Honeydew Production by Sweetpotato Whitefly Adults and Nymphs

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ABSTRACT

We determined honeydew production by male and female sweetpotato whiteflies and the effects of temperature on honeydew production of each sex. We also determined honeydew production by each nymphal instar. Overall, adult SPW produced more honeydew than nymphs. Adult females produced more honeydew than males. The relative differences between honeydew production for males and females and between amounts adults produced compared with nymphs were consistent. However, honeydew production by adult and nymph individuals was subject to large degrees of variation.

Introduction

Bemisia tabaci (Gennadius) (sweetpotato whitefly SPW Strain B), pest status is associated with direct feeding damage and reduced crop yields, virus transmission, plant physiological disorders, and contamination of crops with excreted honeydew that serves as a substrate for several species of fungi. Fungal growth on honeydew on the surface of edible produce and ornamentals is aesthetically objectionable and reduces economic value. It can also reduce photosynthesis and discolors cotton lint. Honeydew deposits on cotton lint adhere to the working surfaces of cotton processing equipment resulting in reduced ginning rates and stoppages of lint processing machinery at the textile mill (Hector and Hodkinson 1989).

The objectives of this work were to investigate factors affecting honeydew production. We determined (1) the amounts and distribution of honeydew production by adult males, females and nymphs over their life-spans, and (2) the effects of temperature on honeydew production.

Materials and Methods

Adults. SPW used in all studies were reared in the greenhouse on cotton plants. Newly emerged adult males and females were obtained by removing all existing adults at 0800 h from the plant(s). The adult free plants were placed in 0.45 m wide x 0.61 m high muslin-covered cages. Adults that emerged on the plants thereafter until 1300 h were collected, sexed and held separately. We determined adult honeydew production over their life spans by placing two males or two females, in each of five, 3.8 cm diameter x 0.85 cm high leaf-clip cages on intact cotton leaves on plants in the two to four-leaf stage of development. Adults were collected from each cage with an aspirator every three or four days and transferred to new leaf-clip cages on new plants to avoid egg hatch in the female infested cages. Plants with SPW were placed in 26.7°C temperature-controlled chambers in a randomized complete block design (5 reps, repeated 3 times) under 14:10 light:dark (L:D) conditions.

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Honeydew Drop Counts, Collection and Sugar Identification. Cage bottoms were removed on each day that adults were transferred to new cages. Numbers of honeydew drops on leaf-cage bottoms were counted and honeydew washed from the leaf-cage bottoms with sugars in the samples were determined using the high performance liquid chromatography (HPLC) methods of Hendrix and Wei (1994) and quantified by comparison with known sugar standards.

Temperature. We determined the effect of temperature on adult honeydew production by confining two males or two females in leaf cages on each of five cotton plants. Plants with adults in leaf cages were placed in constant temperature boxes at 21.1, 26.7, or 32.2°C. Each controlled temperature cabinet was under 14:10 L:D conditions. Adults were transferred to new cages and on new plants every 3 or 4 days for 14 days. The experiment was conducted in a five replicate complete block design and repeated twice.

Nymphs. Honeydew production by SPW nymphs was determined in 26.7°C controlled temperature cabinets under 14:10 L:D conditions. Eight adult pairs were placed in each of 15 leaf cages on cotton plants for 2 h. Adults were removed and each caged leaf examined for eggs. Plants with eggs were placed in the constant temperature chambers and examined each day for egg hatch. When eggs began to hatch, two to six, first-instar nymphs were left on each leaf, all other eggs and nymphs were removed. On the first day of nymph emergence and each day thereafter until adults emerged, numbers of honeydew drops were counted and subsequently collected for HPLC analysis, as described for adults.

Statistical Analysis. All data were analyzed using analysis of variance (ANOVA) (MSTAT-C 1988), a factorial treatment arrangement was applied when appropriate, and means separated contingent on a significant F test using the method of least significant differences at $P \leq 0.05$. Relative sizes and volumes of adult male and female honeydew drops were compared using Students "t" tests.

Results

Laboratory. Male SPW transferred to new leaf cages every 3 or 4 days over their life span lived 22.9 ± 3.2 days (Table 1). Females transferred to new leaf cages every 3 or 4 days lived 29.7 ± 3.3 days. The mean total numbers of honeydew drops per male transferred was 594.3 ± 85.2 compared with 1916.9 ± 359.3 honeydew drops for females. Larger amounts of honeydew sugars were produced by females compared with males.

Effects of Temperature. More honeydew drops were produced by adult SPW at 26.7°C compared with 21.1 and 32.2°C (Table 2). Mean numbers of drops produced at 26.7°C were significantly higher than numbers produced at 21.1°C but not 32.2°C. Over all temperatures, females produced larger numbers of drops than with males.

Nymph Development and Honeydew Production. The average number of days from egg hatch to adult emergence for 42 nymphs at 26.7°C (14:10L:D) was 12.20±0.19 days. The size of honeydew drops (visual observation) and total honeydew sugar production increased with increasing nymphal instar (Table 3). First- and second-instar nymphs produced significantly more honeydew drops than third- and fourth-instar nymphs. Fourth-instar nymphs produced larger amounts of glucose and fructose than first- and second-instar nymphs and larger amounts of total sugars when compared with all other instars.

Discussion

There is little published information comparing the quantity of honeydew produced by SPW male or female adults and nymphs. Honeydew drops of females, on average, were larger in size compared with those of males. The difference reported in this paper are relative since water loss was not considered and sphere droplet dimensions were assumed. The implications of the differences in honeydew excreted by males and females is unknown. However, differences in amounts may be partially explained by differences in the sizes of males and females. Females weigh nearly 2.5x (51 µg) more than males (21 µg) (Isaacs et al. 1998). The carbohydrate aspects of the SPW cotton host interaction is complex and may significantly reflect on biological and ecological adaptations of the insect.

In one report of studies on honeydew produced by SPW nymphs feeding on cotton, Blua and Toscano (1994) found that during 24-h feeding periods, fewer honeydew drops were produced while feeding on high nitrogen fertilized seedlings compared with nymphs feeding on low nitrogen fertilized seedlings. They also reported that nymphs feeding on plants supplied high nitrogen initiated honeydew production earlier (2 days) than nymphs feeding on plants fertilized with low or medium amounts of nitrogen.

Costa et al. (1999) also found a clear pattern of honeydew drop production consisting of periods of drop production followed by periods of no drop production. Blua and Toscano (1994) reported that nymphs did not initiate honeydew production for 3 to 5 days following emergence. Our results differed in that nymphs began producing honeydew drops on the day of emergence. Costa et al. (1999) observed honeydew drop production in some cases before the first molt but results were variable. The reason for the differences remains unclear but may be related to the methods of honeydew drop collection. In each case, Blua and Toscano (1994) and Costa et al. (1999) monitored honeydew drop production on water sensitive paper strips placed beneath the nymphs. Our results were obtained by counting drops collected on plastic leaf cage bottoms. Small drops of honeydew produced by first-instar nymphs on water sensitive paper may not in all cases produce a visible distinctive blue spot as is the case for larger honeydew drops produced by older nymphs.

Similar to our results, the production of larger honeydew drops by older nymphs were reported by Blua and Toscano (1994) and Costa et al. (1999). This has also been reported in other whitefly species. For example, Lei et al. (1996) reported that *Trialeurodes vaporariorum* (Westwood) nymphal numbers of honeydew drops decreased with older nymphs but the volume of honeydew increased and was explained by the increased size of the drops produced by older nymphs.

Changes in plant physiology may be reflected in SPW feeding biology. Increasing our knowledge in these areas of pest-host plant interaction has much potential for practical application. For example, water management in cotton culture is a farmer-adopted method of reducing cotton plant stress and SPW populations (Flint et al. 1996).

Literature Cited

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Tables

Table 1. Mean longevity, numbers of honeydew drops and total µg of honeydew sugars per SPW adult during their life span at 26.7°C.

Treatment[a]	Longevity (days)	Total honeydew drops (no./adult)	Total Sugars[b] (µg/adult)
Males	22.9a	594.3b	19.1b
Females	29.7a	1916.9a	68.6a
F, df 2,14	2.1	7.3	9.4

[a] Means of 8 replications, 2 adults/rep. Means in a column followed by a different letter are significantly different. Method of least significant differences $P \leq 0.05$.

[b] Glucose, fructose, trehalulose, sucrose and melezitose.

Table 2. Effects of temperature on mean numbers of honeydew drops produced by males and females.

Treatment[a]	# Drops
Temperature (°C)	
22.1	286.7 b
26.7	721.9 a
32.2	625.0 a
F[b]	21.3
Males	396.3 b
Females	692.8 a
F[b]	27.0

[a] Means of 8 replications, 2 adults/rep. Means in a column followed by a different letter are significantly different. Method of least significant differences $P \leq 0.05$.

[b] df for temperature comparisons = 2,40; for all male-female comparisons = 1,40

Table 3. Mean numbers of honeydew drops and total µg of honeydew sugars produced per SPW nymphal stage during development.

Nymphal Instar	# Drops	Total[a] µg honeydew sugars produced/nymph[b]
First	185 a	1.0b
Second	144 a	0.8 b
Third	71 b	1.3 b
Fourth	47 b	2.3 a
F[b]		27.0

[a] Glucose, fructose, trehalulose, sucrose and melezitose

[b] Means of 8 replications, 2 adults/rep. Means in a column followed by a different letter are significantly different. Method of least significant differences $P \leq 0.05$.[c] df for honeydew drops = 3,18; for total sugars = 3,42