

Valencia orange (*Citrus sinensis*)
Citrus canker (*Xanthomonas axonopodis* pv. *citri*)
Citrus leafminer (*Phyllocnistis citrella*)

P.D. Roberts, P.A Stansly,
J. A. Qureshi, and R. Sytsma
University of Florida, IFAS
Southwest Florida REC
Immokalee, FL 34142

Evaluation of soil and foliar applied products for management of citrus canker and citrus leafminer and on Valencia orange trees, 2008.

The experiment was conducted at a commercial grove located on SR29 near Immokalee, FL. The trees were planted in 2002 and were 'Valencia' orange grafted to 'Swingle' citromelo rootstock. The tree spacing was 12 × 24 ft on a double row bed, 151 trees/A. Irrigation was via microsprinklers. Trees were scouted prior to plot establishment and marked if canker positive. Only trees marked for canker were included in experiment. Plots contained three trees with at least two trees serving as buffers between each plot and at least one tree row between each row of treatments. There were four replications per treatment arranged in a randomized complete block design. Foliar applications were applied with a Durand Wayland speed sprayer calibrated to deliver 125 GPA (gal per A) operating at 150 psi and 3 mph. AdmirePro was applied on 24 Apr. as a drench in 16 oz water/tree using EZE-DOSE applicator (Model CCI DO 35).

Disease severity was assessed on a scale of 0 to 9 where 0 = no disease, 1 = 1-15%, 2 = 16-30%, 3 = 31-40%, 4 = 41-50%, 5 = 51-60%, 6 = 61-70%, 7 = 71-80%, 8 = 81-90% and 9 = 91-100% coverage of foliage affected. The number of 'hits' (H. Yonce, personal communication) were recorded as discrete hot spots of canker lesions in the tree canopy. The number of fruit per tree exhibiting citrus canker lesions was recorded in all treatments. Area under the disease progress curve (AUDPC) was calculated from the disease severity ratings. Only a subsample of treatments that included AdmirePro, horticulture mineral oil, Kocide 3000, MBT, Zoro, Spintor, and Micromite were evaluated against damage by citrus leafminer. Damage assessment was based on the presence of larval mines and their severity recorded on 12 and 30 May, 20 Jun, 14 Jul, 1 and 25 Aug. New shoots susceptible to leafminer oviposition and larval damage were tagged 2-3 days before sprays were applied and evaluated 2-3 weeks after the sprays. The number of damaged (mined) and undamaged (without mines) leaves on each shoot was noted for a total of nine shoots per plot. Severity of mines was rated on a scale of 0 to 3: 0 = no damage, 1 = low, 2 = medium, and 3 = high. Reduction in leaves infested by leafminer larvae and mines severity was adjusted for control values using Abbott's formula. Data were subjected to ANOVA with mean separation by LSD.

Average monthly high and low temperatures (°F) 80 and 57 in Mar, 84 and 59 in Apr, 90 and 65 in May, 91 and 70 in Jun, 89 and 72 in Jul, 90 and 74 in Aug, 89 and 74 in Sep and 84 and 66 in Oct. Rainfall totals for Mar, Apr, May, Jun, Jul, Aug, Sep, and Oct were 2.8, 2.5, 5.4, 10.1, 12.2, 14.1, 5.4, and 2.9 respectively.

Canker symptoms were evident on foliage and fruit on all sampling dates. Disease severity estimated as the percentage of foliage with symptoms increased throughout the season for most treatments. Similar trends were observed for clusters of canker lesions (hits) in the

tree canopy and symptoms on fruit. Significant treatment effects were observed on all three variables on all sampling dates except 8 May and 12 Jun when symptoms on foliage and fruit did not differ among treatments. At the final rating, applications of Kocide 3000 at 2.5 lb/A alone were as effective as Kocide 3000 at the same rate in programs with Admire Pro or Actigard plus Kasumin. Serenade Max and a reduced rate of Kocide 3000 was not different from the high rate of Kocide. Byotrol, Boyd treatment, and citrus oil provided no control of canker. Neither Citrex nor Omega-Plus appeared to confer any additional canker suppression when added to the Kocide treatment. In general, there does not appear to be any advantage to adding the products tested to a full-rate of Kocide but there may be some potential in combinations with reduced rates or in rotation with copper sprays.

Generally, Admire Pro gave better control than the foliar rotation early in the season but the situation reversed later in the season. Single drench application of Admire Pro alone or with Kocide protected new foliage for 4 months against leafminer infestation (Tables 2, 3). A weak effect on citrus leafminer of AdmirePro plus copper and AdmirePro alone seen on 12 May, indicating that a full dose had not yet translocated to the target tissues 3 weeks after application. Most reduction (81-99%) in infested leaves seen on 30 May and 20 Jun the first two months after application. During the following two months 25-76% reduction was observed. A reduction of 68-76% was observed on 20 Jun and 25 Aug following the Micromite treatment, compared to 27-83% 12 May and 14 Jul following treatments with Zoro, and 29-76% with Spintor on 30 May and 1 Aug. Kocide and Oil by themselves or in combination and the Boyd treatment were all not very effective in providing significant protection against leafminer damage. Trends in mines severity data were similar to the ones seen in the infested leaves. Admire Pro without copper provided some canker suppression whereas the foliar insecticide rotation did not. Given that the overall level of leafminer control was approximately equal, canker suppression afforded by imidacloprid could be conferred through some other mechanism. On the other hand, it may also be true that early leafminer suppression (with Admire Pro) is worth more in terms of canker control than late leafminer suppression when foliar applications did a better job.

Treatment/Rate (Date of application) ^z	8 May		12 Jun			
	DS ^y	Hits ^x	DS	Hits	Fruit ^w	
1 Untreated control	1.2 ^v	3.3 bcd	1.3	6.3 abcde	0.2	
2 Admire Pro 5.5 ml/tree (2).....	1.2	3.4 bcd	1.1	6.4 abcde	0.0	
3 Admire Pro 5.5 ml/tree (2).....	1.1	3 bcd	1.0	6.8 abcd	0.0	
Kocide 3000 2.5 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11)						
4 Citrus oil 435 5% (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	0.8	4.6 abcd	1.2	3.5 cde	0.0	
5 Citrus oil 435 5% (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	1.0	3.1 bcd	1.0	4 bcde	0.0	
Kocide 3000 2.5 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11)						
6 Actigard 50WG 6 oz/A (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11)	0.9	1.7 d	0.9	2.3 cde	0.3	
Kocide 3000 2.5 lb/A (1,2,3,4,5,8,9,10,11)						
Kasumin 64 fl oz/100 gal (6,7)						
7 K-Phite 6 pt/A (1,2,3,4,5,6,7,8,9,10,11).....	0.8	1.8 d	1.1	1.6 e	0	
Kocide 3000 2.5 lb/A (1,2,3,4,5,6,7,8,9,10,11).....						
8 Maury Boyd treatment ^u	1.3	6.3 ab	1.0	9.4 a	0.1	
9 Omega-Plus 5% (1,3,5,7,9,11).....	0.8	2.6 cd	1.0	2.8 cde	0.0	
Kocide 3000 2.5 lb/A (2,4,6,8,10)						
10 Key Plex 3 qt/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	0.9	3.8 abcd	1.1	4.3 bcde	0.2	
11 Byotrol 400 ppm (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	1.3	5.9 abc	1.3	8.6 ab	0.1	
12 Serenade Max 1 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	0.8	2.7 cd	0.9	4 bcde	0.2	
Kocide 3000 1.75 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11)						
13 Citrex 0.25% (1,3,5,7,9,11).....	0.8	1.6 d	0.7	1.8 de	0	
Kocide 3000 2.5 lb/A (2,4,6,8,10)						
14 Kocide 3000 2.5 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	1.0	2.3 d	1.0	3 cde	0.1	
15 Zoro 5oz/A (2,5,8,11).....	1.4	7.1 a	1.0	6.8 abc	0.5	
Spintor 8oz/A (3,6,9)						
Micromite 6oz/A (4,7,10)						
Citrus Oil 435 2% (2,3, 4, 5, 6, 7, 8, 9, 10, 11)						
	<i>P</i> =	0.12	0.03	0.57	0.03	0.37

^z 1=25 Mar; 2=24 Apr; 3=15 May; 4=5 Jun; 5=26 Jun; 6=23 Jul; 7=7 Aug; 8=28 Aug; 9=18 Sep; 10=9 Oct; 11=30 Oct.

^yDS= 0-9 scale where 0=no disease symptoms and 9=100% foliage affected

^xHits= number of discrete areas in tree canopy with clustering of canker lesions

^w Mean number of fruit per tree exhibiting symptoms of citrus canker

^v Means followed by the same letter or no letter are not significantly different at the *P* value indicated in table.

^u Application rate was 105 GPA. – Ingredients/100 gal.: 1.07-lbs. Serenade, 0.95-qts. Di-oxy Solv Organic, 3.8-gal. 14-8-7 w/ K-Phite (1-pt./gal. (1-pt./gal.), 4-lbs. Mg sulfate, 4-lbs. Mn sulfate, 1.3-lbs. Zn sulfate, 0.4-oz. Na molybdate, 4-lbs. 13-0-44 (spray grade KNO₃), 2.4-gal. 435 oil, 1-pt. Saver. Application dates: 11 Apr; 29 May; 8 Sep; and 16 Oct.

Treatment/Rate (Date of application) ^z	1 Aug			19 Sep			
	DS ^y	Hits ^x	Fruit ^w	DS	Hits	Fruit	
1 Untreated control	1.9 ab ^v	14.3 abcd	4.3 ab	2.8 b	29.8 abcd	19.5 ab	
2 Admire Pro 5.5 ml/tree (2).....	1.3 cd	8.7 def	2.1 bcde	2.1 b	20.5 cde	11.7 bcd	
3 Admire Pro 5.5 ml/tree (2)..... Kocide 3000 2.5 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11)	1.3 cd	7.7 ef	0.4 e	1.7 b	14.7 e	5.3 d	
4 Citrus oil 435 5% (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	2 a	16.5 ab	1.6 cde	3.4 ab	39.7 a	21.8 a	
5 Citrus oil 435 5% (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11)..... Kocide 3000 2.5 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11)	5 a	13.7 abcd	0.9 de	2.6 b	31.2 ab	9.8 cd	
6 Actigard 50WG 6 oz/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11)	1.3 cd	5.8 f	0.9 de	1.5 b	18.1 e	4.2 d	
Kocide 3000 2.5 lb/A (1,2,3,4,5,8,9,10,11) Kasumin 64 fl oz/100 Gal (6,7)							
7 K-Phite 6 pt/A (1,2,3,4,5,6,7,8,9,10,11).....	1.1 d	6.2 f	0.1 e	1.8 b	15.6 e	5.8 d	
Kocide 3000 2.5 lb/A (1,2,3,4,5,6,7,8,9,10,11).....							
8 Maury Boyd treatment ^u	2.1 a	18.5 a	3.9 abc	5.4 a	29.7 abcd	21.8 a	
9 Omega-Plus 5% (1,3,5,7,9,11).....	9 cd	9.1 def	1.6 cde	1.7 b	14.8 e	11.7 bcd	
Kocide 3000 2.5 lb/A (2,4,6,8,10)							
10 Key Plex 3 qt/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	1.7 abc	10 def	1.6 cde	2.1 b	24.8 bcde	12.2 bcd	
11 Byotrol 400 ppm (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	2 a	16 abc	4.7 a	2.9 b	30.5 abc	25.0 a	
12 Serenade Max 1 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	1.2 cd	10.3 cdef	0.8 de	1.6 b	15.3 e	5.2 d	
Kocide 3000 1.75 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11)							
13 Citrex 0.25% (1,3,5,7,9,11).....	1.3 cd	5 f	1.1 de	1.8 b	20.2 de	6.0 d	
Kocide 3000 2.5 lb/A (2,4,6,8,10)							
14 Kocide 3000 2.5 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	1.3 d	6 f	1 de	1.6 b	15.9 e	5.1 d	
15 Zoro 5oz/A (2,5,8,11).....	1.4 bcd	12.5 bcde	3.2 abcd	2.4 b	23.8 cde	17.1 abc	
Spintor 8oz/A (3,6,9) Micromite 6oz/A (4,7,10) Citrus Oil 435 2% (2,3, 4, 5, 6, 7, 8, 9, 10, 11)							
	P=	<0.0001	<0.0001	0.0004	0.025	<0.0001	<0.0001

^z 1=25 Mar; 2=24 Apr; 3=15 May; 4=5 Jun; 5=26 Jun; 6=23 Jul; 7=7 Aug; 8=28 Aug; 9=18 Sep; 10=9 Oct; 11=30 Oct.

^yDS= 0-9 scale where 0=no disease symptoms and 9=100% foliage affected

^xHits= number of discrete areas in tree canopy with clustering of canker lesions.

^w Mean number of fruit per tree exhibiting symptoms of citrus canker

^v Means followed by the same letter or no letter are not significantly different at the *P* value indicated in table.

^u Application rate was 105 GPA. – Ingredients/100 gal.: 1.07-lbs. Serenade, 0.95-qts. Di-oxy Solv Organic, 3.8-gal. 14-8-7 w/ K-Phite (1-pt./gal. (1-pt./gal.), 4-lbs. Mg sulfate, 4-lbs. Mn sulfate, 1.3-lbs. Zn sulfate, 0.4-oz. Na molybdate, 4-lbs. 13-0-44 (spray grade KNO₃), 2.4-gal. 435 oil, 1-pt. Saver. Application dates: 11 Apr; 29 May; 8 Sep; and 16 Oct.

Treatment/Rate (Date of application) ^z	23 Oct			AUDPC ^v
	DS ^y	Hits ^x	Fruit ^w	
1 Untreated control.....	2.3 bc ^u	28.7 abc	31.9 bc	2759 ab
2 Admire Pro 5.5 ml/tree (2).....	1.7 def	18.9 cdef	19.9 cde	1938 ab
3 Admire Pro 5.5 ml/tree (2)..... Kocide 3000 2.5 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11)	1.3 f	14.2 ef	9.9 e	1590 b
4 Citrus oil 435 5% (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	2.0 cd	31.4 ab	34.6 ab	3228 a
5 Citrus oil 435 5% (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11)..... Kocide 3000 2.5 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11)	1.9 cde	21 cde	17.3 de	2551 ab
6 Actigard 6 oz/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11) Kocide 3000 2.5 lb/A (1,2,3,4,5,8,9,10,11) Kasumin 64 fl oz/100 Gal (6,7)	1.5 def	17.3 def	15.6 de	1454 b
7 K-Phite 6 pt/A (1,2,3,4,5,6,7,8,9,10,11)..... Kocide 3000 2.5 lb/A (1,2,3,4,5,6,7,8,9,10,11).....	1.3 f	17.4 def	15.1 de	1397 b
8 Maury Boyd treatment ^u	2.8 a	33 ab	42.5 ab	3217 a
9 Omega-Plus 5% (1,3,5,7,9,11)..... Kocide 3000 2.5 lb/A (2,4,6,8,10)	1.4 ef	19.3 cdef	16.1 de	1550 b
10 Key Plex 3 qt/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	2.0 cd	24.5 bcd	28.8 bcd	2195 ab
11 Byotrol 400 ppm (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	2.7 ab	36.2 a	46.6 a	3140 a
12 Serenade Max 1 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11)..... Kocide 3000 1.75 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11)	1.7 f	10.5 f	13.1 e	1538 b
13 Citrex 0.25% (1,3,5,7,9,11)..... Kocide 3000 2.5 lb/A (2,4,6,8,10)	1.3 f	19.6 cdef	13.2 e	1517 b
14 Kocide 3000 2.5 lb/A (1,2,3, 4, 5, 6, 7, 8, 9, 10, 11).....	1.2 f	17.7 def	10.3 e	1427 b
15 Zoro 5 oz/A (2,5,8,11)..... Spintor 8 oz/A (3,6,9) Micromite 6 oz/A (4,7,10) Citrus Oil 435 2% (2,3, 4, 5, 6, 7, 8, 9, 10, 11)	2.3 abc	25.8 bcd	39.4 ab	2459 ab
	P=	<0.0001	<0.0001	0.07

^z 1=25 Mar; 2=24 Apr; 3=15 May; 4=5 Jun; 5=26 Jun; 6=23 Jul; 7=7 Aug; 8=28 Aug; 9=18 Sep; 10=9 Oct; 11=30 Oct.

^yDS= 0-9 scale where 0=no disease symptoms and 9=100% foliage affected

^xHits= number of discrete areas in tree canopy with clustering of canker lesions.

^w Mean number of fruit per tree exhibiting symptoms of citrus canker

^v Area under the disease progress curve

^uMeans followed by the same letter or no letter are not significantly different at the *P* value indicated in table.

^u Application rate was 105 GPA. – Ingredients/100 gal.: 1.07-lbs. Serenade, 0.95-qts. Di-oxy Solv Organic, 3.8-gal. 14-8-7 w/ K-Phite (1-pt./gal. (1-pt./gal.), 4-lbs. Mg sulfate, 4-lbs. Mn sulfate, 1.3-lbs. Zn sulfate, 0.4-oz. Na molybdate, 4-lbs. 13-0-44 (spray grade KNO₃), 2.4-gal. 435 oil, 1-pt. Saver. Application dates: 11 Apr; 29 May; 8 Sep; and 16 Oct.

Table 1

Percent reduction in leafminer infested leaves						
Treatment	12-May	30-May	20-Jun	14-Jul	1-Aug	25-Aug
Admire	3.1 ± 1.9b	92.0 ± 2.4a	99.1 ± 1.0a	75.5 ± 4.8ab	25.0 ± 11.7a	63.9 ± 5.1a
Admire + Kocide	24.1 ± 11.6a	80.7 ± 7.9ab	89.0 ± 7.7a	55.5 ± 8.6b	51.0 ± 12.9a	49.4 ± 22.8ab
Kocide	0.0 ± 0.0b	0.5 ± 0.5c	8.1 ± 5.5c	7.5 ± 2.5c	12.3 ± 5.0a	5.6 ± 5.6c
Oil + Kocide	0.0 ± 0.0b	0.9 ± 0.9c	40.7 ± 9.8bc	22.3 ± 8.8c	11.6 ± 1.7a	12.9 ± 7.7bc
Oil	3.8 ± 3.8b	0.6 ± 0.6c	47.6 ± 22.0bc	18.7 ± 8.3c	25.6 ± 20.5a	10.1 ± 6.4c
MBT	3.2 ± 2.7b	0.7 ± 0.7c	21.9 ± 14.4c	8.2 ± 7.8c	21.3 ± 12.8a	15.9 ± 8.2bc
Zoro/Spin/Mic/Oil	26.8 ± 6.9a	75.8 ± 8.3b	76.3 ± 15.3ab	83.4 ± 1.0a	29.3 ± 20.2a	67.9 ± 22.8a

Table 2

Percent reduction in mine severity						
Treatment	12-May	30-May	20-Jun	14-Jul	1-Aug	25-Aug
Admire	7.4 ± 4.5c	92.5 ± 2.1a	96.2 ± 2.4a	69.2 ± 7.03ab	31.2 ± 12.1a	56.4 ± 4.7ab
Admire + Kocide	25.9 ± 9.9b	83.5 ± 6.8ab	92.2 ± 3.4a	58.3 ± 6.9b	49.7 ± 8.1a	56.7 ± 19.2ab
Kocide	1.9 ± 1.9c	2.8 ± 2.8c	11.8 ± 7.5b	3.9 ± 2.7c	5.9 ± 3.6a	6.3 ± 4.7c
Oil + Kocide	3.7 ± 3.7c	4.2 ± 4.2c	42.8 ± 10.8b	23.3 ± 7.2c	16.5 ± 6.7a	19.9 ± 7.2bc
Oil	6.5 ± 3.8c	3.7 ± 3.7c	27.1 ± 20.7b	16.6 ± 6.7c	28.7 ± 22.5a	43.8 ± 10.5ab
MBT	4.6 ± 2.3c	8.1 ± 5.7c	21.6 ± 12.6b	15.1 ± 12.5c	25.9 ± 17.7a	19.7 ± 8.7bc
Zoro/Spin/Mic/Oil	58.3 ± 5.1a	77.6 ± 5.9b	47.5 ± 17.8b	82.7 ± 2.8a	28.3 ± 18.2a	61.5 ± 21.2a