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Stimulative Effect of High Voltage Electrical Current on Earliness, Yield and Fiber Quality of Cotton (*Gossypium hirsutum* L.)

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Abstract: This study was conducted during the 1997-2000 growing seasons at the Agricultural Faculty's experimental fields of Kahramanmaras Sutcu Imam University. The cultivars of Maras-92, Sayar-314, Cukurova-1518, Nazilli-87 and the Agdas-3 cotton variety obtained by mutation breeding in Azerbaijan were used as a material. High voltage electrical current (30 KV 30^{-1} sec.) was applied to seeds prior to sowing using the CORONA shocking instrument from Azerbaijan. Shocked and unshocked (control) seeds were grown in field experiments using a split plot four block experimental design over four growing seasons. Our goal was to test whether high voltage electrical shock would increase yield and fiber quality traits of the tested cultivars. We found that high voltage electric current can be used in large scale production to reduce the sowing-germination interval and time to first boll opening, while increasing sympodia number, bolls per plant and seed cotton yield. Shock treatment shortened the sowing-germination interval and time to first boll opening both by 3 days, allowing harvest 6 days earlier. Shocked groups averaged 2 more sympodia and bolls per plant compared to controls and had improved cotton yield. The early maturing Agdas-3 variety had the shortest germination and first boll opening times and the highest sympodia number but the lowest seed cotton weight per boll. According to the four years' results, it can be said that the treatment of high voltage electrical current has a little positive stimulative effect on fiber technological traits.

Key words: Boll number per plant, cotton, fiber traits, *Gossypium hirsutum* L., seed cotton yield, shocking treatment, sowing-germination interval, time to first boll opening.

INTRODUCTION

Today cotton has been a quality crops rather than yield because textile industry demands special and highly fiber characteristics in order to produce special and good quality yarn, fabric and finaly ready-made clothing. At the same time, the cotton fiber is always prefered to artificial fibers due to the fact that it is natural and friendly of human health. In this reason, researchers in the all world have worked to obtain new cultivars with higher quality fibers. For instance, cotton varieties cultivated in some countries has been treated with high voltage electrical current in order to obtain earliness, higher yield and higher quality fiber. Although it is well known that high voltage electrical current can effectively stimulate many cultivated plants to increase yield, earliness and quality, there have been few studies in Turkey or elsewhere in the world performed on cotton. A literature review reveals that cotton seeds shocked by cobalt 60 and gamma radiation separately increased earliness by 5-8 days and increased yield by 13 % in Uzbekistan[1,2]. Gencer *et al.*[3] used ethyl methane sulphonate and cobalt 60 to produce mutant cotton plants that differed favorably from the parents in morphological, physiological and technological characteristics in M_3. Shocking potato knots with gamma radiation before planting stimulated potato growth[4] .

Also electrical current has been used to stimulate growth of potato plants[5]. Researchers found that wheat yield was increased by 12-37% and rye yield by 30% with similar treatment[6-8]. High voltage electrical current increased yield and vitamin C content when potato knots were shocked prior to planting[9,10]. Stakanov[11] reported increased growth and development of shrubs after treatment with 50-110 V of electrical current before planting. In the 1920's Micurin[12] used high voltage electrical current during hybridization to increase the efficiency of fertilizers. Seyidova[13,14] reported that high voltage electrical current had both stimulative and mutagenic effects Sarhanbeyli and Kelentarov[15] determined that electrical current alone had a stimulative effect but that the combination of electrical current and gamma radiation produced mutant forms. Furthermore, Mustafayev[16-26], Mustafayev and Stepanova[27] and Mustafayev *et al.*[28,29] reported that combined electrical

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current and temperature treatment of cotton seeds prior to sowing caused mutations but that electrical current by itself stimulated earliness and yield of cotton plant. Additionally, it was determined that shocking seeds was more beneficial than shocking vigorous plants[18,22]. Erol *et al.*[30] reported that germination percentages and seedlings emergency of some forage seeds such as black vetch, alfalfa, field pea, grass pea chickling vetch increased in dose of 25 KV 30^{-1} sec. Caglar and Aras[31] indicated that high voltage treatments improved the seed germination percentage at 25°C, but did not affect the germination period of hot pepper seeds. In addition, researchers noted that treatments with 5 or 15 KV 30^{-1} sec. shortened the seed emergence period of hot pepper seeds. Ozel[32] showed that the effect of high voltage electrical current was statistically significant for vegetative period of bread wheat.

Egamberdiyev and Ibrahimov[2] reported that they have obtained new mutant forms by treating 200 Grey of gamma radiation at squaring period on cultivar of 108-F in the study carried out in Research Institute of Cotton Selection and Seed Production in Uzbekistan and that yield and fiber quality of these forms were superior than original cotton cultivars of 108-F. Basov[33] reported that high voltage electrical current has a stimulative effect not only on cereals but also the other field crops. Izakov *et al.*[34] indicated that treatment of shocking increased protein percentage of grain and that this treatment should be repeated in each year before sowing. It has been reported that abnormalities of chromosomes were determined when high voltage electrical currents were treated to seeds of the cultivars of "3038"[35]. Kelentarov[36] showed that fiber strength was increased by shocking treatment. Similarly, in the study carried out by treating high voltage electrical current on cotton seeds Mustafayev[37] have shown that electrical current of 2500-3000 V cm^{-2} has the best stimulative effect. Also Mustafayev *et al.*[29,38] have reported that the shocking treatment has a little stimulative effect on fiber technological traits. In addition, Erayman[39] showed that high voltage electrical current (30 KV 30^{-1} sec.) prior to sowing increased seed cotton weight per boll and seed cotton yield.

The objective of this study was to test whether the treatment of high voltage electrical current to the cotton seeds would provide stimulative effect on earliness, yield and fiber quality of the tested cultivars.

MATERIALS AND METHODS

This study was conducted in 1997-2000 at the Kahramanmaras Sutcu Imam University Agricultural

Fig. 1: Shocking instrument named CORONA

Faculty's experimental fields using five cotton cultivars (*Gossypium hirsutum* L.). They were the mutant strain Agdas-3 from Azerbaijan, Maras-92 and Sayar-314 cultivars which are standard in the Kahramanmaras region, Cukurova-1518 of the Cukurova region and Nazilli-87, of the Aegean region.

Shocking seeds or vegetative parts of plants with high voltage electrical current is a commonly used method to stimulate yields and technological traits of cultured plants. A shock instrument named CORONA (Fig. 1) was developed and patented in 1987 by Professors Hammed Gozelov and Sefer A. Mustafayev of the Institute of Physics at the Azerbaijan Science Academy. In 1996, CORONA was brought from Azerbaijan to the Agricultural Department of the University of Kahramanmaras Sutcu Imam in Turkey.

This instrument was designed to increase earliness and yield capacity of cultured plants. CORONA produces electrons, ions and ultraviolet rays to shock seed or vegetative plant parts for 20 to 30 sec. Up to 600 kg of seeds can be treated per h^{-1}. The instrument works with 220/380 V and has a power of 2.5 KW. The treatment electricity varies between 5 KV and 25-30 KV. CORONA is 3600x1400x1800 mm and weighs 800 kg.

In this experiment unshocked cotton seeds were treated with high voltage electrical current (30 KV 30^{-1} sec.) prior to sowing. The field experiments were conducted over a four year period using the split plot experimental design of four blocks with shocked and unshocked (control) seeds of each cultivar. The seeds were sown by experimental mechanical planter in four-row plots of 10 m length at a planting space of 65 cm. Plants were thinned to 20 cm in rows. After the plants were cultivated under normal maintenance conditions, samples of 20 bolls (as a suitable sample size) were taken from each plot at harvesting time[40]. In this study, sowing to germination interval (days), time to first boll opening (days), sympodia number, boll number per plant, seed cotton weight per boll (g), seed cotton yield (kg ha^{-1}), fiber length (mm), fiber fineness (micronaire) and fiber strength (g tex^{-1}) were recorded according to related methods. The data were analysed over four years by experimental design of split plots with four blocks using the package program of SPSS[41] and the means were compared using Duncan multiple comparison test[42].

RESULTS

Sowing to germination interval: The results indicated that shorter mean time to germination was obtained with shock treatment (6.33 days), with a longer time for the controls (9.39 days) (Table 1). The early maturing mutant Agdas-3 cotton cultivar had the shortest germination interval (6.53 days), followed by the standard cultivars of Maras-92 (7.22 days) and Sayar-314 (7.72 days). Cuk.1518 (8.68 days) and Nazilli-87 (9.13 days) had the longest germination intervals. Treatment, cultivars, years and the year x cultivar interaction were statistically significant ($P<0.01$).

Time to first boll opening: As seen in Table 2, the shorter time was obtained for the shock treatment (118.1 days), compared to unshocked controls (120.8 days). Examination of cultivar means showed that the early maturing mutant Agdas-3 had the shortest first boll opening time (116.8 days), while the other cultivars did not vary significantly from one another. The mean time to boll opening for all cultivars was shorter after shock treatment than for controls. Differences in the first boll opening time among cultivar varieties, treatments, years and year x cultivar interaction were all statistically significant ($P< 0.01$).

Sympodia number: For sympodia number by plant, the higher mean was observed with shock treatment (12.6), with a lower number for the control (11.1) (Table 3). Shocked groups averaged 2 more sympodia comparing to controls. When the mean sympodia numbers by years were examined, 1997 (12.4), 1998 (12.4) and 2000 (11.7) differed from 1999 (10.9). The sympodia numbers were significantly different for treatment, cultivar, years, treatment x cultivar and treatment x year.

Sympodia numbers varied by year and treatment between 9.8 (Çuk.1518, control and Maraş-92, control) and 15.5 (Maras-92, shocked). The early maturing mutant Agdas-3 cotton cultivar had highest sympodia number (12.4), the standard cultivars of Maras-92 (12.1) and Sayar-314 (11.8) followed. Cuk.1518 (11.5) and Nazilli-87 (11.4) had the fewest.

Boll number per plant: Table 4 presents the mean number of cotton bolls per plant by treatment, year and cultivar. Shock treatment increased boll numbers for all cultivars in all years. Shocked groups averaged 2 more bolls per plant compared to controls. The highest mean boll numbers were found in 1997 (13.5), while the lowest were in 1999 (11.6). Boll number per plant differed by cultivar and treatment, varying between 16.6 (Maras-92, shocked) and 9.9 (Cuk.1518, control).

Seed cotton weight per boll: As seen in Table 5, for the mean seed cotton weight per boll there was no significant difference between treatment and control weights. The mean seed cotton weight per boll was highest (5.74 g) in 1999, followed by 1998 and 2000 with the lowest weight in 1997 (5.08 g). The weights per boll differed by cultivar and treatment, varying between 5.97 g (Cuk.1518, shocked) and 4.57 g (Agdas-3, control). The mean cultivar weight over the four years varied between 5.65 g (Maras-92) and 5.15 g (Agdas-3). The seed cotton weight per boll of the cultivars over the four years differed significantly ($P< 0.01$) for year and year x cultivar.

Seed cotton yield: The yields by cultivars and treatment varied from 4971 kg ha^{-1} (Sayar-314, shocked) to 2053 kg ha^{-1} (Cuk. 1518, control). The standard cultivars (Maras-92 and Sayar-314) had the highest yields, while the rest were lower. The mean yield (3457 kg ha^{-1}) was significantly higher for the treated compared to the untreated plants (3097 kg ha^{-1}). Unique genotypes of the cultivars could explain the significance of their differing reactions by year. We found that shock treatment increased seed cotton yield (Table 6).

Fiber length: The fiber lengths were statistically significantly different for varieties and years ($P< 0.01$). From Table 7, the longest fibers were observed in 1999 with 29.1 mm and then 1998 (28.7 mm), 2000 (28.6 mm) and 1997 (28.4 mm) followed it. There was no statistically significant different between means of treatments (28.8 mm) and control (28.6). Fiber lengths of the cultivars varied between 30.4 mm (Maras-92, control) and 27.5 mm (Agdas-3, shocked and Agdas-3, control). According to the four year's mean results belonging to cultivars, it has been seen that there was two groups for this trait and fiber length of the cultivars varied between 29.4 mm (Sayar-314) and 28.1 mm (Agdas-3).

Fiber fineness: From Table 8, fiber fineness means by years were in three groups and the finest fibers were observed in 1997 with 4.41 mic. and in 1999 with 4.53 mic. then 1998 (4.74 mic.) followed them and finely the thickest

Table 1: Mean sowing to germination interval (days) of shocked and unshocked cotton seeds and arised groups

Treatments	Shocked					
Cultivars	1997	1998	1999	2000	Means	
Agdas-3	4.25±0.25l	4.50±0.29kl	6.00±0.41h-l	5.75±0.48h-l	5.13±0.26g	
Cuk.1518	8.50±0.87b-h	6.25±0.75h-l	7.00±0.41e-l	6.75±0.25f-l	7.13±0.35ef	
Nazilli-87	7.25±0.75e-l	7.50±0.29d-k	7.75±0.25c-j	7.50±0.29d-k	7.50±0.20de	
Maras-92	5.75±0.48h-l	4.75±0.25j-l	6.00±0.41h-l	6.50±0.50g-l	5.75±0.25g	
Sayar-314	5.75±0.48h-l	5.25±0.95i-l	7.25±0.25e-l	6.25±0.48h-l	6.13±0.33fg	
Means of treatments			6.33±0.16b			
Means of years		1997 8.05±0.42a		1998 7.18±0.35 b		
Treatments	Unshocked (Control)					
Cultivars	1997	1998	1999	2000	Means	Means of Cultivars
Agdas-3	7.00±0.58e-l	7.50±0.29d-k	8.50±0.50b-h	8.75±0.63a-h	7.94±0.30de	6.53±0.32c
Cuk.1518	11.75±0.48a	9.50±0.65a-g	9.50±0.29a-g	10.67±0.88a-c	10.33±0.36ab	8.68±0.38a
Nazilli-87	11.00±0.58ab	11.00±0.41ab	11.00±0.71ab	10.00±0.91a-e	10.75±0.32a	9.13±0.35a
Maras-92	8.75±0.48a-h	8.00±0.41b-i	8.50±0.29b-h	9.50±1.04a-g	8.69±0.31cd	7.22±0.33bc
Sayar-314	10.50±0.96a-d	7.50±0.26d-k	9.75±0.85a-f	9.50±0.87a-g	9.31±0.45bc	7.72±0.40b
Means of treatments			9.39±0.19a			
Means of years		1999 8.13±0.28a		2000 8.05±0.33a		

Table 2: Mean time (days) to first boll opening for shocked and unshocked cottons and arised groups

Treatments	Shocked					
Cultivars	1997	1998	1999	2000	Means	
Agdas-3	116.8±2.53g-m	117.5±1.26g-m	119.0±0.82c-k	108.5±0.87n	115.4±1.26d	
Cuk.1518	117.5±1.85f-m	123.5±0.87a-g	124.0±1.23a-f	114.5±0.65i-n	119.9±1.18a-c	
Nazilli-87	114.3±1.49j-n	126.5±0.50ab	124.0±1.23a-f	114.5±0.29i-n	119.8±1.49a-c	
Maras-92	118.3±0.63d-l	120.0±0.82b-k	120.5±0.50b-k	111.8±0.95l-n	117.6±0.96cd	
Sayar-314	118.3±1.75d-l	121.8±1.18a-h	120.0±0.58b-k	111.3±0.95mn	117.8±1.16cd	
Means of treatments			118.1±0.56b			
Means of years		1997 118.4±0.64b		1998 123.3±0.56a		
Treatments	Unshocked (Control)					
Cultivars	1997	1998	1999	2000	Means	Means of Cultivars
Agdas-3	119.0±2.27c-k	121.3±1.49a-i	121.0±0.00a-j	111.8± 0.75l-n	118.3±1.18bc	116.8±0.89b
Cuk.1518	119.8±3.04b-k	126.0±0.58ab	125.5±0.87a-c	116.8± 0.63g-m	122.0±1.25a	120.9±0.86a
Nazilli-87	117.8±2.14e-m	127.5±0.50a	126.3±0.75ab	116.3± 0.48h-n	121.9±1.39a	120.9±1.02a
Maras-92	121.3±1.37a-I	124.0±1.23a-f	123.3±0.75a-g	115.3±0.25h-n	120.9±0.99ab	119.3±0.74a
Sayar-314	121.3±1.97a-i	124.5±1.44a-e	124.8±0.75a-d	113.8± 0.25k-n	121.1±1.28a	119.4±0.90a
Means of Treatments			120.8±0.56a			
Means of Years		1999 122.8±0.44a		2000 113.4±0.43c		

Table 3: Mean sympodia numbers for shocked and unshocked cottons and arised groups

Treatments	Shocked					
Cultivars	1997	1998	1999	2000	Means	
Agdas-3	14.1±1.57a-c	13.6±0.28a-d	12.7±0.48a-e	12.6±0.90a-e	13.3±0.45a	
Cuk.1518	12.9±0.34a-e	12.8±0.22a-e	11.3±0.65b-e	12.0±0.20a-e	12.3±0.25a-c	
Nazilli-87	11.4±0.45b-e	11.9±0.35a-e	11.5±0.17b-e	11.5±0.64b-e	11.6±0.20b-d	
Maras-92	15.5±1.59a	12.0±0.77a-e	11.8±0.26a-e	14.2±1.48ab	13.4±0.65a	
Sayar-314	14.2±1.20ab	12.1±0.28a-e	10.9±0.24b-e	12.3±0.39a-e	12.4±0.43ab	
Means of treatments			12.6±0.20a			
Means of years		1997 12.4±0.36a		1998 12.4±0.14a		
Treatments	Unshocked (Control)					
Cultivars	1997	1998	1999	2000	Means	Means of cultivars
Agdas-3	11.9±0.21a-e	12.6±0.43a-e	10.5±0.74c-e	11.5±0.61b-e	11.6±0.31b-d	12.4±0.31a
Cuk.1518	10.8±0.97b-e	11.8±0.43b-e	9.8±0.39e	10.8±0.19b-e	10.8±0.31cd	11.5±0.24b
Nazilli-87	11.0±0.26b-e	12.3±0.10a-e	10.6±0.72b-e	11.2±0.43b-e	11.3±0.26b-d	11.4±0.16b
Maras-92	10.4±0.58de	12.3±0.19a-e	9.8±0.21e	10.5±0.41c-e	10.7±0.30d	12.1±0.42ab
Sayar-314	12.0±0.06a-e	12.2±0.61a-e	10.1±0.56de	10.8±0.34b-e	11.2±0.30b-d	11.8±0.28ab
Means of treatments			11.1±0.13b			
Means of years		1999 10.9±0.20b		2000 11.7±0.25a		

* Means followed by the same letter are not significantly different at 5 % level of probability.

Table 4: Mean boll numbers per plant for shocked and unshocked cottons and arised groups

Treatments	Shocked				
Cultivars	1997	1998	1999	2000	Means
Agdas-3	13.3±1.09a-c	13.2±0.39a-c	13.8±1.01a-c	13.3±0.66a-c	13.4±0.4a-c
Cuk.1518	13.1±1.24a-c	14.9±0.91ab	12.6±0.83a-c	13.1±0.26a-c	13.4±0.46a-c
Nazilli-87	13.2±0.67a-c	13.0±0.89a-c	11.5±0.17bc	14.5±0.91a-c	13.0±0.43a-d
Maras-92	16.6±1.18a	13.7±0.87a-c	13.9±0.44a-c	14.0±1.05a-c	14.6±0.52a
Sayar-314	13.6±0.82a-c	13.9±1.27a-c	12.5±0.36a-c	14.4±0.33a-c	13.6±0.40ab
Means of treatments			13.6±0.20a		
Means of years		1997		1998	
		13.5±0.40a		12.8±0.28ab	

Treatments	Unshocked (Control)					
Cultivars	1997	1998	1999	2000	Means	Means of Cultivars
Agdas-3	12.3±0.76a-c	11.5±0.54bc	10.6±0.80bc	11.1±0.47bc	11.4±0.34de	12.4±0.31a
Cuk.1518	13.2±1.83a-c	10.7±0.40bc	9.9±0.76c	10.5±0.23bc	11.1±0.56e	12.3±0.41a
Nazilli-87	12.8±1.49a-c	11.7±0.77bc	10.6±0.72bc	12.3±0.30a-c	11.8±0.46b-e	12.4±0.33a
Maras-92	14.3±2.20a-c	12.7±0.18a-c	10.3±0.15bc	10.4±0.38bc	11.9±0.66b-e	13.2±0.48a
Sayar-314	12.8±0.45a-c	12.8±0.80a-c	10.4±0.43bc	10.9±0.44bc	11.7±0.37c-e	12.6±0.32a
Means of treatments			11.6±0.22b			
Means of years		1999		2000		
		11.6±0.29 c		12.5±0.29 bc		

Table 5: Mean seed cotton weight per boll (g) for shocked and unshocked cottons and arised groups

Treatments	Shocked				
Cultivars	1997	1998	1999	2000	Means
Agdas-3	4.62±0.32ef	5.41±0.12a-f	5.50±0.12a-e	5.43±0.10a-f	5.24±0.13bc
Cuk.1518	4.66±0.16d-f	5.55±0.14a-d	5.97±0.16a	5.64±0.16a-c	5.45±0.14ab
Nazilli-87	5.27±0.22a-f	5.55±0.18a-d	5.95±0.22a	5.47±0.14a-f	5.56±0.11ab
Maras-92	5.38±0.25a-f	5.77±0.02ab	5.68±0.11a-c	5.70±0.08a-c	5.63±0.07a
Sayar-314	5.49±0.10a-e	5.87±0.24ab	5.81±0.23ab	5.43±0.05a-f	5.65±0.09a
Means of treatments			5.51±0.05a		
Means of years		1997		1998	
		5.08±0.08c		5.55±0.06b	

Treatments	Unshocked (Control)					
Cultivars	1997	1998	1999	2000	Means	Means of cultivars
Agdas-3	4.57±0.17f	4.97±0.13b-f	5.44±0.16a-f	5.27±0.15a-f	5.06±0.11c	5.15±0.08b
Cuk.1518	4.85±0.25c-f	5.26±0.13a-f	5.88±0.18ab	5.74±0.12a-c	5.43±0.13ab	5.44±0.10a
Nazilli-87	5.13±0.22a-f	5.47±0.09a-f	5.72±0.13a-c	5.35±0.13a-f	5.42±0.09a-c	5.49±0.07a
Maras-92	5.41±0.15a-f	5.96±0.09a	5.86±0.09ab	5.42±0.11a-f	5.66±0.08a	5.65±0.05a
Sayar-314	5.42±0.11a-f	5.69±0.13a-c	5.62±0.12a-c	5.61±0.17a-c	5.58±0.07ab	5.62±0.06a
Means of Treatments			5.43±0.05a			
Means of Years		1999		2000		
		5.74±0.05a		5.50±0.04b		

Table 6: Mean seed cotton yield (kg ha^{-1}) of shocked and unshocked cottons and arised groups

Treatments	Shocked				
Cultivars	1997	1998	1999	2000	Means
Agdas-3	2661±34.33e-j	4190±27.55a-d	2430±1.78h-j	3327±8.06b-j	3152±20.30bc
Cuk.1518	2396±44.06ij	4251±3.88a-d	2521±4.28g-j	3455±26.19b-i	3156±22.61bc
Nazilli-87	3198±9.31c-j	3964±16.47a-e	2738±6.10e-j	3532±21.32b-i	3358±13.31ab
Maras-92	3938±40.36a-f	4650±20.2ab	2727±3.84e-j	3815±14.25a-g	3782±20.7a
Sayar-314	3945±17.43a-f	4971±27.88a	2959±1.18d-j	3465±17.51b-i	3835±2091a
Means of treatments			3457±9.27a		
Means of years		1997		1998	
		3012±14.73c		4208±8.59a	

Treatments	Unshocked (Control)					
Culivars	1997	1998	1999	2000	Means	Means of cultivars
Agdas-3	2298±44.76ij	3752±26.60a-h	2116±3.92j	3450±4.90b-i	2867±22.87bc	3014±15.21b
Cuk.1518	2053±20.25j	3818±10.31a-g	2336±1.49ij	2941±8.13d-j	2777±19.46c	2972±15.15b
Nazilli-87	2631±41.19f-j	3832±23.90a-g	2298±2.25ij	3355±23.44b-j	3029±19.54bc	3194±12.00b
Maras-92	3459±27.00b-i	4426±31.86a-c	2593±4.34g-j	3127±18.28c-j	3401±20.05ab	3592±14.58a
Sayar-314	3544±61.90b-i	4230±18.38a-d	2468±3.37h-j	3252±30.29c-j	3374±22.8ab	3604±15.78a
Means of treatments			3097±9.60b			
Means of years		1999		2000		
		2519±3.87d		3381±6.59b		

Table 7: Fiber length (mm) for shocked and unshocked cottons and arised groups

Treatments	Shocked					
Culivars	1997	1998	1999	2000	Means	
Agdas-3	27.5±0.49e	28.0±0.29b-e	28.6±0.15a-e	28.5±0.19a-e	28.1±0.18c	
Cuk.1518	28.1±0.54b-e	29.3±0.46a-e	29.2±0.29a-e	28.5± 0.29a-e	28.8±0.23a-c	
Nazilli-87	28.5±0.72a-e	28.8±0.23a-e	28.7±0.41a-e	28.7± 0.37a-e	28.7±0.21a-c	
Maras-92	29.1±0.42a-e	29.5±0.28a-e	29.1±0.37a-e	29.2± 0.19a-e	29.2±0.15a	
Sayar-314	29.1±0.37a-e	29.9±0.15a-c	29.5±0.19a-e	28.0± 0.17b-e	29.1±0.21ab	
Means of treatments			28.8±0.10a			
Means of years		1997		1998		
		28.4±0.18b		28.7±0.15ab		
Treatments	Unshocked (Control)					
Culivars	1997	1998	1999	2000	Means	Means of cultivars
Agdas-3	27.5±0.26e	27.9±0.32c-e	28.2±0.48b-e	28.5±0.34a-e	28.0±0.19c	28.1±0.13b
Cuk.1518	27.7±0.43de	27.7±0.06de	28.4±0.30b-e	28.2±0.12b-e	28.0±0.15c	28.4±0.15b
Nazilli-87	28.0±0.61b-e	27.9±0.52de	28.9±0.22a-e	28.6±0.45a-e	28.3±0.24bc	29.1±0.16a
Maras-92	29.6±0.58a-d	29.1±0.15a-e	30.4±0.48a	28.8±0.36a-e	29.5±0.25a	28.5±0.15b
Sayar-314	28.8±0.27a-e	29.1±0.37a-e	30.0±0.25ab	28.5±0.37a-e	29.1±0.20ab	29.4±0.14a
Means of treatments			28.6±0.11a			
Means of years		1999		2000		
		29.1±0.14a		28.6±0.10b		

Table 8: Fiber fineness (micronaire) for shocked and unshocked cottons and arised groups

Treatments	Shocked					
Culivars	1997	1998	1999	2000	Means	
Agdas-3	4.60±0.29a-d	5.23±0.06a	4.80±0.06a-c	5.20±0.14a	4.96±0.10a	
Cuk.1518	4.19±0.21b-d	4.85±0.16a-c	4.33±0.14a-d	5.19±0.07a	4.64±0.12ab	
Nazilli-87	4.59±0.19a-d	4.45±0.07a-d	4.53±0.09a-d	4.94±0.10a-c	4.63±0.07ab	
Maras-92	4.03±0.13cd	4.65±0.34a-c	4.50±0.11a-d	4.79±0.19a-c	4.49±0.12b	
Sayar-314	4.92±0.15a-c	4.78±0.21a-c	4.33±0.17a-d	4.99±0.13a-c	4.75±0.10ab	
Means of treatments			4.69±0.05a			
Means of years		1997		1998		
		4.41±0.09c		4.74±0.06b		
Treatments	Unshocked (Control)					
Culivars	1997	1998	1999	2000	Means	Means of cultivars
Agdas-3	4.48±0.26a-d	4.88±0.17a-c	4.80±0.04a-c	5.04±0.09ab	4.80±0.09ab	4.88±0.07a
Cuk.1518	4.45±0.09a-d	4.68±0.19a-c	4.58±0.15a-d	5.12±0.13ab	4.71±0.09ab	4.67±0.08ab
Nazilli-87	4.75±0.42a-c	4.40±0.12a-d	4.40±0.16a-d	5.09±0.15ab	4.66±0.13ab	4.50±0.10b
Maras-92	3.63±0.34d	4.63±0.14a-c	4.68±0.05a-c	5.10±0.16ab	4.51±0.17b	4.64±0.07ab
Sayar-314	4.53±0.23a-d	4.85±0.09a-c	4.33±0.21a-d	5.07±0.07ab	4.69±0.10ab	4.72±0.07ab
Means of treatments			4.67±0.05a			
Means of years		1999		2000		
		4.53±0.05c		5.05±0.04a		

Table 9: Fiber strength (g tex^{-1}) for shocked and unshocked cottons and arised groups

Treatments	Shocked					
Culivars	1997	1998	1999	2000	Means	
Agdas-3	22.1±1.21h-k	18.6±0.14i-l	29.9±0.42a-d	28.1±0.75b-f	24.7±1.22ab	
Cuk.1518	20.9±0.53i-l	19.7±0.85i-l	30.5±0.61a-d	26.8±0.74d-h	24.5±1.18ab	
Nazilli-87	23.3±0.95f-i	17.8±0.62kl	29.8±1.01a-d	27.8±1.23c-f	24.7±1.28ab	
Maras-92	23.4±0.60e-i	20.2±1.18i-l	30.3±1.05a-d	28.6±1.14b-d	25.6±1.13a	
Sayar-314	22.6±0.94g-k	19.3±0.29i-l	34.1±1.63a	28.0±1.26b-f	26.0±1.54a	
Means of treatments			25.1±0.56a			
Means of years		1997		1998		
		18.7±0.30d		21.8±0.24c		
Treatments	Unshocked (Control)					
Culivars	1997	1998	1999	2000	Means	Means of cultivars
Agdas-3	19.6±0.91i-l	18.3±0.43j-l	30.9±0.88a-d	28.8±0.96b-d	24.4±1.47ab	24.5±0.94bc
Cuk.1518	20.7±0.69i-l	16.8±0.72l	29.4±1.07a-d	27.0±0.73d-g	23.5±1.34b	24.0±0.88c
Nazilli-87	21.0±0.45i-l	18.1±0.77j-l	29.7±0.46a-d	28.1±0.35b-e	24.2±1.27ab	24.4±0.89bc
Maras-92	21.8±1.24i-k	19.2±0.66i-l	32.8±0.51ab	27.8±1.14c-f	25.4±1.42ab	25.5±0.90ab
Sayar-314	22.6±0.54g-j	19.2±0.53i-l	31.9±0.92a-c	28.6±0.95b-d	25.6±1.33a	25.8±1.00a
Means of treatments			24.6±0.60a			
Means of years		1999		2000		
		28.0±0.35b		30.9±0.29a		

* Means followed by the same letter are not significantly different at 5 % level of probability.

fibers were obtained in 2000 with 5.05 mic. Fiber fineness differed by cultivar and treatment, ranging from 3.63 mic. (Maras-92, control) and 5.23 mic. (Agdas-3, shocked). There was not significantly difference between treatments and both treatments took place in the same group. Differences in the fiber fineness among varieties, years and year x cultivar interaction were statistically significant ($P< 0.01$).

Fiber strength: Differences in the fiber strength of the cultivars among varieties and years were statistically significant ($P<0.01$). There was not significantly difference between treatments and both treatments took place in the same group. The most strong fibers were observed in 2000 with 30.9 g tex^{-1}, but the least strong fibers were obtained in 1997 with 18.7 g tex^{-1}. Fiber strength differed by cultivar and treatment, ranging from 34.1 g tex^{-1} (Sayar-314, shocked) and 16.8 g tex^{-1} (Cuk.1518, control). According to the four year's mean results belonging to cultivars, it has been seen that the fiber strength of the cultivars varied between 25.8 g tex^{-1} (Sayar-314) and 24.0 g tex^{-1} (Cuk.1518) (Table 9).

DISCUSSION

Sowing-germination interval and time to first boll opening are important earliness criteria. Earliness is important issue concerning the harvesting of the cottons before autumn rains, minimizing the product lost and the saving the fibre quality. The mean sowing-germination interval was shorter for shocked seeds than for unshocked seeds by a similar amount in all cultivars. The shock treatment stimulated the plants to shorten both the interval to germination and time to first boll opening. Treatment with high voltage electrical current hastened plant maturing rate by shortening the sowing to germination interval about 3 days compared to controls and reducing the time to first boll opening by 3 days. Plant growth was hastened, leading to earlier harvest. In addition, the early maturing mutant Agdas-3 cotton cultivar was ready for first harvest, had the shortest germination interval (6.53 days), the shortest time to first boll opening (116.8 days) and the highest sympodia number (12.4). Because Agdas-3 variety is a mutant variety for earliness. Basof and Izakov[6], Ivanov *et al.*[7], Satilov and Trofimova[8], Ibrahimov[1], Mustafayev[16,20,23,37,25,26], Mustafayev and Stepanova[27], Mustafayev *et al.*[28,29] also reported similar results.

These results show that shocking treatment significantly affected the sympodia number, an important factor for increased yield. Shock treatment increased boll numbers for all culivars in all years. The cultivars did not differ from each other for this trait. Increasing the number of bolls per cotton plant by electrical stimulations is an effective way to improve yield. Shocked groups averaged 2 more sympodia and bolls per plant compared to controls statistically. These two factors contribute to the increase in yield. Just as the mean yield (3457 kg ha^{-1}) was significantly higher for the treated compared to the untreated plants (3097 kg ha^{-1}). Unique genotypes of the cultivars could explain the significance of their different reactions by year. We found that shock treatment increased seed cotton yield. Our results are similar to those of Basof and Izakov[6], Ibrahimov[1], Ivanov *et al.*[7], Satilov and Trofimova[8], Sarhanbeyli and Kelentarov[15], Mustafayev[16,20,23,37,25,26], Mustafayev and Stepanova[27], Mustafayev *et al.*[28,29].

In all cultivars shocking did not negatively affected fiber traits and shocking and control were the same statistically in all cultivars ($P>0.05$). Thus, it can be said that shocking treatment did not deteriorate fiber traits. Obtained data are similar to findings of some researchers[25,26,28,29,38].

Our four year study showed that high voltage electrical treatment improved the sowing to germination time, time to first boll opening, sympodia number, boll number per plant and seed cotton yield of all cultivars in the experiment. Also, it was determined that there was no significantly difference between shocking and control for fiber length, fiber fineness and fiber strength. Moreover, there was a significant difference among cultivars for all investigated traits except the number of bolls per plant. The effect of years was significant for all investigated traits.

Based on the findings of our four-year trial we conclude that shocking of cotton seeds with high voltage electric current (30 KV 30^{-1} sec.) before sowing by using the CORONA instrument greatly shortened the interval to germination and boll opening, improved yield and yield components and had no negative stimulative effect on fiber technological traits.

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