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Comparisons of yield, yield components and fiber technological characteristics of modern cotton varieties

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Abstract: This study was carried out to determine yield, yield components, and fiber quality characteristics of some modern cotton varieties and also to find out their improvement compared to control varieties in terms of investigated traits in the 2015 and 2017 cotton growing season. In the study, 10 genotypes (8 modern cotton varieties which registered after 2010 and two check varieties) were used as plant materials. There were significant differences between varieties in terms of first picking percentage, ginning percentage, plant height, date of first flowering, number of the node to first fruiting branch, number of monopodial branches, boll weight, seed cotton weight, number of seeds per boll, fiber fineness, length, strength, elongation, and uniformity, while non-significant differences were obtained for seed cotton yield, number of sympodial branches, number of boll per plant and short fiber index. Besides, year differences were significant for seed cotton yield, first picking percentage, plant height, date of first flowering, number of the node to first fruiting branches and fiber fineness. A year and variety interactions were also significant for the date of first flowering, fiber length, strength, elongation, and uniformity. In conclusion, there was an improvement in used modern cotton varieties for ginning percentage, plant height, first picking percentage, date of first flowering, number of the node to first fruiting branch, number of monopodial branches, boll weight, seed cotton weight of per boll, number of seeds per boll, fiber fineness, length, strength, and elongation, while they showed similar values in terms of seed cotton yield, number of bolls per plant, number of sympodial branches, fiber uniformity ratio, and short fiber index.

Keywords: cotton; modern variety; yield; fiber technological characteristics; adaptation ability

1. Introduction

Cotton is one of the most important crops of our country and it has been used widely in agriculture and industry. Turkey is one of the major cotton producing countries with a total of 500,000 ha area of cotton cultivated land and 882.000 tons of total fiber production [1]. Due to its selectiveness in terms of climatic characteristics, cotton can be grown in limited areas in Turkey. Therefore, in our country cotton is grown in three regions Southeastern Anatolia, Aegean, and Mediterranean (Cukurova), respectively. Southeast Anatolia Region is the biggest cotton planted area with 293.000 ha which constitutes approximately 60% of the total planted area of the country. However, because the local cotton lint production is not sufficient to meet the ever increasing demands of the textile industry, Turkey imports about 800.000 tons of cotton lint per year. The prerequisite for successful cotton cultivation and high productivity starts with a selection of varieties and continues with the effectiveness of the cultural practices applied to the variety. Climatic conditions are also important factors in reaching the desired level of yield and fiber quality values. Yield and fiber quality characteristics emerge with the interactions of all these factors. In the studies, it was reported that 48% of genetics, 28% crop management, and 24% of the variety × crop management interaction were effective on net yield increase [2]. Raper et al. [3], revealed that environment dominated factors for lint yield, lint percentage, micronaire, length, and uniformity. The fact that climate factors play an important role in yield and fiber quality traits make it necessary to carry out variety yield trial and adaptation studies in the regions where varieties will be grown. Compared to other countries in the world, our country is one of the leading countries with its cotton production and cotton yield. Turkey ranks second after Australia in cotton yield. In Turkey, with cotton breeding researches significant progress has been achieved in terms of yield and fiber quality. In 1980, fiber yield which is 800 kg ha^{-1} increased and reached to 1850 kg ha^{-1} by the year of 2017. Increases in the use of certified seeds over the years have also helped increase yields. According to Variety Registration and Seed Certification Center 168 cotton varieties released so far [1]. In the last 30 years in Australia, it has been reported that an average annual yield of 1.8% is achieved, and the increase in yield is due to the increase in the number of bolls in m^2 and the increase in fiber rate [4] and modern varieties have improved physiological responsiveness at ideal temperatures [5]. Bridge and Meredith [6], reported that a mean annual genetic gain for fiber yield was 9.5 kg ha^{-1}. Wells and Meredith [7], revealed that the yield advantage of modern cotton varieties compared to obsolete varieties is the increasing number of bolls per square meter while reducing boll weight. However, Karademir et al. [1] reported that non-significant differences due to variety indicated that the genetic constitution of new varieties developed and approved for general cultivation has not improved for seed cotton yield. Similar results have been reported that year to year variability in yield of modern cotton cultivars is due to modern cultivars being more sensitive to environmental stress conditions compared to obsolete cultivars [8]. By carrying cotton breeding investigations in our country improvements in yield and fiber quality have been achieved, however, cotton production can meet only 50% of country requirement. The main objective of many breeding programs is improving yield and quality of cotton. The aim of this study is to determine adaptation ability of modern cotton varieties, registered after 2010, under Southeastern Anatolia Region ecological conditions; to determine yield, yield components and quality characteristics; to compare their yield and quality characteristics by standard varieties and finally to observe their current improvement.

2. Materials and Methods

In this research, 10 different cotton varieties were used as material. The first 8 of these varieties are modern (current) cotton varieties (PG 2018, Gaia, Kartanesi, İpek 607, Carisma, BA 440, Lydia, Naz) which are registered after 2010 and 2 varieties (Stoneville 468 and BA119) were used as control (check) varieties in the experiment. Information on the registration years of these varieties is given in Table 1.

Table 1. Information about registration years of varieties used as material.

Varieties	Year of registration
PG 2018	2011
GAIA	2012
KARTANESİ	2011
İPEK 607	2012
CARİSMA	2013
BA 440	2014
LYDIA	2012
NAZ	2015
STV 468 (Control)	2006
BA 119 (Control)	2004

This study was carried out at Siirt University, Department of Field Crop's experimental area in a randomized complete block design with four replications in the 2015 and 2017 cotton growing season. Siirt province is located in the Southeastern Anatolia Region of Turkey. It has a continental climate and the summer is hot and arid in this province. Summer crops cannot be grown without irrigation. Climatic data of the experimental area during two years (2015 and 2017) and average climatic data of the long term period and soil characteristics of the experimental area were given in Table 2 and Table 3, respectively.

From Table 2, it can be seen that the average temperature of two years is higher than that of the long term period. The soil characteristics of the experimental area are slightly alkaline, poor organic matter, saltless, limy, lack of nitrogen and phosphorus, adequate for iron and copper, and high in terms of potassium. This area's water holding capacity is high, it is almost flat, heavy clay and has 1% silt. The plots consisted of four rows of 12 m length. Between and within the row spacing were 70 and 15-20 cm, respectively. The planting was performed on 8 May 2015 and 11 May 2017 with a trial sowing machine.

Table 2. Climatic data belong to the growing season and long-term period.

Months	**Average Temperature (°C)**			**Minimum Temperature (°C)**			**Maximum Temperature (°C)**			**Rainfall (mm)**			**Relative Humidity (%)**		
	2015	**2017**	**Long Term**	**2015**	**2017**	**Long Term**	**2015**	**2017**	**Long Term**	**2015**	**2017**	**Long Term**	**2015**	**2017**	**Long Term**
April	13.6	14.0	13.8	3.1	4.3	8.9	24,5	25.9	19.1	53.8	132.8	105.1	56.2	59.5	57.5
May	20.6	19.5	19.2	9.8	10.1	9.0	33.0	32.0	36.1	29.6	74.6	66.8	41.2	51.7	50.1
June	27.1	26.9	25.9	15.8	12.8	17.8	37.2	39.8	40.2	3.6	0.0	9.3	27.7	29.5	34.1
July	32.0	32.3	30.5	19.5	22.1	23.4	43.2	41.2	44.4	0.1	0.0	1.6	19.9	19.0	26.6
August	31.0	32.0	30.0	19.4	21.5	27.0	41.9	42.9	46.0	2.4	0.4	0.9	23.5	19.0	25.7
September	27.8	28.4	25.0	18.6	17.2	14.7	38.4	39.5	39.9	0.1	0.0	5.2	24.1	19.1	30.9
October	18.5	18.4	17.9	8.5	9.8	12.7	31.1	28,4	36.6	189.6	5.2	48.8	58.3	34.6	46.5

Table 3. Soil characteristics of the experimental area.

Texture	**Clay**	**Description**
pH	7.98	Slightly alkali
EC (mS/cm)	0.363	Saltless
Lime (%$CaCO_3$)	13.02	Limy
Organic matter (%)	1.31	Low
N (%)	0.082	Low
P (ppm)	7.47	Low
K (me/100g)	0.98	High
Fe (ppm)	5.70	Adequate
Cu (ppm)	2.63	Adequate
Zn (ppm)	0.23	Low
Mn (ppm)	6.04	Low

All plots received 140 kg ha^{-1} N and 80 kg ha^{-1} P_2O_5. Half of the N and all P_2O_5 were applied at sowing time and the remaining N was applied before first irrigation at the square stage. Drip irrigation was used for irrigation, irrigation started on 40-45 days after sowing and terminated at a

10% boll opening stage. Plots were harvested twice by hand for yield determination on 13 October 2015 and second on 5 November 2015 in the first year and 2 October 2017 and second on 25 October 2017 in the second year. Fiber samples were taken from first picking cotton and analyzed for fiber quality characteristics. Fiber quality analysis for each treatment after ginning was determined using (HVI) high volume instrument system.

Statistical analysis was performed using the analysis of variance procedure (ANOVA) in JMP 5.0.1 statistical software (SAS Institute, Cary, NC). Means were separated using Fisher's protected least significant difference ($LSD_{0.05}$).

3. Results and Discussion

The differences between investigated traits and LSD ($_{0.05}$) test results given in Tables 4-12.

Table 4. Mean values and statistical groups of seed cotton yield and first picking percentage[1].

Varieties	Seed Cotton Yield (kg ha^{-1})			First Picking Percentage (%)		
	2015	2017	Mean	2015	2017	Mean
1. PG 2018	3456.87	4950.59	4203.73	80.32	91.67	85.99^{bcd}
2. GAIA	2839.04	4240.47	3539.76	77.45	85.23	81.34^{d}
3. KARTANESI	3423.51	4219.34	3821.42	85.42	94.64	90.03^{abc}
4. IPEK 607	2953.15	4112.79	3532.97	90.95	94.01	92.48^{a}
5. CARISMA	2989.55	4623.21	4056.38	80.75	89.47	85.11^{bcd}
6. BA 440	3085.14	4861.30	4223.22	82.11	89.14	85.62^{bcd}
7. LYDIA	3289.82	4704.76	3997.29	82.84	86.03	84.44^{cd}
8. NAZ	3120.32	4579.46	3849.89	86.97	94.81	90.89^{ab}
9. STV 468 (Control)	3593.18	4758.92	4176.05	83.71	91.62	87.66^{abc}
10. BA 119 (Control)	2949.01	4700.00	4074.50	82.45	88.07	85.26^{bcd}
Mean	**3319.96^{b}**	**4575.08^{a}**		**83.30^{b}**	**90.47^{a}**	**86.88**
CV (%)		17.70			6.91	
Variety ($LSD_{0.05}$)		ns			6.00**	
Year ($LSD_{0.05}$)		596.89**			3.14**	
Var × Year ($LSD_{0.05}$)		ns			ns	

[1] ns: non significant; * and **, significantly different from zero at p <0.05 and p<0.01.

Seed Cotton Yield (kg ha^{-1})

The differences between the varieties and varieties × years concerning seed cotton yield was non-significant. Seed cotton yield of varieties changed from 3532.97 kg ha^{-1} to 4223.22 kg ha^{-1}. Although there were non-significant statistical differences among varieties, the highest yield obtained from BA 440 (4223.22 kg ha^{-1}), PG 2018 (4203.73 kg ha^{-1}) and Stv 468 (4176.05 kg ha^{-1}). Year differences were highly significant (p<0.01) for this trait. In 2015 average yield was 3319.96 kg ha^{-1}, while it was 4575.08 kg ha^{-1} in 2017. In the second year of the study, the higher yield was obtained. This may be due to climate and cultural practices in different years. Raper et al. [3], reported that about 70% of the variation in yield from year to year is dependent upon the environment and only 30% of the variation is subject to management. When comparing BA 440 modern cotton variety's yield (4223.22 kg ha^{-1}) with control variety Stv 468, which has the highest yield (4176.05 kg ha^{-1}), there was 47 kg ha^{-1} yield differences. Culp and Green [9], evaluated 29 commercial cultivars and Pee Dee (PD) germplasm lines of cotton (*G. hirsutum* L.), 12 modern and 17 obsolete, they sought to determine what genetic improvements the new cultivars and germplasm lines had compared with the obsolete ones. Two modern cultivars, McNair 235 and SC-1 (a PD cultivar with extra fiber strength genes) produced 399 kg ha-1 more lint than the obsolete cultivar, Earlistaple 7, and 522 kg ha^{-1} more than the PD germplasm line F. The rate of gain in yield of modern compared with obsolete cultivars and PD germplasm lines was 10.5 and 15.1 kg ha^{-1} per year, respectively. The actual rate of gain in related PD germplasm lines was 20.6 kg ha^{-1} per year. They reported that cotton breeders have made continuous progress in improving lint yield, without sacrificing fiber quality. New cultivars, improved management, and their interactions are key drivers of yield progress in field crops [2]. Meredith et al. [10] demonstrated that modern cultivars showed higher responses to increased nitrogen application and in turn higher genetic gain estimates when grown with treatment levels of nitrogen equal to today's commercial usage. Heitholt et al. [11] reported that modern cotton varieties had a higher yield than obsolete ones. Meredith et al. [10] indicated that they did not determine a significant yield difference between modern and old varieties. Brown et al. [12] reported that no significant differences between modern and obsolete cotton cultivars in terms of leaf photosynthesis of leaf temperature. These results are complying with the results of this study.

First Picking Percentage (%)

The differences between the varieties and years concerning first picking percentage were significant at a 1% level, while non-significant differences observed for varieties × year interaction. The average first picking percentage of varieties was changed from 81.34 to 92.48%, the highest values obtained from Ipek 607 (92.48%), Naz (90.89%), Kartanesi (90.03%) and Stv 468 (87.66%) and they statistically shared the same group. Gaia variety late matured than other varieties with 81.34% first picking percentage value. When comparing with control variables, which has the highest value (87.66%), Ipek 607 variety increased as 5.5% and reached to 92.48%. Wells and Meredith [13] indicated that modern cotton varieties able to earlier transition to reproductive growth. This result partly supports the result of this study.

Table 5. Mean values and statistical groups of ginning percentage and plant height[1].

Varieties	Ginning Percentage (%)			Plant Height (cm)		
	2015	**2017**	**Mean**	**2015**	**2017**	**Mean**
1. PG 2018	44.25	44.07	44.16^{a}	76.12	93.83	84.97^{bc}
2. GAIA	41.82	41.47	41.65^{d}	65.80	94.20	80.00^{cde}
3. KARTANESI	40.25	41.50	40.87^{e}	81.22	93.74	87.48^{ab}
4. IPEK 607	36.12	36.25	36.18^{f}	67.10	94.81	80.95^{cd}
5. CARISMA	44.00	43.62	43.81^{ab}	70.72	90.74	80.73^{cd}
6. BA 440	43.37	42.62	43.00^{c}	68.50	92.58	80.54^{cd}
7. LYDIA	41.87	42.00	41.93^{d}	66.80	88.99	77.89^{def}
8. NAZ	44.52	44.02	44.27^{a}	81.07	101.58	91.32^{a}
9. STV 468 (Control)	43.87	43.00	43.43^{bc}	61.35	83.58	72.46^{f}
10. BA 119 (Control)	43.00	42.57	42.78^{c}	63.52	85.24	74.38^{ef}
Mean	**42.31**	**42.11**		**70.22^{b}**	**91.93^{a}**	
CV (%)	1.56			6.99		
Variety ($LSD_{0.05}$)	0.66**			5.66**		
Year ($LSD_{0.05}$)	ns			7.78**		
Var × Year ($LSD_{0.05}$)	ns			ns		

[1] ns: non significant; * and **, significantly different from zero at p <0.05 and p<0.01.

Ginning Percentage (%)

From Table 5, it can be seen that there were significant differences between varieties, while non-significant differences for a year and variety × year interactions. The average ginning percentage of varieties varied between 36.18 to 44.27%. The highest values obtained from Naz (44.27%) and PG 2018 (44.16%) and they were in the same statistical groups. The lowest value obtained from Ipek 607 (36.18%). When comparing with the highest control variety Stv 468 (43.43%), Naz variety had a 1.93% higher ginning percentage as 44.27%. The results of this study complied with previous researchers who reported that modern cotton varieties have a higher ginning percentage than obsolete ones [6,14].

Plant Height (cm)

There were significant differences between varieties and years for plant height, while non-significant differences for variety × years. The average plant height of varieties changed from 72.46 to 91.32 cm, the highest plant height was obtained from Naz variety as 91.32 cm, while the lowest plant height was obtained from control variety Stv 468 as 72.46 cm. As seen in Table 2, years differences were statistically significant. The average plant height of 2017 was higher than that of 2015. When comparing with BA 119 (74.38 cm), which has the highest plant height of the control, Naz variety increased as 22.77% and reached to 91.32 cm.

Table 6. Mean values and statistical groups of date of first flowering and node numbers of first fruiting branches [1].

Varieties	**Date of First Flowering (day)**			**Node Number of First Fruiting Branches (Number/plant)**		
	2015	**2017**	**Mean**	**2015**	**2017**	**Mean**
1. PG 2018	65.00^{e-h}	70.50^{a}	67.75^{a}	6.40	7.71	7.05^{a-d}
2. GAIA	63.00^{ghi}	68.75^{abc}	65.87^{a}	5.35	7.19	6.27^{de}
3. KARTANESI	62.00^{i}	63.50^{f-i}	62.75^{b}	5.90	7.74	6.82^{b-e}
4. IPEK 607	62.25^{hi}	61.75^{i}	62.00^{b}	5.50	7.24	6.37^{de}
5. CARISMA	65.50^{d-g}	69.75^{a}	67.62^{a}	6.45	9.08	7.76^{ab}
6. BA 440	66.50^{b-e}	69.00^{abc}	67.75^{a}	5.90	9.16	7.53^{abc}
7. LYDIA	65.75^{d-g}	68.25^{a-d}	67.00^{a}	6.25	8.66	7.45^{abc}
8. NAZ	65.75^{d-g}	66.25^{c-f}	66.00^{a}	6.80	9.08	7.94^{a}
9. STV 468 (Control)	65.00^{e-h}	69.25^{ab}	67.12^{a}	6.00	7.41	6.70^{cde}
10. BA 119 (Control)	65.00^{e-h}	70.00^{a}	67.50^{a}	4.85	7.24	6.04^{e}
Mean	**64.57^{b}**	**67.70^{a}**		**5.94^{b}**	**8.05^{a}**	
CV (%)		2.99			13.59	
Variety (LSD $_{0.05}$)		1.98**			0.94**	
Year (LSD $_{0.05}$)		1.53**			1.26**	
Var × Year (LSD $_{0.05}$)		2.80*			ns	

[1] ns: non significant; * and **, significantly different from zero at p <0.05 and p<0.01.

Date of First Flowering (day)

It can be seen that there were significant differences between varieties in terms of this trait. The average date of first flowering changed from 62.00 to 67.75 days. The earliest varieties were Ipek 607 (62.00 days) and Kartanesi (62.75 days), while the latest were PG 2018 and BA 440. There were significant differences between years and varieties × years. Ipek 607 was 5.12% earlier opened its flower, but some modern varieties have opened their flower later than those of obsolete ones. It was reported that modern varieties have intense flowering and earlier than obsolete varieties [15].

Node Number of First Fruiting Branches (Number/plant)

From Table 6, it can be seen that there were significant differences between varieties and years in terms of this trait, while there were non-significant for varieties × years. The average values were changed from 6.04 (BA 119) to 7.94 number/plant (Naz). In 2015 the average values were 5.94 number/plant, while it was 8.05 number/plant in 2017. Meredith et al. [10] reported that differences between the varieties the same results determined by Hasan et al. [16].

Table 7. Mean values and statistical groups of monopodial branches and sympodial branches[1].

Varieties	Number of Monopodial Branches (Number/plant)			Number of Sympodial Branches (Number/plant)		
	2015	2017	Mean	2015	2017	Mean
1. PG 2018	2.70	2.46	2.58[ab]	11.25	10.64	10.94
2. GAIA	3.30	2.23	2.76[ab]	10.55	12.01	11.28
3. KARTANESI	2.50	2.01	2.25[bc]	12.35	11.69	12.02
4. IPEK 607	1.25	1.43	1.34[d]	11.05	12.31	11.68
5. CARISMA	2.50	2.49	2.49[abc]	11.50	10.66	11.08
6. BA 440	3.25	2.74	2.99[a]	10.65	9.91	10.28
7. LYDIA	2.20	2.83	2.51[ab]	11.15	10.41	10.78
8. NAZ	1.30	2.24	1.77[cd]	12.15	10.91	11.53
9. STV 468 (Control)	2.70	1.99	2.34[abc]	9.60	10.83	10.21
10. BA 119 (Control)	2.80	2.74	2.77[ab]	10.40	10.58	10.49
Mean	**2.45**	**2.32**	**2.38**	**11.06**	**10.99**	**11.03**
CV (%)		30.25			10.97	
Variety ($LSD_{0.05}$)		0.72**			ns	
Year ($LSD_{0.05}$)		ns			ns	
Var × Year ($LSD_{0.05}$)		ns			ns	

[1] ns: non significant; * and **, significantly different from zero at p <0.05 and p<0.01.

Number of Monopodial Branches (Number/plant)

From Table 7, it can be seen that there were significant differences between varieties in terms of this trait, while there were non-significant for years and varieties × years interaction. The average values were changed from 1.34 to 2.99 number/plant. Ipek 607 showed the lowest value (1.34), while the BA 440 showed the highest value as 2.99. The results of this study supported by the results of Meredith et al. [10] who reported the differences between modern varieties and obsolete varieties in terms of monopodial branches.

Number of Sympodial Branches (Number/plant)

The statistical analysis indicated that there were non-significant differences for varieties, years and varieties × years' interaction. The average values changed from 10.21 to 12.02 number/plant.

Number of Boll (Number/plant)

The statistical analysis indicated that there were non-significant differences for varieties, years and varieties × years' interaction. The average values changed from 10.45 to 13.87 number/plant. The average boll was 11.80 in 2015, while it was 12.52 number/plant in 2017. The results of this study were inconsistent with that of Wells and Meredith [17] and Pettigrew et al. [18], these differences may be due to different varieties, years and environmental conditions.

Boll Weight (g)

There were significant differences at 1% probability level between varieties, but non-significant differences in terms of year and variety × year interactions. The average boll weight of varieties changed from 5.76 (Stv 468) to 6.74 g (Kartanesi). The boll weight of Ipek 607 (6.73 g), Naz (6.65 g), Gaia (6.44 g) and PG 2018 (6.42 g) followed that of Kartanesi and they were statistically in the same group. When comparing with the control variety BA 119, which has the highest boll weight value, the boll weight of Kartanesi variety increased as 12.33% and reached to the 6.74 g. The same results reported by Campbell et al. [14], who determined differences between modern and obsolete cotton varieties. On the other hand, the results of Wells and Meredith [13] was inconsistent with that of the results of this study.

Table 8. Mean values and statistical groups of a number of boll and boll weight[1].

Varieties	Number of Boll (Number/plant)			Boll Weight (g)		
	2015	**2017**	**Mean**	**2015**	**2017**	**Mean**
1. PG 2018	13.00	13.04	13.02	6.29	6.56	6.42^{ab}
2. GAIA	12.65	12.68	12.66	6.43	6.46	6.44^{ab}
3. KARTANESI	9.85	13.74	11.79	6.99	6.50	6.74^{a}
4. IPEK 607	9.00	11.91	10.45	6.47	7.00	6.73^{a}
5. CARISMA	12.60	11.99	12.29	6.17	5.94	6.06^{bcd}
6. BA 440	13.85	10.49	12.17	6.12	6.18	6.15^{bcd}
7. LYDIA	11.20	10.49	10.84	6.31	6.41	6.36^{abc}
8. NAZ	10.75	11.99	11.37	6.76	6.55	6.65^{a}
9. STV 468 (Control)	12.75	14.99	13.87	5.78	5.74	5.76^{d}
10. BA 119 (Control)	12.35	13.83	13.09	6.01	5.99	6.00^{cd}
Mean	**11.80**	**12.52**	**12.16**	**6.33**	**6.33**	**6.33**
CV (%)		18.83			6.31	
Variety (LSD $_{0.05}$)		ns			0.40**	
Year (LSD $_{0.05}$)		ns			ns	
Var × Year (LSD $_{0.05}$)		ns			ns	

[1] ns: non significant; * and **, significantly different from zero at p <0.05 and p<0.01.

Table 9. Mean values and statistical groups of seed cotton weight/ boll and a number of seeds per boll[1].

Varieties	Seed Cotton Weight Per Boll (g)			Number of seeds per boll Number/Boll)		
	2015	**2017**	**Mean**	**2015**	**2017**	**Mean**
1. PG 2018	4.74	4.90	4.82[b-e]	27.98	28.55	28.26[bcd]
2. GAIA	4.94	4.88	4.91[abc]	29.58	30.50	30.04[abc]
3. KARTANESI	5.37	4.89	5.13[ab]	30.24	30.50	30.37[a]
4. IPEK 607	5.04	5.29	5.16[a]	26.63	28.60	28.36[a-d]
5. CARISMA	4.70	4.41	4.55[def]	27.79	28.60	28.19[cd]
6. BA 440	4.41	4.83	4.62[c-f]	27.85	29.10	28.47[a-d]
7. LYDIA	4.85	4.84	4.84[a-d]	25.98	27.50	26.74[d]
8. NAZ	5.17	4.97	5.07[ab]	28.39	32.30	30.34[ab]
9. STV 468 (Control)	4.39	4.30	4.34[f]	27.05	29.85	28.45[a-d]
10. BA 119 (Control)	4.60	4.41	4.51[ef]	28.86	27.85	28.35[a-d]
Mean	**4.82**	**4.77**	**4.80**	**28.13**	**29.38**	**28.76**
CV (%)		6.45			7.23	
Variety ($LSD_{0.05}$)		0.31**			2.08*	
Year ($LSD_{0.05}$)		ns			ns	
Var × Year ($LSD_{0.05}$)		ns			ns	

[1] ns: non significant; * and **, significantly different from zero at p <0.05 and p<0.01.

Seed Cotton Weight Per Boll (g)

From Table 9, it can be seen that there were significant differences between varieties, but non-significant differences in terms of year and variety × year interactions. The average seed cotton weight per boll of varieties changed from 4.34 (Stoneville 468) to 5.16 g (Ipek 607). The seed cotton weight per boll of Kartanesi (5.13 g), Naz (5.07 g), Gaia (4.91g) and Lydia (4.84 g) followed that of Ipek 607 and they were statistically in the same group. When comparing with the control variety the seed cotton weight per boll of Ipek 607 variety increased as 14.41% and reached 5.16 g.

Number of Seeds Per Boll (Number/Boll)

From Table 9, it can be seen that there were significant differences at 5% probability level between varieties, but non-significant differences in terms of year and variety × year interactions. The average number of seeds per boll of varieties changed from 26.74 to 30.37. The highest values were obtained from Kartanesi (30.37), Naz (30.34) and Gaia (30.04), while the lowest seeds number obtained from Lydia variety (26.74). When comparing with the control variety the number of seeds per boll of Kartanesi variety increased as 6.74% and reached the 30.37 seeds per boll.

Table 10. Mean values and statistical groups of fiber fineness and fiber length[1].

Varieties	Fiber Fineness (mic.)			Fiber Length (mm)		
	2015	**2017**	**Mean**	**2015**	**2017**	**Mean**
1. PG 2018	4.70	4.47	4.59^{a}	28.17^{f-h}	27.99^{gh}	28.08^{e}
2. GAIA	4.72	4.43	4.57^{a}	29.51^{c-e}	29.07^{c-g}	29.29^{bc}
3. KARTANESİ	4.56	4.47	4.51^{ab}	29.08^{c-g}	29.33^{c-f}	29.20^{b-d}
4. IPEK 607	4.00	4.21	4.10^{c}	31.72^{a}	31.34^{ab}	31.53^{a}
5. CARISMA	4.65	4.37	4.51^{ab}	28.89^{d-g}	28.12^{f-h}	28.50^{cde}
6. BA 440	4.88	4.20	4.54^{ab}	27.35^{h}	29.75^{cd}	28.55^{cde}
7. LYDIA	4.41	3.94	4.18^{c}	29.30^{c-f}	30.20^{bc}	29.75^{b}
8. NAZ	4.63	4.31	4.47^{ab}	28.95^{c-g}	28.99^{c-g}	28.97^{b-e}
9. STV 468 (Control)	4.52	4.02	4.27^{bc}	28.05^{f-h}	28.61^{d-h}	28.33^{de}
10. BA 119 (Control)	4.67	4.37	4.52^{ab}	28.74^{d-g}	28.25^{e-h}	28.50^{cde}
Mean	**4.57^{a}**	**4.28^{b}**		**28.98**	**29.16**	
CV (%)		6.20			3.13	
Variety ($LSD_{0.05}$)		0.27**			0.91**	
Year ($LSD_{0.05}$)		0.12**			ns	
Var × Year ($LSD_{0.05}$)		ns			1.28*	

[1] ns: non significant; * and **, significantly different from zero at $p < 0.05$ and $p < 0.01$.

Table 11. Mean values and statistical groups of fiber strength and fiber elongation[1].

Varieties	Fiber Strength (g tex^{-1})			Fiber Elongation (%)		
	2015	**2017**	**Mean**	**2015**	**2017**	**Mean**
1. PG 2018	29.18^{d-g}	28.80^{efg}	28.99^{cd}	7.19^{ab}	6.50^{d-g}	6.84^{bc}
2. GAIA	32.72^{ab}	28.82^{efg}	30.77^{bc}	6.52^{d-g}	6.77^{a-e}	6.65^{c}
3. KARTANESI	31.66^{bcd}	29.85^{c-f}	30.75^{bc}	5.64^{h}	6.37^{efg}	6.01^{d}
4. IPEK 607	33.05^{ab}	31.25^{b-e}	32.12^{ab}	5.98^{gh}	6.02^{fgh}	6.00^{d}
5. CARISMA	29.56^{def}	27.12^{fg}	28.34^{d}	7.27^{a}	7.35^{a}	7.31^{a}
6. BA 440	30.70^{b-e}	32.45^{abc}	31.57^{b}	7.14^{abc}	7.37^{a}	7.25^{ab}
7. LYDIA	32.83^{ab}	34.95^{a}	33.89^{a}	5.52^{h}	6.05^{fgh}	5.78^{d}
8. NAZ	26.42^{g}	29.27^{def}	27.87^{d}	7.07^{a-d}	6.62^{b-f}	6.85^{bc}
9. STV 468 (Control)	29.75^{c-f}	29.40^{def}	29.57^{cd}	7.27^{a}	6.55^{c-g}	6.91^{abc}
10. BA 119 (Control)	30.46^{b-e}	31.37^{b-e}	30.92^{bc}	6.45^{efg}	6.80^{a-e}	6.62^{c}
Mean	**30.63**	**30.33**		**6.61**	**6.64**	
CV (%)		6.36			6.49	
Variety ($LSD_{0.05}$)		1.94**			0.43**	
Year ($LSD_{0.05}$)		ns			ns	
Var × Year ($LSD_{0.05}$)		2.74*			0.60*	

[1] ns: non significant; * and **, significantly different from zero at $p < 0.05$ and $p < 0.01$.

Fiber Fineness (micronaire)

From Table 10, it can be seen that there were significant differences at 1% level between varieties and year, but non-significant differences in terms of variety × year interactions. The average fiber fineness of varieties changed from 4.10 to 4.59 mic. The highest values were obtained from PG 2018 (4.59 mic), and Gaia (4.57 mic.), while the lowest fineness values obtained from Ipek 607 (4.10 mic.) and Lydia (4.18 mic.). Year differences were significant in terms of fiber fineness the values of varieties were 4.57 in 2015, while it was 4.28 in 2017. When comparing with the control variety Ipek 607 and Lydia varieties have lesser fiber fineness values, while the other six varieties were in the same statically groups with the control varieties. Wells and Meredith [13] indicated that modern cotton varieties tend to increase in terms of fiber fineness, on the other hand, Campbell et al. [14] expressed that there are not any differences between modern and old cotton varieties for fiber fineness.

Fiber Length (mm)

From Table 10, it can be seen that there were significant differences at 1% level between varieties and variety × year interactions, but non-significant differences in terms of the year. The average fiber length of varieties changed from 28.08 mm to 31.53 mm. The highest values were obtained from Ipek 607 (31.53 mm), Lydia (29.75 mm), Gaia (29.29 mm) and Kartanesi (29.20 mm) varieties, while the lowest fiber length values obtained from PG 2018 (28.08 mm). Variety × year interactions were significant in terms of fiber length the highest value obtained from Ipek 607 (31.72 mm) in 2015, while the lowest value obtained from BA 119 (27.35 mm) in 2015. When comparing with the control variety BA 119, which has the highest value, Ipek 607 variety's fiber length increased as 10.63% and reached to 31.53 mm, the fiber length of all modern varieties except PG 2018 had higher values than control varieties. Wells and Meredith [13] and Luo et al. [19] indicated that modern cotton varieties tend to increase in terms of fiber length which supported by the results of this study, on the other hand, Campbell et al. [14] expressed that there are not any differences between modern and old cotton varieties for fiber length which inconsistent with the results of this study.

Fiber Strength (g/tex)

From Table 11, it can be seen that there were significant differences at a 1% level between varieties and 5% level for variety × year interactions, but non-significant differences in terms of the year. The average fiber strength of varieties changed from 27.87 to 33.89 g/tex. The highest values were obtained from Lydia (33.89 g/tex) and Ipek 607 (32.12 g/tex), BA 440 (31.57 g/tex), BA 119 (30.92 g/tex), Gaia (30.77 g/tex), and Kartanesi (30.75 g/tex) varieties followed these varieties in terms of strength values. Varieties × years interaction was significant in terms of fiber strength, the highest strength obtained from Lydia (34.95 g/tex) in 2017, while the lowest value obtained from Naz (26.42 g/tex) in 2015. When comparing with the control variety BA 119, which has the highest value, Lydia variety's fiber strength increased as 9.60% and reached to 33.89 g/tex. Previous researchers indicated that modern cotton varieties tend to increase in terms of fiber strength [9,13,20–22].

Fiber Elongation (%)

From Table 11 it can be seen that there were significant differences between varieties and variety × year interactions, but non-significant differences in terms of the year. The average fiber elongation of varieties changed from 5.78 (Lydia) to 7.31% (Carisma). BA 440 and Stv 468 control varieties followed Carisma varieties and they were statistically in the same group. Varieties × years' interaction was significant for this trait, the highest fiber elongation value obtained from BA 440 variety (7.37%) in 2017, while the lowest value obtained from Lydia (5.52%) in 2015.

Fiber Uniformity Ratio (%)

From Table 12, it can be seen that there were significant differences for variety × year interaction, while non-significant differences were for varieties and years. The highest uniformity ratio obtained from BA 440 (86.37%) in 2017, while the lowest uniformity ratio obtained from Kartanesi (82.42%) in 2015. The fact that there is no significant difference between varieties in terms of fiber uniformity ratio shows that modern varieties have similar characteristics to the control varieties.

Table 12. Mean values and statistical groups of fiber uniformity ratio and short fiber index[1].

Varieties	Fiber Uniformity Ratio (%)			Short Fiber Index (%)		
	2015	2017	Mean	2015	2017	Mean
1. PG 2018	84.55[bc]	83.90[bcd]	84.22	6.17	6.55	6.36
2. GAIA	84.37[bc]	84.37[bc]	84.37	6.77	5.90	6.33
3. KARTANESI	84.54[bc]	82.42[d]	83.48	6.56	7.15	6.85
4. IPEK 607	83.81[bcd]	83.72[bcd]	83.77	5.73	5.90	5.81
5. CARISMA	84.50[bc]	83.32[cd]	83.91	5.89	7.15	6.52
6. BA 440	84.24[bc]	86.37[a]	85.30	5.71	4.62	5.17
7. LYDIA	83.66[bcd]	84.17[bc]	83.91	6.65	5.65	6.15
8. NAZ	85.11[ab]	83.22[cd]	84.17	6.20	5.92	6.06
9. STV 468 (Control)	84.27[bc]	83.67[bcd]	83.97	6.02	5.82	5.92
10. BA 119 (Control)	84.16[bc]	83.67[bcd]	83.92	6.63	6.77	6.70
Mean	**84.32**	**83.88**		**6.23**	**6.14**	
CV (%)		1.37			16.47	
Variety (LSD $_{0.05}$)		Ns			ns	
Year (LSD $_{0.05}$)		Ns			ns	
Var × Year (LSD $_{0.05}$)		1.64*			ns	

[1] ns: non significant; * and **, significantly different from zero at $p < 0.05$ and $p < 0.01$.

Short Fiber Index (%)

Fort this trait, there were non-significant differences for variety, years and varieties × years' interaction. The average short fiber index of varieties varied from 5.17 to 6.85% (Table 12).

4. Conclusions

This study was carried out to determine yield, yield components and fiber technological characteristics of modern cotton varieties and find out their superiority than control varieties. The study was carried out in the 2015 and 2017 cotton growing season under Siirt ecological condition. There were significant differences between varieties for investigated traits except for seed cotton yield, number of sympodial branches, number of boll per plant, fiber uniformity ratio and short fiber index. The results of the study showed that Naz and PG 2018 for ginning percentage, Kartanesi and Naz for plant height and a number of seeds per boll, Kartanesi, Ipek 607 and Naz for boll weight and seed cotton per boll, Ipek 607 for first picking percentage and fiber length, Ipek 607 and Lydia for fiber fineness and fiber strength, Carisma and BA 440 had superior values than control varieties for fiber elongation. According to the results of this study, it was determined that there was an improvement in modern cotton varieties, which are used as a material in this study, then control varieties in terms of ginning percentage, plant height, first picking percentage, date of the first flower, a node of first fruiting branches, number of monopodial branches, boll weight, seed cotton yield per boll, number of seeds per boll, fiber fineness, fiber length, fiber strength, fiber elongation, while they had similar values with control varieties in terms of seed cotton yield, number of boll per plant, number of sympodial branches, fiber uniformity ratio, and short fiber index. Previous investigations indicated that there was a significant improvement in terms of yield, earliness and fiber quality parameters in cotton. However, the obsolete cotton varieties have some specific characteristics such as strength, hairless leaves, diseases and pest resistance etc.to use in a breeding program.

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References

1. Karademir̈, E.; Karademir̈, Ç.; Ekin̈ci̇, R.; Sevi̇lmi̇s, U. İleri Generasyondaki Pamuk (Gossypium hirsutum L.) Hatlarında Verim ve Lif Kalite Özelliklerinin Belirlenmesi. *Türkiye Tarımsal Araştırmalar Dergisi* **2015**, *2*, 100.
2. Liu, S.M.; Constable, G.A.; Reid, P.E.; Stiller, W.N.; Cullis, B.R. The interaction between breeding and crop management in improved cotton yield. *Field Crops Res* **2013**, *148*, 49–60.
3. Raper, T.B.; Snider, J.L.; Dodds, D.M.; Jones, A.; Robertson, B.; Fromme, D.; Sandlin, T.; Cutts, T.; Blair, R. Genetic and Environmental Contributions to Cotton Yield and Fiber Quality in the Mid-South. *Crop Sci* **2019**, *59*, 307–317.
4. Kilby, C.R.; Tan, D.; Duggan, B. Yield components of high-yielding Australian cotton cultivars. *Cotton Res J 5*, 117–130.
5. Brown, R.S.; Oosterhuis, D.M. High daytime temperature stress effects on the physiology of modern versus obsolete cotton cultivars. *Americas J Plant Sci Biotech* **2010**, 93–96.
6. Bridge, R.R.; Meredith, W.R. Comparative Performance of Obsolete and Current Cotton Cultivars [1]. *Crop Sci* **1983**, *23*, 949–952.
7. Wells, R.; Meredith, W.R. Comparative Growth of Obsolete and Modern Cotton Cultivars. I. Vegetative Dry Matter Partitioning [1]. *Crop Sci* **1984**, *24*, 858–862.
8. Oosterhuis, D.M. Stress Physiology in Cotton. **2011**, 1–175.
9. Culp, T.W.; Green, C.C. Performance of Obsolete and Current Cultivars and Pee Dee Germplasm Lines of Cotton. *Crop Sci* **1992**, *32*, 35–41.
10. Meredith, W.R.; Heitholt, J.J.; Pettigrew, W.T.; Rayburn, S.T. Comparison of obsolete and modern cotton cultivars at two nitrogen levels. *Crop Sci 37*, 1453–1457.
11. Heitholt, J.J.; Meredith, W.R.; Rayburn, S.T. Leaf area index response of four obsolete and four modern cotton cultivars to two nitrogen levels. *J Plant Nutr* **1998**, *21*, 2319–2328.
12. Brown, R.S.; Oosterhuis, D.M.; Coker, D.L. A physiological comparison of modern versus obsolete cultivars under water-deficit stress. *AAES Res Series* **202AD**, *507*, 168–172.
13. Wells, R.; Meredith, W.R. Comparative Growth of Obsolete and Modern Cotton Cultivars. III. Relationship of Yield to Observed Growth Characteristics [1]. *Crop Sci.* **1984**, *24*, 868–872.
14. Campbell, B.T.; Bowman, D.T.; Weaver, D.B. Heterotic Effects in Topcrosses of Modern and Obsolete Cotton Cultivars. *Crop Sci* **2008**, *48*, 593–600.

15. Wells, R. The Use of Obsolete and Modern Cultivars to Examine Advances in Yield and Dry Matter Partitioning. *The J Cotton Sci* **2016**, *20*, 7.
16. Hasan, M.K.; Shopan, J.; Rob, M.M.; Rahman, H.; Azak, A.K.; And Ali, M.M.A.A. Selection of novel upland cotton cultivars (Gossypium hirsutum L.) by investigating fiber quality and yield performance in multilocation trials of Bangladesh. *Int J Biosci* **2016**, *9*, 177–186.
17. Wells, R.; Meredith, W.R. Comparative Growth of Obsolete and Modern Cotton Cultivars. II. Reproductive Dry Matter Partitioning [1]. *Crop Sci* **1984**, *24*, 863–868.
18. Pettigrew, W.T.; Meredith, W.R.; Zeng, L. AGRONOMY & SOILS Response of Obsolete and Modern Cotton Genotypes to Varying Plant Densities Available online: https://www.semanticscholar.org/paper/AGRONOMY-%26-SOILS-Response-of-Obsolete-and-Modern-to-Pettigrew-Meredith/30c815927e16322e902c6be17ab985acc24659e1 (accessed on Mar 29, 2020).
19. Luo, H.H.; Zhang, H.L.; Zhang, Y.L.; Zhang, W.F. Evolution characteristics related to photosynthesis, growth and yield in some old and new cotton cultivars. *Photosynthetica* **2017**, *55*, 301–307.
20. Bayles, M.B. Trends over time among cotton cultivars released by the Oklahoma Agricultural Experiment Station. *Crop Sci* **2005**, *45*, 966–980.
21. Zhang, J.F.; Lu, Y.; Adragna, H.; Hughs, E. Genetic Improvement of New Mexico Acala Cotton Germplasm and Their Genetic Diversity. *Crop Sci* **2005**, *45*, 2363–2373.
22. Akiscan, Y. Determination of genetic improvement on fiber quality traits in some cotton cultivars released between 1980 and 2009 in Turkey. *Journal of the Faculty of Agriculture, Suleyman Demirel University* **2012**, *7*, 32–40.