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The Effect of Removed Squares and Flowers of Cotton (*Gossypium hirsutum* L.): I. Changes in Yield, Earliness and Fiber Properties

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Abstract
In this study, the effects of squares (flower-bud) and flowers removal on yield and fiber quality of cotton (*Gossypium hirsutum* L.) were tested. Field trials were conducted on research field of Harran University Faculty of Agriculture, Department of Field Crops in years of 1998 and 1999, at southeastern of Turkey. Field trials were arranged in completely randomized block design with four replications. The Sayar 314 cotton (*Gossypium hirsutum* L.) variety was used as plant material. Squares were removed at first two weeks of squaring (SR1-2) and flowers were removed throughout first to tenth week of flowering with two weeks interval (FR1-2, FR3-4, FR5-6, FR7-8, FR9-10) and check plot. At the end of variance analysis it was indicated that cotton could compensate for generative organs losses at early stage (SR1-2 and FR1-2) despite dramatically yield reduction at mid-flowering losses (FR3-4 and FR5-6, 21.11% and 10.49% in 1998 and 22.05% and 12.28% in 1999, respectively). Late removals (FR7-8 and FR9-10) have not significant effect on yield. Not any fiber quality parameters were affected by removals.

Keywords: Removal genarative organs, yield distribution, monopodium branches, fruting branches

Pamukta (*Gossypium hirsutum* L.) Tarak ve Çiçek Uzaklaştirmanin Etkisi : I. Verim, Erkencilik ve Lif Özelliklerindeki Değişimler

Özet
Bu çalışma, 1998 ve 1999 yıllarında, pamukta (*Gossypium hirsutum* L.) tarak ve çiçek uzaklaştırmanın verim, erkencilik ve lif özelliklerine etkisinin saptanması amacıyla, HR.Ü. Ziraat Fakültesi Tarla Bitkileri Bölümü araştırma alanında, tesadüf blokları deneme deseninde dört tekrarlamalı olarak yürütülmüştür. Bitki materyali olarak, Sayar 314 pamuk çeşidi kullanılmıştır. Çalışmada, taraklanma başlangıcından itibaren iki hafta boyunca oluşan tarakların (SR1-2), çiçeklenme dönemi başlangıcından başlayarak 10 hafta boyunca, ikişer hafta süreyle oluşan çiçeklerin (FR1-2, FR3-4, FR5-6, FR7-8, FR9-10) uzaklaştırılması ve Kontrol olmak üzere 7 konu uygulanmıştır. Yapılan varyans analizine göre, pamuk erken dönem generatif organ kayıplarını (SR1-2 ve FR1-2) telafi edebilmesine rağmen, orta dönem çiçek kayıpları belirgin şekilde verimi düşürmüştür (FR3-4 ve FR5-6, sırasıyla 1998 yılında 21.11% ve 10.49% ve 1999 yılında 22.05% ve 12.28%). Geç dönem çiçek uzaklaştırmalarının (FR7-8 ve FR9-10) verim üzerine önemli bir etkisi olmamıştır. Lif kalite özellikleri generatif organ uzaklaştırmalarından etkilenmemiştir.

Anahtar kelimeler: Generatif organların uzaklaştırılması, verim dağılımı,odun dalları, meyve dalları.

Introduction

Flowering and fruiting of cotton continues about two-three months and it produces a great deal of squares, flowers and bolls in this period. However, most of the produced fruits are shed. Shedding is observed throughout from initiation of squaring to harvest, even after harvest. Shedding occurs physiological or by pests. Its intensity and duration is important for final yield and earliness (Heitholt, 1993; Demirbilek and

Özel, 1999). A number of studies have been carried out on the basis of simulation of shedding. Some researchers have removed squares (Eid, 1973; Pan et al, 1987; Pettigrew et al., 1992; Pettigrew et al., 1993; Heitholt, 1997; Mann et al., 1997; Sadras, 1998; Holman and Oosterhuis,1999; Cook and Kennedy, 2000) or flowers (Patterson et al., 1978; Aviram and Rimon, 1980; Ahmed and Abdel-Al, 1988; Ungar et al., 1989; Jones et al., 1996a; Jones et al., 1996b; Wells 2001) or combined squares, flowers and bolls (Morton, 1979; Guinn, 1985; Ungar et al., 1987; Deshmukh et al., 1988; Moreno-Alvarado et al., 1990; Guinn and Brummett, 1992; Pettigrew, 1994; Sadras, 1996) at different stages, periods and durations. As like reported by Jones et al., (1996a) that most of these studies have focused on early removals and removed squares that for pest damage simulation. Whereas, in pest free fields most of the shedding occurs physiological and in a few days after anthesis. Nearly all researchers agree on the compensation ability of cotton plant and delaying in maturity after early generative organs losses but there are different results about late removals. Morton, (1979) reported late season removals had no effect on yield. Pan et. al. (1987) removed flower buds manually or with ethylene and reported that no difference was exist between early or late season removals of flower buds in manual removed. Wilson and Bishop (1982) reported that early season damage may enhance yield with only a delay in crop maturation, while late season damage can cause a yield reduction. Moreno-Alvarado (1990), reported that protection against insect damage should be carried out up to the 8th week of flowering. One of the latest research was carried out by Jones et al., (1996a) and they removed flowers at early, mid- and late-season, used long durations at late removals; 4th week and later, 5th week and later in 1991 and in addition to two treatments 6th week and later in 1992. Yield reduction was 24% and 13% in 1991; 33%, 26% and 16% in 1992 for treatments, respectively. On the other hand, Karner et al., (1998), emphasized unimportance of bolls that at 4NAWF and upper zone and reported that scouting for insect pests in cotton can be terminated when the irrigated crop reaches 5NAWF plus 350HU. Results of previous studies are different and controversial for late-season decisions.

Objectives of this study was to evaluate a) the effect of removal of squares at the beginning of squaring and flowers throughout flowering with two weeks interval on yield, earliness and fiber properties b) if difference exist between square and flower removals at early season c) to estimate acceptable yield formation period with late-season removals.

Materials and Methods

Field trials were conducted on research field of Harran University Faculty of Agriculture, Department of Field Crops in years of 1998 and 1999, at southeastern of Turkey. Research field soils belong to Ikızce Serie which spread on the Harran Plain. This serie had A, B and C horizons, flat and/or flat like slope, aluvial main material and deep profile. It was clayey, red pofile and whole profile limely. In this serie soils pH varies between 7.5-7.6. Low N, P and organic matter and high K content and Cation Exchange Capacity are characteristics of this serie (Dinç et al., 1988).

Trials were arranged in completely randomized block design with four replicates. Plots were consisted of four rows, rows 70 cm apart, length was 12 m and

plants were thinned approximately 5 plants m^{-1} when seedlings were at the third or fourth true leaf stage. Seeds of Sayar 314 cotton (*Gossypium hirsutum* L.) variety were planted on 1 May in 1998 and on 3 May in 1999. In both years, 160 kg ha^{-1} N and 70 kg ha^{-1} P was applied. Total of P and half of the N was applied at planting and rest of the N was applied at flowering initiation. In total, 12 irrigations were applied in each year. First irrigations were made for emergence purpose in both years. The first postemergence irrigation was applied 45 and 30 days after planting in 1998 and 1999, respectively. Not any serious pest or disease problem was met during the growing periods. Weed control measurements have been undertaken as needed.

Seven subjects were, in total, chosen as treatments as follows;

1. Squares removal through first two weeks of squaring, (SR1-2).
2. Flowers removal through first-second week of flowering, (FR1-2).
3. Flowers removal through third-fourth week of flowering, (FR3-4).
4. Flowers removal through fifth-sixth week of flowering, (FR5-6).
5. Flowers removal through seventh-eighth week of flowering, (FR7-8).
6. Flowers removal through ninth-tenth week of flowering, (FR9-10).
7. Control (no removal)

Appearance of pinhead square and one white flower m^{-1} were noted as squaring and flowering initiations, respectively. First treatment (SR1-2) started with the apperance of the pinhead square and ended two weeks later. Squaring started on 7 June in both years and flowering on 6 and 7 July in 1998 and 1999, respectively. Squares were removed by pliers but flowers by hand. During the squares and flowers removal of more attention was paid to avoid plant stunning, particullary during the squares removal. Squares and flowers were removed daily. When irrigation required white flowers and floral buds which might be open a day later were removed before irrigation and two days after irrigations red flowers which have opened one day after irrigation and white flowers were removed together. Squares were removed two days after irrigations.

In the two center rows of the plots, ten plants were selected randomisely and tagged for observations in each plot. Bolls on tagged plants were separately harvested according to monopodial and fruiting branches, also positions on fruiting branches. Fruiting branches were seperated in four groups as 1-5, 6-10, 11-15, 16+. and monopodial branches, positions in three groups as first, second and 3+.. Seed cotton that obtained from these bolls on same branches and positions was weighted and then proportioned to total plant seed cotton weight to determine seed cotton ratio of monopodial branches, fruiting branches and positions. First harvests were made on 25 and 28 September, in 1998 and 1999, respectively. Totally four harvests were made periodically with 15 days interval in each year. Hand picking rates were calculated with proportion to seed cotton weight that picked on that hand to total seed cotton yield. Fiber analysis (fiber length, micronaire, uniformity and strength) was performed by HVI (High Volume Instruments).

Data were analysed with using MSTAT-C statistical program. Each year data of seed cotton yield, picking rates, fiber length, micronaire, uniformity and strength were analysed separately in completely

randomized block design and means separated by use of LSD (Least Significant Difference Test) at P ≤ 0.05. Positions were considered as first, second, 3+. (third plus beyond positions) and monopodial branches, sympodial division was considered as 1-5., 6-10., 11-15., 16+. fruiting branches and monopodial branches. Positions and fruiting branches compared according to treatments not with each other via mentioned process.

Results and Discussion

Seed Cotton Yield

Means of seed cotton yield were presented in Table 1. Removals have significantly different effects on seed cotton yield. Removals changed the yield between +0.38% and -21.11% in 1998 and -1.35% and -22.05%, in 1999 compared to control. Yields of FR3-4 and FR5-6 in 1998 and FR1-2, FR3-4, FR5-6 and FR7-8 in 1999 were significantly different from control but others were not.

Table 1. Means of seed cotton yield and yield changes according to control in squares and flowers removal treatments in 1998 and 1999.

	1998		1999	
Treatment	**Yield (kg ha^{-1})**	**Change (%)**	**Yield (kg ha^{-1})**	**Change (%)**
SR1-2	3940.0 a	- 0.63	3983.0 abc	- 1.97
FR1-2	3890.0 a	- 1.89	3946.0 bc	- 2.88
FR3-4	3128.0 c	- 21.11	3167.0 e	- 22.05
FR5-6	3548.5 b	- 10.49	3563.5 d	- 12.28
FR7-8	3857.0 a	- 2.72	3889.0 c	- 4.28
FR9-10	3980.0 a	+ 0.38	4008.0 ab	- 1.35
Control	3965.3 a	0.0	4063.0 a	0.0
Mean	3758.4	-	3802.8	-
LSD (5%)	203.1	-	98.92	-

*: Means within a column followed by the same letter were not significantly different at the 0.05 probability level, according to Least Significant Difference Test.

Possible yield losses due to early season squares and flowers removals has not been noted. In SR1-2 and FR1-2, seed cotton yield decreased 0.63%, 1.89% and 1.97%, 2.88% compared to the control 1998 and 1999, respectively. There was no difference between square and flower removals. Also, these results verify compensation ability to cotton plant that predicted by researchers of previous studies (Stewart and Sterling, 1989; Ungar et al., 1992; Jones et al., 1996a; Sadras, 1996; Mann et al., 1997; Holman and Oosterhuis, 1999; Oosterhuis et al., 1999; Cook and Kennedy, 2000).

On the other hand, removals at mid-flowering have resulted most effective reduction in yield. In FR3-4 and FR5-6 seed cotton yield dramatically decreased and yields, 21.11% and 10.49% in 1998 and 22.05% and 12.28% in 1999, were lower than control in these treatments (Table 1). Cotton plant could have not compensated flower removals and seed cotton yield more decreased in this stage than other stages. These results imply the significance of these weeks of flowering for yield.

Last two removals (FR7-8 and FR9-10) did not changed the yield significantly, expect for that of FR7-8, in 1999. In FR7-8, yield decreased 2.72% and 4.28% in sucessive years. In FR9-10, yield increased slightly, 0.38% in 1998 but decreased by 1.35% in 1999 (Table 1). The results indicated that cotton plant requires at least 7-8 weeks to

reach its acceptable yield and fruits must be protected until the end of 7-8 weeks of flowering. In case of early season damages this period may prolong (Table 4). Flowers removal at the end of flowering has not reduced seed cotton yield remarkable as much as at mid-flowering removals (FR3-4 and FR5-6) probably due to high natural shedding and smaller bolls than earlier stage removals (third manuscript and unpublished data).

Table 2. Yield distribution at positions and monopodium branches according to squares and flowers removals in 1998 and 1999.

Treatments	% of Seed Cotton Yield on Positions							
	1998				1999			
	Mo. Bran.	1. Position	2. Position	3+. Position	Mo. Bran.	1. Position	2. Position	3+. Position
SR1-2	21.58	47.23 b	21.98 abc	9.22 bc	21.34	47.14 b	22.07 b	9.44 b
FR1-2	22.48	45.95 b	22.38 ab	9.19 bc	22.09	46.00 bc	22.08 b	9.84 b
FR3-4	20.29	43.73 c	24.04 a	11.95 a	19.57	44.98 c	24.04 a	11.42 a
FR5-6	20.18	46.04 b	23.61 a	10.18 b	20.37	45.85 bc	24.11 a	9.68 b
FR7-8	19.50	51.59 a	20.22 bc	8.69 cd	20.23	51.95 a	20.10 c	7.72 c
FR9-10	20.38	51.44 a	19.89 c	8.29 cd	19.98	52.07 a	19.91 c	8.05 c
Control	20.09	52.56 a	19.69 c	7.66 d	20.05	52.30 a	19.28 c	8.38 c
Mean	20.64	48.36	21.69	9.31	20.52	48.61	21.65	9.22
LSD (5%)	N.S.	2.200	2.478	1.195	N.S.	1.905	1.934	0.7805

*: Means within a column followed by the same letter were not significantly different at the 0.05 probability level, according to Least Significant Difference Test.

N.S.: No significant, **Mo. Bran.** : Monopodium Branches

In both years, more seed cotton has been obtained from first position than others in all treatments. First position was followed by second position or monopodial branches and 3+. position, respectively. In other words contribution to yield reduced from inside to outside of plant (Table 2). Although removals have no different effect on monopodium branches and did not change positions contribution order but first position contribution ratio was decreased while second and 3+. positions ratio was increased with respect to control by removals except FR7-8 and FR9-10. The slide of fruiting to out of the plant predicts earliness reduction in these treatments (Table 4). In general, last removals (FR7-8 and FR9-10) have close figures with control in both years.

Removals have changed contribution order and ratios of fruiting branches to seed cotton yield. In control treatment, highest contribution provided by 1-5. fruiting branches with 36.63% and 36.51% in 1998 and 1999, respectively to seed cotton. It was followed by 6-10, monopodial branches, 11-15. and 16+. fruiting branches. But except SR1-2, FR1-2 and FR3-4 in other treatments 16+. fruiting branches have no cotribution to seed cotton yield. SR1-2 and FR1-2 have significantly reduced contribution ratio of 1-5. fruiting branches but increased ratio of upper (Table 3).

Table 3. Yield distribution on frutiting and monopodium branches according to squares and flowers removals in 1998 and 1999.

Treatments	% of Seed Cotton Yield on Fruiting Branches				
	Mo. Bran.	1-5. Fr. Br.	6-10. Fr. Br.	11-15. Fr. Br.	16+. Fr. Br.
			1998		
SR1-2	21.58	11.14 e	44.84 a	21.31 a	1.13
FR1-2	22.48	9.32 f	46.56 a	20.29 ab	1.35
FR3-4	20.29	49.99 a	10.75 c	18.68 b	0.29
FR5-6	20.18	43.48 b	35.00 b	1.38 e	0.0
FR7-8	19.50	39.71 c	33.92 b	6.87 d	0.0
FR9-10	20.38	39.56 c	33.48 b	6.61 d	0.0
Control	20.09	36.63 d	33.35 b	9.93 c	0.0
Mean	20.64	32.83	33.99	12.15	0.40
LSD (5%)	N.S.	1.730	2.125	2.008	-
			1999		
SR1-2	21.34	11.14 e	45.05 a	20.96 a	1.51
FR1-2	22.09	9.69 e	46.40 a	20.14 ab	1.64
FR3-4	19.57	49.86 a	11.12 d	19.16 b	0.32
FR5-6	20.37	43.23 b	35.14 b	1.26 e	0.0
FR7-8	20.23	38.47 c	33.85 bc	7.46 d	0.0
FR9-10	19.98	39.82 c	32.93 c	7.27 d	0.0
Control	20.05	36.51 d	33.62 bc	9.82 c	0.0
Mean	20.52	32.67	34.01	12.30	0.50
LSD (5%)	N.S.	1.635	1.552	1.271	-

*: Means within a column followed by the same letter were not significantly different at the 0.05 probability level, according to Least Significant Difference Test.

N.S.: No significant, **Mo. Bran.** : Monopodium Branches, **Fr. Br.** : Frutiting Branches

Jones et al. (1996b), reported that removing flowers at first three weeks of flowering has increased boll numbers above 10. main stem node thereby increased contribution ratio to seed cotton yield. FR3-4 has reduced contribution ratio of 6-10. fruiting branches but increased others, particularly 1-5.. In FR5-6, contribution ratio of 11-15. fruiting branches decreased dramatically in 1998 by 1.38% and in 1999 by 1.26%. Of total yield, 98.62% and 98.74% was achieved from monopodial branches, 1-5. and 6-10. fruiting branches in 1998 and in 1999, respectively. With FR7-8 and FR9-10, 1-5. fruiting branches contribution was increased, 6-10 and 16+. contributions were unchanged and 11-15. contribution was decreased (Table 3). The monopodial branches contribution to seed cotton yield has not been significantly affected by removals and this attributable to similar growing, flowering and fruiting patterns of monopodial branches with cotton plant.

It was indicated that squares or flowers damage by any factors would change fruiting pattern. Also, flowering stage is important for this change. Early season damages shift the fruiting to upper portions of the plant. If occurs at the mid-flowering fruits will shift below and up portions of the plant or will gather at bottom and middle part of the plant. No significant changes will occur if the damage occurs at the end of flowering.

Earliness

Removal of squares and flowers at the early season (SR1-2 and FR1-2) caused delay in earliness. First and second picking rates decreased about 9-10% and 6-7% according to control, respectively (Table 4).

Table 4. Picking rates according to squares and flowers removal treatments in 1998 and 1999.

Treatments	Picking Rates			
	First	Second	Third	Fourth
		1998		
SR1-2	51.18 e	27.98 b	18.23 b	2.63 c
FR1-2	50.53 e	26.85 b	20.00 a	2.63 c
FR3-	67.05 b	15.63 c	9.23 c	8.10 a
FR5-6	74.33 a	10.58 d	8.50 c	6.60 b
FR7-8	62.63 c	34.45 a	2.93 e	0.0 d
FR9-10	60.75 d	34.90 a	4.35 d	0.0 d
Control	61.03 cd	33.63 a	5.35 d	0.0 d
Mean	61.07	26.29	9.80	2.85
LSD (5%)	1.696	1.550	1.219	0.4228
		1999		
SR1-2	53.00 d	26.93 b	17.63 a	2.45 c
FR1-2	52.65 d	26.53 b	18.50 a	2.33 c
FR3-4	65.35 b	16.88 c	9.00 b	8.78 a
FR5-6	73.80 a	10.25 d	8.40 b	7.55 b
FR7-8	62.50 bc	33.23 a	4.28 c	0.0 d
FR9-10	60.25 c	34.83 a	4.93 c	0.0 d
Control	61.45 c	33.93 a	4.63 c	0.0 d
Mean	61.29	26.08	9.62	3.01
LSD (5%)	2.877	2.754	2.024	0.9775

*: Means within a column followed by the same letter were not significantly different at the 0.05 probability level, according to Least Significant Difference Test. **N.S**.: No significant

These results may be a consequence of prevention of boll formation that probably would picked at first and second pickings with removal of squares and flowers. Jones et al. (1996a), reported that maturation has been delayed with flower removals in the early season. On the contrary, an increase was observed at third and fourth picking and about 13-14% and 2-3%, respectively in both years. Also, through two weeks at the initiation of squaring and flowering, removal of squares (SR1-2) and flowers (FR1-2) delayed about a month 15-18% of seed cotton yield than control. If seasons were short perhaps this sum of yield could not have been harvested. Removals at the mid-flowering (FR3-4 and FR5-6) increased first picking rate 4-13% but decreased second picking rate 17-23% compared to control. In third and fourth pickings a recovering was observed by lately formed bolls and picking rates were 3-4% and 6-8% higher than control respectively. In FR3-4 and FR5-6, 10-13% more yield was harvested in last month than control. A probable short season would have affected these treatments yield and decreased too much. Removals at the end of flowering (FR7-8 and FR9-10) did not change picking rates and have similar values with the control in both years.

Fiber Properties

Removals did not change fiber properties probably a consequence of favourable temperatures at late seasons in both years.

Table 5. Fiber properties according to squares and flowers removals in 1998 and 1999.

Treatments	Length	Micronaire	Uniformity	Strength
		1998		
SR1-2	29.2	4.1	85.2	29.8
FR1-2	29.3	4.1	84.7	29.9
FR3-4	29.6	4.3	84.2	30.3
FR5-6	29.4	4.3	85.5	31.1
FR7-8	29.4	4.2	84.3	30.4
FR9-10	29.5	4.1	84.6	30.2
Control	29.4	4.3	84.4	30.3
Mean	29.4	4.2	84.7	30.3
LSD (5%)	NS	NS	NS	NS
		1999		
SR1-2	29.3	4.1	84.5	31.5
FR1-2	29.3	4.0	84.3	30.7
FR3-4	29.7	4.3	84.1	30.5
FR5-6	29.5	4.2	84.7	32.3
FR7-8	29.3	4.1	84.2	31.8
FR9-10	29.2	4.0	84.4	31.2
Control	29.1	4.1	85.0	32.6
Mean	29.3	4.1	84.5	31.5
LSD (5%)	NS	NS	NS	NS

N.S.: No Significant

Despite insignificance of treatments on fiber properties, the highest fiber length and micronaire values occurred in FR3-4 and FR5-6 treatments in both years (Table 5). Jones et al. (1996a) reported that micronaire the only fiber property that affected by removal treatments.

Attachments

This study is prepared part of a Ph.D. thesis supervised by Dr. Abdulhabip ÖZEL and accepted by Harran University Institute of Natural and Applied Sciences on 2000.

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