



The Effect of Removed Squares and Flowers of Cotton (*Gossypium hirsutum* L.): III. Changes in Flowering and Shedding Pattern

Tuncay DEMİRBILEK¹, Abdulhabip ÖZEL^{2*}, Mustafa OĞLAĞCI³

¹Harran University, Graduate School of Natural and Applied Science, Sanliurfa/TURKEY

²Harran University Faculty of Agriculture, Department of Field Crops, Sanliurfa/TURKEY

³KSU, Faculty of Agriculture, Department of Field Crops, Kahramanmaraş/TURKEY

*Corresponding author: hozel@harran.edu.tr

Abstract

This study was conducted to determine the effects of squares and flowers removal on flower distribution on plant, flowering pattern, square and flower shedding rates and boll retention rate 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. In general, effects of FR7-8 and FR9-10 were similar to control on most of the investigated traits. SR1-2, FR1-2 and FR3-4, have changed the flowering pattern and plants reached peak flowering later than control and addition to these treatments FR5-6 has lightened or prevented cut-out, too. Square and flower removals increased the numbers of square and flower in both years. Square numbers were increased from 78.6 to 84.9 and 79.0 to 86.1 per plant by SR1-2 in 1998 and 1999, respectively. Flower numbers increased from 58.38 to 65.00 and 59.53 to 65.30 per plant in FR3-4, in 1998 and 1999, respectively. Square shedding rate was reduced by removal treatments. Boll retention rate was increased by removal treatments. Also, percentage of flower and shedding square, and boll retention rate on positions of fruiting branches were affected by removal treatments.

Key words: Removal generatif organs, Flowering pattern, Square and flower shedding rates, Boll retention rate

Pamukta Tarak ve Çiçek Uzaklaştırmanın Etkisi : III. Çiçeklenme ve Silkme Düzeni

Öz

Bu çalışma, 1998 ve 1999 yıllarında, pamukta (*Gossypium hirsutum* L.) tarak ve çiçek uzaklaştırmanın çiçeklenme düzeni, tarak ve çiçek silkme oranı ve koza tutma oranı üzerine 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. Generatif organ uzaklaştırmanın incelenen özelliklere etkisi farklı olmuştur. Genel olarak, FR7-8 ve FR9-10'un etkileri diğer uygulamalara göre kontrole benzer olmuştur. SR1-2, FR1-2 ve FR3-4 çiçeklenme düzenini değiştirmiş ve kontrolden daha geç çiçeklenme pik yapmıştır, ayrıca bu uygulamalara ek olarak FR5-6 uygulamalarında cut-out dönemi hafif olmuş veya önlenmiştir. Tarak ve çiçek uzaklaştırmalar her iki yılda da tarak ve çiçek sayısını artırmıştır. Tarak sayısı, SR1-2 uygulamasında 1998 ve 1999 yıllarında, sırasıyla bitki başına 78.6'dan 84.9'a ve 79.0'dan 86.1'a artmıştır. Çiçek sayısı, FR3-4 uygulamasında,

1998 ve 1999 yıllarında, sırasıyla bitki başına 58.38'den 65.00'a ve 59.53'den 65.30'a yükselmiştir. Tarak silkme oranı, uzaklaştırma uygulamalarına bağlı olarak azalmıştır. Koza tutma oranı ise, uzaklaştırma uygulamalarına bağlı olarak artmıştır. Aynı zamanda, tarak ve çiçek silkme oranı ve meyve dallarına göre koza tutma oranı uzaklaştırma uygulamalarından etkilenmiştir.

Anahtar kelimeler: Generatif organların uzaklaştırılması, Çiçeklenme düzeni, Tarak ve çiçek silkme oranı, Koza tutma oranı

Introduction

Shedding is a natural event for cotton plant and it sheds its own generative organs throughout the reproductive growth. Shedding occurs regardless of conditions even in ideal conditions for cotton growth. Also, cotton produces more generative organs that it would converted to bolls and more bolls than could bear (Jenkins et al., 1990). Although, aborted generative organs contribute to formation of new ones. Kletter and Wallach (1982) reported natural shedding of square and bolls, has an increased rate of flowering late in the season and percentage boll set. Yield of cotton is highly correlated with the number of flowers and bolls produced (Guinn and Mauney, 1984). Retention rate of bolls is not less important than generative organ numbers and formation of new generative organs. Retention rate of generative organs increases with removal treatments. Guinn (1985) reported that flowers or bolls removal at first node has increased boll retention at second node. Patterson et al. (1978) also, reported that at an early stage flowers removal has increased flowering and fruiting.

An increase in boll retention on most contributory plant zone to yield is a key factor to maximize cotton yield. Jenkins et al. (1990) reported that improvement in boll retention until the harvest is a desirable breeding objective. They have also reported that perhaps breeders could select for plants that retain a boll at position 1 at main stem

from nodes 9 through 14, and thereby increase yields, or select for plants with a harvestable boll at main stem from nodes 6 through 8 and increase both yield and earliness. Naturally shed of generative organs occurs untimely and the shedding rate and its results couldn't be estimated. With removal of generative organs, boll retention rate can be increased in the desired stage of reproductive growth. Previously retained bolls can be propped and their properties might be improved by removal at any stage of reproductive growth. Also, it is important to essay plant response after excessive shedding caused by any factor throughout reproductive growth.

Number of generative organs, conversion rate of each other (conversion of squares to flowers, flowers to bolls) and shedding, generative organs distribution on plant is also important as well as the retention. Heitholt (1997) reported that physiologists and breeders had proposed a plant type that produced primarily FP1 fruit, few FP2 and no FP3 fruits as response to industry wish for high fiber quality. The same author also reported that two reasons were existing for this plant type. First is use of columnar genotypes and second (only for research purposes) remove fruiting forms that on unwanted FP.

Objective of this study to investigate the effects of removal of generative organs on; a) boll retention, square and flower shedding rates and distribution on plant, b) square and flower numbers, flowering pattern

throughout the flowering and distribution of flowers on plant.

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 soil a member of Ikizce Serie which spread on the Harran Plain. This serie soils have a high Catyon Exchange Capacity and pH varies between 7.5-7.6. Low N, P and organic matter and high K content 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, in lengthened 12 m, inter row and intra row spaces were 70 and 20 cm, respectively. Seeds were planted on 1 May in 1998 and 3 May in 1999. The Sayar 314 cotton (*G. hirsutum* L.) variety was used as plant material. In both years, 160 kg ha⁻¹ N and 70 kg ha⁻¹ P₂O₅ were applied. Total of P₂O₅ and half of the N was applied at sowing and rest of the N was applied at flowering initiation in both years. Stands were thinned when seedlings were at the third or fourth true leaf stage. In total, 12 irrigations were applied in each year. First irrigations were made for emergence purpose in both years. The first postemergence irrigation has been applied 45 and 30 days after planting in 1998 and 1999, respectively. Not any serious pest or diseases problem has been matched during the growing periods. Weed control measures have been undertaken as needed.

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

1. Removal of squares through first two weeks of squaring, (SR1-2).
2. Removal of flowers through first and second week of flowering, (FR1-2).

3. Removal of flowers through third and fourth week of flowering, (FR3-4).
4. Removal of flowers through fifth and sixth week of flowering, (FR5-6).
5. Removal of flowers through seventh and eighth week of flowering, (FR7-8).
6. Removal of flowers through ninth and tenth week of flowering, (FR9-10).
7. Control (no removal)

In the two center rows of the plots, ten plants were chosen randomly and tagged for observations in each plot. Appearance of pin head square and one white flower m⁻¹ were noted as squaring and flowering initiation, respectively. On tagged plants, flowers were noted on three days (on Monday, Wednesday and Friday) in a week but during the application of treatments, in that plots, flowers were noted daily before removal. Positions and opening dates of flowers were recorded on plant shaped maps. The same process was applied to shed squares and flowers when flowers were recorded. Shed squares, opened flowers and squares that remained on the plant at the end of season were counted and added later to determine square numbers. Flower numbers were calculated only from papers that noted flowers were counted and determined. Shed squares and shed flowers (unpollinated white flowers) also were counted on papers and proportioned to total square and flower numbers to determine shedding rates. Square numbers that shed at positions and fruiting branches proportionated to total number of squares and percentage of shed squares at positions and fruiting branches were determined. Bolls were harvested at the end of season regarding to their positions and empty positions were recorded and matched with plant shaped maps to indicate shedding stage (square, flower or boll). Harvested boll

numbers were proportioned to total pollinated flower (boll) numbers and boll retention rates were determined. Boll retention rates on positions and fruiting branches were determined with the proportion of harvested boll numbers at that positions and fruiting branches to the pollinated flower (boll) numbers at that positions or fruiting branches. Flower numbers according to opening dates were divided to weekly, weekly flowering rate and seasonal flowering pattern were determined.

First treatment (SR1-2) started with the appearance of the pin head 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 years, respectively. Squares were removed by pliers but flowers by hand. During the removal of squares and flowers more attention was paid to avoid plant stunning, particularly 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.

Obtained values were analysed with using MSTAT-C statistical program. Each year and boll retention rate, squares and flowers shedding, square and flower numbers were analysed separately in completely randomized 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

Flowering Pattern

Flowering has begun in the first week of July in all treatments except in SR1-2 in both years (Table 1). During the first two weeks of July, no squares were to form flowers that previously removed throughout first two weeks of squaring. Baht (1990), reported that flowering was delayed about 28 days in result of square shedding at early stage. Flowering started about two weeks later in this treatment. Flowering rates were higher than other treatments in every week of flowering till ninth week, but were similar to other treatments later (Table 1). This might be caused by cumulative effects of removal of squares. The results confirm the findings of Kennedy et al. (1986). Also, it is indicated that flowering rate was increased by other flower removals and increase was apparently observed throughout two weeks later when removals were ended. The most prominent effect was observed in SR1-2 and FR1-2 due to zero boll load during the removal in either treatments. At first, flower numbers per week were low but reached its highest level between 4th-6th week of flowering varied to treatments and declined later in all treatments. The highest flowering rates were obtained at sixth, fifth and fourth week of flowering in SR1-2 (10.90 and 10.60 flower/plant/week), FR1-2 (9.35 and 9.42 flower/plant/week) and FR3-4 (9.13 and 9.20 flower/plant/week) and in other removal treatments, respectively.

Table 1. Weekly flowering pattern of cotton plant (number/plant/week) according to squares and flowers removal treatments in 1998 and 1999 years

Çizelge 1. 1998 ve 1999 yıllarında uygulamalara göre saptanan haftalık ortalama çiçek sayıları (adet/bitki/hafta)

| Flowering Weeks Çiçeklenme Haftaları | SR1-2** | | FR1-2 | | FR3-4 | | FR5-6 | | FR7-8 | | FR9-10 | | Control Kontrol | |
|---|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-----------------|-------------|
| | '98 | '99 | '98 | '99 | '98 | '99 | '98 | '99 | '98 | '99 | '98 | '99 | '98 | '99 |
| 1. (4-10.7)* | 0.00 | 0.00 | 1.52 | 1.55 | 1.50 | 1.46 | 1.63 | 1.58 | 1.40 | 1.43 | 1.35 | 1.30 | 1.43 | 1.34 |
| 2. (11-17.7) | 0.00 | 0.00 | 4.18 | 4.09 | 4.20 | 4.27 | 4.23 | 4.13 | 4.45 | 4.55 | 4.43 | 4.40 | 4.20 | 4.33 |
| 3. (18-24.7) | 2.33 | 2.29 | 6.68 | 6.76 | 5.95 | 5.86 | 6.00 | 6.10 | 6.23 | 6.33 | 5.95 | 5.84 | 6.50 | 6.65 |
| 4. (25-31.7) | 7.60 | 7.56 | 8.47 | 8.51 | 8.80 | 8.88 | 8.38 | 8.28 | 8.00 | 8.10 | 8.23 | 8.28 | 8.58 | 8.40 |
| 5. (1-7.8) | 9.78 | 9.70 | 9.35 | 9.42 | 9.13 | 9.20 | 7.23 | 7.11 | 7.35 | 7.29 | 7.15 | 7.12 | 7.35 | 7.58 |
| 6. (8-14.8) | 10.9 | 10.6 | 7.95 | 7.88 | 7.73 | 7.71 | 7.25 | 7.17 | 6.60 | 6.56 | 6.70 | 6.77 | 6.45 | 6.58 |
| 7. (15-21.8) | 9.57 | 9.66 | 7.13 | 7.10 | 6.98 | 6.90 | 6.50 | 6.40 | 5.48 | 5.40 | 5.65 | 5.66 | 5.60 | 5.57 |
| 8. (22-28.8) | 7.74 | 7.90 | 5.68 | 5.60 | 5.91 | 5.87 | 5.55 | 5.48 | 4.43 | 4.30 | 4.50 | 4.43 | 4.43 | 4.61 |
| 9. (29.8-4.9) | 5.15 | 5.10 | 4.08 | 4.17 | 4.03 | 4.12 | 4.10 | 4.00 | 3.10 | 3.33 | 2.85 | 2.80 | 2.58 | 2.67 |
| 10. (5-11.9) | 3.23 | 3.30 | 2.83 | 2.87 | 3.75 | 3.68 | 3.70 | 3.60 | 2.98 | 3.06 | 3.23 | 3.20 | 3.45 | 3.52 |
| 11. (12-18.9) | 2.13 | 2.22 | 2.75 | 2.85 | 2.88 | 2.90 | 3.25 | 3.30 | 3.50 | 3.52 | 3.70 | 3.76 | 3.25 | 3.42 |
| 12. (19-25.9) | 1.82 | 1.88 | 2.42 | 2.49 | 2.18 | 2.36 | 2.85 | 2.80 | 3.08 | 3.12 | 3.40 | 3.43 | 2.75 | 2.81 |
| 13. (26.9-2.10) | 1.30 | 1.34 | 0.83 | 0.88 | 1.12 | 1.14 | 2.05 | 2.10 | 1.68 | 1.81 | 1.58 | 1.54 | 1.46 | 1.62 |
| 14. (3-9.10) | 0.60 | 0.71 | 0.40 | 0.35 | 0.64 | 0.68 | 0.73 | 0.70 | 0.75 | 0.72 | 0.68 | 0.62 | 0.24 | 0.28 |
| 15. (10-16.10) | 0.10 | 0.14 | 0.13 | 0.21 | 0.20 | 0.27 | 0.23 | 0.20 | 0.20 | 0.26 | 0.15 | 0.18 | 0.11 | 0.15 |
| Mean | 4.15 | 4.16 | 4.29 | 4.32 | 4.33 | 4.35 | 4.25 | 4.20 | 3.95 | 3.99 | 3.97 | 3.96 | 3.89 | 3.97 |

*: Figures in parentheses describe the date of flowering, described as day and month, i.e. 4-10.7: between 4-10 days of July. (Parantez içerisinde çiçeklenme tarihleri gün ve ay şeklinde verilmiştir, örneğin, 4-10.7: Haziran ayı 4-10. Günleri.)

** : Removal of squares through first two weeks of squaring. (Tarak uzaklaştırma, taraklanmanın ilk iki haftası.)

In control, flowering rates were 1.43 and 1.34 flower/plant/week at first week, reached its highest level, 8.58 and 8.40 flower/plant/week at fourth week of flowering and then began to decline and reached 2.58 and 2.67 flower/plant/week at ninth week in 1998 and 1999, respectively. After the ninth week, the flowering slightly increased about 2 weeks and then declined again to reach its lowest level, 0.11 and 0.15 flower/plant/week in 1998 and 1999, respectively. This case caused to establish two cycles in flowering (Figure 1b). The first cycle maintained about 8 weeks (50-55 days), flowering ceased (cut-out) about 2 weeks (10-15 days) and then the second cycle began and maintained about 6 weeks (35-40 days). During the first cycle, the flowering rate was higher than in the second

one in both years. Verhalen et al. (1975), reported that flower numbers per plant and flowering rate were maximum at the middle of flowering and declined later.

Flowering has occurred as a main cycle in SR1-2, FR1-2, FR3-4 and FR5-6 (Figure 1a). In these treatments flowering rates were reached their highest levels about 1-2 weeks later (varied to treatments) and in this period more flowers have been produced than control. Cut-out has not been observed in these treatments and the reducing boll load has caused continuing flowering. Ungar et al. (1987), reported that cut-out was delayed and flowering rate was low at the beginning of flowering due to removal of squares. Guinn (1985), reported that removal of flowers through first three weeks of flowering caused to delaying in cut-out.

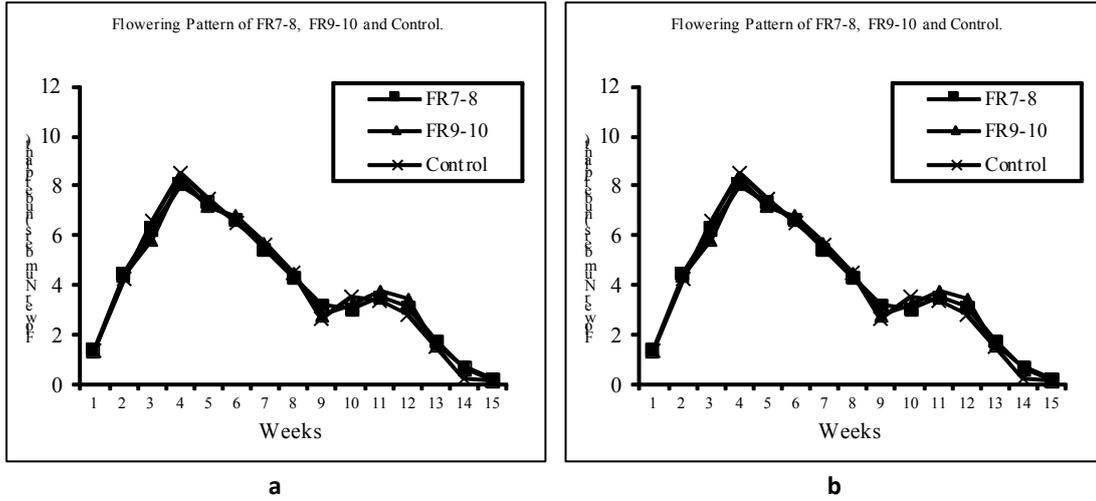


Figure 1. Flowering pattern of removal treatments according to combined values (average of 1998 and 1999 years), a) SR1-2, FR1-2, FR3-4 and FR5-6 and b) FR7-8, FR9-10 and Control

Şekil 1. Birleşik değerlere göre haftalık ortalama çiçek sayıları (1998 ve 1999 yılları ortalaması), a) SR1-2, FR1-2, FR3-4, FR5-6 ve b) FR7-8, FR9-10, Kontrol

Square and Flower Numbers and Flowers Distribution on Plant

Square and flower numbers have been affected significantly by removal treatments in both years but years were not different and interactions did not have any effect. Removing the squares and flowers at an early stage (SR1-2, FR1-2, FR3-4 and FR5-6) has caused an increase in square and flower numbers although square and flower numbers have not changed significantly with late stage removals (FR7-8 and FR9-10) but in 1998 flower numbers of late stage removals were also different from control (Table 2). Treatments from which highest square numbers have been obtained have not represented highest flower numbers. Highest square numbers, 84.9 and 86.1 per plant, were obtained with SR1-2 but flower numbers, 65.00 and 65.30 per plant, were obtained with FR3-4 in both years. Lowest square numbers, 78.6 and 79.0 per plant, were obtained from control in both years. On the other hand, the lowest flower numbers, 58.38 per plant, in 1998, was

obtained from control while was obtained with FR9-10 (59.33 per plant) in 1999. Abrina and Cosico (1987) reported that square and flower numbers varied between 40.00-74.33 and 31.00-63.00 per plant, respectively. The difference between square and flower numbers resulted from the high conversion rate of squares in to flowers in FR3-4 and FR1-2 than SR1-2. Also, more squares have remained on the plants in SR1-2 at the end of season (data not presented). Removal of squares and flowers at early stage has given a chance to produce more squares and flowers to plants. Ungar et al. (1987), support our findings with pointing square numbers has increased with removal of generative organs. Also, similar results were observed by Kennedy et al. (1986) and reported that flower numbers and flowering rate have increased with generative organs removal.

None of the treatments have changed flowers percentage on monopodial branches (Data not presented). On fruiting branches and positions were significantly different

according to removal treatments. In all treatments, highest percentage of flowers has been determined at 3+. position and followed by first (SR1-2 has a higher value on monopodial branches than on first position), second position and/or monopodial branches in both years First three removal treatments (SR1-2, FR1-2 and FR3-4) increased percentage of flowers at 3+. position 1-9% but decreased up to 3% on first and second positions while last three treatments (FR5-6, FR7-8 and FR9-10) decreased about 1% at 3+. but increased on first and second positions up to 1.5-2% when compared to control. On fruiting branches, in control, highest percentage of flowers

occured on 1-5. and followed by 6-10., monopodial branches, 11-15. and 16+. fruiting branches, respectively. This order has been changed by removals. With removals flowering slided up upper zone of plant, flowers percentage increased about 6% and it was clear in early removals. SR1-2 caused to decline 6% in percentage of flowers at the bottom of the plants in result of squares removal that prevent flowers formation on that zone. Other removals reduced flowers percentage about 1-2% at the bottom and middle portion of the plant. In general, last two removals have the similar values with the control.

Table 2. Means of square and flower numbers (number/plant) according to removal treatments in 1998 and 1999

Çizelge 2. 1998 ve 1999 yıllarında uygulamalara göre saptanan ortalama tarak ve çiçek sayıları (adet/bitki)

| Treatments | Squares Tarak | | Flowers Çiçek | |
|-----------------|------------------|--------------|------------------|--------------|
| | 1998 | 1999 | 1998 | 1999 |
| SR1-2** | 84.9 a* | 86.1 a | 62.25 c | 62.40 b |
| FR1-2 | 84.6 a | 85.8 a | 64.40 a | 64.73 a |
| FR3-4 | 84.7 a | 85.1 a | 65.00 a | 65.30 a |
| FR5-6 | 83.0 b | 84.4 a | 63.68 b | 62.95 b |
| FR7-8 | 79.5 c | 80.7 b | 59.23 d | 59.78 c |
| FR9-10 | 79.4 c | 79.9 b | 59.55 d | 59.33 c |
| Control | 78.6 c | 79.0 b | 58.38 e | 59.53 c |
| Mean | 82.1 | 83.0 | 61.78 | 62.00 |
| LSD (5%) | 1.599 | 2.322 | 0.6660 | 1.260 |

*: 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 (LSD).

** : Removal of squares through first two weeks of squaring. (Tarak uzaklaştırma, taraklanmanın ilk iki haftası.)

Square Shedding Rate (%)

In both years, treatments were significantly different in relation to square shedding rate but the difference between years and interactions effect was not significant. At early stage (SR1-2, FR1-2, FR3-4 and FR5-6) squares and flowers removals resulted in lower square shedding rate than at late stage flower removals (FR7-8 and

FR9-10). Most reduction in square shedding rate occurred in SR1-2 and square shedding rate decreased from 20.73% to 14.08% in 1998 and from 20.88% to 14.63% in 1999 when compared to control. Also square shedding rate was reduced by FR3-4, FR1-2 and FR5-6 (Table 3). Highest square shedding rates, 20.73% and 20.88% were occurred in control in both years. Ungar et al. (1987),

reported that square shedding has been reduced by removal of generative organs.

In SR1-2 removed squares which have not been permitted to shed naturally haven't been counted as shed. Of course some of them would have shed naturally and included in calculations. This situation might be effective on this reduction. In FR1-2 and FR3-4 squares have been propped by excess assimilates due to zero boll load or lack of adequate bolls that boll formation has been prevented with flowers removal. In FR5-6

square shedding rate higher than early removals but lower than late removals and control. In this treatment flowers removal gave more support to squares with excess assimilates. In early removal treatments, more assimilates have been permitted to flow new squares and this situation alleviated assimilate competition thereby shedding rates have decreased. In late removals, assimilates have been sinked by bolls that number of them was high and previously retained.

Table 3. Square shedding rates (%) according to removal treatments in 1998 and 1999

Çizelge 3. 1998 ve 1999 yıllarında uygulamalara göre saptanan ort. tarak silkme oranları (%)

| Treatments Uygulamamalar | 1998 | 1999 |
|-----------------------------|--------------|--------------|
| SR1-2** | 14.08 d* | 14.63 d |
| FR1-2 | 16.33 c | 16.68 bc |
| FR3-4 | 15.88 c | 15.58 cd |
| FR5-6 | 17.60 b | 17.33 b |
| FR7-8 | 19.90 a | 19.65 a |
| FR9-10 | 20.18 a | 20.68 a |
| Control | 20.73 a | 20.88 a |
| Mean | 17.81 | 17.92 |
| LSD (5%) | 1.123 | 1.519 |

*: 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.

** : Removal of squares through first two weeks of squaring. (Tarak uzaklaştırma, taraklanmanın ilk iki haftası.)

Our square shedding rate values similar to the ones reported in the literature. Singh et al. (1992), reported that the square shedding rate changes between 10.4% and 14.6% depending on the development stage of cotton plant. Mauney et al. (1980) reported that normal plants shed 10-50% of its squares.

Removal of squares and flowers has significantly affected the percentage of shed squares on all positions and fruiting branches but on monopodial branches, in both years (Data not presented). In all treatments squares shedding increased from inside to out of plant. Ungar et al. (1987), reported that square shedding increases with plant

growth advance. By SR1-2, FR1-2, FR3-4 and FR5-6 percentage of shed squares was reduced or unchanged on first and second but increased at 3+. position with respect to control. FR7-8 and FR9-10 haven't changed percentage of shed squares on all positions and in the same group with the control. Most of the squares shed on 6-10. or 11-15. fruiting branches depend on treatments and followed by 1-5., monopodial branches and 16+. fruiting branches, but in SR1-2 percentage of shed squares was higher on 16+. than on 1-5. fruiting branches. By SR1-2, percentage of shed squares was reduced on 1-5. and 6-10. but increased on 11-15. and 16+. fruiting branches. By FR1-2 and FR3-4,

while percentage of shed squares was unchanged or decreased on 1-5, 6-10. and 11-15. and increased on 16+. fruiting branches. FR5-6 increased percentage of shed squares on 1-5. and unchanged on 6-10. but decreased on 11-15. and increased on 16+. in 1998 and unchanged in 1999. In general, effects of FR7-8 and FR9-10 were the similar on all fruiting branches to control in both years but percentage of shed squares has decreased on 16+. in both treatments and increased on 6-10. and 11-15., respectively, in 1999.

Flowers Shedding Rate

In both years we did not find shed flowers (unpollinated white flowers). Flower shedding rates were 0.0% in all treatments. These figures haven't been exposed to analyses and presented. Stewart et al. (1992), reported that squares which would open soon and new opened flowers have resistant to any stress factors due to speed cell development and divisions and even severely wilt plants carry normal seemed flowers and flower shedding occurs rarely.

Boll Retention Rate

Boll retention rates were influenced significantly by removals in both years. The difference between years was not significant and interactions did not have any effect on boll retention rate. Boll retention rates changed between 29.58-36.50% in 1998 and 28.98-37.13% in 1999 depend on treatments. Frejtag and Coleman (1973), reported that 30-40% of unpollinated flowers have formed mature boll. Abrina and Cosico (1987) reported that the highest percent boll retention was 34% among five varieties. At early stage removals resulted in higher boll retention rate than late two removals (FR7-8 and FR9-10) and control. In

1998, both but in 1999 only last flowers removal treatment in the same group with control. Ehlig and Lemert (1973), reported that flowering and boll retention rates have decreased depending on boll load. Highest boll retention rate was determined in SR1-2. In this treatment boll retention rate increased up to 36.50% and 37.13% in 1998 and 1999, respectively and has increased particularly on 1-5. and 6-10. fruiting branches (Table 4). Ungar et al. (1987) reported that boll shedding rate decreased with squares removal at early stage. Also, boll retention rate increased in FR1-2, FR3-4 and FR5-6 in both years and even in FR7-8 in 1999. Removal of squares and flowers at early or at the mid-flowering has stimulated vegetative growth and assimilate production, alleviated assimilate competition thereby boll retention rate increased. Lowest boll retention rate was obtained from control in 1998 and with FR9-10 in 1999. FR9-10 took part in the same group with control in both years.

Boll retention rate has been affected by removal treatments on all positions and fruiting branches in both years (Data not presented). Years were not different and interactions did not have any effect. In all treatments, the highest boll retention rate was occurred at first position and followed by monopodial branches, second and 3+. position in both years. In other words, boll retention decreased from inside to out of the plant. Out of the some exceptions on all positions the highest boll retention rates were determined in SR1-2 and the lowest boll retention rate was occurred in control. Most increase in boll retention rate was occurred by SR1-2 and FR1-2. This increase has maintained until end of FR5-6 (end of sixth week of flowering). Boll retention rate was increased at all positions by these

treatments. Guinn (1985), reported that boll retention increased at second position with flowers or bolls removal at first position. Increase in boll retention may be a consequence of reduction of assimilate competition and this effect hasn't been

observed in FR7-8 and FR9-10. Values of FR7-8 and FR9-10 were in the same group with control. Verhalen et al. (1975) reported that the percentage boll set was highest at the beginning of the season, then steadily fell at the end.

Table 4. Boll retention rates (%) according to removal treatments in 1998 and 1999

Çizelge 4. 1998-1999 yıllarında uygulamalara göre saptanan ort. koza tutkunluğu oranları (%)

| Treatments Uygulamamalar | 1998 | 1999 |
|-----------------------------|---------------|---------------|
| SR1-2** | 36.50 a* | 37.13 a |
| FR1-2 | 35.90 a | 36.20 b |
| FR3-4 | 34.10 b | 34.40 c |
| FR5-6 | 32.10 c | 32.23 d |
| FR7-8 | 30.38 d | 30.60 e |
| FR9-10 | 29.93 d | 28.98 f |
| Control | 29.58 d | 29.33 f |
| Mean | 32.64 | 32.69 |
| LSD (5%) | 0.9194 | 0.8377 |

*: 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.

** : Removal of squares through first two weeks of squaring. (Tarak uzaklaştırma, taraklanmanın ilk iki haftası.)

All the treatments have the highest boll retention rate on 1-5. fruiting branches and followed by 6-10., monopodial branches, 11-15. and 16+. fruiting branches. SR1-2, FR1-2 and FR3-4 have most effect on boll retention rate on all fruiting branches while other removal treatments, particullary FR7-8 and FR9-10 in the same group with control on most of the fruiting branches. Retention of bolls before the starting of treatments was proped by removal and increase maintained in some treatments untill the end of season. Effects of removal treatments were low if boll load was high. FR7-8 and FR9-10 have affected boll retention rate only on 11-15. fruiting branches due to high boll load though most of the flowers were removed on these fruiting branches in both treatments. Guinn (1985), reported that boll retention has decreased as boll load increased.

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