Original Research Article

Fiber Quality Characteristics of Cotton (*Gossypium hirsutum* L.) in Main Production Areas of Aegean Region

ABSTRACT

High-quality cotton fiber has an important role in the textile industry. The regional differences due to environmental factors, genotype and cultural management lead to variation in fiber characteristics. A two-year field experiment was conducted to reveal the intra-regional differences in the Aegean region. The samples from Great Meander, Little Meander, Bakırçay, Gediz and Söke basins were analyzed by High Volume Instrument (HVI) for fiber length (mm), fiber fineness (mic.), fiber strength (g tex^{-1}), reflectance (Rd), yellowness (+b) and trash count (number per unit area) in 2019 and 2020. Range was 29.82-30.77 mm for fiber length; 4.62-5.09 mic. for fiber fineness; 31.26-33.36 g tex^{-1} for fiber strength; 69.62-71.0 for reflectance; 7.70-9.12 for yellowness and 56.04-101.48 for trash count. Although all fiber quality parameters were within the commercial limits, the higher quality fibers were produced in Little Meander and Söke basins in 2019. It was concluded that the main important differences among growing areas of the Aegean region might be in terms of trash count.

Keywords: Climatic parameters, cotton bale, regional differences, trash count

1. INTRODUCTION

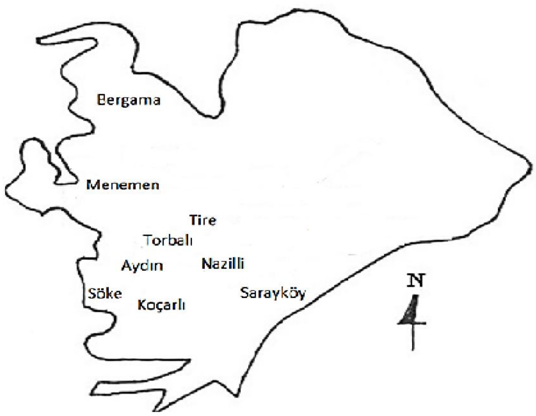
It is estimated that 121.1 million bales of lint cotton will be produced in an area of 32.9 million hectares in 2022/2023 [1]. In addition, global lint yield is forecast at 800 kg ha^{-1}. In the same period, Türkiye’s cotton production is forecast at 925 thousand metric tons (4.2 million bales) [2]. Fiber qualities are a major factor affecting cotton quality [3]. Fiber quality of cotton is primarily determined by physical properties such as length, fineness and strength within commercial limits in terms of the textile industry [4]. The growth environment plays an important role in determining fiber quality [5] and environment-related variability affected fiber physical attributes, which have been shown to affect the finished-product quality and manufacturing efficiency [6, 7, 8, 9]. High-quality yarns are highly dependent on raw materials [10].

During the growing season, climatic factors such as temperature, humidity, precipitation, and solar radiation cause regional differences. Temperature is the most important factor affecting fiber quality characteristics among climatic factors during boll development [11, 12, 13, 14]. [15] determined the significant differences among Aegean, Çukurova and Southeastern Anatolia Regions for fiber length, micronaire and strength. The important fiber quality characteristics such as fiber length, fineness and strength exhibited a performance within commercial limits in the provinces of Diyarbakır and Şanlıurfa of the Southeastern Anatolia Region [16]. Similarly, it was demonstrated that all quality characteristics were affected by regional climatic characteristics in important cotton-producing regions in Greece and each region, therefore, produces different quality cotton [14].

The Aegean region is the second most important cotton-growing region in Turkey. There are few studies examining the effects and variation of growing basins on cotton quality in the Aegean region. Therefore, we aimed to evaluate the samples from ginning companies of the five major cotton-producing regions of Aegean in 2019–2020.

2. Materials and Methods

Within the scope of the "Research of Fiber Quality Distributions in Production Basins in the Aegean Region" project carried out by Nazilli Cotton Research Institute, the cotton-growing areas of the Aegean region were evaluated in 5 basins. These basins were Great Meander, Söke, Little Meander, Gediz and Bakırçay basins. Aydın, Sarayköy and Nazilli in the Great Meander Basin; Menemen in the Gediz basin; Bergama in the Bakırçay basin, Tire and Torbalı in the Little Meander basin; Söke and Koçarlı in the Söke basin were evaluated in 2019 and 2020 (Figure 1).



Aydın	:	37° 43′ 42″ N, 27° 56′ 14″ E
Nazilli	:	37° 54′ 35″ N, 28° 19′ 27″ E
Sarayköy	:	37° 55′ 35″ N, 28° 55′ 35″ E
Koçarlı	:	37° 39′ 51″ N, 27° 41′ 25″ E
Söke	:	37° 45′ 21″ N, 27° 24′ 14″ E
Tire	:	38° 05′ 19″ N, 27° 44′ 06″ E
Torbalı	:	38° 09′ 06″ N, 27° 21′ 44″ E
Menemen	:	38° 36′ 37″ N, 27° 04′ 10″ E
Bergama	:	39° 07′ 14″ N, 27° 10′ 49″ E

Figure 1. Sample areas of study sites

The climate data of the basins are given in Figure 2. Apart from the low average temperatures in the Bergama region since July, similar average temperatures have been realized between the regions. It is noteworthy that the maximum temperatures in July, August and September in the Great Meander basin are significantly higher, whereas the humidity levels in July and August are low. On the contrary, it is seen that maximum temperatures and humidity are low in Söke.

Figure 2. Climatic data of different basins in 2019 and 2020

Samples were taken from the bales of the ginning factories in every region, especially in TARİŞ (Cotton and Oil Seeds Agricultural Sales Cooperatives Union). The number of samples taken from each region was 45. Sampling studies included the period from the beginning of ginning to the end of ginning. After the ginning started, fiber samples were collected from the ginning factories at regular intervals. In order to ensure that the samples represent the production season in the best way, sample collection was carried out at regular intervals throughout the ginning season. Sampling was planned from the bales stored in the cotton ginning factories operating in the Aegean Region cotton planting basins. Care was taken to ensure that the bales represent different lots. 250 g of samples were taken from two different parts of the randomly selected bales according to the International Cotton

Association Limited Regulation and Rules [17]. 45 bales were sampled from each region. Samples were measured on the (USTER) HVI 1000 device for fiber quality analysis.

Statistical Procedure

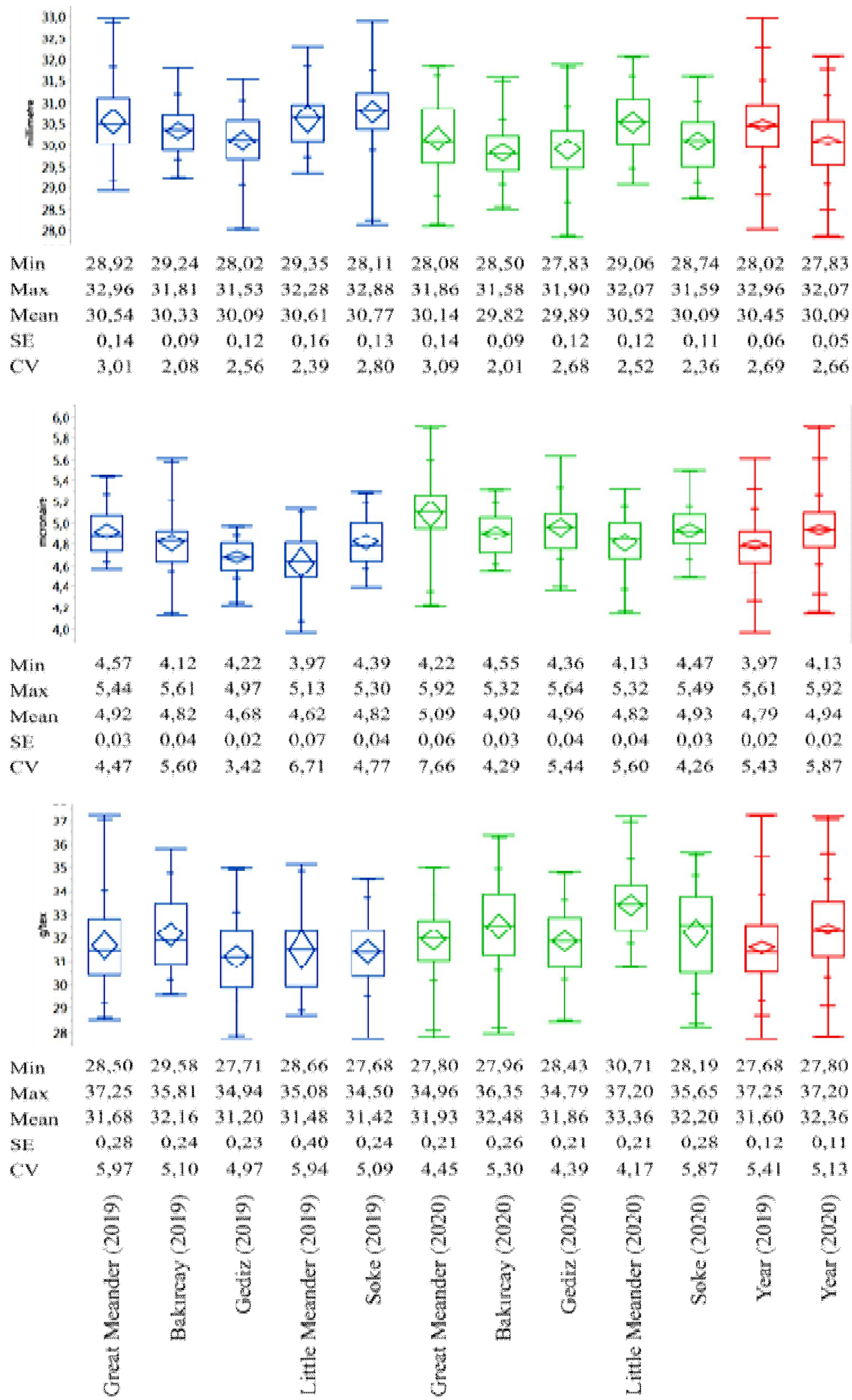
Box plots with box and whisk were used for the graphical presentation of the descriptive statistics of the characteristics. Forty-five data were evaluated in each region. There are maximum and minimum values, median, lower and upper quartile on the box plot. Additionally, standard error, mean and coefficient of variation (%) were tabulated below the box plots. Descriptive statistics were obtained in the R Studio [18] using the 'stats' package [19; v. 4.1.2] and boxplots were drawn in JMP 14® statistical package program [20].

3. RESULTS and DISCUSSION

The basic statistics of samples collected from basins over the experiment years indicated that the higher fiber length recorded in Söke (30.77 mm) and Great Meander (30.54 mm) for 2019, respectively, whereas Bakırçay (29.82 mm) and Gediz (29.89 mm) in 2020 produced the lower fiber length (Figure 3). The ecological zone, temperature and agronomical practices affected the cotton fiber quality [37]. Similarly, there are differences in fiber length between years, even in the same region and in the same variety [21]. Yarn quality is adversely affected by the reduction in fiber length [22]. Although the low standard errors and CV values of basins showed low fluctuations within regions, the higher CV values in Great Meander (3.09 and 3.01%) compared with Bakırçay (2.01 and 2.08 %) indicated that it is difficult to obtain bales with homogeneous fiber length from Great Meander basin. It was demonstrated that fiber length was non-stable within a genotype or within a testing sample due to the inherent variability of cotton fiber [23]. Based on CV above 40%, fiber length can vary significantly from sample to sample [24].

Our analysis results showed that Little Meander (4.62 mic.) and Söke (4.68 mic.) basins in 2019 produced thicker fiber (Figure 3). On the contrary, Great Meander (5.09 mic.) and Gediz (4.96 mic.) in 2020 exhibited coarse fiber. The base micronaire is between 3.50 and 4.90 [25]. Cotton with fiber fineness other than commercial values is limited in the range of use by the textile industry. Fiber fineness with low values is composed of immature fibers that do not readily absorb the dye, whereas coarse fibers cannot be spun efficiently into fine yarns [26]. In our study, the high CV values between 3.42 and 7.66 within basins indicated that fiber fineness is affected by many important factors such as growing conditions, cultivar and cultural management. A coarsening of the fibers was observed in all basins in 2020. While there is no change in the Söke region, the average temperatures, especially in Bakırçay and Great Meander basins, increased by 1.2 and 6.0 °C after July 2020, respectively. Many studies have shown that micronaire responds to environmental changes and cultural practice differences [38, 39, 40]. It was clearly stated that fiber fineness is affected by daily maximum and mean temperature and the increase in temperature makes the fibers coarser [27, 28].

The open-rotor system in the textile industry is based on higher fiber quality such as strength [29]. Fiber strength emerges as a function of fiber extension and duration of fiber thickening, and environmental factors and genotypic characteristics affected fiber strength [30]. We determined the strongest fibers in the Little Meander (33.36 g tex^{-1}) and Bakırçay (32.48 g tex^{-1}) basins in 2020, while the weakest fibers were found in the Gediz (31.26 g tex^{-1}) and Söke (31.42 g tex^{-1}) basins in 2019 (Figure 3). Fiber strength was clearly higher in 2020. The association of fibre strength with daily mean temperature during the formation of the fibre in cotton indicated that fiber strength increased linearly with daily mean temperature [31, 32]. Our climatic data in experimental years demonstrated the increase in daily average temperatures of 2020 between 1.2-6.0 °C since August in the Great meander and Bakırçay basins. However, it has been stated that high temperatures adversely affect all fiber properties [41]. The higher standard errors and CV values show that there are bale samples with extreme fiber strength in the same year and the same region. The most obvious proof of this is the extreme values above the average in 2019, especially in the Great Meander basin (maximum 37.25 g tex^{-1}).



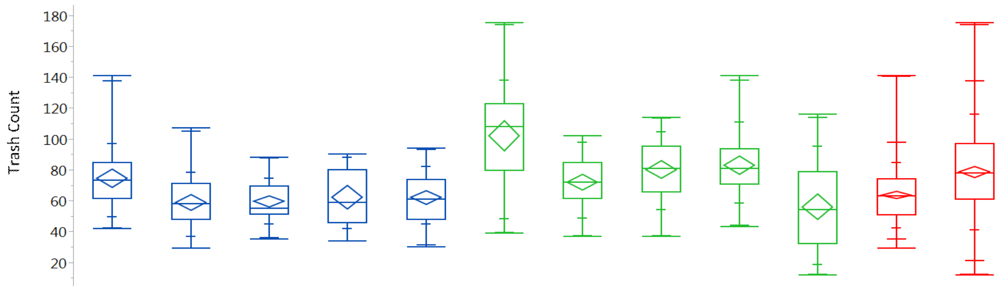
	Great Meander (2019)	Bakircay (2019)	Gediz (2019)	Little Meander (2019)	Soke (2019)	Great Meander (2020)	Bakircay (2020)	Gediz (2020)	Little Meander (2020)	Soke (2020)	Year (2019)	Year (2020)
Min	28,92	29,24	28,02	29,35	28,11	28,08	28,50	27,83	29,06	28,74	28,02	27,83
Max	32,96	31,81	31,53	32,28	32,88	31,86	31,58	31,90	32,07	31,59	32,96	32,07
Mean	30,54	30,33	30,09	30,61	30,77	30,14	29,82	29,89	30,52	30,09	30,45	30,09
SE	0,14	0,09	0,12	0,16	0,13	0,14	0,09	0,12	0,12	0,11	0,06	0,05
CV	3,01	2,08	2,56	2,39	2,80	3,09	2,01	2,68	2,52	2,36	2,69	2,66

	Great Meander (2019)	Bakircay (2019)	Gediz (2019)	Little Meander (2019)	Soke (2019)	Great Meander (2020)	Bakircay (2020)	Gediz (2020)	Little Meander (2020)	Soke (2020)	Year (2019)	Year (2020)
Min	4,57	4,12	4,22	3,97	4,39	4,22	4,55	4,36	4,13	4,47	3,97	4,13
Max	5,44	5,61	4,97	5,13	5,30	5,92	5,32	5,64	5,32	5,49	5,61	5,92
Mean	4,92	4,82	4,68	4,62	4,82	5,09	4,90	4,96	4,82	4,93	4,79	4,94
SE	0,03	0,04	0,02	0,07	0,04	0,06	0,03	0,04	0,04	0,03	0,02	0,02
CV	4,47	5,60	3,42	6,71	4,77	7,66	4,29	5,44	5,60	4,26	5,43	5,87

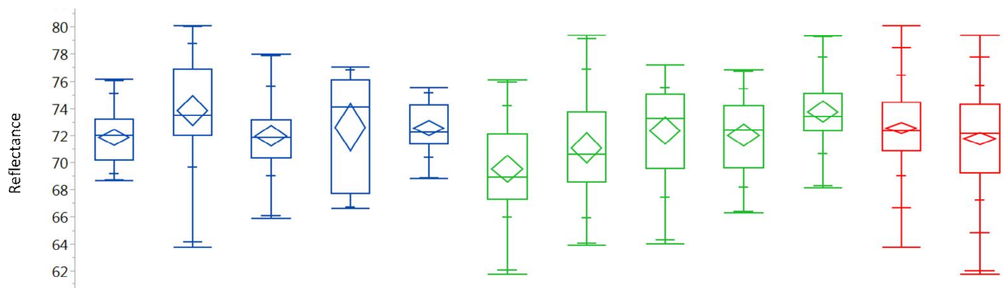
	Great Meander (2019)	Bakircay (2019)	Gediz (2019)	Little Meander (2019)	Soke (2019)	Great Meander (2020)	Bakircay (2020)	Gediz (2020)	Little Meander (2020)	Soke (2020)	Year (2019)	Year (2020)
Min	28,50	29,58	27,71	28,66	27,68	27,80	27,96	28,43	30,71	28,19	27,68	27,80
Max	37,25	35,81	34,94	35,08	34,50	34,96	36,35	34,79	37,20	35,65	37,25	37,20
Mean	31,68	32,16	31,20	31,48	31,42	31,93	32,48	31,86	33,36	32,20	31,60	32,36
SE	0,28	0,24	0,23	0,40	0,24	0,21	0,26	0,21	0,21	0,28	0,12	0,11
CV	5,97	5,10	4,97	5,94	5,09	4,45	5,30	4,39	4,17	5,87	5,41	5,13

Figure 3. Box plot with standard error and basic statistics for fiber length, micronaire and fiber strength in basins over two years.

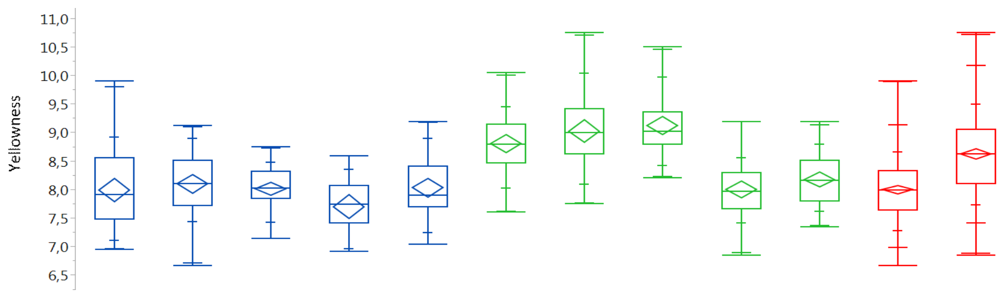
Reflectance (Rd) and yellowness (+b) affected by both genotype and environment are two important factors that determine the fiber color grade in cotton [33]. The reflectance scale is between +40 (darker) and +85 (lighter/brighter) [24]. In studies from different regions, reflectance values changed from 72.28 to 74.50 in Southeastern Anatolia of Türkiye [34], and from 71.5 to 73.3 in Thrace, Macedonia, Central Greece and Thessaly of Greece [14]. Our results indicated that Rd values fluctuated from 69.62-71.0 (Great Meander and Bakırçay in 2020) to 73.74 (Söke in 2020)- 73.82 (Bakırçay in 2019) (Figure 4). CV value showed higher values in both years in the Bakırçay basin, whereas the CV value of Great Meander was low in 2019 but high in 2020. It could be concluded that both the environmental effect and the interaction of the environment with the year (season) were the important source of variance for reflectance (Rd). Minimum values such as 61.72 and 63.72 indicated that exposure to sunlight for a long time can reduce the reflectance value in some areas [34].



	Great Meander (2019)	Bakircay (2019)	Gediz (2019)	Little Meander (2019)	Soke (2019)	Great Meander (2020)	Bakircay (2020)	Gediz (2020)	Little Meander (2020)	Soke (2020)	Year (2019)	Year (2020)
Min	42	29	35	34	30	39	37	37	43	12	29	12
Max	141	107	88	90	94	175	102	114	141	116	141	175
Mean	74,42	58,85	59,62	62,18	62	101,98	71,89	80,00	83,02	56,04	63,56	78,58
SE	2,93	2,51	1,78	3,73	2,26	4,82	4,49	2,83	2,98	4,03	1,21	1,86
CV	26,43	28,65	20,08	28,16	24,48	31,72	23,22	23,74	24,09	48,23	27,09	35,51



	Great Meander (2019)	Bakircay (2019)	Gediz (2019)	Little Meander (2019)	Soke (2019)	Great Meander (2020)	Bakircay (2020)	Gediz (2020)	Little Meander (2020)	Soke (2020)	Year (2019)	Year (2020)
Min	68,66	63,72	65,89	66,62	68,82	61,72	63,90	63,98	66,27	68,11	63,72	61,72
Max	76,15	80,06	77,95	77,04	75,51	76,08	79,36	77,17	76,80	79,29	80,06	79,36
Mean	71,85	73,82	71,97	72,60	72,55	69,52	71,07	72,36	72,00	73,74	72,55	71,74
SE	0,30	0,54	0,37	0,83	0,27	0,48	0,56	0,49	0,41	0,38	0,20	0,23
CV	2,77	4,93	3,47	5,37	2,47	4,63	5,26	4,52	3,82	3,50	3,89	4,75



	Great Meander (2019)	Bakircay (2019)	Gediz (2019)	Little Meander (2019)	Soke (2019)	Great Meander (2020)	Bakircay (2020)	Gediz (2020)	Little Meander (2020)	Soke (2020)	Year (2019)	Year (2020)
Min	6,95	6,66	7,13	6,91	7,04	7,60	7,76	8,20	6,85	7,34	6,66	6,85
Max	9,90	9,11	8,74	8,59	9,19	10,04	10,75	10,50	9,19	9,19	9,90	10,75
Mean	7,98	8,10	8,01	7,70	8,03	8,80	9,02	9,12	8,00	8,17	7,99	8,62
SE	0,10	0,08	0,06	0,10	0,08	0,08	0,10	0,08	0,07	0,07	0,04	0,05
CV	8,40	6,67	4,62	6,23	6,97	6,02	7,32	5,70	6,13	5,39	6,88	8,12

Figure 4. Box plot with standard error and basic statistics for trash count, reflectance and yellowness in basins over two years.

As can be seen in Figure 4, we found the yellowness value (+b) between 7.70 (Little Meander in 2019) and 9.12 (Gediz in 2020). The +b scale is from +4 to +18 with the higher +b indicating an increasing degree of yellow saturation [24]. It was emphasized that the late sowing times increased the yellowness depending on the genotype [34], and the +b value changed from 9.2 to 9.8 [14]. When the maximum yellowness values above 10.0 were evaluated, it was shown that there might be cotton bales in the light yellow class according to Uster Classification. High variation in Great Meander and Bakırçay basins in both years indicated that it is difficult to obtain bales with homogeneous lint color.

Trash is a measure of the amount of non-lint materials in cotton, such as leaf and bark from the cotton plant, and the number of trash particles visible (particle count) is calculated [35]. In our study, the trash count changed from 56.04 (Söke) to 101.48 (Great Meander) in 2020 (Figure 4). Trash count values of Great Meander, Little Meander and Gediz in 2020 were classified as medium, whereas other all environments were in low class according to Uster Classification. Trash count was found between 15.50 and 66.25 depending on the ginning and type [36]. Similarly, it was stated that 66% of cotton in South East Anatolian is in a low class, despite calculating the trash count varying between 12 and 233 [16]. In the present study, the higher CV value (23.22-48.23) indicated a great variable among trash counts of samples and heterogenic bales, especially in Söke and Great Meander basins.

It is seen in figure 5 that it has similar properties except for trash count, with non-significant differences between regions. The trash count value of the Great Meander basin is higher than the other 4 regions. In the other 4 regions, it is seen that the trash count has decreased significantly in Söke. Trash counts were found to vary between 36.56 and 88.48 [16], whereas this amount is between 38.3 and 53.2 according to [14]. It can be said that the higher trash counts found in our study are due to incorrect harvest management such as early harvest after defoliant use. In many studies carried out, untimely defoliant application [42], weed problems [43] and late flowering [14] have been shown as the cause of the trash count. Great Meander Basin had the lowest humidity during the harvest season in September and October of both years (Figure 2). It was speculated that low humidity could decrease defoliant absorption and therefore the amount of leaf trash could increase.

Figure 5. The differences among basins for investigated characters on radar plot.

(FL: Fiber length; FF: Fiber fineness; FS: Fiber strength; Rd: Reflectance degree; b: Yellowness)

4. CONCLUSION

This study clearly demonstrates that although fiber length, fineness, strength and lint color parameters of different growing areas in the Aegean Region were within commercial limits, trash count had an important problem in terms of yarn technology (Figure 5). Although it is difficult to say that each region produces cotton of significantly different quality, the fiber quality characteristics of cotton obtained from the Little Meander and Söke basins were particularly superior but the Great Meander basin had lower quality fibers.

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