# Agronomic, Yield, and Fiber Quality Performance of Improved Cotton Varieties under Irrigated Conditions of Weyto and Sille Cotton Growing Areas of Ethiopia

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**Abstract**

A number of cotton varieties are presently available in Ethiopia, all of which differ in adaptability, yield potential, and agronomic characteristics. It is important that producers should be aware of both the superior and poor characteristics of each variety to produce the most suitable ones. The aim of this study was to evaluate the agronomic, yield, and fiber quality performances of improved cotton varieties under irrigation conditions in cotton producing farms in Weyto and Sille areas of Ethiopia. The combined analysis of variance revealed significant ($P \leq 0.01$) differences among the varieties for plant height, boll number per plant, boll weight, seed cotton yield, ginning out-turn, lint yield, micronaire, fiber length, and fiber strength. There was no significant interaction effect of variety by location (V*L) and variety by environment (V*Y*L) for economically most important traits (seed cotton yield, lint yield, fiber length, and fiber strength). The highest seed cotton yield (4.35 t ha$^{-1}$) was recorded for Deltapine-90 cotton variety. The lint yields obtained from the cotton varieties ranged between 1.02 t ha$^{-1}$ and 1.70 t ha$^{-1}$. It is concluded that Weyto is more suitable for cotton production than Sille since all varieties showed better performances for economically important traits at this location. This implies that future cotton research should focus on developing varieties having diverse genetic bases, high yielding potential and fiber quality merits to enhance cotton productivity and meet the demand of manufacturing industries in the country.

**Keywords:** Cotton variety; Deltapine-90; Fiber quality; Ionia; Seed cotton and lint yield

## 1. Introduction

Cotton (*Gossypium* spp.) is the most important of all natural fiber crops and a significant contributor of oilseed in the *Gossypium* genus. Worldwide all cultivated cotton belongs to one of the four species viz. *G. hirsutum* L., *G. barbadense* L., *G. herbaceum* L., and *G. arboretum* L. The primary product of the cotton plant is the lint (fiber), which covers the seeds within the seed pod or boll. Cotton is a source of quality fiber for the multibillion dollar textile industry around the globe. The cotton seed, the primary byproduct of lint production, is also an important source of margarine, oil for human consumption, and a high protein meal used as livestock feed. The waste after ginning can be used as fertilizer, and the cellulose from the stalk is used for products such as paper and cardboard (Freeland *et al*., 2006; Abdellatif *et al*., 2012).

Cotton is grown on every continent, except in Antarctica (Shakeel *et al*., 2011; Abdellatif *et al*., 2012). It is predominantly cultivated in warmer regions and is grown as a leading commercial crop in more than 30 countries of the world (Riaz *et al*., 2013). According to Statista (2022), China is the world's leading producer of cotton, producing an estimated 5.8 million metric tons in 2021/2022. India is second with production of 5.3 million metric tons, followed by USA with 3.8 million metric tons and Brazil producing 2.6 million metric tons. Ethiopian cotton production sector is constrained in part by lack of cotton seed supply chain, lack of integration among actors in the sub-sector, poor post harvesting technologies, and lack of access to credit and financial problems in smallholder producers as discussed by Bedane Gudeta *et al*. (2016) and Tiliksew Addis *et al*. (2021).

Despite such constraints, cotton is important cash crop and provides employment opportunities to thousands of people in the farms, industries and other cotton related sectors (Donis Gurmessa *et al*., 2022a). According to Alebel Bayrau *et al*. (2014), the suitable cotton production area in Ethiopia was estimated by the Ethiopian Ministry of Agriculture to be over 3 million hectares. However, the domestic area coverage of cotton cultivation per annum reached only 136,000 hectares at its peak in 2011/2012. In 2021/2022, it is estimated to be about 83,000 hectares. The harvested


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seed cotton yield and the domestic consumption were estimated to be 62,000 and 56,000 tons, respectively (ICAC, 2023). The domestic consumption of cotton in the country expected to increase due to increased number of apparel and textile industry parks and growing demand from existing and newly installed spinning mills. As a result, by 2032 the national cotton production target is about one million hectares of land and 2596 million seed cotton yield. Additionally, there is a plan to increase the current national average seed cotton productivity in the country from 2.5 to 3.5 t $ha^{-1}$ for irrigated and from 1.5 to 2.0 t $ha^{-1}$ for rain fed cotton production system (NCDS, 2016). The largest irrigated areas are middle Awash in Afar, upper Awash in Oromia, and South and North Omo in Southern Nations, Nationalities and Peoples' Regional State. In addition, cotton is produced as a rain-fed crop in Gambella, Benishangul Gumuz, Tigray, Amhara, and Somali National Regional States (Donis Gurmessa *et al.*, 2022b, 2022c; Merdasa Balcha *et al.*, 2022).

Whilst a number of cotton varieties are available in Ethiopia, Deltapine 90 has been almost the only cotton variety under production for a long time in Sille and Weyto areas of the Southern part of Ethiopia. Deltapine 90 is a variety that has good seed cotton and lint yield but it is characterized by having a medium fiber quality (Bedane Gudeta *et al.*, 2019; Merdasa Balcha, *et al.*, 2019a, 2019b, 2022). Changes in the modern spinning technology and textile products have increased the demand for higher quality fiber. Moreover, cotton producers require varieties with high quality fiber that meet the local, regional, and international market standards (Fang *et al.*, 2014; Constable *et al.*, 2015; Islam *et al.*, 2016; Keerio *et al.*, 2018). Thus, cotton fiber quality is as important as seed cotton and lint yield to address the needs of cotton producers for high yield potential and the demands of the textile industries for better fiber quality. Consequently, among the available cotton varieties, it is imperative to select the most suitable ones in terms of yield and fiber quality.

In several studies, it has been documented that cotton varieties vary significantly in terms of agronomic and yield performances (Wang *et al.*, 2004; Ali *et al.*, 2005; Sezener *et al.*, 2006; Ehsan *et al.,* 2008) and fiber quality (Mohammad, 2001). Furthermore, sustainable cotton production requires identification and cultivation of high yielding varieties possessing acceptable fiber qualities as this contributes to the reduction of risk while optimizing yield and quality, which in turn affects income. That is, evaluation of cotton varieties for their agronomic performances and fiber quality related traits is very importance in cotton production. However, there is limited information regarding the adaptability, yield potential, agronomic characteristics, and fiber quality traits of improved cotton varieties presently available in Sille and Weyto areas. Therefore, the objective of this study was to evaluate the agronomic, yield, and fiber quality performances of improved cotton varieties under irrigation conditions of Weyto and Sille cotton producing areas in Ethiopia.

## 2. Materials and Methods

### 2.1. Description of the Study Areas and Plant Materials

The study was conducted for two consecutive years (2016 and 2017) at Weyto and Sille cotton growing areas of Southern Nations, Nationalities and Peoples' Regional State of Ethiopia under irrigation conditions (Figure 1). Weyto is located at 5°23'31" N latitude and 36°58'41" E longitude in Bena Tsemay district, South Omo zone, which is about 645 km away from Addis Ababa. The altitude, average annual rainfall and temperature of Weyto are 550 meters above sea level (m a.s.l.), 517 mm and 31 °C, respectively with Eutric fluvisols soil type. Sille of Arba Minch Zuria district is found in Gamo Gofa Zone, 520 km away from Addis Ababa and astronomically located at 5°51'42" N latitude and 37°28'32" E longitude at an elevation of 1120 m a.s.l. The annual temperature ranges from 25 to 36 °C and the mean annual rainfall is 1100 mm. The soil texture class of Sille area is silty clay loam. The cotton production system of both Weyto and Sille area is semi-mechanized farming and irrigation water is used.

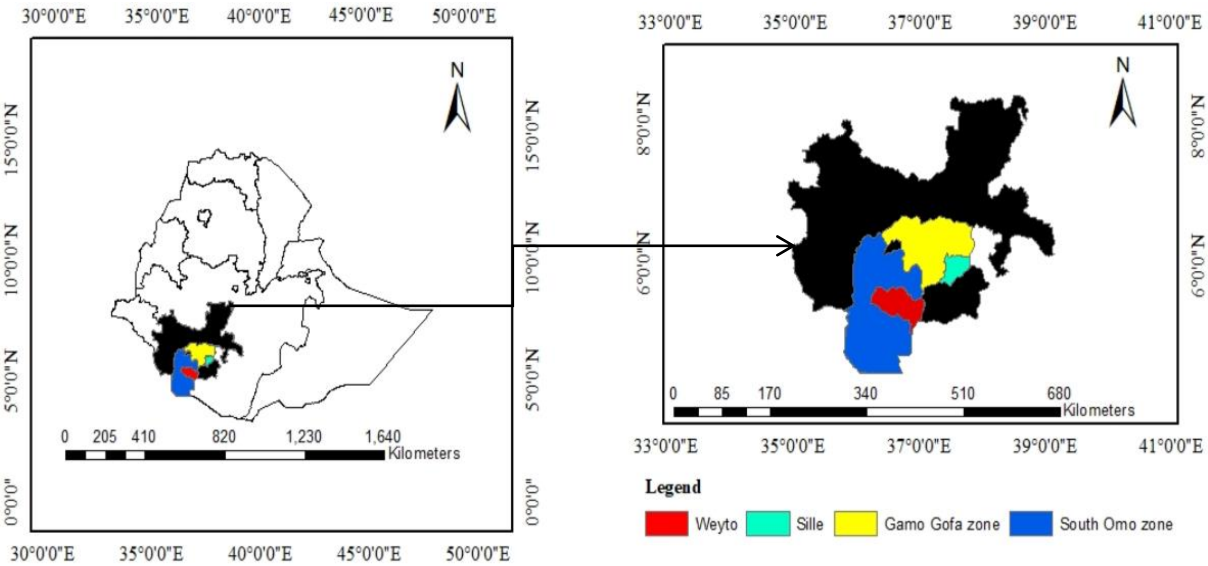


Figure 1. Map of study areas.

A total of ten released cotton varieties viz. Deltapine-90, Stam-59A, Ionia, Acala SJ2, Arba, Bulk-202, Carolina Queen, Cucurova-1518, Cu-okra, and Sille-91 were used in this study (Table 1). The seed source of all the cotton varieties was national cotton research coordinating center, i.e., Werer Agricultural Research Center (WARC). All the varieties were *G. hirsutum* L. species cotton varieties released for irrigated and rain-fed cotton production belts in Ethiopia.

Table 1. Description of cotton varieties used in the study.

| S/N | Variety name | Year of release | Maintainer | Recommended area of production | Days to maturity |
|---|---|---|---|---|---|
| 1 | Acala SJ2 | 1986 | WARC | Irrigated | 148-155 |
| 2 | Arba | 1987 | WARC | Rain fed | 140-150 |
| 3 | Bulk-202 | 1989 | WARC | Rain fed | 140-150 |
| 4 | Carolina Queen | 1994 | WARC | Irrigated | 145-152 |
| 5 | Cucurova-1518 | 1994 | WARC | Irrigated | 129-140 |
| 6 | Deltapine-90 | 1989 | WARC | Irrigated | 138-145 |
| 7 | Cu-okra | 1994 | WARC | Irrigated | 130-135 |
| 8 | Stam-59A | 2007 | WARC | Irrigated | 140-150. |
| 9 | Ionia | 2008 | WARC | Irrigated | 130-140 |
| 10 | Sille-91 | 1997 | WARC | Irrigated | 143-152 |

Note: *WARC = Werer Agricultural Research Center.*

### 2.2. Experimental Design

The experiment was carried out from the month of mid-May to the first week of October. Two cotton seeds per hole were hand sown on the top of the ridges. Thinning was done fifteen days after emergence to allow a density of 5.5 plants $m^{-2}$. A post-sowing application of irrigation water, using furrow irrigation system was applied every two weeks for 126 days. Hand weeding was used to control weeds and chemical insecticides were used to control insect pest. The experimental design used was randomized complete block design with three replications. The plot size included 5 rows of 5 m length with a 0.9 m row width and a spacing of 0.20 m between plants. Prior to data collection, five consecutive plants, in total 15 from the three central rows were marked with red-colored wool threads and used for data collection for all traits considered, except seed cotton yield.

Plant height was measured using a wooden ruler from the ground to the tip of the plant at time of maturity. Both opened and un-opened bolls were counted and averaged for boll number per plant. The weight of thirty opened bolls (2 from each sampled plant) was taken to determine average boll weight (g) and ginned to measure ginning out-turn (%). The resulting fiber was exposed to the approved atmospheric conditions, 65 ± 2% relative humidity and temperature of 21 ± 0.6 °C for 48 h to bring the moisture content of fiber to equilibrium prior to testing fiber quality traits using USTER HVI 1000. All plants from the central rows were harvested and weighed including 30 picked bolls to determine seed cotton yield (t $ha^{-1}$). Lint yield (t $ha^{-1}$) was calculated by dividing the product of seed cotton yield and ginning out-turn (%) by 100.

### 2.3. Data Analysis

The data were subjected to analysis of variance using the generalized linear model of SAS statistical package version 9.3 (SAS Institute, 2012). After testing the homogeneity of the error variance of the individual environment, combined analysis of variance over the two locations was performed. The following statistical equation was used for combined analysis of variance:

$$Yijk = \mu + Gi + Ej + GEij + Bk(j) + \varepsilon ijk$$

Where, Yijk = observed value of genotype i in block k of environment (location) j; μ = grand mean of the experiment; Gi = effect of genotype i; Ej = environment or location effect; GEij = the interaction effect of genotype i with environment j; Bk(j) = the effect of block k in location (environment) j; and Ɛijk = error (residual) effect of genotype i in block k of environment j.

All pairs of treatment means were separated using Fisher's least significance difference test (LSD) at 5% level of significance.

## 3. Results and Discussion

### 3.1. Analysis of Variance

The results of the combined analysis of variance for all agronomic performances and fiber quality traits of the cotton varieties are presented in Table 2. The results showed significant variation among varieties across the two locations for all the traits considered indicating the existence of genetic variation among the studied cotton varieties. Variety and year (V*Y) interacted to significantly (P ≤ 0.01) influence seed cotton yield, and lint yield. Furthermore, plant height and micronaire were significantly (P < 0.05) influenced by the three factor interaction of variety, location, and year. However there was no genotype by environment interaction (V*Y*L) for economically important traits, such as seed cotton yield, lint yield, fiber length, and fiber strength. This promotes large scale cultivation of a few varieties that combine the most desirable traits though it can increase the risk of genetic vulnerability (Donis Gurmessa, 2019).

Table 2. Mean squares for agronomic performances and fiber quality traits of cotton varieties in Weyto and Sille cotton growing areas of southern Ethiopia.

| Traits | Source of Variation | | | | | Error | CV (%) | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| | V (*df* = 9) | L (*df* = 1) | V * Y (*df* = 9) | V * L (*df* = 9) | V * Y * L (*df* = 9) | (*df* = 72) | | |
| Plant height (cm) | $1911.27^{**}$ | $11650.19^{**}$ | $369.67^{ns}$ | $1014.78^{**}$ | $588.34^{*}$ | 198.93 | 10.58 | 0.81 |
| Boll number per plant | $38.93^{**}$ | $1113.74^{**}$ | $4.05^{ns}$ | $8.94^{ns}$ | $5.86^{ns}$ | 11.12 | 20.38 | 0.76 |
| Boll weight (g) | $2.88^{**}$ | $2.74^{*}$ | $0.22^{ns}$ | $0.33^{ns}$ | $0.49^{ns}$ | 0.43 | 12.06 | 0.58 |
| Seed cotton yield (t $ha^{-1}$) | $1.67^{**}$ | $88.27^{**}$ | $1.26^{**}$ | $0.51^{ns}$ | $0.41^{ns}$ | 0.33 | 14.80 | 0.86 |
| Ginning out-turn (%) | $67.73^{**}$ | $267.81^{**}$ | $5.01^{ns}$ | $4.49^{ns}$ | $3.22^{ns}$ | 2.60 | 4.09 | 0.85 |
| Lint yield (t $ha^{-1}$) | $0.52^{**}$ | $9.2^{**}$ | $0.20^{**}$ | $0.11^{ns}$ | $0.08^{ns}$ | 0.05 | 15.34 | 0.84 |
| Micronaire | $0.68^{**}$ | $4.45^{**}$ | $0.20^{*}$ | $0.05^{ns}$ | $0.22^{*}$ | 0.08 | 7.27 | 0.83 |
| Fiber length (mm) | $24.69^{**}$ | $58.88^{**}$ | $1.45^{ns}$ | $0.26^{ns}$ | $0.53^{ns}$ | 1.51 | 4.30 | 0.77 |
| Fiber strength (g $tex^{-1}$) | $74.53^{**}$ | $57.96^{**}$ | $1.07^{ns}$ | $2.53^{ns}$ | $1.21^{ns}$ | 2.08 | 5.32 | 0.86 |

Note: *ns = non-significant, * = significant at P < 0.05, and ** = significant at P ≤ 0.01. V = variety, Y = year, and L = location. CV = coefficient of variation, df = degrees of freedom, and* $R^2$ *= coefficient of determination.*

### 3.2. Agronomic, Yield, and Fiber Quality Performances of Cotton Varieties

#### 3.2.1. Agronomic performances

The mean performance for plant height, boll number per plant, and boll weight of the varieties are indicated in Table 3. The plant height was found to be significantly different among the varieties. The cotton varieties exhibited tallness at Sille as compared to Weyto, except for Ionia variety. The tallest plants belonged to Arba, Acala SJ2, and Ionia at Weyto, while at Sille, Stam-59A was the tallest followed by Arba, Acala SJ2, and Bulk-202. At the overall environment, the tallest plants were recorded for variety Arba which was in statistical parity with the height of plants of Acala SJ2 variety, followed by Stam-59A and Bulk-202. The shortest plants were measured for Deltapine-90 which was in statistical parity with the heights of plants of varieties including Carolina Queen, Cucurova-1518, Sille-91, and Cu-okra.

The differences observed for plant height among cotton varieties can be ascribed to genetic variation in cotton plants, and environmental conditions as indicated by Wankhade and Gobble (2002) and Zia *et al.* (2018). The present result is consistent with finding of a previous study on evaluation of cotton advanced inbreed lines for seed cotton yield and yield components done by Samuel Damtew (2019) who observed highly significant differences for plant height among cotton varieties. In the Ethiopian cotton farming sector, cotton plants with above 150 cm and below 60 cm plant height is not preferable due to the reason associated with efficiency of suppressing weed growth, difficulty at harvesting time and lodging problems. In this regard almost all the varieties showed a desirable range of plant height.

One of the important seed cotton yield contributing traits is the number of bolls per plant though it is not enough alone for higher yield (Copur, 2006). All the varieties showed low numbers of boll per plant at Sille as compared to Weyto unlike that of plant height (Table 3). In the overall environment, the maximum boll number per plant was recorded for Deltapine-90 followed by Stam-59A, Cucurova-1518 and Sille-91. The minimum boll number per plant belongs to Acala SJ2. This variety was the only statistically different variety from the top four maximum boll number producing varieties. The observed differences in the number of bolls per plant among varieties were probably a direct consequence of differences in the number of sympodial branches per plant and number of bolls formed. Different studies revealed that cotton cultivars differed in boll number per plant (Copur, 2006; Zia *et al.*, 2018; Samuel Damtew, 2019; Baksh *et al.*, 2019; Merdasa Balcha *et al.*, 2020).

Besides number of bolls per plant, boll weight in cotton is another yield contributing trait. Among the varieties Acala SJ2 exhibited numerically the highest bolls per plant followed by Ionia and Carolina Queen with no statistical difference. Similarly, the lowest boll weight belongs to Sille-91 followed by Arba and Bulk-202. Variation observed in boll weight among the varieties ranges from medium to large weight. According to Rathinavel *et al.* (2005), the weight of cotton bolls at first picking is categorized as Small (<3.0 g), Medium (3.1–5.0 g) and Large (>5.0 g). The significant variation observed in boll weight among the studied varieties was in agreement with the finding of Samuel Damtew (2019) who also reported a significant variation in boll weight among 34 advanced cotton lines in Ethiopia. Under ideal condition, the boll weight of cotton is determined by the number of seeds per boll and 100-seed weight. Hence, those cotton varieties with higher boll weights probably have a higher number of seeds within boll and or seed weight.

Table 3. Combined mean performances for plant height, boll number, and boll weight performance of cotton varieties at Weyto and Sille during the 2016 and 2017 cropping season.

| Varieties | Plant height (cm) | | | Boll number per plant | | | Boll weight (g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Weyto | Sille | Combined | Weyto | Sille | Combined | Weyto | Sille | Combined |
| Acala SJ2 | 131.99$^{ab}$ | 165.94$^{ab}$ | 148.97$^{ab}$ | 14.45$^{c}$ | 10.15$^{c}$ | 12.3$^{c}$ | 6.35$^{a}$ | 6.12$^{a}$ | 6.24$^{a}$ |
| Arba | 140.11$^{a}$ | 169.28$^{a}$ | 154.70$^{a}$ | 20.23$^{ab}$ | 13.31$^{abc}$ | 16.77$^{ab}$ | 4.75$^{d}$ | 5.01$^{cde}$ | 4.88$^{ef}$ |
| Bulk-202 | 128.95$^{abc}$ | 152.47$^{bc}$ | 140.71$^{b}$ | 19.71$^{ab}$ | 13.12$^{abc}$ | 16.42$^{bc}$ | 5.21$^{cd}$ | 4.86$^{de}$ | 5.04$^{def}$ |
| Carolina Queen | 117.61$^{bcd}$ | 128.83$^{de}$ | 123.22$^{cd}$ | 19.77$^{ab}$ | 11.93$^{bc}$ | 15.85$^{bc}$ | 5.87$^{abc}$ | 5.84$^{ab}$ | 5.86$^{ab}$ |
| Cucurova-1518 | 120.68$^{bcd}$ | 127.23$^{de}$ | 123.95$^{cd}$ | 20.89$^{ab}$ | 14.6$^{ab}$ | 17.74$^{a}$ | 5.93$^{abc}$ | 4.92$^{de}$ | 5.42$^{bcd}$ |
| Deltapine-90 | 112.00$^{cd}$ | 122.04$^{e}$ | 117.02$^{d}$ | 22.51$^{a}$ | 14.28$^{ab}$ | 18.39$^{a}$ | 5.47$^{bcd}$ | 5.15$^{bcde}$ | 5.31$^{cde}$ |
| Cu-okra | 126.44$^{abc}$ | 128.45$^{de}$ | 127.44$^{cd}$ | 16.77$^{bc}$ | 12.61$^{abc}$ | 14.69$^{bc}$ | 5.90$^{abc}$ | 5.37$^{bcd}$ | 5.63$^{bc}$ |
| Stam-59A | 115.45$^{bcd}$ | 170.61$^{a}$ | 143.03$^{b}$ | 20.73$^{ab}$ | 14.96$^{ab}$ | 17.84$^{a}$ | 5.33$^{bcd}$ | 5.22$^{bcde}$ | 5.27$^{cde}$ |
| Ionia | 131.78$^{ab}$ | 125.39$^{de}$ | 128.58$^{c}$ | 20.5$^{ab}$ | 12.81$^{abc}$ | 16.66$^{ab}$ | 6.07$^{ab}$ | 5.67$^{abc}$ | 5.87$^{ab}$ |
| Sille-91 | 109.00$^{d}$ | 140.83$^{dc}$ | 124.92$^{cd}$ | 19.03$^{ab}$ | 15.88$^{a}$ | 17.45$^{a}$ | 4.82$^{d}$ | 4.50$^{e}$ | 4.66$^{f}$ |
| Mean | 123.40 | 143.11 | 133.25 | 19.46 | 13.36 | 16.41 | 5.57 | 5.27 | 5.42 |
| LSD (0.05) | 17.35 | 15.58 | 11.48 | 4.26 | 3.52 | 2.72 | 0.81 | 0.74 | 0.53 |

Note: *Means in a column followed by the same letter(s) are statistically non-significant at P < 0.05 probability level.*

**3.2.2. Seed cotton yield, ginning out-turn, and lint yield performances**

The seed cotton yield performance of the varieties was significantly (P ≤ 0.05) lower at Sille than at Weyto (Table 4). Three varieties, namely, Deltapine-90, Carolina Queen and Stam 59A each produced a higher seed cotton yield, which was more than 5 t ha$^{-1}$ at Weyto. The combined data of both locations also indicated that Deltapine-90, Carolina Queen and Stam-59A had relatively higher yield advantages of 11.2, 9.7 and 6.1%, respectively, than the overall average mean yield performance of the test entries. The least yield was in variety Acala SJ2. Similar to this result, differences in seed cotton yield among cotton varieties were reported by Coper (2006), Hussain *et al.* (2007), Samuel Damtew (2019), and Merdasa Balcha *et al.* (2020). The seed cotton yield is a function of the combined effect of entire yield components exposed under particular set of environmental conditions and contribution from other growth factors. A variety with more number of fruiting branches and number of bolls, high number of seeds per bolls and 100 seed weight is likely to have high seed cotton yield and economically advantageous.

Cotton is mainly grown for lint yield. Higher ginning out-turn is a big advantage as it is the ratio of lint to fuzzy cotton seed. In other words, ginning out-turn is the fraction of the lint separated from a seed-cotton sample by ginning. All the cotton varieties differed from each other for ginning out-turn (Table 4). Unlike that of seed cotton yield, the ginning out-turn of the varieties was numerically higher at Sille than at Weyto. Most varieties had over 40% ginning out-turn at Weyto. The highest ginning out-turns were obtained for Stam-59A variety, followed by Cucurova-1518 which was in statistical parity with the ginning outturns of varieties Cu-okra and Arba at overall location. Moreover, the lowest ginning out-turn was recorded for Acala SJ2 variety. Furthermore, half of the varieties, namely, Arba, Stam-59A, Carolina Queen, Cucurova-1518 and Cu-okra showed very high (>40%) ginning out-turn as per the classification of cotton ginning out-turn by Rathinavel *et al.* (2005). This result is in agreement with the findings of Alehegn Workie *et al.* (2020) who studied fourteen $F_5$ segregating generation and two cotton varieties.

In this study, the varieties showed higher performances at Weyto with almost all varieties yielding over 1.5 t ha$^{-1}$ (Table 4). The combined data showed that about seven varieties showed the maximum lint yield that ranging from 1.54 to 1.7 t ha$^{-1}$ with no statistically significant differences between them. In contrast, Acala SJ2 was the least yielding variety in terms of lint. Lint yield, the most important industrial raw material for which cotton is widely cultivated, is affected by the interaction of factors, including number of bolls per plant, boll weight, seed cotton yield, and ginning out-turn. Comparatively, cotton varieties Acala SJ2 and Bulk 202 with low seed cotton yield and ginning out-turn yielded low lint. In contrast, Deltapine-90, Stam-59A, and Carolina Queen produced higher lint yield, which could be attributed to high seed cotton yield and ginning out-turn. The significant differences observed in this study in lint yields among the cotton varieties are in agreement with the findings of Khan *et al.* (2007), Guzman *et al.* (2018), and Merdasa Balcha *et al.* (2020)

who found significant differences among different cotton cultivars for lint yield.

Table 4. Combined mean performances for seed cotton yield, ginning outturn, and lint yield performance of the cotton varieties at Weyto and Sille during the 2016 and 2017 cropping seasons.

| Varieties | Seed cotton yield (t ha$^{-1}$) | | | Ginning out-turn (%) | | | Lint yield (t ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Weyto | Sille | Combined | Weyto | Sille | Combined | Weyto | Sille | Combined |
| Acala SJ2 | 3.99$^{d}$ | 2.08$^{c}$ | 3.03$^{d}$ | 32.76$^{e}$ | 35.58$^{e}$ | 34.17$^{e}$ | 1.31$^{e}$ | 0.74$^{c}$ | 1.02$^{d}$ |
| Arba | 4.85$^{abc}$ | 2.94$^{ab}$ | 3.90$^{abc}$ | 39.94$^{ab}$ | 42.06$^{bc}$ | 41.00$^{ab}$ | 1.94$^{ab}$ | 1.24$^{ab}$ | 1.59$^{ab}$ |
| Bulk-202 | 4.45$^{bcd}$ | 2.61$^{bc}$ | 3.53$^{c}$ | 36.62$^{cd}$ | 39.35$^{d}$ | 37.98$^{d}$ | 1.62$^{cd}$ | 1.04$^{b}$ | 1.33$^{c}$ |
| Carolina Queen | 5.19$^{ab}$ | 3.30$^{a}$ | 4.24$^{ab}$ | 38.17$^{bc}$ | 42.18$^{bc}$ | 40.17$^{bc}$ | 1.97$^{ab}$ | 1.39$^{a}$ | 1.68$^{a}$ |
| Cucurova-1518 | 4.34$^{cd}$ | 3.31$^{a}$ | 3.83$^{bc}$ | 40.54$^{a}$ | 42.82$^{ab}$ | 41.68$^{a}$ | 1.75$^{bcd}$ | 1.42$^{a}$ | 1.58$^{ab}$ |
| Deltapine-90 | 5.51$^{a}$ | 3.20$^{a}$ | 4.35$^{a}$ | 38.18$^{bc}$ | 40.06$^{d}$ | 39.12$^{cd}$ | 2.10$^{a}$ | 1.29$^{ab}$ | 1.69$^{a}$ |
| Cu-okra | 4.62$^{bdc}$ | 3.09$^{ab}$ | 3.85$^{bc}$ | 40.00$^{ab}$ | 42.39$^{abc}$ | 41.20$^{ab}$ | 1.84$^{abc}$ | 1.31$^{a}$ | 1.58$^{ab}$ |
| Stam-59A | 5.00$^{abc}$ | 3.20$^{a}$ | 4.10$^{ab}$ | 40.05$^{ab}$ | 44.16$^{a}$ | 42.11$^{a}$ | 2.00$^{ab}$ | 1.41$^{a}$ | 1.70$^{a}$ |
| Ionia | 4.95$^{abc}$ | 3.02$^{ab}$ | 3.99$^{abc}$ | 37.67$^{c}$ | 39.57$^{d}$ | 38.62$^{d}$ | 1.88$^{abc}$ | 1.20$^{ab}$ | 1.54$^{ab}$ |
| Sille-91 | 4.33$^{cd}$ | 3.32$^{a}$ | 3.83$^{bc}$ | 35.23$^{d}$ | 40.88$^{cd}$ | 38.05$^{d}$ | 1.52$^{de}$ | 1.36$^{a}$ | 1.44$^{bc}$ |
| Mean | 4.72 | 3.01 | 3.87 | 37.92 | 40.90 | 39.41 | 1.79 | 1.24 | 1.51 |
| LSD (0.05) | 0.74 | 0.58 | 0.47 | 1.94 | 1.80 | 1.31 | 0.28 | 0.26 | 0.19 |

Note: *Means in a column followed by the same letter(s) are statistically non-significant at P < 0.05 probability level.*

### 3.2.3. Fiber quality performances

Cotton fiber quality is defined by the properties that relate to its spinnability into yarn and contribution to textile performance and quality (Chee *et al.*, 2005a). The most valued properties are micronaire, fiber length, and fiber strength. The data pertaining to mean performance for micronaire, fiber length, and fiber strength of the varieties are shown in Table 5. All the varieties exhibited superior micronaire values relatively at Weyto. The combined data indicated, the highest micronaire was obtained for Arba variety, which was in statistical parity with the micronaire obtained for Deltapine-90 and Stam-59A varieties, followed by other five varieties including Sille-91, Bulk-202, Cu-okra, Carolina Queen and Cucurova-1518, with a range of 3.79 to 3.89 micronaire values.

On the contrary, Acala SJ2 showed the most significantly least micronaire value followed by Ionia variety. Cotton fiber having lower than 3.5 and above 5.0 micronaire values are considered as immature and coarse fibers, respectively and the market value of such cotton is considered in the discount range. The prime micronaire range lies between 3.7 and 4.2 (Anonymous, 2018). In this regard, except Acala SJ2 at Weyto and Sille, Carolina Queen, Cucurova-1518, Cu-okra and Ionia varieties at Sille, the remaining cotton varieties showed quality fiber property in terms of micronaire. In other studies, higher mean micronaire value over 4.5 was reported (Merdasa Balcha *et al.*, 2019b). Comparatively, lower overall mean micronaire value among the varieties tested in this study could be due to the fact that the genotypes used were from different breeding sources. Furthermore, micronaire can be influenced during the growing period by environmental factors such as soil moisture, temperature, sunlight, plant nutrients and extremes in plant or boll population as indicated in Anonymous, (2018).

The data of fiber length showed that, similar to that of micronaire, all the varieties exhibited better fiber length at Weyto as compared to Sille (Table 5). Previous study of Ahmad *et al.* (2009), revealed cotton fiber length is largely influenced by variety, although the cotton plant's exposure to extremely high temperatures, water stress, and nutrient deficiencies may result in shorter fibers. Ionia cotton variety showed better fiber length while Cu-okra produced the shortest fiber, followed by Cucurova-1518 with no statistical difference between these two varieties. The result of this study is more or less in agreement with that of Merdasa Balcha *et al.* (2019b) who reported a mean of 29.07 mm fiber length among 15 early maturing *G. hirsutum* L. cotton genotypes in Ethiopia. Longer fibers can be processed at greater efficiencies and produce finer and stronger yarns by allowing fibers to twist around each other more times, while shorter fibers requiring increased twisting during spinning, causing low-strength and poor-quality yarns

(Chee *et al*., 2005b). Accordingly, cotton varieties with greater fiber length are preferable in modern spinning industries globally though there is considerable demand of short length fiber cotton at local handlooms to produce traditional hand woven products. In line with this, there is a demand of either short fiber producing varieties likes of Cu-okra and Cucurova 1518 or long fiber producing varieties.

Differences in fiber strength were observed among cotton varieties ranging from weak to very strong fiber (Table 5). Among the varieties, Sille-91, Acala SJ2, Arba, Bulk-202 and Carolina Queen produced average fiber strengths of 27.24 g $tex^{-1}$ to 28.98 g $tex^{-1}$. Moreover, statistically, the highest fiber strength was obtained for Ionia and the least was found for Cu-okra, Cucurova-1518 and Deltapine-90 varieties, respectively. Fiber strength is largely determined by variety though weather conditions and plant nutrient deficiencies can affect it (Gormus and Yucel, 2002; Lokhande and Reddy, 2014; Shah *et a*l., 2021). Corroborating the results of this study, Merdasa Balcha *et al.* (2019a), reported comparative mean fiber strength among 15 *G. hirsutum* L. genotypes. Fiber strength and yarn strength are highly correlated. Also, cotton with high fiber strength is more likely to withstand breakage during the manufacturing process (Anonymous, 2018). Consequently, in modern textile factories the demand of high strength cotton fiber is increasing and those cotton varieties producing more strong fiber strength is ideal option in cotton farming.

Table 5. Combined mean performances for fiber quality traits of the cotton varieties at Weyto and Sille and during the 2016 and 2017 cropping seasons.

| Varieties | Micronaire | | | Fiber length (mm) | | | Fiber strength (g $tex^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Weyto | Sille | Combined | Weyto | Sille | Combined | Weyto | Sille | Combined |
| Acala SJ2 | $3.37^{c}$ | $3.08^{e}$ | $3.22^{d}$ | $30.55^{ab}$ | $28.91^{b}$ | $29.73^{b}$ | $29.08^{b}$ | $26.78^{c}$ | $27.93^{dc}$ |
| Arba | $4.27^{a}$ | $3.98^{a}$ | $4.12^{a}$ | $30.33^{ab}$ | $29.15^{b}$ | $29.74^{b}$ | $29.53^{b}$ | $28.42^{b}$ | $28.98^{bc}$ |
| Bulk-202 | $4.01^{ab}$ | $3.68^{bcd}$ | $3.84^{bc}$ | $28.37^{cde}$ | $27.09^{cde}$ | $27.73^{def}$ | $26.62^{c}$ | $25.92^{cd}$ | $26.27^{e}$ |
| Carolina Queen | $4.05^{ab}$ | $3.46^{d}$ | $3.76^{bc}$ | $29.12^{bcd}$ | $27.49^{cd}$ | $28.31^{de}$ | $28.37^{bc}$ | $26.12^{cd}$ | $27.24^{de}$ |
| Cucurova-1518 | $4.11^{ab}$ | $3.58^{bdc}$ | $3.84^{bc}$ | $27.82^{de}$ | $26.30^{ef}$ | $27.06^{fg}$ | $24.75^{d}$ | $23.17^{e}$ | $23.96^{f}$ |
| Deltapine-90 | $4.21^{ab}$ | $3.75^{abc}$ | $3.98^{ab}$ | $28.40^{cde}$ | $26.76^{def}$ | $27.58^{ef}$ | $24.48^{d}$ | $24.92^{d}$ | $24.70^{f}$ |
| Cu-okra | $4.03^{ab}$ | $3.55^{cd}$ | $3.79^{bc}$ | $26.97^{e}$ | $25.86^{f}$ | $26.42^{g}$ | $24.72^{d}$ | $22.72^{e}$ | $23.72^{f}$ |
| Stam-59A | $4.10^{ab}$ | $3.72^{abcd}$ | $3.91^{ab}$ | $29.74^{bc}$ | $28.92^{b}$ | $29.33^{bc}$ | $30.02^{ab}$ | $28.73^{b}$ | $29.38^{b}$ |
| Ionia | $3.86^{b}$ | $3.48^{cd}$ | $3.67^{c}$ | $31.99^{a}$ | $30.26^{a}$ | $31.12^{a}$ | $31.73^{a}$ | $31.10^{a}$ | $31.42^{a}$ |
| Sille-91 | $3.96^{ab}$ | $3.82^{ab}$ | $3.89^{bc}$ | $29.33^{bcd}$ | $27.86^{c}$ | $28.59^{dc}$ | $28.63^{b}$ | $26.17^{cd}$ | $27.40^{de}$ |
| Mean | 3.99 | 3.61 | 3.80 | 29.26 | 27.86 | 28.56 | 27.79 | 26.40 | 27.10 |
| LSD (0.05) | 0.38 | 0.27 | 0.22 | 1.79 | 0.97 | 1.00 | 1.82 | 1.61 | 1.17 |

Note: *Means in a column followed by the same letter(s) are statistically non-significant at P < 0.05 probability level.*

## 4. Conclusion

The results of this study have demonstrated cotton varieties possessing high seed cotton and lint yield, showed low fiber quality traits. Specifically, the fiber length and strength qualities of Deltapine-90 and Stam-59A varieties are not suitable for modern spinning factories. However, these varieties meet the quality standards of some old textile industries and local handlooms in the country. On the other hand, Ionia cotton variety exhibited better fiber qualities and it seems to be the best for quality fiber production. Furthermore, this study infers the need for simultaneously improved cotton varieties and also infusion into production is indispensable. Hence, future cotton research should focus on developing and promoting cotton varieties having diverse genetic bases, high yielding potential and fiber quality merits.

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