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The Effect of Removed Squares and Flowers of Cotton (*Gossypium hirsutum* L.): II. Changes in Dry Matter Production, Distribution and Fruiting Pattern*

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Abstract

This study was conducted to determine the effects of squares and flowers removal on dry matter production and allocation, boll number and fruiting pattern of cotton plant (*Gossypium hirsutum* L.). Field experiments were conducted at research field of the Harran University Faculty of Agriculture, Department of Field Crops in years of 1998 and 1999 at southeastern of Turkey. Experiments were arranged in completely randomized block design with four replications. The Sayar 314 cotton (*G. hirsutum* L.) variety was used as plant material. Squares were removed through first two weeks of squaring (SR1-2), and flowers were removed with two weeks intervals from flowering initiation to the end of the tenth week of flowering (FR1-2, FR3-4, FR5-6, FR7-8, FR9-10) and control. Effects of removal treatments on investigated traits were different. SR1-2, FR1-2, FR3-4 and FR5-6 have higher dry matter than control and changed dry matter allocation among plant parts. All the treatments have lower boll number than control and removal of squares and flowers also changed boll percentage on positions and fruiting branches except on monopodium branches in both years.

Key words: Removal genaratif organs, Dry matter, Fruiting pattern, Boll number

Pamukta (*Gossypium hirsutum* L.) Tarak ve Çiçek Uzaklaştırmanın Etkisi : II. Kuru Madde Üretimi, Birikimi ve Meyvelenme Düzeni

Öz

Bu çalışma, 1998 ve 1999 yıllarında, pamukta (*Gossypium hirsutum* L.) tarak ve çiçek uzaklaştırmanın kuru madde üretimi ve birikimi, koza sayısı ve meyve dağılımı üzerine etkisinin saptanması amacıyla, Harran Üniversitesi, 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. Generatif organ uzaklaştırmanın incelenen özelliklere etkisi farklı olmuştur. SR1-2, FR1-2, FR3-4 ve FR5-6 uygulamaları kontrole göre daha yüksek kurumadde üretmiş ve kurumadde birikimi farklı bitki aksamlarında farklı bulunmuştur. Kontrole göre tüm uygulamalar daha düşük koza sayısı oluşturmuştur ve her iki yılda da odun dalları hariç, tarak ve çiçek uzaklaştırma ile her pozisyondaki koza yüzdesi değişmiştir.

Anahtar kelimeler: Generatif organların uzaklaştırılması, Kuru madde, Meyve dağılımı, Koza sayısı

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Introduction

Dry matter production rate is different throughout the season in cotton plant. Most of the total dry matter accumulate during the reproductive stage and the difference among genotypes appear after anthesis (Kerby et al., 1990). Halevy (1976), reported that 75% of total dry matter was accumulated in the period of 72-112 days after emergence. RVR (reproductive to vegetative ratio) of cotton plant changes throughout the growth (Wells and Meredith, 1984). Sadras and Wilson (1997), reported that foliar pests can affect reproductive allocation in plant and Sadras (1997), reported that vegetative growth rate decreases during the reproductive stage but fruit shedding, as induced by insect, could counteract this decrease. Exclusive sheddings or damagings during flowering and fruiting period, also could change boll number and fruiting pattern in addition to dry matter production and allocation (Jones et al., 1996; Kennedy et al., 1986; Ungar et al., 1987). Cotton yield is determined by boll weight and the number of bolls produced per plant. Singh et al. (1983), reported that the production of bolls was controlled by the number of fruiting points produced, which depended on the total dry matter produced by the plant. Therefore, it is important to study the effects of simulation of shedding to determine dry matter production and allocation, boll number and fruiting pattern of cotton plant.

This study was conducted to determine the effects of squares removal for two weeks at the beginning of squaring and flowers removal throughout the flowering on a) dry matter production and allocation b) boll number and fruiting pattern of cotton.

Materials and Methods

Field experiments of this study were conducted at Harran University Faculty of Agriculture, on research field of Department of Field Crops, in years of 1998 and 1999 at southeastern of Turkey. Ikızce Serie which spread on the Harran Plain include the research field soils. This serie soils have high Cation Exchange Capacity and pH varying between 7.5-7.6. Also, have low N, P and organic matter and high K and lime content (Dinç et al., 1988). Experiments were arranged in completely randomized block design with four replications. Four rows were in each plot and row length was 12 m, rows spaced 70 cm and 5 plants in one m^{-1}. Sayar 314 cotton (*Gossypium hirsutum* L.) variety was used and seeds 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 were applied. Total fosfor and half of the N was applied at planting and rest of the N was applied at flowering initiation in each year. Plants were thinned when seedlings were at the third or fourth true leaf stage. In total, 12 irrigations were applied include the preemergence irrigation that has been made for emergence purpose in either year. The first postemergence irrigation has been applied 45 and 30 days after planting in 1998 and 1999, respectively. Plant protection measurements were undertaken as needed although not any serious pest or disease problem was matched.

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 pin head square and one white flower m^{-1} were noted as squaring and flowering initiations, respectively. First treatment (SR1-2) started with apperance of pin head square and ended two weeks later. Flowers removal started one flower m^{-1}, continued with two weeks intervals and lasted end of tenth week of flowering. Squares were removed by pliers but flowers by hand. During the removals, 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 randomizely and tagged for measurements in each plot. Bolls were harvested at the end of season regarding to their positions. Boll percentage on positions and fruiting branches were determined with the proportion of harvested boll numbers on that positions or fruiting branches to the total boll numbers. Also, for dry matter measurements randomizely selected ten plants were cutted from soil surface, separated into generative and vegetative organs (also into main stem and branches, leaves) and dried in oven at 70 °C until to reach constant weight. Weight of plant parts were collected to determine dry matter weight of per plant, with collection of main stem and branches and leaves weights the vegetative dry matter sum was determined. The dry weight percentage for a given plant parts in whole plant was estimated from plant parts dry weight in proportion to whole plant dry weight.

Obtained data was analysed with using MSTAT-C statistical program. In each year, dry matter sum (per plant), dry matter allocation among plant parts (%), boll numbers (per plant) were analysed separately in randomizely complete block design and means separated by use of LSD (Least Significant Difference Test) at $P \leq 0.05$. 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 compared with each other via mentioned process.

Results and Discussion

Dry Matter Sum

It was found that dry matter production per plant was significantly increased with removals and varied between 211.3-275.2 g per plant in 1998 and 215.0-280.9 g per plant in 1999.

Years were not different about total dry matter production. Dry matter values agree with research by Reddy et al. (1991), reported that dry matter per plant has varied between 219.4 - 326.6 g per plant. Removal of squares and flowers at early stage has promoted dry matter production. Most increase was observed in FR1-2 and SR1-2 then declined (in FR3-4 and FR5-6), last two treatments (FR7-8 and FR9-10) have similar values with the control (Table 1). This difference must be related to the boll load.

In SR1-2 and FR1-2, during the removals zero boll load contributed to use assimilates for more plant parts production. In FR3-4 and FR5-6, previously retained bolls sinked assimilates and prevented to being removals effect as much as in SR1-2 and FR1-2. On the other hand, high boll load in FR7-8 and FR9-10 barried any difference from control. These findings indicate that boll load a significant barrier in front of the plant development. It prevents new plant vegetative and generative organs production.

Table 1. Means of total dry matter (g) per plant that obtained from square and flowers removal treatments in 1998 and 1999.

Çizelge 1. 1998 ve 1999 yıllarında tarak ve çiçek uzaklaştırma uygulamalarına göre bitkide saptanan toplam kuru madde ortalamaları (g).

Treatments	1998	1999
SR1-2	271.4 a*	276.8 a
FR1-2	275.2 a	280.9 a
FR3-4	247.1 b	250.8 b
FR5-6	229.7 c	232.5 c
FR7-8	211.3 d	215.7 d
FR9-10	217.4 d	216.2 d
Control	213.6 d	215.0 d
Mean	237.96	241.13
LSD (5%)	10.01	9.6114

*: 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.

Dry Matter Allocation Among Plant Parts (%)

Removals have significantly changed dry matter allocation to plant parts. Dry matter allocation varied between 33.2-46.1% and 34.2-46.0% in generative organs, 53.9-66.8% and 54.0-65.8% in vegetative organs, 43.5-48.2% and 44.0-47.4% in main stem and branches, 10.4-18.6% and 10.0-18.4% in leaves in 1998 and 1999, respectively (Table 2).

Our results are similar to that reported by Bassett et al. (1970) and Mullins and Burmester (1990).

All of the treatments have lower generative organs percentages than vegetative organs in dry matter, also, leaves than main stem and branches. Whereas removals enhanced total dry matter but did not change this fact (Table 1 and 2). Removals have induced excessive growth in vegetative parts, more leaves and branches production. Ungar et al. (1987), reported that vegetative development enhanced by genarative organs removal. Conversely, generative organs percentage was decreased by removals. Most reduction in generative organs percentage occured in FR3-4 and FR5-6. Reproductive growth had progressed and boll load had increased when flowers were removed in FR3-4 and FR5-6, plants cuuldn't compensate generative organs losses. Jones et al. (1996), reported that generative/vegetative organs dry matter ratio has been reduced by removing flowers at fourth week of flowering and later and confirm our results. Also, generative organs percentage decreased in SR1-2 and FR1-2 but not as much as in FR3-4 and FR5-6 due to compensation ability. Seed cotton yield of SR1-2 and FR1-2 were similar to control (first

manuscript) but generative organs percentages of SR1-2 and FR1-2 lower than control. This results may be a consequence of more dry matter production in SR1-2 and FR1-2 (Table 1).

Leaves percentage in total dry matter was increased by removals and the changes of leaves percentages were similar to vegetative organs percentages. Sadras (1997), reported that flowerbuds and young fruits removed plants had greater leaf area and more vegetative dry matter than non-removed ones. Main stem and branches percentages were close to generative organs percentages. But main stem and branches percentages were higher in SR1-2, FR1-2, FR3-4, FR5-6 and were lower in FR7-8, FR9-10 and control than generative organs percentage in 1998 and were higher in all treatments except in FR9-10 and control, values were same in FR9-10 and lower in control in 1999. In FR3-4 and FR5-6 more total dry matter was produced but generative organs stimulation observed lately and slowly, vegetative growth was rapid than reproductive growth and generative organs percentages were lower than main stem and branches percentages. In FR7-8, conversely changed to years but in FR9-10 and control generative organs percentages higher than main stem and branches.

Table 2. Dry matter allocation (%) among plant parts according to removal treatments in 1998 and 1999.

Çizelge 2. 1998 ve 1999 yıllarında uygulamalara göre bitki aksamlarında biriken ortalama kuru madde oranları (%) dağılımı.

Treatments	Generative Organs	Vegetative Organs	Main stem and Branch.	Leaves
		1998		
SR1-2	40.7 b	59.3 c	45.8 bc	13.5 c
FR1-2	41.1 b	58.9 c	44.7 cd	14.2 bc
FR3-4	33.2 d	66.8 a	48.2 a	18.6 a
FR5-6	38.6 c	61.4 b	46.4 b	15.0 b
FR7-8	44.3 a	55.7 d	44.1 d	11.6 d
FR9-10	45.2 a	54.8 d	43.9 d	10.9 d
Control	46.1 a	53.9 d	43.5 d	10.4 d
Mean	41.31	58.69	45.23	13.46
L.S.D..(5%)	1.867	1.867	1.640	1.269
		1999		
SR1-2	39.8 cd	60.2 bc	45.2 bc	15.0 b
FR1-2	41.5 c	58.5 c	44.9 bc	13.6 b
FR3-4	34.2 e	65.8 a	47.4 a	18.4 a
FR5-6	38.7 d	61.3 b	46.5 ab	14.8 b
FR7-8	43.9 b	56.1 d	44.9 bc	11.2 c
FR9-10	44.8 ab	55.2 de	44.8 bc	10.4 c
Control	46.0 a	54.0 e	44.0 c	10.0 c
Mean	41.28	58.72	45.38	13.34
L.S.D..(5%)	1.715	1.715	2.062	1.461

*: 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.

Boll Numbers (number/plant)

All the removal treatments have produced significantly lower boll numbers than control in both years (Table 3).

Effects of treatments did not change to years and there was no any interaction effect. Boll number dramatically decreased in FR3-4 and FR5-6 to 14.65 and 15.23 per plant in 1998 and to 13.30 and 14.64 per plant in 1999, respectively. It was indicated that flowers of through 3th-6th week of flowering were most important for boll numbers and thereby for seed cotton yield. Also, seed cotton yields of FR3-4 and FR5-6 were lowest among all treatments (first manuscript). It is necessary to prevent or reduce shedding of bolls that caused by any factor at least through this period. Jones at al. (1996), reported that removal flowers at fourth week of flowering and later significantly reduced boll numbers and supports our findings. In SR1-2 and FR1-2 adverse effect of removal has been compensated but this wasn't sufficent to prevent boll number reduction. Boll numbers of SR1-2 and FR1-2 were close to control but also different from control. Seed cotton yields were not significantly different in contrast to boll numbers. On the other hand, boll weight of SR1-2 and FR1-2 were slightly higher than control (unpublished data). Both of these insignificant differences perhaps prevented significant effects of boll numbers on seed cotton yield in both treatments.

Table 3. Boll numbers per plant according to removal treatments in 1998 and 1999.
Çizelge 3. 1998 ve 1999 yıllarında uygulamalara göre bitkide saptanan ortalama koza sayıları.

Treatments	**1998**	**1999**
SR1-2	17.30 b	17.90 c
FR1-2	17.38 b	17.76 c
FR3-4	14.65 c	13.80 e
FR5-6	15.23 c	14.64 d
FR7-8	17.40 b	17.75 c
F9-10	18.05 b	18.61 b
Control	20.05 a	19.68 a
Mean	17.15	17.16
L.S.D. (0.05)	1.014	0.6526

*: 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.

Boll Percentages at Positions and Fruiting Branches

Removals have changed boll percentages significantly at all positions except on monopodium branches. In all treatments most of the bolls occured at first position and followed by second position or monopodium branches and 3+. position (Table 4).

Almost half of the bolls have been at first position and other half distributed at other positions. Means of boll percentage overall treatments were 46.57% and 46.68% at first, 22.10% and 22.12% at second position, 21.35% and 20.98% on monopodium branches and 9.98% and 10.22% at 3+. position in 1998 and 1999, respectively. Civaroğlu (1995), reported that 40-60% of bolls have occured at the first position but more lower at the other positions (at second and 3+.). Removals reduced bolls percentage at first position but increased at second and 3+. positions (Table 4). In other words, removal of squares and flowers has slided

boll retention out of plant. Jones et al. (1996), reported that removal of flowers at early stage has caused to slide boll retention out of plant (at 3+. position) and reduced boll number ratio at the first position.

Table 4. Boll percentages (%) on positions according to removal treatments in 1998 and 1999

Çizelge 4. 1998 ve 1999 yıllarında uygulamalara göre nodi bölgelerinde saptanan ortalama koza oranları (%)

Treatments	1998				1999			
	M. B.	1. Pos.	2. Pos.	3+. Pos.	M.B.	1. Pos.	2. Pos.	3+. Pos.
SR1-2	22.65	45.08 c	22.14 ab	10.14 bc	21.33	45.40 b	22.49 bc	10.79 b
FR1-2	23.15	44.28 c	22.42 ab	10.16 bc	21.78	44.25 b	22.77 bc	11.21 a
FR3-4	20.50	43.76 c	24.14 a	11.61 a	20.80	44.21 b	24.07 ab	10.93 ab
FR5-6	20.85	44.10 c	24.22 a	10.84 ab	21.13	43.98 b	24.43 a	10.47 b
FR7-8	20.58	48.63 b	21.02 b	9.79 bc	20.20	48.88 a	21.00 cd	9.93 c
FR9-10	21.15	49.40 ab	20.57 b	8.89 cd	20.90	49.75 a	20.35 d	9.00 d
Control	20.58	50.73 a	20.24 b	8.47 d	20.75	50.33 a	19.75 d	9.18 d
Mean	21.35	46.57	22.10	9.98	20.98	46.68	22.12	10.22
L.S.D. (5%)	N.S.	1.697	2.273	1.385	N.S.	1.476	1.702	0.4280

*: 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, **M. B.** : Monopodium Branches, **Pos** : Position

Table 5. Boll percentages (%) on fruiting branches according to removal treatments in 1998 and 1999.

Çizelge 5. 1998 ve 1999 yıllarında uygulamalara göre meyve dalı bölgelerinde saptanan ortalama koza oranları (%).

Treatments	Mo. Bran.	1-5. Fr. Br.	6-10. Fr. Br.	11-15. Fr. Br.	16+. Fr. Br.
			1998		
SR1-2	22.65	12.20 e	43.13 a	20.70 a	1.33
FR1-2	23.15	10.65 f	44.38 a	20.25 a	1.58
FR3-4	20.50	47.08 a	11.80 c	20.30 a	0.33
FR5-6	20.85	44.08 b	33.68 b	1.40 d	0.0
FR7-8	20.58	39.88 c	31.73 b	7.83 c	0.0
FR9-10	21.15	39.73 c	31.88 b	7.25 c	0.0
Control	20.58	37.20 d	31.73 b	10.50 b	0.0
Mean	21.35	32.97	32.61	12.60	0.46
LSD (5%)	N.S.	1.537	2.047	2.181	-
			1999		
SR1-2	21.33	13.38 e	42.95 a	20.63 a	1.73
FR1-2	21.78	11.53 f	44.50 a	20.33 a	1.88
FR3-4	20.80	47.15 a	11.68 d	19.95 a	0.43
FR5-6	21.13	43.75 b	33.70 b	1.43 d	0.0
FR7-8	20.20	39.63 c	31.93 c	8.25 c	0.0
FR9-10	20.90	40.05 c	31.43 c	7.62 c	0.0
Control	20.75	37.05 d	31.48 c	10.73 b	0.0
Mean	20.98	33.22	32.52	12.70	0.58
LSD (5%)	N.S.	1.516	1.422	1.468	-

*: 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.

Mo. Bran. : Monopodium Branches, **Fr. Br.** : Frutiting Branches

Boll percentages on all fruiting branches have been affected by removals but monopodium branches has not been affected (Table 5). Early stage removals have lower boll percentages at the bottom of the plant but late stage removals have higher boll percentage than control. Conversely, early stage removals have higher boll percentage on upper zone of the plant but late stage removals have lower boll percentage than control. In SR1-2 and FR1-2 boll percentage has decreased on 1-5. fruiting branches but increased on other fruiting branches particullary on 6-10. In FR3-4 decreased on 6-10 but other fruiting branches values constitute a higher percentage. In FR5-6 boll percentage dramatically decreased on 11-15. (1.40% and 1.43% of bolls in 1998 and 1999, respectively) and 98.60% and 98.57% of total bolls gathered at the bottom of plant (on monopodium, 1-5. and 6-10.). Jones et al. (1996), reported that removing of flowers in the early stage has caused to increase in boll number ratio above 10. main stem node but at the late stage removal has decreased it above 11. main stem node. In FR7-8 and FR9-10 boll percentage increased on all fruiting branches except on monopodium branches and 6-10. It is clear that most reduction in boll percentage occured on fruiting branches that on squares and flowers were removed.

Results obtained indicated that the effects of removal treatments on investigated traits were different. SR1-2, FR1-2, FR3-4 and FR5-6 have higher dry matter than control and changed dry matter allocation among plant parts. All the treatments have lower boll number than control and removal of squares and flowers also changed boll percentage on positions and fruiting branches except on monopodium branches in both years.

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