NOTE

Effects of a Natural Pesticide From *Nicotiana gossei* on Controlling Whiteflies (Homoptera: Aleyrodidae) on a Susceptible and Resistant Soybean Line[1]

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Whiteflies, particularly the sweetpotato whitefly, *Bemisia tabaci* (Gennadius), have become a serious threat to agricultural production in the United States (Faust, 1992, USDA/ARS Publ. 107). *B. tabaci* has been reported as an economic pest of poinsettias produced in greenhouses in Florida (Price et al., 1986, Greenhouse Grower, Dec.) and exported throughout the United States and Canada (Broadbeat et al., 1989, Can. Entomol. 121: 1027-1028). Besides damaging plant foliage with their piercing/sucking feeding habits, whiteflies also secrete honeydew on which sooty mold develops limiting photosynthesis. In addition, these insects transmit a complex of plant viruses (Duffus and Flock, 1982, Calif. Agric. 36: 4-6). Annual economic losses in the United States exceed $200 million due to whitefly damage that occurs in cotton, peanuts, soybeans, ornamentals, and vegetables (Faust, 1992, USDA/ARS Publ. 107). Although whitefly damage is less severe in vegetable and row crops in Georgia than that observed in the southwestern U.S., the problem with this pest is intensifying in the Southeast (McPherson and Douce, 1992, Ga. Agric. Expt. Stn. Spec. Publ. 81).

Chemical Control of whiteflies with conventional insecticides is becoming more difficult due to insecticide resistance (Prabhaker et al., 1985, J. Econ. Entomol. 78: 748-752). Studies to evaluate different spray regimes and application equipment are being undertaken (Sumner et al., 1993, USDA/ARS Publ. 112). Recent investigations have identified a biorational insecticide consisting of sugar esters present in the cuticular extract of *Nicotiana gossei* Domin, which has potential for control of whiteflies (Akey et al., 1993.

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USDA/ARS Publ. 112; Buta et al., 1993, Phytochem. 32: 859-864; Severson et al., 1993, USDA/ARS Publ. 112; Severson et al., 1994, Am. Chem. Soc. Symp. Series 557). Therefore, this study was conducted to examine the effects of these sugar esters on whitefly egg deposition and immature development on a susceptible and resistant soybean line in the greenhouse.

'Cobb,' a susceptible soybean cultivar, and N88-91, a whitefly-resistant breeding line (R. M. M., pers. obs.), were planted on 21 Sep 1993 in 0.9-L plastic pots filled with potting soil. Ten seeds were placed in each pot 2.5 cm below the soil surface and labeled by variety, with eight pots of each variety. All pots were watered every 1 to 2 days with 240 ml of water sprinkled over the plots and plants. The pots were placed in the Entomology greenhouse at the Coastal Plain Experiment Station in Tifton, GA where a colony of *B. tabaci* was being maintained on eggplant. However, during the course of this study, some greenhouse whiteflies, *Trialeurodes vaporariorum* (Westwood), also were observed at low population densities. On 30 Sep, 5 d after germination, all pots were thinned to 5 plants. The pots were randomly assigned to one of two treatments, Cobb treated or untreated and N88-91 treated or untreated. The pots were arranged in a 2 X 2 factorial design with 4 replications, with soybean genotype and treatment being the factors examined. The *N. gossei* biorational, a mixture of glucose esters (1-0-acetyl-2,3-di-0-acylglucose and 2,3-di-0-acylglucose) and sucrose esters (2,3-di-0-acyl-1′-0-acetylsucrose and 2,3-di-0-acyl-1′,6′-di-0-acetylsucrose), was isolated from its cuticular extract by solvent partitioning and Sephadex LH-20 chromatography, the major acyl moieties being 5-methylhexanoyl-and 5-methylheptanoyl- (Severson et al., 1994, Am. Chem. Soc. Symp. Series 557). A 1-g portion of the sugar ester isolate was dispersed into 1 L of water and sprayed until runoff onto potted plants using a hand-held compressed air sprayer. The treated pots were sprayed weekly from 30 Sep until 4 Nov.

At the phenological growth stages V_3, V_5, V_7, and R_2 (Fehr et al., 1971, Crop Sci. 11: 929-931), a random leaflet from each unifoliate and trifoliate leaf from a randomly-selected plant was obtained from each pot and returned to the laboratory. Each leaflet was examined with a dissecting microscope at 12X magnification, giving a total viewing area of 2.54 cm^2. All normal and desiccated whitefly eggs and nymphs were recorded. The percent desiccated eggs was determined for each of the four experimental units. On 22 Nov, at soybean growth stage V_7, cluster size also was recorded for all eggs observed. Eggs that were in contact and in the same age classification were considered in a cluster. The total number of eggs in each cluster was recorded for each leaflet. A 2 X 2 factorial analysis of variance was performed on egg and immature numbers and percent desiccation (SAS Institute, 1989, SAS User's Guide, Version 6). The percent desiccation was transformed using the square-root arcsine transformation prior to analysis.

The overall effect of *N. gossei* biorational treatments on whitefly egg and immature population densities on Cobb and N88-91 soybeans are recorded in Table 1. There were significantly more whitefly eggs on Cobb than on N88-91 during both the V_7 (six uncurled trifoliates) and R_2 (blooming) stages. The *N. gossei* treatments significantly reduced the number of eggs on both genotypes on all four sampling dates. A Genotype X Treatment interaction

Table 1. Effects of *N. gossei* biorational treatments on the incidence of whitefly eggs and immatures at four plant growth stages of two soybean genotypes, 1993.

	Sampling date and plant growth stage			
Soybean genotypes*	18 Oct V_3	2 Nov V_5	22 Nov V_7	7 Dec R_2
	Mean eggs per cm^2			
Cobb trt.	12.7	13.7	99.8	55.7
Cobb untrt.	22.2	14.8	110.5	119.9
N88-91 trt.	12.8	11.9	30.1	49.8
N88-91 untrt.	13.1	18.1	44.8	69.4
Statistical Analyses**				
Genotype	NS	NS	b	a
Treatment	a	a	a	b
Gen. × Trt.	a	NS	NS	NS
	Mean immatures per cm^2			
Cobb trt.	10.1	9.6	22.0	37.8
Cobb untrt.	11.3	18.2	24.1	71.4
N88-91 trt.	3.8	8.9	8.6	23.6
N88-91 untrt.	12.9	11.6	24.0	38.1
Statistical Analyses**				
Genotype	NS	a	NS	a
Treatment	a	b	b	b
Gen. × Trt.	a	NS	a	NS

* Treated plots received 6 weekly foliar sprays of *N. gossei* extract during vegetative plant growth stages V_2 to V_6.

** NS indicates no significant difference ($P > 0.05$) on that sampling date,a, and b indicate significant differences at $P = 0.05$ and 0.01, respectively.

was detected only on the V_3 growth stage, when egg numbers were greatly reduced on treated Cobb and not reduced on treated N88-91. There were no other Genotype X Treatment interactions, indicating that the biorational activity was similar in reducing egg numbers on both the susceptible and resistant genotypes. The effects of genotype and treatment on immature whitefly numbers were similar to the effects on eggs. More immatures were observed on Cobb, if a significant genotype difference was detected, while *N. gossei* treatments significantly reduced immature numbers on both genotypes on all dates. Significant Genotype X Treatment interactions were detected on both the V_3 and V_7 growth stages. On both of these sampling dates, the *N. gossei* treatments greatly reduced immature whitefly numbers on the N88-91 but did not reduce immatures on the Cobb.

The effects of *N. gossei* biorational treatments on the desiccation of whitefly eggs and immatures on soybean are recorded in Table 2. More eggs were desiccated on N88-91 than on Cobb on the V_3 and V_5 sampling dates, but *N. gossei* treatments increased egg desiccation on both genotypes on all four growth stages sampled. The biorational activity was similar for both genotypes except on the V_7 stage when the *N. gossei* treatments greatly increased the number of desiccated eggs on Cobb but did not increase the number of desiccated eggs on N88-91. Eggs on the lower leaves (unifoliate-V_3) were desiccated by as much as 50 to 60%, while only 0 to 5% of the eggs were desiccated on the upper leaves (V_4-V_7) which had received little or no *N. gossei* extract. No genotype differences were detected in the numbers of desiccated immatures on any of the four sampling dates, while the biorational treatments significantly increased desiccation on all four dates. No Genotype X Treatment interactions were detected for desiccated immatures. Immatures on the lower leaves were about 40 to 50% dehydrated while very few immatures on the upper leaves were desiccated. Immature stages on the treated foliage also were visually smaller than corresponding immatures on untreated foliage.

More viable eggs were observed on Cobb soybean than on N88-91 soybean. This difference in egg numbers was primarily due to an increase in the number of single eggs being deposited. Whitefly eggs were usually laid singly on the under leaf surface on all the soybean foliage, regardless of variety or treatment. There were 154 and 201 single eggs on Cobb treated and untreated soybean foliage, respectively, compared to 50 and 81 on the N88-91 treated and untreated foliage. However, this represented 75% of the total eggs deposited on Cobb and 78% on N88-91, indicating very little difference in the proportion of eggs that were deposited singly. The proportion of eggs in clusters of 2, 3, and 4 or more also were similar among the two genotypes and the two treatments. The largest egg clusters occurred on untreated Cobb foliage on the upper trifoliates (V_5-V_7) when egg densities reached over 235 per cm^2. Clusters of 20, 15, and 14 were observed on these plants and were simply a response to a very high whitefly population density. No egg cluster larger than 10 was observed on the Cobb treated foliage or either N88-91 entry.

These results demonstrate that a naturally-occurring sugar ester isolate of *N. gossei* applied to soybean foliage reduces the number of viable whitefly eggs and immatures by about 50% on the treated foliage and 25% overall (including the uncurling new trifoliates) on a susceptible and resistant soybean line

Table 2. Effects of *N. gossei* biorational treatments on the percent desiccation of whitefly eggs and immatures at four plant growth stages of two soybean genotypes, 1993.

Soybean genotypes*	Sampling date and plant growth stage			
	18 Oct V_3	2 Nov V_5	22 Nov V_7	7 Dec R_2
		Percent desiccated eggs		
Cobb trt.	22.1	17.4	18.7	14.6
Cobb untrt.	3.2	3.4	5.1	9.5
N88-91 trt.	32.3	24.9	14.6	23.6
N88-91 untrt.	4.1	3.9	13.9	8.9
Statistical Analyses**				
Genotype	a	a	NS	NS
Treatment	b	b	a	b
Gen. × Trt.	NS	NS	a	NS
		Percent desiccated immatures		
Cobb trt.	28.4	19.3	17.6	21.1
Cobb untrt.	2.8	0.2	11.1	9.9
N88-91 trt.	27.4	20.9	19.9	15.7
N88-91 untrt.	1.4	1.2	11.5	11.9
Statistical Analyses**				
Genotype	NS	NS	NS	NS
Treatment	b	b	a	a
Gen. × Trt.	NS	NS	NS	NS

* Treated plots received 6 weekly foliar sprays of *N. gossei* extract during vegetative plant growth stages V_2 to V_6.

** NS indicates no significant difference ($P > 0.05$) on that sampling date,a, and b indicate significant differences at $P = 0.05$ and 0.01, respectively.

produced under greenhouse conditions and very heavy whitefly pressure. This reduction was caused primarily by desiccation of eggs and immatures. The N88-91 soybean demonstrated an innate characteristic to resist whitefly infestations, and in combination with the biorational treatment, caused an even further reduction in infestations, even under heavy population pressure.

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