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Six-year Evaluation of Brown Citrus and Spirea Aphid Populations in a Citrus Grove and the Effects of Insecticides on these Populations

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Abstract. **The population densities of the brown citrus aphid (BrCA) (*Toxoptera citricidus* Kirkaldy) and the spirea aphid (SA) *Aphis spiraecola* Patch were monitored by scouting weekly for 6 years in a replicated citrus plot treated with 7 insect control regimes: Admire (imidacloprid) applied at 12, 6, 3, or 2 month intervals; Temik applied annually; Meta-Systox-R applied annually; or no insect control. The numbers of both aphid species varied greatly from month to month and year to year. The brown citrus aphid was normally only detected in the fall (August through December) with populations peaking in September, October, or December depending on the year. The spirea aphid could be detected throughout the year during years when overall populations were high. Spirea aphid populations often peaked both in the spring and fall. Annual applications of Temik or Metasystox were ineffective in reducing aphid populations. Generally, all four Admire treatment regimes controlled aphids, although at least 2 annual Admire treatments per year were required to control the spirea aphid during some years.**

Four aphid species may predominate in citrus groves in Florida: *Toxoptera citricidus* Kirkaldy [brown citrus aphid (BrCA)], *Aphis gossypii* Glover [melon aphid (AG)], *Aphis spiraecola* Patch (spirea aphid) and *Toxoptera aurantii* (Boyer de Fonscolombe) [black citrus aphid (BlCA)]. The BrCA, AG, and spirea aphid are well-documented vectors of citrus tristeza virus (CTV) (Roistacher and Bar-Joseph, 1987).

The BrCA is probably the most serious aphid pest in citrus because it can cause direct feeding damage and is the most efficient vector of CTV (Roistacher and Bar-Joseph, 1987). Reported transmission rates of CTV by BrCA vary from 0% to nearly 100% (Broadbent et al., 1996, Costa and Grant, 1951, Lin et al., 2002, Nickel et al., 1984, Yokomi et al., 1994). Transmission of Florida isolates of CTV by BrCA has been inefficient (Lin et al., 2002). The BrCA is found throughout Asia, Australia, New Zealand, Pacific Islands, Sub-Sahara Africa, and South America. It moved into the Caribbean Basin in the early 1940s and into Florida in 1995. The BrCA host range is normally limited to citrus.

The Spirea aphid has worldwide distribution and host range beyond citrus including apples (Pfeiffer et al., 1989) and ornamentals. It is one of the most abundant aphids on citrus in the United States (Yokomi and Tang, 1995). The melon aphid has a very wide host range and its presence in citrus is well-documented (Powell et al., 1997). The BlCA, which is easily confused with the BrCA, is not normally a vector or feeding damage threat (Pelosi and Powell, unpublished data).

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Few recent extensive surveys for aphids in citrus have been reported. A recent survey in Spain revealed *A. gossypii* (53%) and *A. spiraecola* (32%) to be the most commonly captured aphids in citrus (Marroquin et al., 2004). Likewise, the effects of various chemical controls, in particular imidacloprid, on citrus aphids is not well-documented. We present the results of a six year evaluation of aphid populations in a Florida Citrus grove in a replicated citrus block with and without insect control strategies. The primary objective of the study is to assess the ability of BrCA to become established in this grove. The secondary objective is to determine how chemical control strategies affect BrCA and spirea aphid populations.

Materials and Methods

The experimental area consisted of 294 'Valencia' sweet orange (*Citrus sinensis* L.) Osbeck) trees grafted on to sour orange rootstock (*C. aurantium* L.) The trees were in single beds (rows) with 9.15 m between rows. The between-tree spacing was 4.5 m.

The experiment was a randomized complete block design with each of six rows serving as a replication. There were seven treatments in each of the six replications, with seven trees per experimental unit (plot). The treatments were an annual application of Temik (Rhone-Poulenc, Research Triangle Park, N.C.) (8.5 g a.i. per tree, incorporated into the soil); an annual application of Meta-Systox-R (Mobay Corp., Kansas City, Mo.) (trunk drenched, 0.62 mL·L^{-1}); soil drenches with imidacloprid (1-[(6-chloro-3-pyridinyl) methyl]-N-nitro-2-imidazolidinimine) (Admire) (Bayer, Vero Beach, Fla.) at 1920 mg a.i./plant applied at 12, 6, 3, or 2 month intervals; and no insecticide application. Temik was applied the last week of April, and the trunk drenches were applied in the spring between 19 Apr. and 22 May. The levels of insecticides were based on manufacturer's recommendations.

Every week, from September 1997 to April 2003 the experimental area was scouted for aphids. Each tree was examined and the total number of aphids of each aphid species was recorded. Weekly data was combined into monthly totals recorded within each replication for each treatment. Representatives of each colony were speciated under a microscope (Bullock) since *T. aurantii* can be misidentified as BrCA.

Aphid numbers (square root transformed to smooth out the variance) were subjected to an analysis of variance (ANOVA) by the SAS software program (SAS Inst., Cary, N.C.). Main treatment effect means that had a significant F test were separated by Fisher's protected least significant difference (LSD) test, 5% level.

Results

The results of the 6-year survey and the effects of six insecticide control strategies are shown in Table 1. BrCA populations varied considerably from year to year. Higher than average populations occurred in 1997, 1998, 1999, and 2001; in comparison, populations were very low in 2000 and 2002. Virtually all the BrCA were detected during the fall and winter months (September through December); it was rare to detect any BrCA from January through August. Annual treatments of Temik or Metasystox were ineffective in BrCA control. All the Admire treatments were effective in BrCA control, even the annual applications.

The results with the spirea aphid (Table 2) were somewhat different than those with the BrCA. Spirea aphid populations were much higher than BrCA, and they were detected throughout most of the year. Spirea aphids were present in high numbers in 1998 and 1999, during most of the months. In 1998, the months with the lowest number of spirea aphids were April through August; while in 1999, spirea aphids were not detected in January or February. Spirea aphid populations fell dramatically in 2000 and have not recovered (up until 2005, continuous scouting observation). As with BrCA, Temik and Metasystox treatments were ineffective in controlling spirea aphids. All the Admire treatments were effective in controlling spirea aphids; however, complete control required two annual applications when heavy infestations occurred. Every 3- or 2-month Admire applications were not necessary.

Discussion

Of the four aphid species commonly found in Florida citrus, only the BrCA and the spirea aphid were prevalent at this site during the survey period. Less than 50 *A. gossypii* and no *T. aurantii* were detected; *A. gossypii* has been prevalent in years before the introduction of the BrCA in 1995 (Powell et al., 1997). The reason for the disappearance of *A. gossypii* is unknown.

The brown citrus aphid flourished in the Indian River region of Florida area after becoming established in 1997. It then remained prevalent for two more seasons before essentially disappearing in 2000. Since then the BrCA populations have been sporadic, but never reaching pre-2000 levels. These results are contrary to those expected. We and others predicted that BrCA would become endemic and develop high populations whenever new flush was available. Spirea aphids also became virtually undetectable in 2000, and populations have not recovered. The reason for the great reduction in aphid numbers is unknown. The phenomenon cannot be correlated with any obvious weather conditions (drought, abnormal temperatures). It may be related to natural parasites or predators, which were usually present. The research area became infested with the Asian citrus psyllid (*Diaphorina citri* Kuwayma) in 1999, and perhaps these insects provided a continuous food source to maintain aphid predator populations such as lady bugs.

Application of Admire (even only once a year) was the only insect control strategy tested that suppressed aphid populations. Since aphid populations in the control trees were not damaging the trees (unpublished observations), and good aphid control has been shown not to affect citrus tristeza virus movement (Powell et al., 2005), chemical control of aphids is probably not economically justified unless more severe infestations should occur.

Literature Cited

Broadbent, P., R.H. Brlansky, and J. Indsto. 1996. Biological characterization of Australian isolates of citrus tristeza virus and separation of subisolates by single aphid transmission. Plant Dis. 80:329–333.

Costa, A.S. and T.J. Grant. 1951. Studies on trans-

Table 1. Population densities of brown citrus aphids in a Florida orange grove under seven different insecticide control strategies from 1997–2003.[z]

Year	Treatment[y]	Month												
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean[x]
1997	Admire 1×	---[w]	---	---	---	---	---	---	---	24 a	0 a	0	0 a	6 ab
	Admire 2×	---	---	---	---	---	---	---	---	42 a	0 a	0	0 a	10 a
	Admire 4×	---	---	---	---	---	---	---	---	0 b	0 a	0	0 a	0 b
	Admire 6×	---	---	---	---	---	---	__	__	0 b	0 a	0	0 a	0 b
	Temik	---	---	---	---	---	---	---	---	0 b	0 a	3	0 a	1 b
	Metasystox	---	---	---	---	---	---	---	---	383 c	20 a	0	167 b	142 c
	Control	---	---	---	---	---	---	---	---	788 c	48 b	0	0 a	209 c
1998	Admire 1×	0	0	0	3	0	0	0	0	0 a	0 a	0 a	1 a	0 a
	Admire 2×	0	0	0	0	0	0	0	0	0 a	0 a	0 a	0 a	0 a
	Admire 4×	0	0	0	0	0	0	0	0	0 a	0 a	0 a	0 a	0 a
	Admire 6×	0	0	0	0	0	0	0	0	0 a	0 a	0 a	0a	0 a
	Temik	0	0	0	0	0	0	0	0	0 a	37 b	68 b	168 b	23 b
	Metasystox	0	0	0	0	0	0	0	0	92 b	19 b	334 b	2040 c	207 c
	Control	7	0	0	0	0	0	0	0	0 a	110 b	134 b	733 bc	82 bc
1999	Admire 1×	0	0	0	0	0	0 a	0	0	0 a	0 a	0 a	0 a	0 ab
	Admire 2×	0	0	0	0	0	0 a	0	0	0 a	0 a	0 a	0 a	0 ab
	Admire 4×	0	0	0	0	0	0 a	0	0	0 a	0 a	0 a	0 a	0 ab
	Admire 6×	0	0	0	0	0	0 a	0	0	0 a	0 a	0 a	0 a	0 ab
	Temik	0	0	0	0	0	0 a	13	0	2 a	26 a	50 b	0 a	8 b
	Metasystox	0	0	0	0	0	25 b	4	8	30 a	7 ab	1692 c	0a	147 c
	Control	0	0	0	0	0	0 a	0	0	0 a	0 a	89 b	29 b	10 b
2000	Admire 1×	0	0	0	0	0	0	0	0	0	3	0	0	0
	Admire 2×	0	0	0	0	0	0	0	0	0	1	0	0	0
	Admire 4×	0	0	0	0	0	0	0	0	0	0	0	0	0
	Admire 6×	0	0	0	0	0	0	0	0	0	0	0	0	0
	Temik	0	0	0	25	0	0	0	0	0	32	0	0	5
	Metasystox	0	0	0	0	0	0	0	3	0	8	0	0	1
	Control	0	0	0	50	0	0	0	0	0	33	0	0	7
2001	Admire 1×	0	0	0	0	0	0	0	0 a	0 a	33 a	0	0	3 a
	Admire 2×	0	0	0	0	0	0	0	0 a	0 a	2 b	0	0	0 a
	Admire 4×	0	0	0	0	0	0	0	0 a	0 a	0 b	0	0	0 a
	Admire 6×	0	0	0	0	0	0	0	0 a	0 a	0 b	0	0	0 a
	Temik	0	0	0	0	0	0	0	13 b	23 b	1265 c	0	0	108 b
	Metasystox	0	0	0	0	0	0	0	78 c	188 c	1971 c	0	0	168 b
	Control	0	0	0	0	0	0	12	33 bc	23 b	699 c	0	0	64 b
2002	Admire 1×	0	0	0	0	0	0	0	0	0 a	0	0	0	0
	Admire 2×	0	0	0	0	0	0	0	0	2 a	0	0	0	0
	Admire 4×	0	0	0	0	0	0	0	0	0 a	0	0	0	0
	Admire 6×	0	0	0	0	0	0	0	0	0a	0	0	0	0
	Temik	0	0	0	0	0	0	8	0	114 b	0	0	0	10
	Metasystox	0	0	0	0	0	0	0	0	62b	50	0	0	9
	Control	0	0	0	0	0	0	0	0	75 b	0	0	0	6
2003	Admire 1×	0	0	0	0	---	---	---	---	---	---	---	---	---
	Admire 2×	0	0	0	0	---	---	---	---	---	---	---	---	---
	Admire 4×	0	0	0	0	---	---	---	---	---	---	---	---	---
	Admire 6×	0	0	0	0	---	---	---	---	---	---	---	---	---
	Temik	0	0	0	0	---	---	---	---	---	---	---	---	---
	Metasystox	0	0	0	0	---	---	---	---	---	---	---	---	---
	Control	0	0	0	0	---	---	---	---	---	---	---	---	---

[z]Numbers represent the mean aphids counted weekly and summed for each month. The mean was determined from six replications. Numbers in a column followed by different letters are significantly different (5% level) by Fisher's protected LSD.

[y]Admire 1× = Imidacloprid applied annually, Admire 2× = Imidacloprid applied every 6 months, Admire 4× = Imidacloprid applied every 3 months, Admire 6× = Imidacloprid applied every 2 months, Temik = applied annually, Metasystox = applied annually, Control = no insecticide applied.

[x]Average aphids counted per replication.

[w]Brown citrus aphids were not collected during that month.

Table 2. Population densities of spirea aphids in a Florida orange grove from 1997–2003.[z]

Year	Treatment[y]	Month												
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean[x]
1997	Admire 1×	---[w]	---	---	---	---	---	---	---	0	0 a	0 a	0 a	0 a
	Admire 2×	---	---	---	---	---	---	---	---	0	0 a	0 a	0 a	0 a
	Admire 4×	---	---	---	---	---	---	---	---	0	0 a	0 a	0 a	0 a
	Admire 6×	---	---	---	---	---	---	---	---	0	0 a	0 a	0 a	0 a
	Temik	---	---	---	---	---	---	---	---	0	2 a	47 b	228 b	69 b
	Metasystox	---	---	---	---	---	---	---	---	1	1 a	0 a	25 ab	8 ab
	Control	---	---	---	---	---	---	---	---	3	26 b	133 b	1 a	41 b
1998	Admire 1×	1 a	0 a	2 a	496 a	0	0	0	0 a	2 a	6 a	9 a	0 a	43 a
	Admire 2×	0 a	0 a	0 a	0 b	0	0	0	0 a	0 a	0 a	0 a	4 a	0 b
	Admire 4×	1 a	0 a	0 a	8 b	0	0	0	0 a	0 a	5 a	0 a	0 a	1 b
	Admire 6×	0 a	0 a	0 a	0 b	0	0	0	0 a	0 a	0 a	0 a	4 a	0 b
	Temik	1758 b	186 b	56 b	1567 bc	0	0	0	0 a	58 b	518 b	200 b	0 a	354 c
	Metasystox	32 c	10 a	26 b	3063 d	0	0	0	0 a	202 c	102 c	201 b	60 b	308 c
	Control	854 b	4 a	50 b	2842 d	0	10	0	41 b	340 c	484 b	450 b	151 bc	435 c
1999	Admire 1×	0	0	164 a	164 a	0 a	0 a	183 a	48 a	0 a	0 a	0 a	0 a	47 a
	Admire 2×	0	0	0 b	0 b	0 a	0 a	0 b	0 b	0 a	0 a	0 a	0 a	0 b
	Admire 4×	0	0	0 b	2 b	7 a	0 a	0 b	0 b	0 a	0 a	0 a	0 a	1 b
	Admire 6×	0	0	0 b	0 b	0 a	0 a	0 b	0 b	0 a	0 a	0 a	0 a	0 b
	Temik	0	0	132a	850 c	0 c	0 a	25 ab	0 b	10 a	19 b	104 b	18 b	96 c
	Metasystox	0	0	595 c	453 c	19 b	129 b	38 ab	44 a	17 ab	33 b	86 b	0 a	118 c
	Control	0	0	145 c	310 c	22 b	0 a	143 a	104 c	66 b	10 b	59 b	15 b	95 c
2000	Admire 1×	0	0	8	0	0	0	0	0	0	1	0	0	1
	Admire 2×	0	0	6	0	0	0	0	0	0	0	0	0	0
	Admire 4X	0	0	0	0	0	0	0	0	0	0	0	0	0
	Admire 6×	0	0	0	0	0	0	0	0	0	0	0	0	0
	Temik	0	0	4	67	0	0	0	0	0	0	0	0	6
	Metasystox	0	0	0	0	0	0	0	0	0	0	0	0	0
	Control	0	0	0	0	0	0	0	0	0	0	33	0	3
2001	Admire 1×	0	0	0	0	0	0	0	0	0	8	0	0	1
	Admire 2×	0	0	0	0	0	0	0	0	0	2	0	0	0
	Admire 4×	0	0	0	0	0	0	0	0	0	1	0	0	0
	Admire 6×	0	0	0	0	0	0	0	0	0	0	0	0	0
	Temik	0	0	0	0	0	0	0	0	0	0	0	2	0
	Metasystox	0	0	0	0	0	0	0	0	0	0	0	17	1
	Control	0	0	0	0	0	0	0	0	0	0	0	12	1
2002	Admire 1×	0	0 a	0	1	0	0	0	0	0	0	0	0	0 a
	Admire 2×	0	0 a	0	0	0	0	0	0	0	0	0	0	0 a
	Admire 4×	0	0 a	2	0	0	0	0	0	0	0	0	0	0 a
	Admire 6×	0	0 a	0	0	0	0	0	0	0	0	0	0	0 a
	Temik	19	0 a	0	0	0	0	0	0	2	0	0	0	2 a
	Metasystox	2	0 a	0	0	0	0	0	0	1	0	0	0	0a
	Control	0	171 b	0	0	0	0	0	0	0	0	0	0	14 b
2003	Admire 1×	0	0	0	0	---	---	---	---	---	---	---	---	0
	Admire 2×	0	0	0	0	---	---	---	---	---	---	---	---	0
	Admire 4×	0	0	0	0	---	---	---	---	---	---	---	---	0
	Admire 6×	0	0	0	0	---	---	---	---	---	---	---	---	0
	Temik	0	0	0	0	---	---	---	---	---	---	---	---	0
	Metasystox	0	0	0	0	---	---	---	---	---	---	---	---	0
	Control	0	0	0	0	---	---	---	---	---	---	---	---	0

[z]Numbers represent the mean aphids counted weekly and summed for each month. The mean was determined from six replications. Numbers in a column followed by different letters are significantly different (5% level) by Fisher's protected LSD.

[y]Admire 1× = Imidacloprid applied annually, Admire 2× = Imidacloprid applied every 6 months, Admire 4× = Imidacloprid applied every 3 months, Admire 6× = Imidacloprid applied every 2 months, Temik = applied annually, Metasystox = applied annually, control = no insecticide applied.

[x]Average aphids counted per replication.

[w]Brown citrus aphids were not collected during that month.

mission of the tristeza virus by the vector *Aphis citricidus*. Phytopathology 41:105–122.

Lin, Y., R.H. Brlansky, and C.A. Powell. 2002. Ineffective transmission of citrus tristeza virus from grapefruit by single brown citrus aphids. (*Toxoptera citricida* Kirkaldy). HortScience 37:936–939.

Marroquin, C., A. Olmos, M.T. Gorris, E. Bertolini, M.C. Martinez, E.A. Carbonell, A.H. de Mendoza, and M. Cambra. 2004. Estimation of the numbers of aphids carrying Citris tristeza virus that visit adult citrus trees. Virus Res. 100:101–108.

Nickel, O., F. Klingauf, and H. Fischer. 1984. Transmission of citrus tristeza virus (CTV) from "decliamiento"—Diseased sweet orange tree on trifoliate orange and its epidemiology to the flight activity of the vector, *Toxoptera citricida* Kirkaldy (Homoptera: Aphididae) in Misioness, Argentina, p. 33–38. In: L.W. Timmer, S.M. Garnsey, and L. Navano (eds.) Proc. 10th Conf. Intl. Org. Citrus Virol. (IOCV), Riverside, Calif.

Pfeiffer, D.G., M.W. Brown, and M.W. Varn. 1989 Incidence of spirea aphid (Homoptera: Aphididae) in apple orchards in Virginia, and Maryland. J. Entomol. Sci. 24:145–149.

Powell, C.A., R.R. Pelosi, M.S. Burton, P.A. Rundell, M.A. Ritenour, and R.C. Bullock. 2005. Natural field spread of decline and nondecline inducing isolates of citrus tristeza virus in Florida after the introduction of the brown citrus aphid. HortScience 40:691–693.

Powell, C.A., R.R. Pelosi, and R.C. Bullock, 1997. Natural Spread of mild and severe isolates of citrus tristeza virus in Florida. Plant Dis. 81:18–20.

Roistacher, C.N., and M. Bar-Joseph. 1987 Aphid transmission of citrus tristeza virus: A review. Phytophylatica 19:163–167.

Yokomi, R.K., R. Lastra, M.B. Stoetzel, V.D. Damsteegt, R.F. Lee, S.M. Garnsey, T.R. Gottwald, M.A. Rocha-Pena, and C.L. Niblett. 1994. Establishment of the brown citrus aphid (Homoptera: Aphididae) in Central America and the Caribbean Basin and transmission of the citrus tristeza virus. J. Econ. Entomol. 87:1078–1085.

Yokomi, R.K. and Y.Q. Tang. 1995. Host preference and suitability of two aphelinid parasitoids (Hymenoptera: Aphelinidae) for aphids (Homoptera: Aphididae) on citrus. J. Econ. Entomol. 88:840–845.