is preferable between spraying pesticide (which is 22.6 % of the total cost) and cultivation of Bt-cotton (which the cost of seeds is 25-30% of the production cost).

Table 2. Cost of production (USD per hectare) in studied COMESA countries [24].

Country	Ethiopia	Kenya	Tanzania		Uganda		Zambia
Activities/Inputs			Eastern cotton growing areas	Western cotton growing areas[1]	Low input	High input[2]	
Chemical fertilizer	-	3.8	-	7.6	-	24.9	-
Labor for other activities	146.7	75.0	76.8	52.0	122.2	176.8	71.6
Land preparation	230.1	58.5	40.0	12.0	-	-	33.3
Land rent	-	-	30.0	30.0	76.7	70.9	-
Organic fertilizer	-	-	-	-	-	21.4	-
Other costs, e.g., bags, transport	-	22.4	20.0	12.0	-	-	-
Pesticides	93.3	16.7	24.0	16.2	25.3	39.3	83.4
Pesticides spraying labor	53.8	13.5	8.0	6.0	5.9	14.1	55.0
Seed/sowing	55.6	4.0	2.4	2.4	2.5	3.0	8.3
Weeding labor	71.1	94.7	60.0	36.0	61.6	97.0	24.8
Total Cost	**650.6**	**288.6**	**261.2**	**174.2**	**294.2**	**447.4**	**276.4**

TCB [27] estimates that 99% of total cotton produced in Tanzania comes from the western cotton growing area (WCGA). [2]The high input system represents farmers who use fertilizer and more than average amount of pesticide, and they comprise about 18% of all farmers in Uganda.

For example, cotton is an important crop for Turkey the country which ranks eight in the world in terms of cotton production [36]. In Western Turkey, where pest problems are more serious, pesticide applications of up to ten times and in Çukurova, where the pest invasion is most acute, 15 applications per season can be observed [37]. One of the major insects in Çukurova region threatening cotton farming is reported to be the cotton bollworm (Helicoverpa armigera) which is the bollworm threatening COMESA cotton farm regions. Researchers recommend Bt cotton would be beneficial to pest infested Çukurova, Ege and GAP regions in Turkey [38]. But, the government of Turkey didn’t officially accept the use of genetically modified seeds. One of the possible reasons explained by the authors is that Turkey is successful in the cultivation of organic cotton which resulted in having trust in consumer organisations in Europa and all over the world.

The cotton cultivators in Ethiopia are also advised to analyse all the other possible positive and/or negative outcomes before they are directly accepting the Bt cotton seed as a solution to pest infested cotton cultivating regions.

Besides, with fibre quality parameters gaining greater prominence especially the fibre fineness and maturity, fibre length and length uniformity, short fibre content and level of neps, fibre tenacity/strength and elongation, there is a need to identify Bt hybrids which are stable with respect to not only seed cotton yield, but also acceptable fibre quality properties.

The aim of the present study is to evaluate the performance of the Bt-cotton when subjected to the saw ginning process. The performance, to the saw ginning process, of the known commercial non-Bt cotton type, Deltapine 90 (DP-90), [39], was used as a control.

2. MATERIALS and METHODS

We selected the two varieties of cotton because we want to comparatively study the performance of the newly released JKCH1947 Bt-cotton which is under breeding in Gambela region with that of the well-known commercial non-Bt variety Deltapine 90 (DP-90). Both varieties used in the study were Upland varieties of type (*Gossypium hirsutum L.*) grown in the Gambela region under similar environmental condition and cultural practices (Table 3).

Table 3. Materials used in the study

Variety	Harvesting Type	Type of cultivation	Region of Cultivation
JKCH1947 Bt-cotton	Hand	Irrigation	Gambela
DP-90 non-Bt cotton	Hand	Irrigation	Gambela

In the study, the first experiment was done for evaluating the fibre properties of both Bt and non-Bt seed cotton (Before ginning) and the second experiment of the study was done to assess the impact of ginning on cotton fibre properties both Bt and non-Bt genotypes by evaluating the fibre properties of lint cotton (after ginning) and comparing with the values found prior to ginning. For all the experiments samples were tested by single fibre testing instruments (FAVIMAT+, AFIS) and HVI bundle fibres testing instrument.

Experiment 1: For evaluating the fibre properties of seed cotton (before ginning), among twelve different Ethiopian cotton varieties [40], samples representing the Deltapine 90 (DP-90) commercial variety which represents the non-Bt genotypes and samples representing the new genetically modified cotton variety JKCH1947 Bt-cotton which is under breeding in Gambela region was selected.

These two cotton varieties with three hundred replications for 5 lint cotton samples randomly collected from each variety were used for the FAVIMAT+ single fibre testing (2 varieties × 1 zone × 5 samples × 300 tests replications). The same subset of samples was used to investigate the HVI and AFIS, fibre properties. The HVI fibre properties was tested with (2 varieties × 1 zone × 5 samples × 100 tests replications). The AFIS fibre properties was tested with 30 replications of 3,000 fibres (i.e., 2 varieties × 1 zone × 5 samples × 30 tests of 3000 fibres replications). One technician per every instrument was used throughout the testing days.

Seed cotton samples were directly collected from the harvested modules in the field and/or warehouses before ginning to avoid any mixing between the varieties.

Samples were also collected from the same harvesting field in Gambela so that to control the climatic effect on the fibre quality. Thus, difference between the varieties considered as the effect of genotype.

Fibres from the seed cotton were later removed by careful hand ginning for conducting the experiments.

Experiment 2: It is done to assess effect of ginning on the cotton fibre properties. From the same varieties used to evaluate seed cotton properties, the amount required for ginning was transported using module trucks to the ginnery found in Addis Ababa. Samples were ginned under standard commercial conditions at the full-scale gin (7 bales/h) of 217 kg bale. The ginning machinery sequence consisted of a master feed controller, tower drier with ambient air, 6-cylinder cleaner, stick and leaf remover, tower drier, 6-cylinder cleaner, extractor feeder, gin stand and two stages of saw cylinder lint cleaning. The same ginning rate of 7 bales per hour were used throughout the experiment. Moisture content, room temperature and relative humidity were not different between varieties and averaged 6.4%, 26°C, and 55%, respectively. To maintain confidentiality for the gin participating in this study, the local name of the ginnery is not mentioned. The studied varieties were Deltapine 90 (DP-90) and the new genetically modified cotton genotype JKCH1947 Bt-cotton harvested in Gambela plantation zone, in 2017.

The procedure of testing is similar to the previous, which was for the FAVIMAT+ single fibre testing (2 varieties × 1 zone × 1 ginnery × 5 samples × 300 tests replications). The AFIS fibre properties was tested with 30 replications of 3,000 fibres (2 varieties × 1 zone × 1 ginnery × 5 samples × 30 tests of each 3000 fibres replications), the HVI fibre properties was tested with (2 varieties × 1 zone × 1 ginnery × 5 samples × 100 tests replications).

The AFIS mean maturity ratio for the studied varieties were: JKCH1947 Bt-cotton = 0.88 and non-Bt (DP-90) = 0.87.

The samples collected before and after ginning were tested with:

(1) FAVIMAT+ single fibre testing instrument using the following testing parameters: gauge length = 3.0 mm, pre-tension = 1 cN/tex, and testing speed = 100 mm/min.

(2) Advanced Fibre Information System (USTER AFIS PRO 2), with 30 replications of 3,000 fibres.

(3) High Volume Instrument (USTER HVI 1000). With the following testing parameters: gauge length 3.175 mm, unknown pretension. The HVI testing speed, from literatures is 100 - 140 mm/min.

As it was mentioned in experiments 1 and 2, fibre properties of the representative samples from seed cotton (before the ginning treatment) and lint cotton (after the ginning treatment) were evaluated using two single fibre (FAVIMAT+, AFIS) and one HVI bundle fibres testing instrument.

Correlation was demonstrated to study the relations between FAVIMAT+ Single fibre and HVI bundle tenacity (Figure 2)

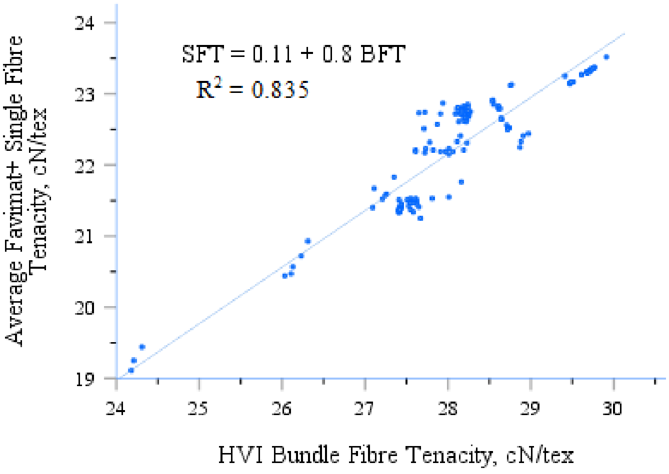

Figure 2. HVI bundle tenacity Vs. average FAVIMAT+ single fibre tenacity

3. RESULTS and DISCUSSION

3.1 Micronaire and maturity

Usually, fibre fineness is reported by micronaire value. However, variation in micronaire value for any one variety typically indicates change in maturity rather than change in fineness because, micronaire value calculated by normal airflow instruments is influenced by fibre maturity.

Both higher maturity and coarser fibres can give a high Micronaire reading and conversely both fine fibres and immature fibres can give a low Micronaire reading. Therefore, a particular reading could arise from a variable combination of the two factors. In practice the maturity of the cotton has a greater effect on its Micronaire value than its fineness.

In view of the above interdependence between the fibre fineness and maturity, in this study, the Advanced Fibre Information System (USTER AFIS PRO 2) was also used to measure fineness and maturity ratio in addition to HVI micronaire.

ANOVA analysis (table 5) demonstrates that micronaire was unaffected (at 0.05 level of significance) by gin treatments on both varieties: average before ginning micronaire values: Bt cotton variety (4.48), non-Bt (DP-90) cotton variety (4.29) and average after ginning micronaire values: Bt cotton variety (4.40), non-Bt (DP-90) cotton variety (4.22). The decrease in after ginning micronaire value of both varieties could be explained by the fact that the trash in the seed cotton (before ginning) can allow air to pass through the plug easily and high micronaire reading is indicated. While, the ginning removed the trash particles and this results in relatively low micronaire reading in the lint cotton (after ginning).

These ranges of micronaire values, for both varieties, are considered good for spinning. Analysis of variance (ANOVA) conducted on IBM SPSS Statistics 25 also shows that there was insignificant effect on micronaire values (at 0.05 level of significance): Bt cotton variety (p value = .179) and non-Bt (DP-90) cotton variety (p value = .261), i.e., p value > 0.05 for both varieties (table 4). Differences in AFIS fineness between the two varieties: Bt cotton variety (163 mtex), non-Bt (DP-90) (161 mtex) is also very small (result not show in this report).

High volume instrument (HVI) measurements were also showed that the saw ginning process together with saw type lint cleaners improved the colour grade (Table 4). The percentage light reflectance (Rd) values increased, the yellowness (+b values) decreased and there was some improvement in the colour grade index for both Bt and non-Bt cotton varieties.

Table 4. Bundle and single fibre properties and their statistical parameters

Cotton Varieties	Fibre properties	Statistical Parameters					
		Before Ginning			After Ginning		
		N	Mean	S. D	N	Mean	S. D
BT_Cotton	Micronaire, MIC	100^{H}	4.48	0.42	100	4.40	0.42
	Upper half mean length, mm	100^{H}	27.71	0.96	100	27.4	0.81
	Uniformity index, %	100^{H}	83.74	1.37	100	83.2	1.28
	Short fibre content, n	30^{A}	27.71	2.78	30^{A}	30.93	0.98
	Short fibre content, w	30^{A}	11.89	1.32	30^{A}	15.34	1.21
	NEPS, count/g	30^{A}	222	25.04	30^{A}	248	26.54
	Single fibre tenacity, cN/tex	300^{F+}	25.15	1.45	300	24.88	1.49
	Single fibre elongation, %	300^{F+}	6.81	1.11	300	6.63	1.05
	Colour grade, Index	100^{H}	12-1			11-3	
	Colour reading:						
	% Reflectance, Rd	100^{H}	80.6			82.9	
	Yellowness, +b values	100^{H}	12.1			10.6	
Non-Bt (DP-90)	Micronaire, MIC	100^{H}	4.29	0.44	100	4.22	0.44
	Upper half mean length, mm	100^{H}	28.2	0.56	100	27.96	0.88
	Uniformity index, %	100^{H}	84.08	1.28	100	83.47	1.93
	Short fibre content, n	30^{A}	26.5	2.17	30^{A}	28.5	0.85
	Short fibre content, w	30^{A}	8.57	1.05	30^{A}	10.66	0.99
	NEPS, count/g	30^{A}	168	26.54	30^{A}	184	29.28
	Single fibre tenacity, cN/tex	300^{F+}	27.07	1.9	300	26.73	1.92
	Colour grade, Index	100^{H}	11-3			11-1	
	Colour reading						
	% Reflectance, Rd	100^{H}	83.7			85.9	
	Yellowness, +b values	100^{H}	10.0			9.4	

A (AFIS), F+ (FAVIMAT +), H (HVI), N (Number of tests), S.D (Standard Deviation)

Table 5. ANOVA analysis for effecting of ginning on fibre quality properties of Bt cotton.

Variety		Sum of Squares	df	Mean Square	F	Sig.	Fibre properties
Bt cotton	Between Groups	.320	1	.320	1.818	.179	MIC
	Within Groups	34.856	198	.176			
	Total	35.176	199				
	Between Groups	4.845	1	4.845	6.157	.014	UHML
	Within Groups	155.809	198	0.787			
	Total	160.655	199				
	Between Groups	14.634	1	14.634	8.328	.004	UI
	Within Groups	347.918	198	1.757			
	Total	362.552	199				
	Between Groups	156.171	1	156.171	35.801	.000	SFC_n
	Within Groups	253.005	58	4.362			
	Total	409.176	59				
	Between Groups	178.883	1	178.883	111.729	.000	SFC_w
	Within Groups	92.861	58	1.601			
	Total	271.743	59				
	Between Groups	10480.817	1	10480.817	15.742	.000	NEPS
	Within Groups	38616.433	58	665.801			
	Total	49097.250	59				
	Between Groups	10.857	1	10.857	5.019	.025	SFT
	Within Groups	1293.558	598	2.163			
	Total	1304.415	599				
	Between Groups	4.894	1	4.894	4.223	.040	SFE
	Within Groups	693.025	598	1.159			
	Total	697.919	599				

3.2. Length and length uniformity

The HVI length measurements are based on the formation of a beard of aligned fibres with fibres forming the base of the beard gripped at random positions along their length (Figure 3). A non-destructive optical technique interrogates the thickness of the beard as a function of position along the beard to generate the 'Fibrogram'. Fibre length characteristics are estimated from the Fibrogram.

Figure 3. Bundle of fibres extended from HVI clamp.

Fibrogram corresponds to the arrangement of fibres at the nip line of drafting rollers of spinning machines. It gives a good representation of the drafting operation and of the arrangements of the fibres in the yarn.

The length parameters commonly used by the cotton industry are the upper half mean length (UHML, the average of the longest 50% of fibres by weight), the mean length and the uniformity index (the ratio of the mean length to the UHML).

HVI test results on fibre length and length uniformity are presented on table 4 for the Bt and non-Bt (DP-90) varieties used in the study. From ANOVA tables 5 and 6 we can observe that ginning results a significant difference (at 0.05 level of significance) in fibre upper half mean length and length uniformity index of both Bt and non-Bt (DP-90) cotton varieties. The average before and after ginning UHML and UI values were: for Bt cotton variety (before ginning UHML= 27.71, after ginning UHML = 27.40; before ginning UI = 83.74, after ginning UI = 83.20), for Non Bt (DP-90) cotton variety (before ginning UHML = 28.20, after ginning UHML = 27.96; before ginning UI = 84.08, after ginning UI = 83.47).

Analysis of variance (ANOVA) also shows that there was significant ginning effect on both UHML and UI (which is an indication of the relative uniformity of fibre length in a sample) at 0.05 level of significance. UHML and UI values: Bt cotton variety (UHML, p value = .014; UI p value = .004) and non-Bt (DP-90) cotton variety (UHML p value = .021; UI p value = .009), i.e., p value < 0.05 for both varieties (table 4 and 5).

Short fibre content and level of neps

Literatures shows that while HVI measurements are adequate for predicting yarn tensile properties, they are inadequate for predicting yarn evenness related parameters. The AFIS measurement of short fibre content are quite good in predicting yarn evenness (though large sample size is required for having improved results). High quality yarns should also have a low number of imperfections such as thin places, thick places, and neps.

Table 6. ANOVA analysis for effecting of ginning on fibre quality properties of non-Bt (DP-90) cotton.

Variety		Sum of Squares	Df	Mean Square	F	Sig.	Fibre properties
Non-Bt (DP-90)	Between Groups	.245	1	.245	1.273	.261	MIC
	Within Groups	38.104	198	0.192			
	Total	38.349	199				
	Between Groups	2.933	1	2.933	5.434	.021	UHML
	Within Groups	106.881	198	0.540			
	Total	109.814	199				
	Between Groups	18.973	1	18.973	7.055	.009	UI
	Within Groups	532.502	198	2.689			
	Total	551.475	199				
	Between Groups	64.067	1	64.067	23.540	.000	SFC_n
	Within Groups	157.853	58	2.722			
	Total	221.919	59				
	Between Groups	65.731	1	65.731	63.162	.000	SFC_w
	Within Groups	60.359	58	1.041			
	Total	126.089	59				
	Between Groups	4067.267	1	4067.267	5.210	.026	NEPS
	Within Groups	45282.333	58	780.730			
	Total	49349.600	59				
	Between Groups	17.391	1	17.391	4.751	.030	SFT
	Within Groups	2189.112	598	3.661			
	Total	2206.503	599				
	Between Groups	4.408	1	4.408	3.934	.048	SFE
	Within Groups	670.069	598	1.121			
	Total	674.478	599				

Number of neps per gm of fibres and also nep size are influencing factors in quality of yarn, particularly of finer count. AFIS is considered one of the most reliable process control instruments used to measure neps at different stages in processing. The negative effect of a high percentage of short fibres is usually associated with: extreme drafting difficulties, increased yarn irregularity and ends down (Lawrence, 2003).

The before and after ginning AFIS measurements of short fibre content and neps in the studied Bt and non-Bt (DP-90) cotton varieties are provided in table 4. To report the short fibre content, we used both mean length by number and by weight. So, we have: for Bt cotton variety (SFC_n_BG = 27.7, SFC_n AG = 30.93; SFC_w BG = 11.89, SFC_w AG = 15.34), for non-Bt (DP-90) variety (SFC_n_BG = 26.5, SFC_n AG = 28.5; SFC_w BG = 8.57, SFC_w AG = 10.66). Where, BG = Before Ginning and AG = After Ginning.

To report the level of neps, we used the AFIS parameter nep count per gram, because, it is commonly used in spinning industry, in accord, we have: for Bt cotton variety (Neps_BG = 222 count/g, Neps AG = 248 count/g); for non-Bt (DP-90) cotton variety (Neps BG = 168 count/g, Neps AG = 184 count/g).

Three types of neps are usually reported in literatures: fibre entangled with seed coat fragments, fibres entangled with trash particles, and entangled fibres with no nonfibrous particles present. Eliminating them in ginned lint may require different approaches. Seed coat fragment type may be due to a genetically week seed coat as well as mechanical action at the gin. Trash type neps are a harvesting or gin cleaning problem primarily, but could also be linked to genetic characteristics of the cotton (i.e., leaf hairiness, etc.). The third type could have several causes, including fibre fineness and immaturity, both being affected by environmental as well as genetic conditions. Improper machine setting is also possible cause of nep formation. There was no significant difference in AFIS maturity ratio of the studied varieties: (AFIS mean maturity ratio for the JKCH1947 Bt-cotton = 0.88 and non-Bt (DP-90) = 0.87). This revels that the difference in the level of neps for the studied varieties is because of the seed (genotype) variation.

3.3 Fibre Tenacity and Elongation

In order to compare different cottons, their work of rupture should be evaluated sot that it is possible to take into account of the various masses of different varieties. Hence, specific work of rupture, which is the amount of energy needed to break a sample of unit mass, should be used [29]. This work considers both FAVIMAT+ single fibre tenacity and elongation which are more consistent for the comparison between the studied Bt and non-Bt (DP-90) cotton varieties.

FAVIMAT+ test results on single fibre tenacity and elongation for the studied Bt and non-Bt (DP-90) varieties used in the study is presented on table 4. The average before and after ginning single fibre tenacity and elongation values were: for Bt cotton variety (before ginning SFT = 23.15, after ginning SFT = 22.88; before ginning SFE. = 6.81, after ginning SFE. = 6.63), for non-Bt (DP-90) variety (before ginning SFT = 27.07, after ginning SFT = 26.73; before ginning SFE. = 6.92, after ginning SFE. = 6.75). From ANOVA tables 4 and 5 we can observe that ginning results a significant effect (at 0.05 level of significance) in FAVIMAT+ single fibre tenacity and elongation of both Bt and non-Bt (DP-90) cotton varieties. Single fibre tenacity and single fibre elongation values: for Bt cotton variety (SFT, p value = .025; SFE, p value = .040) and for non-Bt (DP-90) cotton variety (SFT, p vlue = .030; SFI, p value = .048), i.e., p values < 0.05 for both varieties, which implies that the ginning significantly affect bot single fibre and tenacity and elongation of the studied varieties.

4. CONCLUSIONS

In conclusion, the result of this study revealed that introduction of the new Bt cotton varieties requires a need to continuously evaluate their cost-effectiveness as well as to evaluate their performance to the mechanical action of the modern high rotating textile machines parts and develop efficient plans for their deployment.

Ginning results a significant effect (at 0.05 level of significance) in fibre upper half mean length and length uniformity index of both Bt and non-Bt (DP-90) cotton varieties. Ginning also significantly affects the short fibre content by number and by weight as well as level of neps. Significant difference in short fibre percentage by number and by weight of machine ginned cotton over hand ginning cotton indicates rupture of fibres.

FAVIMAT+ single fibre tenacity and elongation of both Bt and non-Bt (DP-90) cotton varieties was also significantly affected by ginning.

According to USDA system of cotton classification the Bt cotton variety strength is categorized in the descriptive designation “intermediate” strength group while the non-Bt (DP-90) variety strength is categorized in the descriptive designation “average” strength group.

The finding of this research work can be used as a guide for the spinners during their preparation of a mix by using Bt and non-Bt cotton varieties. For example, to produce relatively high tenacity yarns spinners have to use less proportion by weight of Bt cotton variety and more proportion by weight of non-Bt (DP-90) cotton variety.

A comparative study on the effect of ginning on the newly released JKCH1947 Bt-cotton genotype which is under breeding in Gambela region with that of the well-known commercial non-Bt variety Deltapine 90 (DP-90) grown in the same Gambela region was conducted. Though, the effect of ginning was relatively severe on Bt-cotton genotype than the commercial non-Bt (DP-90) genotype, continuous assessment is required for recommending the desired fibre quality of the new Bt cotton variety coupled with its high yielding potential.

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