DISPERSAL AND MOVEMENT OF THE GLASSY-WINGED SHARPSHOOTER AND ASSOCIATED NATURAL ENEMIES IN A CONTINUOUS, DEFICIT-IRRIGATED AGRICULTURAL LANDSCAPE

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ABSTRACT

Outlined experiments in this study have only recently begun and are designed to advance our ability to define the operative host-plant factors utilized by adult glassy-winged sharpshooter (GWSS) and associated natural enemies as long-range cues to locate feeding and oviposition hosts in a complex agricultural landscape. Specifically, experiments are underway to determine how continuous deficit irrigation regimes in Valencia oranges influence the population dynamics of GWSS and other associated natural enemies. Populations of GWSS were monitored in a citrus orchard maintained under continuous irrigation schedules receiving 60%, 80%, and 100% of evapo-transpiration (ET_c) rates. Throughout the season, citrus trees irrigated at 60% ET_c had warmer leaves and higher water potential than the trees irrigated with 80% and 100% ET_c. Mean numbers of adults collected on beat samples, caught on sticky traps, and observed during the visual inspection, and egg masses within foliage were higher in the 80% and 100% ET_c treatments than the 60% ET_c treatment. Preliminary caged experiments using grape and oleander conducted in Riverside, California, illustrated GWSS population shifts that occurred between plants. Individual plants maintained under a well-watered treatment (ET_c=100%) exhibited higher insect counts compared with a continuous deficit-irrigated treatment (ET_c=50%). Identifying how the dispersing lifestages of GWSS locate and exploit specific host species will begin to provide the necessary information required to develop strategies for control of this highly mobile insect and further to limit the spread of *Xf* movement into susceptible crops.

INTRODUCTION

The GWSS is a highly polyphagous and mobile insect utilizing numerous plant species as both feeding and oviposition hosts (Adlerz, et al. 1979, Daane et al. 2003, Groves et al. 2003). Recent research has documented that different host plant species are not equally utilized by all GWSS lifestages. Mizell and Anderson (2003) report that host plant xylem chemistry plays a key role in the regulation of GWSS feeding and oviposition over a wide range of host plant species. Similarly, Daane and Johnson (2003) concluded that ornamental landscape plant species greatly influence GWSS seasonal population biology. Specifically, ornamental species which favorably support adult GWSS oviposition and feeding do not equally support comparable nymphal populations. Although significant new information has become available regarding the sequence of hosts in which GWSS populations thrive, little is understood about the host-location strategies of GWSS, which are critical behavioral responses that assist the insect in locating suitable hosts. Successful insect-host associations depend upon an insect's ability to locate a suitable host(s) in a complex, heterogeneous landscape. Mechanisms of host location in many phytophagous insects are often mediated by long-range, semiochemical cues arising from their host plant(s), which vary by plant physiological conditions including nutrition (available nitrogen and carbohydrate), xylem water potential, and plant age or developmental stage (Finch 1986). Similarly, we have an incomplete understanding of host-selection cues utilized by the mymarid egg parasitoids of GWSS, which may involve the host (GWSS egg mass), the host plant, or a combination of both.

The outlined experiments in this study are designed to advance our ability to define the operative host-plant factors utilized by adult GWSS and associated natural enemies as long-range cues to locate feeding and oviposition hosts in a complex agricultural landscape. Identifying how the dispersing lifestages of GWSS locate and exploit specific host species will begin to provide the necessary information required to develop strategies for control of this highly mobile insect and further limit the spread of *Xf* movement into susceptible crops.

OBJECTIVES

1. Evaluate host-plant factors utilized by adult GWSS and associated natural enemies as long-range cues to locate feeding and oviposition hosts in a complex agricultural landscape.
2. Monitor adult GWSS movement and host selection behavior, ovipositional preference, and nymphal population performance on host plants maintained under continuous irrigation deficits

RESULTS

Objective 1

The response(s) of adult GWSS to olfactory cues and their corresponding host-selection behavior will be comparatively examined in a modified, four-chamber, air-flow olfactometer large enough to accommodate movement of adult GWSS (Vet et al. 1983). In these laboratory experiments, we will investigate GWSS orientation responses to odor fields of varying levels of humidified air in combination with selected host plant species. In addition, the host selection behavior of gravid and nongravid adult female GWSS representing two ages (10 and 50 day-old) will be comparatively examined. A total of 30 experimental replicates will be conducted with adult GWSS representing both age classes in a factorial design containing three levels of relative humidity (10, 50, and 100%) in combination with two host plant species including lemon and avocado. A set of experimental replicates will be performed to evaluate the host-selection behavior of the GWSS mymarid parasitoid *Gonatocerus ashmeadi* in a similar factor-level design containing the three humidity levels in combination with the presence of GWSS egg masses oviposited on leaves of lemon and avocado. Adult female parasitoids reared from parasitized GWSS egg-masses laid on lemon and avocado, respectively, will be used for these assays. As an additional control, *G. asmeadi* reared from parasitized GWSS egg masses on cowpea will be included in the bioassays. Personnel have recently been hired to conduct these analyses.

Objective 2

A complementary set of screen-house and field experiments are underway to define the relative importance of host-plant cues for GWSS host selection and oviposition. GWSS population dynamics were monitored on selected host plant species including oleander and grape. This experiment was constructed as a randomized complete block design with 2 levels of water stress as main effects: a well-watered treatment (ET_c=100%), and a continuous deficit-irrigated treatment (ET_c=50%). Potted (10.6. liter) plants of each host species were randomly placed in screened cages, and infested with 50 even-aged GWSS adults. Detailed daily observations of adult GWSS feeding and resting preference were recorded throughout the experiment. These results illustrate GWSS population shifts that occurred between plants maintained under a well-watered treatment (ET_c=100%) compared with a continuous deficit-irrigated treatment (ET_c=50%) (Figure 1). The pattern of insect movement within the oleander did not follow that observed with the grape. The number of GWSS feeding on deficit-irrigated plants increased until day 3, when the first irrigation took place and the number of insects feeding on the plants slowly changed until day 10, when the proportion of insects in each plant reached 0.5. The second irrigation did not cause a quick insect response as observed with grapevines, the insects continued to slowly switch from non-irrigated to irrigated plants. Oleander plants are known to be somewhat more resistant to water stress than grapevines, and such a characteristic might have played a role in differential patterns of GWSS movement between plants.

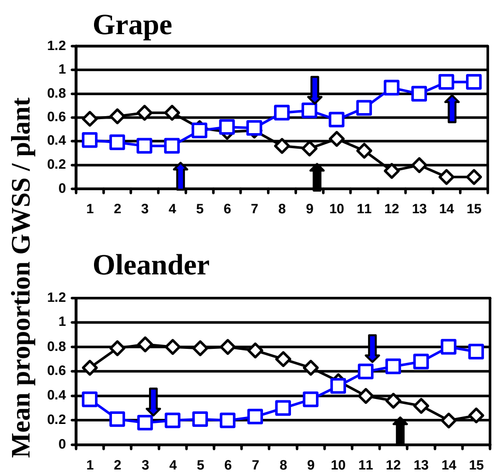

Figure 1. Mean proportion of adult GWSS / plant observed daily on grape and oleander maintained at 100% (□—□) and 50% (◇—◇) Et_c. Colored arrows indicate the day water was applied in each treatment.

A second set of field experiments were recently established to determine the effects of continuous, deficit-irrigation (CDI) practices on the population dynamics of GWSS over the course of a two year study, within the UC Riverside, Valencia Field 5 Citrus Research Block (Figure 2). The experiment is designed as a Latin square with 3 irrigation treatments and 3 replications, each consisting of 120 trees in a replicated block under micro-sprinkler irrigation. The CDI schedules evaluated in this experiment include: 1) trees irrigated at 100% ET_c; 2) a continuous deficit-irrigated treatment maintained at 80% ET_c, and 3) a continuous deficit treatment irrigated at 60% of ET_c throughout the crop year. The severity of water stress is being characterized by measurements of soil water content, pre-dawn leaf water potential (Ψ), and mid-canopy, leaf surface temperatures. GWSS populations within experimental blocks are sampled weekly during the growing season and will be sampled bimonthly during the upcoming winter period. Different sampling techniques will be used throughout the year to detect different development stages of GWSS. GWSS nymphs and natural enemies will be sampled using systematic beat-sample methods at cardinal points around sample trees methods as developed for GWSS on citrus.

The seasonal movement patterns of adult GWSS within and among the experimental blocks is being monitored using a combination of directional, yellow sticky cards collected and replaced weekly coupled with a set of novel proteins for mark-capture. Together, systematically placed traps and protein signatures will record any shifts in plant use of adult populations (Figure 2). The field portion of this research will focus on the role of CDI conditions on GWSS host-selection strategy and dispersal. At regular intervals during the 2005 season, CDI replicates were sprayed with inexpensive proteins using conventional spray equipment. In turn, insects that are contacted by the protein solutions or that encounter plant material containing protein residues will obtain enough protein to be detected by protein-specific enzyme-linked immunosorbent assays (ELISA). Because the three marking ELISAs (chicken egg whites, soy milk, and non-fat dry milk) do not cross-react, we can apply the materials to the three different treatments in close proximity to one another. Then, insects can be collected using temporal and spatial sampling schemes and analyzed for the presence of each respective protein mark to determine not only the insect's point of origin, but the timing and extent to which portions of the population move among different plant species.

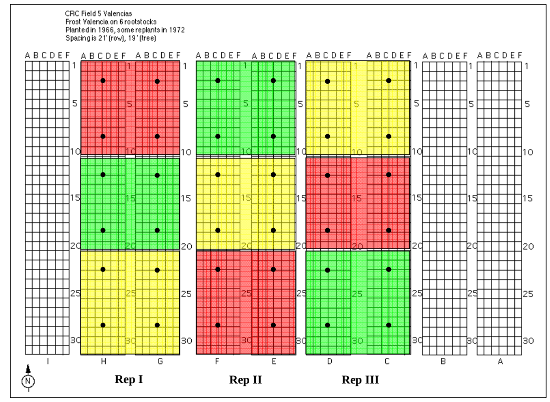

Figure 2. Latin square experimental design for GWSS movement study located at Agricultural Operations, in the Field 5 Valencia illustrating yellow card positions (●) and CDI treatments (100% Et_c ■, 80% Et_c ■, 60% Et_c ■)

CONCLUSIONS

We believe that findings from this recently funded project will generate significant new information regarding the host selection behavior and movement patterns of GWSS in California. Preliminary results from greenhouse studies illustrate that GWSS population shifts occurred between plants maintained under varying, CDI treatments. Further, measurements of in-field plant condition suggested no differences in leaf temperatures and water potentials between trees irrigated at 80% and 100% ET_c. Trees irrigated with 60% ET_c had warmer leaves, higher water potential, and also hosted fewer GWSS than the well irrigated trees. Patterns of adult GWSS capture throughout the 2005 sampling interval (July – August), estimated from a combination of yellow traps, beat samples, and visual inspections, suggest comparatively higher population densities of GWSS in CDI treatments 80 and 100% ET_c. Furthermore, higher counts of GWSS adults and egg masses were found on trees irrigated at 80% ET_c compared with the 100% ET_c treatment.

This research will provide more information about sharpshooter feeding, host-finding behavior, preferences, and the factors that influence reproductive success and natural-enemy-caused mortality. Elucidation of the preference for and performance upon host plant species under differential water stress will aid our understanding of the mechanism of spread of PD and speed with which pathogen spread might occur. A more complete understanding of the operative host-plant cues that influence GWSS population dynamics may result in the deployment of strategies to focus control efforts, enhance the efficacy of biological control, and effectively limit the spread of *Xf* induced diseases to susceptible crops.

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