Evaluation of Selected Soybean Genotypes for Resistance to Two Whitefly Species (Homoptera: Aleyrodidae) in the Greenhouse[1]

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ABSTRACT Fourteen soybean cultivars and breeding lines in Maturity Groups VII and VIII were monitored for silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring, and greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), infestation levels in the greenhouse. Unifoliate leaves became infested with whitefly immatures and eggs 4 wks after planting. LA88-32 and F90-700 had significantly higher total whitefly populations than 11 and eight of the other entries, respectively, at growth stage V7. Whitefly populations were higher 6 wks after planting (growth stage V8-V9) when a unifoliate leaf and trifoliate leaves 1, 2, and 3 were sampled. G89-5180, Perrin, F90-988, G89-5066, N89-1, and N88-91 had significantly lower total numbers of whiteflies than F90-724, F90-700, and LA88-32. At 10 wks after planting (growth stage R2), G89-5180 and N88-91 had the lowest numbers of whiteflies, and total counts were significantly higher for F90-724 on trifoliolates 2, 4, and 6. Leaf damage ratings (% leaf burn) ranged from 1.3% (F90-724) to 74.0% (F90-1054). Sampling ceased after 10 wks because of excessive whitefly-induced plant injury to most soybean entries. This study reflected significant differences in soybean varietal response to whitefly population densities and demonstrated that the greenhouse can be used effectively to screen soybeans for resistance to whiteflies.

KEY WORDS *Bemisia argentifolii, Trialeurodes vaporariorum,* host plant resistance

Whiteflies (Homoptera: Aleyrodidea) are small delicate insects that damage plant foliage with their piercing-sucking feeding habits. Feeding by adults and nymphs stunts plant growth and wilts the foliage (Smith et al. 1970). In addition, these insects secrete abundant honeydew on which sooty mold develops and disrupts normal photosynthetic processes. Whiteflies also vector a complex of plant viruses in vegetable and row crops (Duffus and Flock 1982). Control of the insects with conventional insecticides is becoming more difficult

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because of resistance (Prabhaker et al. 1985). An abundance of suitable weed hosts insures that some whitefly species can maintain themselves when agronomic crops are lacking (Coudriet et al. 1985).

The silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring, formerly known as sweetpotato whitefly "strain B" (Perring et al. 1993), has become a major threat to agricultural production in North America. Southern states have suffered extensive damage since 1986, when silverleaf whitefly first appeared in the United States (Price et al. 1987). Annual economic losses attributed to silverleaf whitefly exceed $200 million and occur in cotton, peanuts, soybeans, vegetables, and ornamentals (Faust 1992). Although silverleaf whitefly damage is much less severe in vegetable and row crops in Georgia than that observed in the southwestern United States, problems with this pest are intensifying (McPherson and Douce 1992).

The greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), is another vegetable and row crop pest with worldwide distribution (Simpson 1977). It was first reported in 1870 as a pest of greenhouse tomatoes in America and has since become a major pest of greenhouse crops throughout much of the world (Smith et al. 1970). In the United States, the greenhouse whitefly is a destructive pest in home gardens, home greenhouses and on houseplants (Webb et al. 1985). The greenhouse whitefly is highly polyphagous, attacking at least 294 plant genera in 84 families (Russel 1977), and is resistant to many insecticides.

All et al. (1989) demonstrated the usefulness of screening soybean cultivars for resistance to defoliating insect pests within the controlled environment of a greenhouse. However, very little has been published on whitefly infestations on soybeans in the greenhouse, and information on the life cycles of these insects is lacking in soybeans. Therefore, research was initiated to evaluate whitefly biology and to evaluate selected soybean germplasm resistant to silverleaf whitefly and greenhouse whitefly in the greenhouse.

Materials and Methods

Fourteen soybean cultivars and breeding lines in Maturity Groups VII and VIII were planted in a whitefly-infested greenhouse at the Coastal Plain Experiment Station in Tifton, GA on 8 December 1993. These soybean genotypes were chosen based on resistance/susceptibility ratings obtained from 36 genotypes evaluated in a preliminary host plant resistance field test in 1992 (McPherson and Severson 1993). The 14 soybean entries included three lines that appeared to be less susceptible to whiteflies, nine lines with moderate susceptibility, and two susceptible cultivars.

Ten seeds of each variety were planted in 15.2-cm diam pots, 2.5 cm below the surface of Pro-Mix potting soil. Plants were later thinned to four plants per pot. Each entry was labeled, replicated four times, and placed in a randomized block arrangement. Plants were watered every two days from planting until the end of the test. A 20-20-20 fertilizer (0.5%) was applied to all plants 3 wks after emergence. Plants were supported with cane stakes (91.4 cm × 0.64 cm diam) 4 wks after planting. A 14:10 L:D photophase with flourescent lighting and an ambient temperature of 25-27° were maintained throughout the study.

Insects used in the experiment originated from a silverleaf whitefly colony being maintained on eggplant in the laboratory. Pots of whitefly-infested eggplants were transferred from the USDA Insect Biology Population Dynamics Laboratory (Tifton, GA) to a greenhouse in late November. A natural population of greenhouse whitefly was also established on the soybeans during the course of this study.

Whitefly infestations on each soybean variety were evaluated by taking the middle leaflet from lower, middle, and upper trifoliolates from a single plant within each pot and returned to the laboratory for observation. Only a unifoliate leaf was examined on 3 January because this was the only fully expanded leaf. A unifoliate leaf plus leaflets from trifoliolates 1, 2, and 3 were collected and examined on 18 January. On 15 February, samples were taken from the second, fourth, and sixth trifoliolates. The unifoliate leaves had already dried and fallen from the plants by this date, and thus were not sampled. Sampling ceased after 15 February because of excessive plant injury to most soybean entries.

All samples were examined with a dissecting microscope set at 12X. Because silverleaf and greenhouse whitefly immatures are difficult to distinguish prior to the development of the pupal stage, which takes 2-3 wks to develop (Butler et al. 1983, Gerling and Horowitz 1986), the number of eggs and nymphs of all whiteflies (SLWF + GHWF) were counted on randomly selected soybean plants. The number of whitefly eggs, nymphs, and pupae was recorded for the 2.54-cm^2 mid-vein section of foliage being observed under the microscope. Percent damage ratings also were obtained on 18 January by visually estimating percent browning of leaf margins, and in some instances the entire leaflet (James 1971). Whitefly population densities and damage ratings were analyzed using an ANOVA; means for each soybean entry were separated (P = 0.05) using Duncan's multiple range test (SAS institute 1985).

Results

Total populations ranged from 47.8 to 622.3 whiteflies (eggs and nymphs) per 2.54 cm^2 on 3 January (growth stage V7). LA88-32 had significantly higher total whitefly populations than 11 of the other genotypes, while F90-700 had more whiteflies than 8 of the other entries (Table 1). The number of whitefly eggs and immatures was lower for most soybean entries on 3 January than on the other two sampling dates. Egg counts were significantly higher for LA88-32 than 11 of the entries, and F90-700 had a higher number of nymphs than 8 of the entries. Pupal counts were extremely low ranging from 0.0 to 0.5 pupae per unifoliate leaf on 3 January, indicating the presence of a recent infestation.

Whitefly populations increased by 18 January (growth stage V8-V9), and several significant differences in varietal response were detected. G89-5180, Perrin, F90-988, G89-5066, N88-91, and N89-1 had significantly lower total whitefly populations than F90-724 and F90-700. Variety G89-5180 had a significantly lower number of eggs than five of the entries on 18 January. G89-5180 also had significantly lower nymphal counts than 6 of the entries on this date.

Table 1. Mean number of whitefly eggs, nymphs, pupae and percent leaf burn on 14 soybean varieties and breeding lines, CPES Entomology Greenhouse, 1993.

Soybean Genotype	Mean total whiteflies per plant*							
	3 January				18 January			
	E	N	P	Total	E	N	P	Total
Cook	73.3 bc	24.0 b	0.0 a	97.3 c	407.3 b-e	249.8 abc	16.8 ab	673.9 bcd
Perrin	30.8 c	17.0 b	0.0 a	47.8 c	283.0 dce	141.5 b-e	8.5 ab	433.0 de
Cobb	85.0 bc	24.0 b	0.0 a	109.0 c	556.0 bcd	234.0 a-d	14.0 ab	804.0 a-d
F90-988	134.0 bc	53.0 ab	0.0 a	187.0 bc	271.5 cde	128.0 cde	16.3 ab	451.8 de
F90-724	221.3 bc	14.3 b	0.0 a	235.5 bc	1031.3 a	172.7 a-e	3.0 b	1207.0 a
F90-700	359.5 ab	120.8 a	0.0 a	480.3 ab	750.8 ab	260.3 abc	24.3 a	1034.3 ab
G89-5180	37.0 c	11.0 b	0.0 a	48.0 c	86.3 e	36.3 e	8.0 ab	130.6 e
Braxton	106.5 bc	5.3 b	0.0 a	111.8 c	534.5 bcd	204.8 a-d	16.5 ab	755.8 a-d
F90-1054	75.3 bc	20.0 b	0.5 a	95.8 c	359.3 b-e	290.8 ab	25.3 a	675.4 bcd
LA 88-32	545.5 a	76.8 ab	0.0 a	622.3 a	655.3 bc	314.0 a	19.0 ab	988.3 abc
G89-5172	78.0 bc	23.0 b	0.3 a	101.3 c	345.5 cde	165.5 a-e	10.3 ab	521.3 cde
G89-5066	62.5 bc	36.8 ab	0.0 a	99.3 c	225.5 de	101.0 cde	11.0 ab	337.5 de
N88-91	158.3 bc	41.3 ab	0.0 a	199.5 bc	198.8 de	128.3 cde	12.8 ab	339.9 de
N89-1	326.0 abc	45.0 ab	0.0 a	371.0 abc	369.0 b-e	87.7 de	0.3 b	456.0 de

Table 1. Continued.

Soybean Genotype	Mean total whiteflies per plant* 15 February E	N	P	Total	% Leaf Burn 18 January
Cook	169.3 b	243.5 ab	13.3 ab	426.1 bc	18.5 bc
Perrin	249.8 b	233.0 ab	12.0 ab	494.8 bc	33.0 abc
Cobb	319.3 b	320.0 a	12.3 ab	651.6 ab	28.0 bc
F90-988	201.0 b	146.3 ab	19.0 ab	366.3 bc	16.8 bc
F90-724	592.5 a	308.0 a	12.8 ab	913.3 a	1.3 c
F90-700	228.3 b	208.8 ab	9.8 ab	446.9 bc	41.5 abc
G89-5180	144.8 b	39.3 b	2.5 b	186.6 c	45.7 ab
Braxton	307.8 b	172.8 ab	4.5 ab	485.1 bc	40.8 abc
F90-1054	48.8 b	149.5 ab	16.8 ab	215.1 bc	74.0 a
LA 88-32	128.8 b	161.3 ab	20.8 a	310.9 bc	32.3 abc
G89-5172	176.3 b	160.8 ab	8.8 ab	345.9 bc	20.5 bc
G89-5066	324.3 b	128.0 ab	6.5 ab	458.8 bc	49.5 ab
N88-91	154.3 b	71.3 b	4.8 ab	230.4 c	53.5 ab
N89-1	193.3 b	226.3 ab	13.5 ab	433.1 bc	30.3 bc

* Mean number of whitefly (SLWF + GHWF) eggs (E), nymphs (N), and pupae (P) per 2.54 cm^2 from all leaflets sampled on each date. Column means followed by the same letter are not significantly different according to Duncan's multiple range test ($P = 0.05$).

By 15 February, the soybeans were in the bloom (R2) or early pod stage (R3-R4) (Fehr et al. 1971), and whitefly populations remained relatively constant on most soybean varieties. Again, total counts were lowest for G89-5180. F90-724 had significantly higher total whitefly counts than 12 of the entries on 15 February. F90-724 had significantly higher egg counts than all the other soybean entries on 15 February.

Damage ratings obtained on 18 January indicated significant differences in varietal response to whitefly feeding. Leaf damage ratings (% leaf burn) ranged from 1.3% (F90-724) to 74.0% (F90-1054). The variety F90-724 had significantly lower damage ratings than four of the entries, while F90-1054 had significantly higher damage ratings than six of the entries.

Discussion

This greenhouse study reflects significant differences in varietal response to whitefly (silverleaf and greenhouse whiteflies) population densities. G89-5180 and N88-91 consistently had the lowest total whitefly counts throughout the study, and F90-724 had the highest counts. However, leaf damage ratings indicated that G89-5180 and N88-91 were somewhat susceptible to whitefly feeding, while F90-724, with significantly lower percent leaf burn but high whitefly populations, appeared to possess a tolerance mechanism of resistance (Smith 1989) to whitefly-induced plant injury. These results were similar to those reported by McPherson and Severson (1992), although whitefly populations and plant damage ratings were lower in their field test. In our study, soybean entries with intermediate densities of whiteflies and lower damage ratings (e.g. Cook) appeared to be the least susceptible.

Several difficulties were encountered during our study. Because silverleaf whitefly and greenhouse whitefly immatures are difficult to distinguish except for the pupal stage, a total whitefly count was made. However, observations of greenhouse whitefly pupae and adults indicated that these populations were higher than silverleaf whitefly populations in this greenhouse study. This can be explained by reports that silverleaf whitefly reproduction is much reduced in winter months (Avidov 1956). Ohnesorge et al. (1980) stated that the development of the silverleaf whiteflies during the winter months can be delayed to such an extent that the pupae can only be found on the very oldest, senescent leaves. Therefore, pupae may often be missed with ordinary sampling procedures. This may account for the low pupal counts for all three sampling dates.

Information concerning whitefly infestations on soybean is lacking. Turnipseed (1977) sampled several soybean genotypes with trichome variation for resistance to bandedwinged whitefly, *Trialeurodes abutiloneus* (Haldeman), but found no correlation between plant pubescence and whitefly populations. However, insect populations were sampled with a D-Vac suction sampler that most likely collected adult whiteflies only (Vaishampayan and Kogan 1980). Other studies have examined within-plant and between-plant distributions of each developmental stage of greenhouse whitefly and silverleaf whitefly on poinsettia, gerbera daisy, and chrysanthemum in the greenhouse (Liu et al. 1993).

Whiteflies are a potential serious threat to soybean production. The whitefly complex caused over 40% leaf burn in one-third of the entries evaluated in the present study. While there were significant differences in soybean varietal response, additional testing and plant breeding is necessary before whitefly-resistant soybean material will be available to producers. A simple and effective morphological method for immature whitefly species differentiation needs to be established. Mistaking greenhouse whitefly populations for silverleaf whitefly populations has led to unnecessary spraying and the evolution of pesticide resistance in silverleaf whitefly and increased resistance in greenhouse whitefly (Omer et al. 1993). Although plant resistance to whiteflies is a highly desirable characteristic, soybean varieties must also be agronomically desirable and not be more susceptible to other pest problems than the currently available recommended varieties.

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