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Effect of three irrigation methods on incidences of *Bemisia tabaci* (Hemiptera: Aleyrodidae) and some whitefly-transmitted viruses in four vegetable crops

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ABSTRACT

Whiteflies and whitefly-transmitted viruses cause major agricultural problems in environments ranging from arid to humid climates. Experiments were conducted to assess the effect of some cultural irrigation practices (drip, furrow and sprinkler) on the population of the sweetpotato whitefly, *Bemisia tabaci* (Gennadius) and on the infection of some whitefly-transmitted viruses in the Egyptian vegetable cropping system. Each irrigation treatment was conducted in cucumber (*Cucumis sativus* L.), green bean (*Phaseolus vulgaris* L.), squash (*Cucurbita pepo* L.) and tomato (*Solanum lycopersicum* L.). Less than 30% of the plants in each plot displayed whitefly-transmitted virus infection symptoms (*Cucumber vein yellowing virus*, *Squash leaf curl virus* and *Tomato yellow leaf curl virus*). The daily drip irrigation treatment resulted in the lowest whitefly populations (adults and nymphs) and lowest incidences of plants with virus symptoms, while the highest infestations and infections were observed for the weekly sprinkler irrigation treatment and the biweekly furrow irrigation treatment, respectively. Regardless of irrigation treatment, whitefly populations were highly correlated with incidences of plants with virus symptoms. However, percentages of plants displaying virus infection were similar among irrigation treatments on many sample dates within a given crop. Integration of management strategies is essential for sustainable management of whiteflies and whitefly-transmitted viruses. This study demonstrates that certain irrigation methods can affect whitefly populations and incidences of whitefly-transmitted viruses in vegetable crops in Egypt.

KEYWORDS: *Bemisia tabaci*, irrigation, virus transmission, sweetpotato whitefly, vegetable

INTRODUCTION

Arthropods are exposed to various abiotic and biotic stress factors in the field. Numerous studies have been conducted on the impact of the environment, including humidity and water, on the populations of diverse arthropods [e.g., 1, 2, 3, 4, 5, 6]. Rainfall has long been reported to negatively affect whitefly populations [7, 8]. Depending on location, the frequency and quantity of rainfall for crops varies greatly. Yet, irrigation is a source of water that is controlled. In the Nile Delta region of Egypt, as a substitute for rainfall, the abundant source of water associated with the Nile River facilitates the use of furrow and other irrigation methods by growers. Increased drip irrigation on grapes has been demonstrated to result in increased populations of two species of leafhoppers, *Erythroneura eleguntula* Osborn and *E. variabilis* Beamer [9]. Conversely, Castle *et al.* [10] reported

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that sprinkler irrigation can reduce the population of whiteflies.

The B-biotype sweetpotato whitefly, *Bemisia tabaci* (Gennadius) (synonymous with *B. argentifolii* Bellows and Perring) and other members of the *Bemisia* complex are problems on a global scale. The B and Q biotypes of *B. tabaci* are found in fields in Egypt [11, 12]. *B. tabaci* is a highly adaptive insect that is known to feed on over 1,000 species of plants including numerous crops in greenhouse and field production systems [5, 13].

In addition to direct damage to plants by its feeding, *B. tabaci* is known to transmit over 100 plant viruses [14]. Among the *B. tabaci*-transmitted viruses in vegetable crops are *Cucumber vien yellowing virus* (CVYV), *Squash leaf curl virus* (SqLCV), and *Tomato yellow leaf curl virus* (TYLCV). TYLCV (family *Geminiviridae*; genus *Begomovirus*) is an economically important virus of tomato (*Solanum lycopersicum* L.). The epidemiology of TYLCV and its whitefly vector have been studied extensively because of their widespread distribution which includes Egypt [15, 16, 17]. TYLCV has a long history of being a problem on tomato in Egypt [15]. SqLCV, another member of *Begomovirus*, is a New World problem in squash (*Cucurbita pepo* L.) that has spread to Egypt and other Middle Eastern countries [18, 19, 20, 21]. Symptomatic SqLCV plants showing leaf curling, yellow mottling, stunting and reduced fruit set are relatively recent problems in Egypt [18, 19]. SqLCV causes severe problems on squash in Egypt. CVYV (family *Potyviridae*; genus *Ipomovirus*) is another important whitefly-transmitted virus. CVYV is a problem in cucumber (*Cucumis sativus* L.) in the Middle Eastern and Mediterranean regions and it is pervasive in Egypt [22, 23, 24, 25]. This virus causes severe vein yellowing on young leaves, stunting and reduction of fruit set [26]. In general, whitefly-transmitted plant viruses can display mild, non-existent or prominent characteristic symptoms among different plant species [17].

Integration of management strategies is essential for sustainable management of whiteflies and whitefly-transmitted viruses. Cultural control methods have a long history of being used to manage pests and diseases in crop production. Identifying ways to reduce whitefly populations in vegetable crops may also result in a reduction in incidence of viruses that are transmitted by whiteflies. We conducted experiments to assess the effect of some irrigation practices on the population of *B. tabaci* and the infection of some whitefly-transmitted viruses in the Egyptian vegetable cropping system.

MATERIALS AND METHODS

Four vegetables crops were established in plots of grower fields in Egypt in 2011. The crops were cucumber (cv. 'Nagah'), green bean (*Phaseolus vulgaris* L., cv. 'Giza 3'), squash (cv 'Escandarany'), and tomato (cv. 'Castle Rock'). Pesticides were not used in any of the crops. Field plots were set up for each type of irrigation treatment. Within fields, plots of the four crops were separated by 300 m, and there was one treated plot within a given field. This experiment was carried out in the Nobaria region (Behira Governorate). Each crop received different fertilization according to local practices [27]. The soil in this region has a composition of 86% sand, 8% silt and 6% clay. Three fields were chosen using treatments of surface drip (daily irrigation), sprinkler (weekly irrigation) and furrow (biweekly) irrigation methods for each crop (squash, cucumber, green bean and tomato). Within a treatment, each crop was 0.39 ha which was divided into three plots of 0.13 ha. Samples of 30 leaves were chosen at random, from each plot. A count was made on the number of adult whiteflies from a leaf on a given plant using the leaf turn method [28]. The leaves were then detached, placed in polyethylene bags with minute holes and transferred to the laboratory for nymphal whitefly examination with the aid of a microscope. All live *B. tabaci* nymphs found on each leaf surface were counted and recorded for four sampling dates for each irrigation treatment for each crop. The treatments were started upon the establishment of each crop and the plots were first sampled 15 days after the establishment of cucumber and squash, and 21 days after the establishment of green bean and tomato. Plots were also sampled 7, 14, and 21 days after the first sample. The weekly samples were randomly selected from separate plants in a zigzag pattern in each plot.

Additional data were collected from each plot on each sampling date on an estimation of the percentage of plants displaying infection symptoms of CVYV in cucumber, SqLCV in squash, and TYLCV in green bean and tomato. The percentage of infected plants in each sample was calculated based on the percentage of sample leaves that appeared to be infected with the above mentioned viruses. Viral incidences and whitefly counts were assessed on the same dates for each crop.

Data analyses

Data were analyzed using SAS computations [29] and significance was determined at $P<0.05$. Data for each insect stage and virus were subjected to the Student-Newman-Kuels test for a comparison of means of insect counts and incidences of virus symptoms among irrigation treatments. Percentage data were transformed using arcsine transformation before the analysis, but the results are presented on back-transformed data. Correlation relationships were tested between whitefly counts and incidences of virus symptoms for each treatment.

RESULT AND DISCUSSION

For population counts of whitefly nymphs, population counts of whitefly adults and percentages of virus infection, there were significant ($P<0.0001$) effects for variables of irrigation, crop and sample date. Regardless of treatment, the whitefly population was highest in squash and lowest in cucumber (Table 1). These differences in whitefly infestation among vegetable crops in Egypt are common [27, 30]. The data further indicated that drip irrigation for squash resulted in lower whitefly populations (nymphs or adults, Fig. 1) than treatments of furrow or sprinkler irrigations, and percentage infections of whitefly-transmitted viruses were likewise lowest in the drip irrigation treatment (Fig. 2). The same trend was observed for whiteflies and viruses in the cucumber, tomato and green bean crops. However, the magnitude among insect populations or virus incidences among the different treatments were generally not dramatic. On the first sample date, there was no difference in the whitefly count among treatments within each crop. However, both whitefly nymphal and adult counts were significantly higher on the 7, 14 and 21 d sample dates in the sprinkler treatment followed by the furrow and drip treatments, respectively (Fig. 1). The magnitudes of the differences among treatments were much greater on each successive sample date. Symptoms of virus incidence was the

Table 1. Mean number of whiteflies (*B. tabaci*) on 30 leaves of plants for a given plant species on the first sample date for field plots of three irrigation treatments in 2011.

Irrigation method	Crop	No. of Adults	No. of Nymphs
Drip	Squash	246.7 a	447.0 a
	Tomato	187.7 b	339.7 b
	Green bean	123.7 c	223.7 c
	Cucumber	108.7 d	197.3 d
Furrow	Squash	242.0 a	459.0 a
	Tomato	184.3 b	348.7 b
	Green bean	121.7 c	230.0 c
	Cucumber	106.7 d	202.3 d
Sprinkler	Squash	260.0 a	457.7 a
	Tomato	197.7 b	348.0 b
	Green bean	130.3 c	229.3 c
	Cucumber	114.3 d	201.7 d

Means within irrigation method and in columns followed by different letters are significantly different ($P<0.05$) according to Student-Newman-Kuels test.

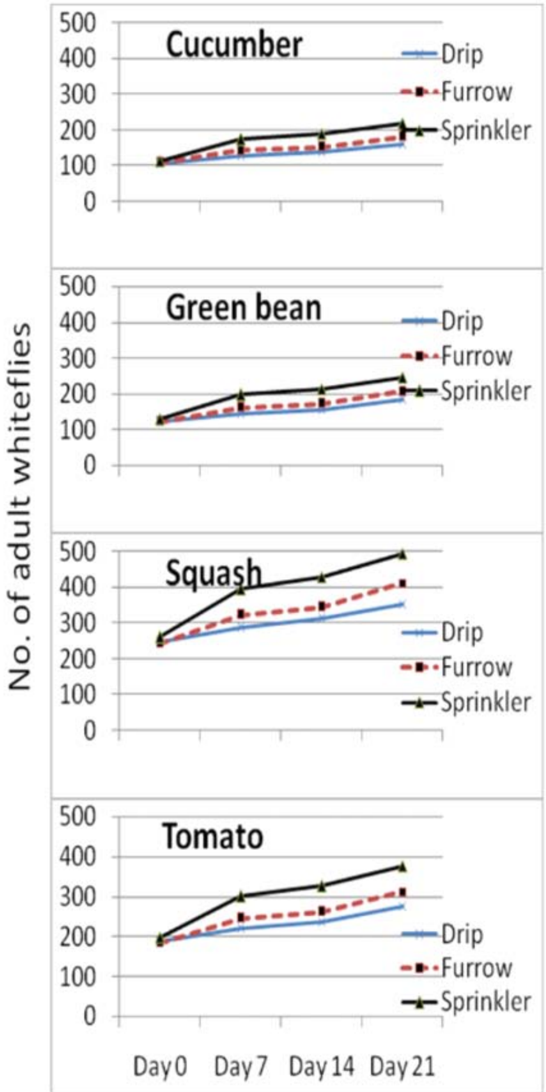

Fig. 1. Comparison among three irrigation methods on the mean number of adult *B. tabaci* per 30 leaves in field plots of four vegetable crops in 2011.

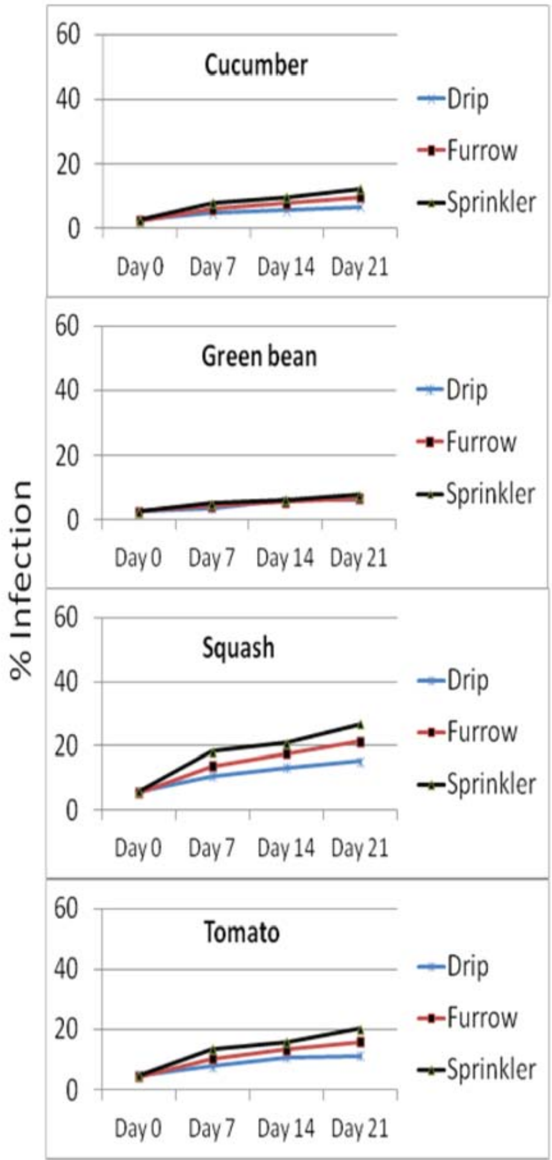

Fig. 2. Comparison among three irrigation methods on the percentage of leaves showing infection symptoms of whitefly-transmitted virus in field plots of four vegetable crops in 2011 (*Cucumber vein yellowing virus* in cucumber, *Squash leaf curl virus* in squash, and *Tomato yellow leaf curl virus* in green bean and tomato).

same among treatments on the first sample date for all crops, but there was a slight significant increase in virus symptoms by day 21 for the sprinkler treatments followed by the furrow irrigation treatment as compared with the drip treatment (Fig. 2). The impact of sprinkler irrigation was opposite of what we expected. Frequency of sprinkler irrigation may have been a factor in the results as compared with other research. For example, we used weekly sprinkler irrigation while in a study in cotton and cantaloupe in California, fewer immature *B. tabaci* was observed in daily sprinkler irrigation than a biweekly sprinkler irrigation treatment, and the sprinkler treatments generally resulted in lower whitefly populations in that study as compared with a furrow irrigation treatment [10].

For each treatment, there were strong correlations between incidences of virus symptoms and adult counts (r^2 = 0.92, P<0.0001, drip irrigation; r^2 = 0.93, P<0.0001, furrow irrigation; r^2 = 0.94, P<0.0001, sprinkler irrigation), and between incidences of virus symptoms and nympal counts (r^2 = 0.92, P<0.0001, drip irrigation; r^2 = 0.94, P<0.0001, furrow irrigation; r^2 = 0.92, P<0.0001, sprinkler irrigation). These strong correlations were consistent with our previous observations between whitefly populations and associated whitefly-transmitted viruses in vegetable crops [31]. Because of the positive correlation between whitefly population and incidence of whitefly-virus infection, the overall elevated virus incidence under the sprinkler treatment was apparently in response to the elevated whitefly population in the sprinkler treatment as compared with the other irrigation treatments.

In a study on *B. tabaci* on cotton in Turkey, Gencsoylu *et al.* [32] concluded that drip irrigation resulted in a lower number of 3rd and 4th instar whiteflies than furrow irrigation. In their study, plant stages of flowering through early boll open were examined, and irrigation was provided at a frequency of about every 2-3 weeks. In our experiment on vegetables, insect data were collected during early vegetative growth on all instars of nymphs as well as adults, but we followed the frequency of irrigation to reflect the practice of local growers; thus, irrigation frequency was not consistent among the treatments. In a study on cotton in Israel, Mor [33] concluded that water stress can result in an increase in whitefly populations. Similarly, Gencsoylu *et al.* [32] reported that regardless of drip or furrow irrigation, plants which received a greater amount of water had fewer whitefly nymphs than those that received less water. Conversely, researchers in California [9] concluded that for leafhoppers on grapes, increased drip irrigation (i.e., less plant stress) resulted in an increased number of leafhopper nymphs. Although plants did not display symptoms of water stressed in our study, data were not collected to assess plant water stress. Other research on cotton in Arizona is consistent with results on two of the treatments in our study. Namely, researchers in the Arizona study concluded that immature *B. tabaci* were reduced in drip irrigation as compared with biweekly furrow irrigation [34]. Integration of management strategies is essential for sustainable management of whiteflies and whitefly-transmitted viruses. This study demonstrates that certain irrigation methods can affect whitefly populations and incidences of associated viruses in vegetable crops in Egypt.

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