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Yield and Quality Parameters of Current Commercial Cotton (*Gossypium hirsutum* L.) Cultivars under Mediterranean Climatic Conditions of Turkey

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Abstract— *This study was conducted to determine yield and quality parameters of current commercial cotton cultivars under Mediterranean climatic conditions of Turkey. The experimental design was a randomized block design with three replications. Nineteen cotton cultivars (ADN-123, BA-119, BA-440, Bir-949, Candia, Clodia, DPL-396, DPL-332, DPL-499, Edessa, Flash, Gloria, Lodos, Lydia, Naz-07, Poyraz, Sezener-76, ST-468 and ST-498) were used as plant material. At the end of the study, it was determined that there were significant differences among the cotton cultivars for all of the investigated characteristics. The results showed that plant height, number of sympodial branches, boll number, seed cotton weight, 100-seed weight, seed cotton yield, ginning outturn, fiber yield, fiber length, fineness, strength, uniformity, elongation, short fiber content, spinning consistency index (SCI), reflectance (Rd) and yellowness (+b) ranged between 54.78-83.45 cm, 5.45-7.93 no. plant^{-1}, 5.22-11.29 no. plant^{-1}, 3.71-5.52 g, 7.87-10.06 g, 225.69-452.88 kg da^{-1}, 38.25-46.17%, 97.32-202.80 kg da^{-1}, 27.05-29.97 mm, 3.95-5.35 micronaire, 28.87-33.43 g tex^{-1}, 83.52-84.98%, 4.98-7.12%, 5.65-7.12%, 131.33-151.50 SCI, 76.40-80.50 Rd and 9.20-11.00 +b, respectively. Cotton cultivar DPL-499 was distinguished with high plant height, sympodial branches, boll number, seed cotton and fiber yield, and fiber strength. Cultivar DP-396 for fiber uniformity and short fiber content, cultivar Gloria for SCI, cultivar Bir-949 for fiber length and cultivar Lodos for fiber fineness gave the best results*.

Keywords— *Cotton, yield, quality*.

I. INTRODUCTION

Cotton is one of the most important cash crop grown in Aegean, Mediterranean and Southeastern Anatolia region of Turkey. In Turkey, total cotton acreage of 478 thousand hectare resulted in production of 814 thousand tons of lint cotton with an average lint yield of 1700 kg ha^{-1} (Anonymous, 2019). Although our country produces a significant amount of cotton, the country is an important cotton importer due to the higher cotton fiber demand of the cotton textile industry. For this reason, newly improved commercial cotton varieties with high yield and quality are offered to cotton producers through seed companies from within the country and abroad. Undoubtedly, it is necessary to determine the yield and quality performances of cotton varieties that have just entered the seed market with field trials in order to provide accurate information to producers. The usability of cotton fibers is directly related to quality parameters. Length, fineness, strength, uniformity and elongation are the most important quality characteristics of cotton fibers. Intensive agronomic and breeding studies are carried out by cotton researchers to improve the technological properties of cotton (Bowman, 2000; Başal and Turgut, 2003; Başal et al. 2009; Newaskar et al. 2013; Constable et al. 2014; Zeng et al. 2018). Additionally, production and adaptation studies are performed to determine high yield and quality cotton varieties for production areas (Killi and Aloglu, 2000; Sivaslıoglu and Gormus, 2001; Unay et al. 2001; Karademir et al. 2015; Killi and Beycioglu, 2020a; Killi and Beycioglu, 2020b; Killi and Beycioglu, 2020c; Killi and Beycioglu, 2020d).In this study, it was aimed to determine seed cotton yield, yield components and important fiber quality properties of 18 cotton varieties under Kahramanmaras ecological conditions located in East Mediterranean region.

II. MATERIALS AND METHODS

Nineteen different current commercial cotton (*Gossypium hirsutum* L.) cultivars (ADN-123, BA-119, BA-440, Bir-949, Candia, Clodia, DPL-396, DPL-332, DPL-499, Edessa, Flash, Gloria, Lodos, Lydia, Naz-07, Poyraz, Sezener-76, ST-468 and ST-498) were grown during the 2019 growing season in Kahramanmaras, which is located in the Eastern Mediterranean region of Turkey (between 37º 36' north parallel and 46º 56' east meridians). The soils of the experimental area are alluvial soils carried by rivers and they are deposited horizontally in different layers and first class agricultural land. The pH of soils is 7.53, slightly alkaline, lime content is high (20.24%) and organic matter content (2.08%) is low (Anonymous, 2019a). Kahramanmaras province has typical Mediterranean climatic conditions with hot and dry summers and mild, rainy winters. In 2019, Average air temperature during the growing season changed from 14.20°C (April) to 29.50°C (August). The temperature at the experimental field during the growing season was convenient for cotton farming, while the temperatures of July and August were higher than the other months. There was considerable versatility in amount and distribution of precipitation from month to month. The rainfall was highest in April (78.40 mm), and there was an extended dry and hot period during July and August (Anonymous, 2019b).

The experimental design was a randomized complete block with three replications. Cultivars, consisting of four rows 5.0 m long with 0.70 m spacing between rows, were planted on 10 May 2014. Cotton cultivars were sown by hands, and after

emergence, plants hand-thinned to the desired intra-row spacing of 0.20 m. Recommended insect and weed control methods were employed during the growing season as needed. The experimental area received 80 kg N and 80 kg P_2O_5 ha^{-1} as a seedbed application. Additional band-dressing of 80 kg N ha^{-1} was applied at the square stage. Overall 7 irrigations were applied and weeds were controlled by hoeing. In the experiment, the harvest was done twice by hand. The first harvest commenced when the cotton was approximately 70% open; the second harvest was three weeks later. In the experiment, ten randomly tagged plants from each plot were evaluated for plant height, sympodial branches, boll number, seed cotton weight, 100-seed weight and ginning outturn. Seed cotton yield was determined after hand harvesting from each plot twice and weighing the seed cotton. Harvested seed cotton was ginned with the machine of roller gin and separated as seed and fiber. Fiber yield (kg ha^{-1}) was calculated as: [fiber percentage (%) X seed cotton yield (kg ha^{-1})]. After ginning, 50-g lint samples were used for determination of various quality parameters. Fiber length, fineness, strength, uniformity, elongation, short fiber content, spinning consistency index (SCI), reflectance (Rd) and yellowness (+b value) were determined by High Volume Instrument (HVI) at the laboratory of ISKUR yarn plant in Kahramanmaras - Turkey. Analysis of variance was performed for each traits by the MSTAT-C statistical program and where F- test indicated significant effects ($p<0.05$), means were separated using LSD tests.

III. Results and Discussion

A significantly variation was recorded for investigated properties among cotton cultivars (Table I, II and III). According to the nineteen cotton cultivars (Table I), Plant height values ranged from 54.78 cm (AND-123) to 83.45 cm (DPL-499). The variety Naz-07 (74.91 cm) ranked second in plant height closely followed by ST-498 (73.90 cm) and Bir-949 (73.02 cm). These differences are due to variability in environmental conditions and genetic makeup (Usman *et al.*, 2017). The variety DPL-499 produced highest sympodial branches (7.93 no. $plant^{-1}$) followed by Poyraz (7.49), BA-119 (7.29) and ST-498 (7.20). However significantly minimum number of sympodial branches per plant (5.45) was recorded in variety Candia. DPL-499, which was the highest plant height and sympodial branches, had the highest boll per plant (11.29). It was followed by BA-440 (9.44) and Poyraz (9.42). The lowest number of bolls per plant (5.22) was recorded in variety Candia. The differences in boll numbers of cotton cultivars might be due to different plant height and sympodial branches. Ahmad *et al.* (2009) stated that sympodial branches changed in cotton cultivars. Similar findings with cotton were also reported by Kaynak *et al.* (1997). Boll number is an important yield contributing parameter (Ritchie *et al.*, 2009; Sharma *et al.*, 2015). In some of studies related with boll number per plant, Khan *et al.* (2009), Bibi *et al.* (2011) and Usman *et al.* (2017) observed variation in variety. This variable response of different cultivars might be attributed to the unavoidable genetic diversity among cultivars (Killi and Beycioglu, 2020a).

TABLE 1. Average values of yield and yield components of cotton cultivars.

Cultivars	Plant height (cm)	Sympodial branches (no.$plant^{-1}$)	Boll number (no.$plant^{-1}$)	Seed cotton weight (g)	100-Seed weight (g)	Seed cotton yield (kg ha^{-1})
ADN-123	54.78 e	5.98 de	6.89 cde	3.96 bc	8.59 bcde	2490.8 ij
BA-119	68.67 bcd	7.29 abc	8.87 bc	4.19 bc	8.59 bcde	3669.1 cd
BA-440	66.89 bcde	6.40 bcde	9.44 ab	4.03 bc	8.31 de	3390.9 def
Bir-949	73.02 abc	5.94 de	8.74 bc	4.06 bc	9.34 abc	3490.5 de
Candia	57.33 de	5.45 e	5.22 e	4.53 abc	8.57 bcde	2342.2 ij
Clodia	58.56 de	6.73 abcd	8.09 bcd	4.15 bc	8.17 de	3035.3 fg
DPL-396	65.63 bcde	6.03 cde	8.20 bcd	3.95 bc	8.36 cde	3499.4 de
DPL-332	61.42 cde	6.51 bcde	7.31 bcde	4.67 abc	9.01 bcd	3537.3 d
DPL-499	83.45 a	7.93 a	11.29 a	4.85 ab	8.88 bcde	4528.8 a
Edessa	62.73 bcde	6.27 bcde	8.16 bcd	3.97 bc	8.28 de	3354.6 def
Flash	59.51 de	6.40 bcde	6.80 cde	3.97 bc	8.20 de	2659.5 hi
Gloria	68.47 bcd	6.93 abcd	7.62 bcd	4.57 abc	9.15 abcd	3349.2 def
Lodos	69.29 bcd	6.42 cde	7.31 bcde	3.91 bc	7.87 e	2949.1 gh
Lydia	59.69 de	6.13 cde	7.93 bcd	4.37 bc	8.74 bcde	2256.9 j
Naz-07	74.91 ab	7.09 abcd	7.56 bcd	4.52 abc	8.35 cde	3153.5 efg
Poyraz	73.06 abc	7.49 ab	9.42 ab	5.52 a	10.06 a	4227.9 ab
Sezener-76	62.38 bcde	6.22 bcde	6.04 de	4.28 bc	9.44 ab	2557.7 ij
ST-468	62.71 bcde	6.75 abcd	7.00 cde	3.71 c	8.29 de	3327.4 def
ST-498	73.90 abc	7.20 abcd	7.76 bcd	4.41 bc	9.10 abcd	4016.3 bc
LSD (0.05)	13.01	1.28	2.27	1.01	1.03	35.93

For each trait, values within columns followed by the same letter are not significantly at 5% level.

Average seed cotton weight values of cultivars were ranged from 3.71 to 5.52 g (Table I). Maximum seed cotton weight was observed in Poyraz followed by DPL-499 while minimum seed cotton weight was observed in ST-468. Seed cotton weight is directly related to the seed cotton yield (Usman *et al.*, 2017). Average 100 seed weight of cultivars varied from 7.87 to 10.06 g. Poyraz gave the highest 100 seed weight followed by Sezener-76 (9.44 g). The lowest 100 seed weight was obtained from Lodos (7.87 g). The differences among cultivars for seed cotton weight per boll and 100 seed weight might have been due to the difference in genetic potential of the cultivars. The significant differences among

varieties for seed cotton weight per boll and 100 seed weight had also been reported by Ehsan *et al.* (2008), Ali *et al*. (2009), Ali *et al.* (2017), and Killi and Beycioglu (2020a). Seed cotton yield was significantly affected by cultivars (Table I). DPL-499 (4528.8 kg ha^{-1}) gave the highest seed cotton yield followed by Poyraz (4227.9 kg ha^{-1}) and ST-498 (4016.3 kg ha^{-1}). The lowest seed cotton yield was obtained Lydia (2256.9 kg ha^{-1}). Seed cotton yield of DPL-499 was maximum among the cultivars by producing highest plant height, sympodial branch and boll number per plant. Jones (2001) and Iqbal and Khan (2011) reported that seed cotton yield differed significantly among different genotypes.

Average ginning outturn values of cultivars were ranged from 38.25% to 46.17% (Table II). The genotype Candia (46.17%) gave significantly the highest ginning outturn followed by Naz-07 (45.59%) and Poyraz (45.43%). However significantly minimum ginning outturn was recorded in variety Gloria (38.25%). All cultivars produced higher ginning outturn than 40% except Gloria. In studies related with upland cotton, different results of ginning outturn have been reported by the researchers. Avgoulas *et al.* (2005), Gul *et al.* (2016) and Ahuja *et al.* (2018) reported ginning outturn of 38.9-40.5%, 34.54-36.52%, 32.73-40.60%, respectively. Killi and Beycioglu (2020b) reported that ginning outturn values of cotton cultivars ranged from 28.57 to 42.57%. Significant differences in average fiber yield of cultivars were observed and they varied from 973.2 to 2028.0 $kgha^{-1}$ (Table II). Maximum fiber yield was obtained from DPL-499 (2028.0 kg ha^{-1}) and Poyraz (1919.8 kg ha^{-1}) gave higher fiber yield than the yield of other cultivars. These two genotypes (DPL-499 and Poyraz) showed high yield potential, while cultivar Lydia showed very low yield potential. Also other genotypes had moderate yield potential. Fiber yield characteristic has been shown to differ due to genotype and growing conditions, and ginning (Fransen and Verschraege, 1985). The high yield of DPL-499 and Poyraz varieties is due to their high seed cotton yield, number of sympodial branches and bolls per plant. Seed cotton yield was positively correlated with boll number per plant (Gul *et al.*, 2016). Ismail and Al-Enani (1986), Killi (1995) and Gul *et al.* (2016) reported that there are positive and significant relationship between fiber yield and seed cotton yield, ginning outturn.

TABLE II. Average values of ginning outturn, fiber yield and fiber quality traits of cotton cultivars.

Cultivars	Ginning outturn (%)	Fiber yield (kg ha^{-1})	Fiber length (mm)	Fiber fineness (mic.)	Fiber strength (g tex^{-1})	Fiber uniformity (%)
ADN-123	41.64 ef	1037.9 i	28.33 abcd	4.70 abcd	30.92 ab	84.50 ab
BA-119	42.47 def	1559.4 bcd	27.42 cd	4.66 abcd	29.78 ab	84.50 ab
BA-440	44.26 abcde	1502.0 bcde	27.05 d	4.52 bcd	29.13 b	84.03 ab
Bir-949	40.02 fg	1398.9 def	29.97 a	4.51 bcd	32.47 ab	84.75 ab
Candia	46.17 a	1082.0 hi	28.02 abcd	4.59 abcd	30.80 ab	83.75 ab
Clodia	44.68 abcd	1357.0 ef	29.12 abc	4.52 bcd	32.38 ab	84.62 ab
DPL-396	43.82 abcde	1533.5 bcde	28.26 abcd	5.35 a	31.75 ab	84.98 a
DPL-332	45.23 abcd	1599.1 bc	27.51 cd	5.10 abc	30.73 ab	84.87 ab
DPL-499	44.83 abcd	2028.0 a	27.37 cd	5.19 ab	33.43 a	83.72 ab
Edessa	44.41 abcde	1490.8 bcde	27.36 cd	4.76 abc	31.80 ab	84.22 ab
Flash	42.65 cdef	1134.6 ghi	28.41 abcd	4.54 bcd	29.50 b	84.83 ab
Gloria	38.25 g	1288.0 fg	29.68 ab	4.45 bcd	32.60 ab	84.47 ab
Lodos	42.70 cdef	1259.5 fgh	27.68 cd	3.95 d	30.63 ab	84.37 ab
Lydia	43.15 cde	973.2 i	28.40 abcd	4.46 bcd	31.67 ab	84.23 ab
Naz-07	45.59 ab	1439.6 cdef	28.14 abcd	4.41 cd	30.77 ab	84.45 ab
Poyraz	45.43 abc	1919.8 a	29.16 abc	4.54 bcd	32.40 ab	84.90 ab
Sezener-76	43.27 bcde	1106.5 ghi	28.93 abcd	4.81 abc	28.87 b	84.03 ab
ST-468	43.39 bcde	1443.5 cdef	27.86 bcd	4.79 abc	32.00 ab	84.77 ab
ST-498	41.85 ef	1681.2 b	27.31 cd	4.84 abc	32.42 ab	83.53 b
LSD (0,05)	2.78	19.20	1.97	0.77	3.75	1.42

For each trait, values within columns followed by the same letter are not significantly at 5% level.

Fiber length, fineness, strength and uniformity were significantly affected by cultivars (Table II). Fiber length, fineness, strength and uniformity are very important characteristics regarding the fiber quality of cotton and are very useful for textile industry. Bir-949 (29.97 mm) had the longest fiber length and this variety was followed by Gloria, Poyraz and Clodia. All varieties showed a fiber length value below 30 mm. Micronaire value of cotton cultivars ranged from 3.95 to 5.35. The micronaire value of Lodos cultivar was under 4.0 micronaire while the micronaire values of DPL-396, DPL-332 and DPL-499 cultivars were up 5.0 micronaire. DPL-396, DPL-332 and DPL-499 varieties had coarse fibers than others. All cultivars gave fiber strength values over 30 g tex^{-1} except BA-119, BA-440, Flash and Sezener-76. Among cultivars, BA-119 (29.78 g tex^{-1}), BA-440 (29.13 g tex^{-1}), Flash (29.50 g tex^{-1}) and Sezener-76 (28.87 g tex^{-1}) had lower strength value compared to all other genotypes. All cultivars produced similar fiber uniformity values ranged from 83.53 to 84.98%. The significant differences among varieties for fiber quality parameters had also been reported by Azhar and Naeem (2008), Foulk *et al.* (2009), Koli *et al.* (2014), Bechere *et al.* (2016) and Killi and Beycioglu (2020a).

TABLE III. Average values of fiber elongation, short fiber content, spiny consistency index, reflectance and yellowness of cotton cultivars.

Cultivars	Fiber elongation (%)	Short fiber content (%)	Spinning consistency index	Reflectance (Rd)	Yellowness (+b)
ADN-123	6.75 ab	6.38 abc	141.2 abc	78.5 abcd	9.8 cde
BA-119	6.25 abcde	6.05 abc	136.0 abc	76.7 cdef	11.0 a
BA-440	6.37 abcd	6.53 abc	131.3 c	75.8 ef	10.1 abcde
Bir-949	5.33 ef	6.27 abc	150.7 ab	76.9 cdef	10.0 abcde
Candia	5.38 def	6.08 abc	138.0 abc	78.7 abcd	9.9 bcde
Clodia	5.53 def	6.33 abc	148.7 abc	77.9 abcde	9.8 bcde
DPL-396	6.15 abcde	5.65 c	140.0 abc	77.5 cdef	9.9 bcde
DPL-332	6.58 abc	6.97 ab	136.5 abc	77.5 cdef	10.2 abcde
DPL-499	6.10 abcde	6.15 abc	138.7 abc	79.2 abc	9.6 de
Edessa	7.12 a	5.95 bc	139.3 abc	77.2 cdef	10.7 abc
Flash	6.80 ab	6.68 abc	139.7 abc	77.2 cdef	10.3 abcd
Gloria	4.98 f	6.08 abc	151.5 a	80.4 ab	9.2 e
Lodos	6.28 abcde	6.52 abc	144.2 abc	77.2 cdef	9.9 bcd
Lydia	5.48 def	6.58 abc	145.7 abc	80.5 a	9.6 de
Naz-07	5.87 bcdef	7.12 a	143.2 abc	78.5 abcd	10.5 abcd
Poyraz	4.98 f	5.75 c	150.2 ab	77.8 bcdef	10.5 abcd
Sezener-76	6.28 abcde	6.65 abc	133.0 bc	78.1 abcde	10.0 abcde
ST-468	6.62 abc	6.23 abc	142.2 abc	75.3 f	10.9 ab
ST-498	5.62 cdef	6.85 ab	136.7 abc	76.4 f	10.5 abcd
LSD (0.05)	1,04	0.56	17.99	2.58	1.01

For each trait, values within columns followed by the same letter are not significantly at 5% level.

All studied characters such as fiber elongation, short fiber ratio, spiny consistency index, reflectance and yellowness were significantly affected by cultivars (Table III). Maximum fiber elongation was observed in Edessa with 7.12% followed by Flash and AND-123. Minimum fiber uniformity was observed in Gloria (4.98%) and Poyraz (4.98%). Fiber elongation plays an important role in almost all of the textile manufacturing processes (Mathangadeera *et al.*, 2020). Benzina *et al.* (2007) reported that the cotton fibers which do not possess an adequate degree of elongation, as well as tenacity, fail to withstand the stresses applied during ginning and mechanical processing stages which results in fiber breakage. Fibers that exhibit a high degree of elongation also exhibit better spinning performance (Waters *et al.*, 1966). Cultivars differed in the short fiber content with values varying from 5.65 to 7.12%. Naz-07 cultivar showed the highest short fiber content, while DPL-396 and Poyraz showed the lowest short fiber content. The impact of short fiber in commercial cotton spinning was reported by Backe (1986). He emphasize that short fiber showed a statistically significant influence on ends-down in spinning. Thibodeaux *et al.* (2008) indicated that most of the yarn properties are strongly correlated with short fiber content. Significant differences in mean spinning consistency index (SCI) of cotton cultivars were observed and they varied between 131.3 and 151.5 (Table III), and the highest value was obtained in cultivar Gloria followed by Bir-949 and Poyraz. However significantly minimum SCI was recorded in variety BA-440. The spinning consistency index (SCI) is a calculation for predicting the overall quality and spin ability of the cotton fibre (Majumdar *et al.*, 2004; Günaydın *et al.*, 2018). Messiry and Abd-Ellatif (2013) reported SCI values of 145-196 for different global cotton cultivars and they also reported 146-218 SCI for different Egyptian cotton varieties. Cultivars differed in the reflectance (Rd) and yellowness (+b) with values varying from 75.3 to 80.5% and from 9.2 to 11%, respectively. Cultivars Lydia and Gloria showed the highest reflectance and the lowest yellowness. Cultivars BA-119 and ST-468 showed the highest yellowness degree. Color is one of the most important properties of cotton and the color grade of cotton is determined by the degree of reflectance (Rd) and the yellowness (+b) (Matusiak and Walawska, 2010). 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 (Xu *et al.*, 1997; Duckett *et al.*, 1999).

IV. Conclusion

The present study was aimed to determine yield and quality parameters of current commercial cotton cultivars under Mediterranean climatic conditions of Turkey. It was found as a result of the study that there were significant differences among the cotton cultivars for all investigated characteristics. It was concluded from the present study that 19 commercial cotton varieties were identified in field conditions, and DPL-499 were found high efficiency and quality for yield and yield components such as plant height, sympodial branches, boll number, seed cotton and fiber yield, and fiber strength. It was also determined that DPL-396 for fiber uniformity and short fiber ratio, cultivar Gloria for spinning consistency index, cultivar Bir-949 for fiber length and cultivar Lodos for fiber fineness gave the best results.

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