Yield and Yield Parameters of 46 Cotton (*Gossypium spp.*) Cultivars under Kahramanmaras (Turkey) Conditions

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Abstract**—** *Variety yield and adaptation studies are of great importance in increasing cotton production and cultivation. This work was carry out to determine yield(seed cotton and fiber) and yield parameters (plant height, sympodial branches, boll number, seed cotton weight, 100 seed weight and ginning outturn) of 46 cotton genotypes, two of which belong to barbadense and forty-four of hirsutum species, under east Mediterranean ecological conditions of Kahramanmaras – Turkey in 2013 and 2014. According to the analysis of variance yield and yield parameters showed significant differences between genotypes. Year and genotype-year interactions were not significant for all characteristics studied. Based on two-year average results, cotton cultivars BA-119, ST-468 and Furkan gave higher seed cotton and fiber yield per hectare than the others. Minimum seed cotton and fiber yield was observed in Maydos. Cotton varieties BA-119, ST-468 and Furkan can be recommended to cotton producers for production regions due to their high seed cotton and fiber yield*.

Keywords**— *Seed cotton yield, fiber yield, yield parameters.***

I. INTRODUCTION

The cotton plant is of great economic importance for country producers with its value and employment opportunities. Cotton is used by the gin industry, fiber and textile industry in terms of processing, and cotton seed that contains a significant amount of oil is the raw material of the feed industry. Cotton has an important place in Turkish agriculture and economy. Although Turkey 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. According to the average data of the last three years in Turkey, 499.452 hectares of cotton was cultivated and 2.400.000 tons of seed cotton was produced (Anonymous, 2019). Turkey's cotton fiber consumption has increased with advances in textile sectors and has reached 1.6 million tons per year. For cotton producers, cotton varieties must be highly yielding and well adapted to environmental conditions. For consumers, it must have quality fibers. The choice of cotton produced in our country by the domestic industry depends on their high fiber yields as well as their quality parameters such as length, fineness and strength at an acceptable level. For this reason, intense studies are carried out to improve cotton yield and quality parameters (Alam et al., 1991; Dolancay et al., 2015; Sullu et al., 2015; Cicek et al., 2015; Ogur et al., 2015; Tekeli et al., 2015; Cicek and Coban, 2017; Killi et al., 2019; Killi and Beycioglu, 2020a). Additionally, production and adaptation studies are performed to determine high yield and quality cotton varieties and lines suitable for production regions (Kıllı and Aloglu, 2000; Sivaslıoglu and Görmüş, 2001; Ünay et al., 2001; Dolancay et al., 2015; Kocturk et al., 2015; Sullu et al., 2015; Cicek et al., 2015; Ogur et al., 2015; Tekeli et al., 2015; Karademir et al., 2015; Cicek and Coban, 2017; Killi and Beycioglu, 2020b).In this study, it was aimed to determine yield and yield parameters of 46 cotton varieties under Kahramanmaras– Turkey ecological conditions.

II. MATERIALS AND METHODS

Forty-six different cotton genotypes (Table 1), two of which belong to *barbadense* and forty-four of *hirsutum* species, were grown during the 2013 and 2014 growing seasons in Kahramanmaras, which is located in the Eastern Mediterranean region of Turkey (between 37º 36' north parallel and 46º 56' east meridians). The soils where the experiment was established are alluvial soils carried by rivers and they are deposited horizontally in different layers. The slope of the land is close to flat, deep, good drainage, clayey-loam body and first class agricultural land. The pH of the experimental area soils is 7.5, slightly alkaline, lime content is high (20.24 %) and organic matter content (0.96 %) is very low (Anonymous, 2013). Kahramanmaras province has typical Mediterranean climatic conditions with hot and dry summers and mild, rainy winters. Climatic data were obtained at the nearest climate station placed about 5 km from the experimental area. Mean temperature, total rainfall, and humidity are given in Table 2.

TABLE 1
COTTON GENOTYPES USED IN THE STUDY

Genotype number	Genotype name	Genotype number	Genotype name	Genotype number	Genotype name
1	ST-468	17	Beli İzvor-432	33	Cosmos
2	ST-488	18	Carmen	34	Özbek-100
3	Primera	19	Neli	35	Hersi
4	Gaia	20	ST-453	36	Samon
5	Nazilli-87	21	Baly-308	37	GSN-12
6	Taşkent-1	22	Flash	38	Dicle-2002
7	Eisa	23	Julia	39	Famosa
8	Flora	24	İs-1	40	Veret
9	Candia	25	Urania	41	Gosipolsüz-86
10	Sahel-I	26	Orgost-644	42	Tamcot-24
11	Gedera-10	27*	Giza-45	43	MaydosYerlisi
12	BA-119	28	Bulgar-33	44	BA-525
13	Cascot-2910	29	Gacot-79	45	Gloria
14	ST-373	30	Fibermax-832	46	Furkan
15	Aleppo-1	31*	Giza-70		
16	Zeta-2	32	Claudia		

) barbadense cotton cultivars.

TABLE 2
SOME CLIMATOLOGICAL DATA OF THE RESEARCH LOCATION IN 2013 - 2014

Months	Mean temperature (°C)		Relative humidity (%)		Rainfall (mm)	
	2013	2014	2013	2014	2013	2014
April	17.2	15.6	51.9	32.7	65.9	45.4
May	22.2	16.1	51.0	41.3	76.5	52.8
June	25.6	20.4	41.5	44.9	16.3	19.8
July	28.8	26.0	35.4	34.9	0.0	1.0
August	27.0	26.7	52.0	44.4	0.0	0.9
September	24.8	19.4	40.0	46.7	37.9	44.6
October	17.5	12.5	32.8	30.7	35.1	37.6

Average air temperature during the growing season changed from 17.2°C (April) to 28.8°C (July) in 2013, and from 12.5°C to 26.7°C in 2014, respectively. 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 May, and this was followed by April. There was an extended dry and hot period during July and August when only an average of 1.9 mm precipitation occurred. September was warm, with 37.9 mm and 44.6 mm of rainfall, for 2013 and 2014, respectively.

The experimental design was a randomized complete block with three replications. Genotypes, consisting of one rows 5.0 m long with 0.70 m spacing between rows, were planted on 10 May 2013 and 2014. These genotypes were initially over-seeded and then hand-thinned to the desired intra-row spacing of 0.20 m. Recommended insect and weed control methods were employed during each growing season as needed. Each year, 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 6 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 study seed cotton and fiber yield, yield components (plant height, sympodial branches, boll number, seed cotton weight, 100 seed weight and ginning outturn) were investigated. At harvesting time, 10 randomly tagged plants from each plot were evaluated plant height, sympodial branches and boll number. Seed cotton weight and 100 seed weight were determined as the average number of studying on seed cotton samples of the harvested twenty bolls in each plot. 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 lint. Fiber yield was calculated as: [ginning outturn X seed cotton yield]. Analysis of variance was performed for each characteristic by the MSTAT-C statistical program and where F- test indicated significant effects ($p<0.05$), means were separated using Duncan test.

III. RESULTS AND DISCUSSION

From the analysis of variance (Table 3), plant height (PH), sympodial branches (SB), boll number (BN), seed cotton weight (SCW), 100 seed weight (SW), ginning outturn (GO), seed cotton yield (SCY) and fiber yield(FY) showed significant differences between genotypes. Year and genotype-year interactions were not significant for all characteristics studied, indicating that genotypes responded similarly to the years.

TABLE 3
RESULTS OF VARIANCE ANALYSIS FOR YIELD AND YIELD PARAMETERS

Source of variation	PH	SB	BN	SCW	SW	GO	SCY	FY
G[a]	**	*	*	**	*	**	**	**
Y[b]	NS[d]	NS	NS	NS	NS	NS	NS	NS
G x Y[c]	NS	NS	NS	NS	NS	NS	NS	NS

[a]G, genotypes; [b]Y, years; [c]GxY, genotype x year interactions; [d]NS, Non significant at the 0.05 probability level.
*,**Significant at the 0.05 and 0.01probability level.

PH: Plant height; SB: Sympodial branches; BN: Boll number; SCW: Seed cotton weight; SW: 100 seed weight; GO: Ginning outturn; SCY: Seed cotton yield; FY: Fiber yield

3.1 Yield components

Differences in plant height among cultivars are presented in Table 4. Two year average plant height values of genotypes were ranged from 68.32 cm to 107.37 cm. Maydos gave the maximum plant height (107.37 cm), followed by Baly-308 (105.73 cm) and Giza-45 (104.71 cm), and minimum plant height (68.32 cm) was recorded in Candia. In some of studies related with cotton genotypes in similar ecological conditions, Kaynak et al. (1997), Mert and Bayraktar (1997) and Yılmaz (1997) reported that plant height values of cotton cultivars ranged from 70.35 cm to 129.50 cm. These differences are due to variability in environmental conditions and genetic makeup [Usman et al. 2017]. Our results are also in accordance with Mert and Bayraktar (1997) and Bibi et al. [2011], they reported that cotton cultivars significantly differed in plant height and this difference might be due to cultivar behavior and ecological conditions. The sympodial branches were significantly changed in cotton genotypes with values from 4.62 to 9.75 when averaged across cultivars (Table 4). The highest sympodial branches was obtained from the Giza-45 while the lowest value was obtained Is-I genotype. Shape of plant, position of levels and branches are traits that affect crop productivity (McGarry et al. 2016). Ahmad et al. (2009) stated that sympodial branches changed in cotton cultivars. Similar findings with cotton were also reported by Kaynak et al. (1997).

Variance analysis table shows significant ($P\leq0.05$) differences among genotypes for boll number per plant while non-significant difference was observed in year and interaction (Table 3). Two year average boll number per plant values of genotypes were ranged from 4.37 to 11.05 (no, $plant^{-1}$). Furkan gave the maximum boll number per plant (11.05 no, $plant^{-1}$), followed by ST-468 (10.87no, $plant^{-1}$) and BA-119 (10.67 no, $plant^{-1}$), and minimum boll number per plant (4.37 no, $plant^{-1}$) was recorded in Is-I variety. In some of studies related with boll number per plant, Khan et al. (2007), 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. Highly significant ($P\leq0.01$) differences were recorded in genotypes for seed cotton weight whereas year and interaction was non-significant.

TABLE 4
TWO YEAR AVERAGE VALUES OF INVESTIGATED PARAMETERS OF COTTON CULTIVARS

Cultivars	PH	SB	BN	SCW	SW	GO	SCY	FY
ST-468	80,60	7,20	10,87	4,89	9,37	41,17	4255,3	1770,4
ST-488	80,79	8,15	8,95	5,85	11,10	40,44	4049,7	1637,7
Primera	88,85	9,32	5,70	4,42	9,61	42,12	2016,3	849,1
Gaia	78,38	8,27	8,52	5,36	9,97	40,81	3218,9	1313,5
Nazilli-87	86,38	6,25	5,05	6,13	12,20	36,53	2479,5	901,1
Taşkent-I	82,22	5,85	5,87	4,91	11,02	36,31	2224,2	807,7
Eisa	79,26	5,72	6,35	4,59	10,02	39,76	2328,2	926,9
Flora	76,41	7,42	6,45	5,71	10,74	39,38	2757,8	1086,3
Candia	68,32	6,12	6,82	4,69	10,02	42,57	2562,8	1091,0
Sahel-I	87,28	6,20	7,17	5,38	11,18	36,35	3164,1	1150,1
Gedera-10	95,44	8,15	6,15	5,85	13,05	38,67	2932,5	1133,9
BA-119	80,85	8,55	10,67	5,11	10,44	41,89	4246,9	1779,2
Cascot-2910	76,12	7,60	5,40	5,15	10,60	37,09	2014,8	780,7
ST-373	78,95	6,72	9,10	5,03	11,87	40,28	3729,6	1502,2
Aleppo-I	86,82	6,50	5,05	5,18	12,40	34,68	2094,8	726,5
Zeta-2	89,82	5,57	5,87	5,99	12,59	37,37	2626,4	981,5
Beli İzvor-432	94,75	5,35	6,87	4,76	10,86	35,87	2348,3	842,1
Carmen	79,00	5,12	8,60	5,26	10,51	39,82	3615,5	1441,5
Neli	80,41	5,25	4,87	5,34	10,63	37,28	2081,0	775,6
ST-453	86,28	8,15	7,50	5,19	10,94	39,03	3116,9	1210,8
Baly-308	105,73	8,12	7,82	5,24	11,47	37,83	3193,1	1207,4
Flash	81,71	5,50	6,90	4,75	9,34	41,39	2622,8	1087,0
Julia	70,96	5,37	6,35	5,16	10,27	39,96	2602,7	1040,0
Is-I	83,45	4,62	4,37	5,32	12,83	37,71	1859,8	701,3
Urania	83,30	5,85	6,67	6,06	12,52	37,19	3235,7	1203,6
Orgost-644	92,81	5,00	6,02	4,55	10,75	35,58	2195,5	781,2
Giza-45	104,71	9,75	8,05	4,89	11,51	33,13	3008,4	996,6
Bulgar-33	92,58	6,47	5,20	4,94	9,64	30,64	2057,1	630,2
Gacot-79	86,59	6,37	5,10	5,02	9,88	37,64	2048,1	770,7
Fibermax-832	76,82	5,67	6,85	5,48	10,86	39,11	3004,0	1174,8
Giza-70	83,80	5,22	6,90	4,61	9,72	37,06	2631,2	975,0
Claudia	70,36	5,57	6,07	5,05	9,62	42,15	2455,4	1034,9
Cosmos	72,53	5,15	6,10	4,74	10,25	40,13	2200,8	884,2
Özbek-100	77,00	4,92	7,07	4,48	10,68	37,99	2563,2	973,6
Hersi	75,32	6,50	5,05	5,45	11,04	38,73	2238,8	867,1
Samon	95,32	8,17	5,20	4,75	11,89	37,56	2021,6	759,2
GSN-12	90,80	8,77	7,07	5,77	10,62	41,73	3229,5	1347,4
Dicle-2002	93,62	6,85	7,22	4,76	10,57	38,94	2794,4	1071,3
Famosa	83,36	7,07	9,35	4,68	10,30	39,92	3516,3	1403,9
Veret	96,45	6,95	5,67	5,22	13,23	39,72	2369,4	941,0
Gosipolsüz-86	95,17	6,82	6,02	5,49	10,49	40,37	2646,0	1068,5
Tamcot-24	100,67	7,62	6,05	5,27	10,95	37,93	2554,2	969,3
Maydos	107,37	6,62	4,05	4,86	11,12	28,57	1574,5	449,7
BA-525	77,92	6,90	7,07	6,02	9,95	40,61	3410,3	1385,2
Gloria	80,73	7,60	8,00	4,91	10,04	40,86	3145,6	1285,4
Furkan	91,67	8,20	11,05	5,09	11,67	38,94	4497,1	1701,1
Average	85,38	6,72	6,81	5,16	10,87	38,45	2772,6	1074,3

PH: Plant height (cm), SB: Sympodial branches (no. plant^{-1}), BN: Boll number (no, plant^{-1}), SCW: Seed cotton weight (g, boll^{-1}), SW: 100 seed weight (g), GO: Ginning outturn (%), SCY: Seed cotton yield (kg, ha^{-1}) and FY: Fiber yield (kg, ha^{-1}).

Two year average seed cotton weight values of genotypes were ranged from 4.42 to 6.13 g. Maximum seed cotton weight was observed in N-87 followed by Urania and BA-525 while minimum seed cotton weight was observed in Primera. Seed cotton weight is directly related to the seed cotton yield (Usman et al., 2017). The differences among cultivars for seed cotton weight per boll might have been due to the difference in genetic potential of the cultivars. The significant differences among varieties for seed cotton weight per boll had also been reported by Ehsan et al. (2008).

Significant differences in 100 seed weight of genotypes were observed (Table 3) and two year average 100 seed weight of genotypes varied from 9.37 to 13.23 g (Table 4). Veret (13.23 g) and Gedera-10 (13.05 g) gave higher 100 seed weight than the weight of other genotypes. The lowest 100 seed weight values were obtained from Flash (9.34 g) and ST-468 (9.37 g). Genotypes differed in the ginning outturn with values varying from 28.57 to 42.57 %. Candia cultivar showed the highest ginning outturn, while Maydos cultivar showed the lowest. Ginning outturn values of 14 cultivars (ST-468, ST-488, Primera, Gaia, Candia, BA-119), ST-373, Flash, Claudia, Cosmos, GSN-12, Gosipolsüz-86, BA-525 and Gloria) were over 40%. Ahuja et al. (2018) reported that ginning outturn values of cotton cultivars ranged from 32.73 to 40.60 %.

3.2 Seed cotton and fiber yield

Results of variance analysis table shows highly significant ($P \leq 0.01$) differences among varieties for seed cotton and fiber yield while non-significant difference was observed in year and interaction (Table 3). All cultivars produced similar response from year to year in seed cotton and fiber yield, so the cultivar-year interaction was not significant. According to two-year results genotypes responded differently in terms of yield. Maximum seed cotton yield was observed in Furkan with 44097.1 kg ha^{-1} followed by ST-468 and BA-119 in which seed cotton yield was 4255.3 and 4246.9 kg ha^{-1} respectively. Minimum seed cotton and fiber yield was observed in Maydos with 1574.5 and 449.7 kg ha^{-1} respectively. Low boll number per plant and ginning outturn caused a decrease in yield of Maydos variety. Maximum fiber yield was obtained from BA-119 (1779.2 kg ha^{-1}), ST-468 (1770.4 kg ha^{-1}) and Furkan (1701.1 kg ha^{-1}), respectively. These three genotypes (BA-119, ST-468 and Furkan) showed high yield potential, while two genotypes (Maydos and Is-I) showed very low 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 BA-119, ST-468 and Furkan varieties is due to their high number of 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.

IV. CONCLUSION

In this experiment, which was carry out under Kahramanmaras (Turkey) province condition to find out the yield and yield components of 46 cotton genotypes, demonstrated that all investigated characteristics were significantly affected by genotypes. Among the investigated cultivars, plant height of 68.32-107.37 cm, number of sympodial branches per plant of 4.62-9.75, boll number per plant of 4.37-11.05, seed cotton weight per boll of 4.42-6.13 g, 100 seed weight of 9.37-13.23 g, ginning outturn of 28.57-42.57 %, seed cotton yield of 1574.5-4497.1 kg ha^{-1} and fiber yield of 49.7-1779.2 kg ha^{-1} were changed. Overall, genotypes BA-119, ST-468 and Furkan showed best performance and found more adaptive to the growing conditions.

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