Volume 36
Numbers 3 & 4 - Fall/Winter 2003 *Numbers 3 & 4 - Fall/Winter 2003*

Article 2

October 2003

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SPRINKLER IRRIGATION AS A MANAGEMENT PRACTICE FOR *BEMISIA TABACI* (HOMOPTERA: ALEYRODIDAE) IN COTTON FIELDS

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ABSTRACT

Field experiments were conducted in 1999 and 2000 to investigate the effect of irrigation method on populations of *Bemisia tabaci* (Gennadius) and natural enemies in cotton fields in Aydın Province, Turkey. Two irrigation methods, sprinkler and border, were studied each year. All plots were irrigated during different phenological periods including initial bloom, boll initiation, 50% boll filling and 5-10% boll opening stages. Irrigation methods and periods significantly affected whitefly populations. Densities of *B. tabaci* were significantly reduced in sprinkler-irrigated plots compared to border-irrigated plots in 2000 but not in 1999. Irrigation methods did not affect the population of natural enemies. However, significant differences in numbers of natural enemies were observed among irrigation periods. Natural enemies were most abundant during the second irrigation period when whiteflies were also most abundant. These results suggest that sprinkler irrigation may be useful in cotton fields as a management practice for whitefly without reducing natural enemy populations.

Bemisia tabaci (Gennadius), the sweetpotato whitefly, is one of the most serious pests attacking industrial and food crops throughout Turkey. Its presence in Turkey was first recorded in 1928. This insect became an extreme economic pest and resulted in 20% damage to vegetable crops in İzmir Province in 1958 (Bodenheimer 1958). It later became a problem in the cotton-growing regions and caused annual yield losses of 80% in 1975 (Sengonca 1975; Sengonca and Yurdakul 1975). No research has been conducted in recent years on the effect of whitefly populations in cotton. However, Baspınar et al. (1998) and Gencsoylu (2001) reported that it is an economically important pest in cotton fields in Aydın Province.

Although significant advances have been made in understanding the biology, behavior and ecology of *B. tabaci*, pest management systems continue to rely on insecticides in cotton-growing regions of Turkey. The same insecticide groups including organophasphates (Pirimiphos-methyl, Phorate, Monocrotophos, Dialifos) and synthetic pyrethroids (Cypermethrin, Delthametrin, Permethrin) have been used since 1980 and are applied to whitefly populations 6-10 times per season. Consequently, insecticide resistance was reported in this pest from the Cukurova region of Turkey (Yuzbas et al. 1996). Therefore, alternative management practices are needed to reduce whitefly populations.

Integrated pest management strategies are essential for long-term strategies in cotton production. One approach in integrated management is the use of sprinkler irrigation. Castle et al. (1996) consistently found in several experiments that densities of immature whiteflies were significantly reduced in sprinkler-irrigated cotton fields. Other researchers have documented the negative impact of rainfall on populations of whiteflies (Gameel 1977, Hennebery et al. 1995, Hilje 1994, Riley and Wolfenbarger 1993, and Zwick 1985) and other pests (Nakahara et al. 1985, Parihar and Name 1999, Tabashnik and Mau 1986).

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There has been no research comparing the efficacy of different irrigation methods for controlling *B. tabaci* in Turkey. The aim of this study was to investigate the use of sprinkler and border irrigation systems for management of *B. tabaci* in cotton fields in Turkey.

MATERIALS AND METHODS

The experiments were conducted during the 1999 and 2000 growing seasons in cotton fields at Adnan Menderes University, Research Center of Agricultural Faculty, Aydın Province, Turkey. The cotton variety 'Nazilli-84', which is well adapted to the local environment, was used during the study.

Two irrigation methods, sprinkler and border, were studied each year. Experiments were organized into completely randomized blocks with three replicated plots. Each replicate within blocks consisted of 30 rows that were 50 m long. Of the 30 rows, 6 were used for border and 24 were used for sprinkler irrigation, including edge rows. Blocks were separated by 3 m to reduce the edge effect. Four sprinkler systems with a 7.5 x 7.5 m spacing between lateral lines and the sprinkler head were established in each sprinkler plot. Heads with 0.031-cm nozzles were used throughout. The timing of sprinkler irrigation was manually controlled by switching the power on or off. Border irrigation is a system where a designated volume of water is delivered to a defined border. Water was delivered by PVC pipeline to the edge of the border, then passed through a water counter into the border plots.

Moisture deficiency in the cotton root zone was measured gravimetrically (Jensen 1974) and was used to determine the amount of irrigation water applied to each plot. Moisture measurements were obtained on 14 and 27 July, 17 August and 4 September in 1999 and on 6 and 17 July and on 1 and 22 August 2000. The four dates in each year corresponded to the phenological periods of initial bloom, boll initiation, 50% boll filling and 5-10% boll opening. In each irrigation period the designated amount of water was given during a single day in the border-irrigated plots whereas it was given over the course of 4 days in the sprinkler-irrigated plots. During irrigation, totals of 569 mm (5690 m3/ha) in 1999 and 798 mm (7980 m3/ha) in 2000 were applied to the border irrigated-plots whereas 506 mm (5060 m3/ha) in 1999 and 660 mm (6600 m3/ha) in 2000 were applied to the sprinkler-irrigated plots. The time from the first to the second irrigation date was defined as the first irrigation period; the time from the second to the third date was the second irrigation period; and the time from the third irrigation to fourth date was called the third irrigation period. All plots received the same fertilization and cultivation practices during the two years of the experiment. No insecticides were applied to control whitefly populations in either year.

Densities of 3rd and 4th *B. tabaci* nymph populations in each irrigation plot were estimated weekly by sampling four leaves between the 5th mainstem node and the apex of each plant (Ohnesorge and Rapp 1986). We collected 20 leaves from 5 randomly selected plants from each replicate near the center of each plot. A total of 180 leaves from 15 plants per each irrigation period were checked for whitefly within each irrigation method. Nymphs were counted on whole leaves due to low levels (Flint et al. 1995, Gencsoylu et al. 2003). Sampling was done three times for each irrigation period. The leaves were placed in paper bags and brought to the laboratory for examination under a stereomicroscope.

Within each replicate, 180 leaves and 90 flowers from 5 plants were visually inspected for natural enemies during each irrigation period. During the sampling of natural enemies adults of Heteroptera, Aranea and Hymenoptera and the eggs, larvae and adults of Neuroptera were counted.The samples of parasitized specimens were kept in plastic containers to collect emerging parasitoids. Samples obtained were taken into the laboratory for identification and unknowns were sent to specialists for confirmation.

Data from the three sampling weeks for whitefly and natural enemy populations were combined within each irrigation period. All count data were transformed logarithmically and analyzed using the PROC MIXED (SAS 1999) procedure. A repeated measures statement with a covariance structure that defines the relationship between observations coming from the same replicate was included. Comparisons among least square means of year, irrigation methods and irrigation period were made using contrasts when significant ($P < 0.05$). F-statistics were obtained for each factor in the model.

RESULTS

In the statistical analysis of data, year (df = 1, 34, $F = 61.63$, $P = 0.0024$), irrigation period (df = 2, 33, $F = 160.84$, $P < 0.0001$), irrigation method (df = 1, 34, $F = 68.59$, $P = 0.0009$), and the two-way interactions between year and period (df = 2, 32, $F = 168.14$, $P < 0.0001$), year and treatment (df = 1, 33, $F = 35.09$, $P = 0.0061$), and treatment and period (df = 2, 32, $F = 13.26$, $P = 0.0045$) were found to be significant. As seen in Table 1, the sprinkler-irrigation method resulted in significantly lower mean whitefly densities compared to the border-irrigation method in 2000; however, the difference was not significant in 1999. Whitefly populations in the sprinkler-irrigated plots were 33% lower in 1999 and 50% lower in 2000 compared to populations in the border-irrigated plots.

The means for irrigation method within the different irrigation periods are given in Table 2. The number of whiteflies was statistically lower in sprinkler plots than in border plots within each irrigation period, except irrigation period 3. The highest mean whitefly population density was obtained during the second irrigation period. Whitefly populations were first observed in mid-July and reached their peak in the first week of August.

The effect of irrigation period was different within each irrigation method and year as seen in Table 2 and Table 3. The rank of means of irrigation periods for whitefly changed within 1999 and 2000. Significantly fewer whiteflies were counted in period 1 and 2 of 2000 compared to 1999 which can be attributed to seasonal variation.

Predators and parasitoids of pest insects that were observed during the study included: *Chrysoperla carnea* Steph. (Neuroptera:Chrysopidae), *Orius minutus* (L.) (Heteroptera: Anthocoridae), *Geocoris ater* (F.) (Heteroptera: Lygaeidae), *Deraeocoris* spp. (Heteroptera: Miridae), *Nabis* spp. (Heteroptera: Nabidae), Aranea species, *Eretmocerus mundus* Mercet and *Encarsia* sp. (Hymenoptera: Aphelinidae).

The greatest numbers of natural enemies were observed in the orders Heteroptera and Neuroptera. In contrast, Aranea and Hymenopteran species were found at lower frequencies. Statistical analysis showed that there were no

Table 1. Means (±SE) number of *Bemisia tabaci* 3rd and 4rd instar nymphs by irrigation method and year.

	Irrigation Method[a]	
Year[b]	**Border**	**Sprinkler**
1999	133.5 ± 7.4Aa	100.4 ± 5.5Aa
2000	122.1 ± 7.3Aa	52.9 ± 3.2Bb

[a]Different capital letters indicate significant differences between years within irrigation method.
[b]Different lower case letters indicate significant differences between irrigation methods within year.

Table 2. Mean (±SE) number of *Bemisia tabaci* 3rd and 4rd instar nymphs by irrigation method and period.

	Irrigation Method[a]	
Irrigation Period[b]	**Border**	**Sprinkler**
1	180.3 ± 13.1Aa	68.3 ± 4.9Bb
2	197.6 ± 14.3Aa	130.7 ± 9.5Ab
3	58.2 ± 4.2Ba	43.3 ± 3.1Ca

[a]Different capital letters indicate significant differences between irrigation periods within irrigation method.
[b]Different lower case letters indicate significant differences between irrigation methods within irrigation period.

Table 3. Mean (±SE) number of *Bemisia tabaci* 3rd and 4rd instar by irrigation period and year.

	Year[a]	
Irrigation Period[b]	**1999**	**2000**
1	205.1 ± 12.2Aa	60.0 ± 3.9Bb
2	199.8 ± 11.9Aa	129.3 ± 8.4Ab
3	37.8 ± 2.2Bb	66.7 ± 4.3Ba

[a]Different capital letters indicate significant differences between irrigation periods within years.
[b]Different lower case letters indicate significant differences between years within irrigation period.

effects of irrigation methods or the two-way interaction between year and irrigation periods on the population of natural enemies (df = 1, 34, $F = 3.05$, $P = 0.13$). However, significant differences in number of natural enemies were observed between irrigation periods for both years combined (df = 2, 34, $F = 18.63$, $P = 0.0009$) with the greatest number (6.8 ± 1.2) being observed during the second irrigation period and 2.8 ± 0.5 observed in both irrigation periods 1 and 3. The number of natural enemies observed during each irrigation period differed between 1999 and 2000; the highest mean densities of natural enemies were observed during the first and second irrigation periods in 1999 but during the second and third irrigation periods in 2000 (Table 4).

DISCUSSION

Whitefly populations were higher in 1999 than in 2000, and were higher in border-irrigated plots compared to sprinkler-irrigated plots. Whitefly populations were significantly reduced in sprinkler-irrigated plots compared with border-irrigated plots in 2000. These results agree with those of Castle et al. (1996) for a series of experiments to determine whitefly infestations in both sprinkler and furrow-irrigated cantaloupe and cotton plots in Imperial Valley, USA. They found, consistently throughout all experiments, that densities of immature whiteflies were significantly reduced in sprinkler-irrigated plots. Tabashink and Mau (1986) and Nakahara et al. (1985) also found that sprinkler irrigation affected diamondback moth, *Plutella xylostella* (L.) infestations by severely reducing egg deposition. Moreover, Parihar and Name (1999) found the lowest aphid, *Mysus persicae* (Sulzer), densities were observed in sprinkler-irrigated tomato fields.

Table 4. Mean number (±SE) of natural enemies by irrigation period and year.

	Year[a]	
Irrigation Period[b]	**1999**	**2000**
1	5.7 ± 1.3Aa	1.3 ± 0.5Bb
2	6.0 ± 1.2Aa	7.6 ± 2.1Aa
3	1.6 ± 0.2Bb	5.9 ± 1.3Aa

[a]Different capital letters indicate significant differences between irrigation periods within year.
[b]Different lower case letters indicate significant differences between years within irrigation period.

In our research the mean number of *B. tabaci* in sprinkler-irrigated plots was lower in 2000 than in 1999. Higher amounts of rainfall in 2000, including 29.7 mm in June and 20.3 mm in August, likely contributed to the suppression of whitefly populations. It is possible that the two rainfalls in 2000 did not significantly reduce the population of whiteflies in the border-irrigated plots. However, the combination of the two rainfalls and the four periods of sprinkler irrigation in the sprinkler plots resulted in a significant reduction in whitefly populations in 2000. Gameel (1977), Zalom et al. (1985), Hilje (1994), Riley and Wolfenbarger (1993) and Henneberry et al. (1995) reported that rainfall reduced whitefly populations. Rainfall involves mechanical disturbance to leaves, which results in less time for feeding, mating and oviposition. Byrne and von Bretzel (1987) reported that mechanical disturbance could be highest if the timing of sprinkler application coincided with these behaviors.

The populations of natural enemies did not differ between sprinkler- and border-irrigated plots. No studies have been found that compared the effects of these irrigation methods on natural enemy populations. Zwick (1985) did not find any differences in predator populations in drip-and-furrow-irrigated cotton. Leggett (1993) found that furrow and drip irrigation did not affect the population of *Orius* spp. at Eloy, or of *C. carnea* and spiders at Coolidge cotton fields in Arizona. However, the densities of natural enemies varied significantly between irrigation periods in our research. Natural enemy populations were highest during the second irrigation period. Whitefly populations were also highest during this period. Leigh et al. (1974) found that Heteropteran species were the most abundant natural enemies in cotton fields. In our research, Heteropteran species were also the highest among natural enemy populations.

The present research demonstrated that sprinkler irrigation could be applied in cotton fields to reduce whitefly populations. High costs of irrigation might be partially offset if lower whitefly populations result in fewer insecticide applications (Castle et al. 1996). These results suggest that sprinkler irrigation can be applied in cotton fields as a management practice for whitefly without reducing natural enemy populations.

ACKNOWLEDGMENTS

We acknowledge Prof. Dr. Nedim Uygun and Prof. Dr. İrfan Tunç for identifying the natural enemies and Kadir Kızılkaya for his critical reading of the manuscript.

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