Table 2. Broadleaves (Preemergence)

Camphorweed	*Heterotheca subaxillaris*
Dayflower	*Commelina benghalensis*
Florida pusley	*Richardia scabra*
Goatweed	*Scoparia dulcis*
Jerusalem oak	*Chenopodium ambrosioides*
Lambsquarters	*Chenopodium album*
Lantana (seedling)	*Lantana camara*
Nightshade, black	*Solanum nigrum*
Nutsedges*	*Cyperus spp.*
Phasey bean	*Macroptilium lathyroides*
Pigweed	*Amaranthus spp.*
Purslane	*Portulaca oleraccea*
Ragweed, common	*Ambrosia artemisiifolia*
Spanish needles	*Bidens pilosa*
Spurge	*Chamaesyce hyssopifolia*
Teaweed	*Sida acuta*
Virginia pepperweed	*Lepidium virginicum*
Vetch, hairy	*Vicia villosa*

*Suppression or partial control

Table 3. Vines (Preemergence)

Balsamapple vine	*Momordica charantia*
Citron	*Citrullus lanatus*
Maypop	*Passiflora incarnata*
Milkweed vine (seedling)	*Morrenia odorata*
Virginia creeper (seedling)	*Parthenocissus quinquefolia*
Peppervine (seedling)	*Ampelopsis arborea*

species and Table 3 lists the vine species that are controlled by azafenidin based on field studies to date.

Summary

DuPont is actively developing azafenidin for the Florida citrus market. It should be available to Florida citrus growers for use on non-bearing groves by fourth quarter 1997 and for use on bearing groves by fourth quarter 1999.

DuPont has successfully developed and registered several sulfonylurea herbicides, but azafenidin represents a new family of chemistry that functions as a porphyrin biosynthesis inhibitor. It is characterized by low use rates, low toxicity and safety to the environment. Degradation in the environment occurs primarily via microbial pathways.

Citrus has demonstrated excellent tolerance to azafenidin. Studies to date have resulted in excellent preemergence control of most key citrus weeds, including narrowleaf panicum, Spanish needles, goatweed, pigweed, and balsamapple vine.

Development of azafenidin is a part of DuPont's ongoing, long-term commitment to the citrus industry, and we are moving forward as rapidly as possible to bring this new herbicide to the Florida citrus market. We believe azafenidin will provide citrus growers with an important new tool for controlling a broad range of weeds and do so in an environmentally friendly manner.

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METHODS FOR EVALUATION OF SPRAY CHEMICAL PHYTOTOXICITY TO CITRUS

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Additional index words. Urea, N-SURE, Unocal, Aliette, Morestan, tissue culture.

Abstract. **For Florida citrus, pesticides, nutritionals and growth regulators are often sprayed together in tank mixes in order to reduce sprayer use when timings for efficacy are relatively coincident. Many individual spray components are marginally phytotoxic and can result in spray burns when used together or if applied with adjuvants that increase absorption. The toxicity level of many standard spray materials is unknown and new products are not routinely tested for phytotoxicity in citrus, particularly as tank mixes with other pesticides or nutritionals. Three test methods were developed to allow spray chemical phytotoxicity testing using cell cultures, peel disks and whole fruit. Cell suspension cultures initiated from 'nucellar derived' embryonic callus of 'Hamlin' sweet orange and 2) peel disks of orange or grapefruit were grown in culture and exposed to media incorporated test chemicals. Reduced weight gain (Method 1) or color changes and callus growth reduction (Method 2) were used to evaluate phytotoxicity. Dilute sprays and droplet applications to on-tree fruit (Method 3) were used to evaluate individual and combinations of chemicals with and without spray adjuvants. The three tests effectively determined thresholds for phytotoxicity and will be useful for testing new citrus production chemicals. These were preliminary evaluations and could be refined for statistical application. Chemicals tested and found to have some level of phytotoxicity by these methods included Aliette, Morestan, Pro-Gibb with 2,4-D, citric, phosphorus, and phosphoric acids, and some additional pesticides in combination with urea. Two herbicide grade adjuvants tested (Herbex and Induce) increased phytotoxicity in on-tree tests. Salty water often reduced the influence of a surfactant. Acidity, in itself, was phytotoxic to the peel of the fruit indicating buffering is important to minimize spray burn.**

Citrus in Florida often develops spray burn injury. This is particularly true for grapefruit in the Indian River area. The cause of greater susceptibility of Indian River grapefruit is not known but may be related to higher absorption due to high humidity, ideal temperatures and thinner cuticles on the fruit. Tank mixing often creates mixtures with more than one phytotoxic chemical which probably increases spray injury. In addition, growers have been using adjuvants to enhance effectiveness of chemicals, but tank mixtures often include materials that are meant to be contact/surface-

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active as well as systemic chemicals that should be absorbed by the plant. Many growers are using penetrant grade surfactants (formulated for herbicide uptake) in their tree sprays. Some chemical combinations are generally recognized to be phytotoxic to citrus fruit (Albrigo, 1978).

There is no standard methodology to determine if a new chemical, which has demonstrated efficacy for use in citrus, is potentially phytotoxic. Also, these chemicals will probably be applied to citrus in combination with other commonly used products that may be phytotoxic and the combination could result in a burn. The purpose of these studies was to (1) develop a series of tests that could be used to evaluate the phytotoxicity of a given chemical at the cellular level without cuticular barriers common to whole plants, (2) develop testing methods that could be used to evaluate phytotoxicity in typical spray mix combinations, and (3) learn more about factors associated with tank mixtures that would increase the tendency for spray burns to occur. Several compounds or mixes with reported histories of possible spray burn inducement were used.

Materials and Methods

Tissue culture tests: Suspension cultures initiated from 'nucellar derived' embryonic callus of 'Hamlin' sweet orange were grown in a nutrient solution (Grosser and Gmitter, 1990) until they reached the rapidly growing log phase. The solution was then changed after drained weights were obtained. The fresh media contained the desired test chemical (Aliette) sterilized through microfiltering or suspension in benzene in the case of Morestan (mixture considered sterile). These cultures were maintained on a low-speed shaker for 2 wk and drained weights were determined before and 2 wk after addition of the test chemical.

Peel disks were prepared by surface sterilizing grapefruit or navel orange fruit for 10 to 20 min in 1% sodium hypochlorite solution and then punching 9 mm circles into the peel with a heat-sterilized and cooled cork borer. Excess oil from the cut was removed with sterile cotton and the disks were surgically removed with a scalpel and forceps. Disks were placed on modified Tucker solid agar media (Vakis et al., 1970) in four section petri dishes (5 ml/section) to which test chemicals were added to the surface of the media. Benomyl (Dupont Chemicals, Wilmington, Delaware) at 100 ppm was added to the media to prevent growth of fungi that were established in the peel of the fruit during its field growth and were not killed by surface sterilization (Oberbacher and Brown, 1968). Cultures were grown for 2 wk and then evaluated for indications of normal growth. These included regreening of the flavedo, healthy appearance of the cut edge and callus formation (greening) on the cut surface. Disks were often first grown for 1 wk on regular media to establish that they were not contaminated before transferring them to divided petri dishes containing test chemicals. The tissue culture methods worked well with water soluble compounds.

Spot application tests to on-tree fruit: Spray solutions were made to equal or exceed a standard recommended rate in 1186 l/ha (125 gal/acre). These solutions were applied using a micro-syringe (2 µl/spot) as droplets without puncturing the surface, onto pinprick spots, onto cut lines (1 cm long in crosses) or alternatively the mixtures were infused into the flavedo with a 1 ml syringe and injecting solution (about 2-4 µl) just below the fruit surface. These tests (13) were done on local trees from May 1993 (postbloom) until late fall of 1993. Standard Aliette (Rhone Poulenc, Research Triangle Park, North Carolina), Morestan (Mobay Inc., Kansas City, MO), acids, and GA_3 (Abbott Labs., Chicago, IL) + 2,4-D rates and spray mixes reported to have caused spray burn in groves the previous season were among materials tested.

Small pressurized hand-sprayer tests: Small limb units with two to three fruit, on the east side of mature Ruby Red grapefruit trees (Vero Beach), were sprayed with solutions approximating 125 or 62.5 gal/acre. All chemicals were applied using a CO_2 pressurized Sure Shot (Milwaukee Sprayer Mfg. Co. Inc., Milwaukee, WI) sprayer held about 0.3 m distance from the tree. One limb unit in each of three trees received each spray. Treatments including Aliette or Morestan were applied late morning to early afternoon on 9 Sept 1993. Other treatments similar to those tested by droplet tests were applied to adjacent trees during the next 6 wk. Each spray was applied to a limb unit in each of three adjacent trees. Final evaluation of spray burn was made in the laboratory on 6 Jan 1994.

A high salt (2700 ppm total dissolved salts) source (Vero Beach well) of water was compared with deionized water for spray solutions because many of the Indian River water sources are high in salt. Two surfactants were compared to active chemicals alone. Induce (Setre Chemical Co.), a alkyl aryl polyoxylkane ether, free fatty acid and IPA mix, was used at 0.0025 or 0.005% with the high salt water). Herbex (Goldschmidt Co.), an organo-modified siloxane, was used at 0.001 or 0.00125% with the high salt water. Other chemicals and rates tested in 1993-94 and 1994-95 are given in data tables in the results and discussion section.

Results and Discussion

Suspension cultures. In three cell suspension culture tests, Aliette at 0.075 mg/ml of solution reduced growth to 33-63% of the control (Table 1). In one test using higher concentrations, the double rate of 0.15 mg/ml reduced growth to 24%. The four times rate (0.3 mg/ml) killed two cultures, but one survived at a moderate growth rate. The average growth was 14% of the control. The survivor colony at the high rate may have mutated, or it is possible that the concentration applied was incorrect. The phytotoxicity of Aliette (a water soluble compound) to citrus suspension cultures was clearly demonstrated. The normal field spray rate is 4 to 5 mg/ml or about 14 times the highest rate in these tests.

In similar tests using Morestan (technical grade) and benzene to solubilize it, benzene reduced growth to 50% to 0% of the control in combinationn with 0.16mg/mlMorestan the growth was 11 and 12.5% of the control or it completely killed the tissue (data not shown). Results were highly variable from test to test. These tests indicate that using organic solvents to solubilize water insoluble compounds is not a good procedure. If the emulsified mix for spraying is not autoclavable, an alternative technique such as toxic gas or ultra-violet sterilization might be employed. Unfortunately, we did not have the appropriate chambers to test these methods.

Peel disk cultures. Peel disks of navel orange and grapefruit (not shown) demonstrated increasing phytotoxicity when treated with higher concentrations of Aliette (Table 2). The highest rate of Aliette (0.24 mg/ml) appeared to result in more dead disks (dark brown) when combined with copper than when used alone. There was no apparent increase in phytotoxicity at the lower Aliette level when combined with copper. Disks and suspension cultures do not grow as well when the pH is below 5 (Dr. J. Grosser, personal communication), but all Aliette treatments included buffering to 6.5.

The only way we could treat the disks with Morestan was to lightly or heavily (quantity unknown) dust the bottom of the peel disk with technical powder before placing the disks on the solid agar. There was some decrease in vigor of the heavily dusted disks but the amount of chemical could not be quantified and the amount l

Table 1. Suspension culture tests of Aliette using Hamlin orange callus derived cells.

Treatment	Gms gained per gm original cells		
	Test 1	Test 2	Test 3
Control	1.8a	0.8a	2.1a
Aliette (0.075 mg/ml)	0.6b	0.5b	1.0b
% of control	33%	63%	48%
Aliette (0.15 mg/ml)	ND	ND	0.5c
% of control			24%
Aliette (0.3 mg/ml)	ND	ND	0.3d
% of control			14%

Aliette buffered with KCO_3, ND = no data.
Numbers with unlike letters are significantly different at 5% level.

Table 2. Peel disk culture tests with Aliette or Morestan and using navel orange peel.

Treatment	Flavedo top color[z]	Flavedo edge color	Albedo cut side color
Control	2 grn, 3 dk grn[y]	4 light brn	2 grn, 2 white
Copper (0.1 mg/ml)	3 grn, 1 dk grn	3 lt brn, 1 grn	4 white
Aliette (0.12 mg/ml)	3 lt grn, 2 grn	1 brn, 4 lt brn	5 white
Aliette (0.24 mg/ml)	2 dead, 3 lt grn	4 lt brn	1 white, 2 brn,1 dk brn
Aliette + Cu (0.12 mg + 0.1 mg)	3 lt grn, 2 grn	3 brn, 2 lt brn	5 white
Aliette + Cu (0.24 mg + 0.1 mg)	4 dead = dk brn	4 dk brn	4 dk brn
Morestan dusted light[x]	1 grn, 2 dk grn	3 lt brn	3 white
Morestan dusted heavy	1 brn, 2 lt grn, 2 grn	2 brn, 2 lt brn	3 white, 1 brn

[z]Grn = green, brn = brown, lt = light, dk = dark.
[y]Colors listed from healthiest to weakest disks.
[x]Morestan (tech. grade) dusted on bottom of disks before placing on agar.

of technical material solubilized was not known. In order to routinely test new compounds, some methodology needs to be developed to sterilize and aseptically measure out quantities of these non-water soluble compounds. The emulsions formulated for spray mixes break down when passed through a micron filter leaving the active ingredient on the filter.

Droplet applications to on-tree-fruit: The first test of this droplet method (May, 1993 postbloom) resulted in light yellowing from Aliette plus Cu without buffer and no puntures. Punctures alone left injury spots 1 mm in diameter. When the Aliette + Cu combination was applied to the punctures, the spots were 4 mm in diameter on grapefruit and 2 mm on Valencia oranges. The line cut and application procedure was not suitable because of variability in the extent of wounding injury. The infusion technique resulted in a raised lesion with extensive cell division in the flavedo in young fruit when these chemicals were included. This effect did not occur later when the fruit was more mature, perhaps because cell division activity is only in the epidermis in mature citrus peel. On young fruit, this infusion technique may be a good test of phytotoxicity that should be explored with different concentrations of a phytotoxic chemical.

The first five tests were done with and without Cu but without buffer in order to increase the probability of getting a phytotoxic reaction. The next tests were done with and without buffer and no Cu. No difference was seen in the diameter of the injuries caused by Aliette alone or with buffer when the peel surface was punctured (1-2 mm diameter brown with yellow halo). The fruit did not appear as susceptible as it had been in earlier tests. No injury was seen when the material was deposited as a droplet on the surface without a puncture hole. Aliette was phytotoxic at the cellular level in tissue culture, so when applied to open wounds, injury was expected.

Morestan, in similar tests at the early stage of fruit development, did not result in enlargement of puncture injury areas when applied with or without Cu. During 2 pairs of morning vs afternoon tests, it was observed that early morning treatments resulted in severe injury to the peel from any injury (puncture or cut) whether chemical was applied or not. It was concluded that the moisture on the fruit surface and cooler temperatures in the morning decreased vaporization of some fractions of toxic peel oils released by the wounding which is similar to oleocellosis development during citrus fruit harvest.

Acid tests: The next series of droplet tests examined the effect of acids themselves in causing injuries. Attempts to surface sterilize fruit with 1% HCl resulted in rapid fruit burn. Citric acid at 4% and 0.4% caused burns when deposited as droplets even without a puncture. Injury diameters increased from 1 or 2 mm to more than 3 mm with a puncture. The 0.04% rate slightly increased the injury area diameter compared to punctures alone. Buffering only reduced the injury diameter to half of the non-buffered for the 0.4% rate indicating that citric acid itself may be slightly phytotoxic at high concentrations, or it may have been a salt burn (Maas, 1993) since the acid (4,000 ppm) plus buffer salts equalled 7 to 8,000 ppm. In a second test when no punctures were made, burn only occurred at the 4% rate. The 4% treatment with buffer did not develop a burn, but without buffer, this concentration resulted in 1 mm spots. With addition of Herbex or Induce to buffered 4% citric acid, the spots were 2 and 3 mm in diameter, respectively. These results suggest that acidity may play a direct role in citrus peel burns from chemicals rather than just affecting chemical absorption.

Table 3. Spray burn injury ratings on Ruby Red grapefruit treated with various mixes that included Aliette. Averages of six to nine fruit on three trees sprayed 9 Sept 1993 and evaluated 6 Jan 1994.

Main treatment = Additives	Control	Aliette 1×		Aliette 2×	
		DI H_2O	Salt H_2O	DI H_2O	Salt H_2O
	Rating	Rating	Rating	Rating	Rating
No adjuvants	0.1	1.3	2.3	2.3	3.0
Copper		3.3	2.1	1.9	2.9
Induce		2.1	2.3	2.7	1.9
Induce + buffer		ND	ND	2.2	1.3
Herbex		3.1	0.9	4.2	3.6
Herbex + buffer		ND	ND	2.8	2.3

Spray concentration relative to 125 gal/acre. ND = no data. 0-5 rating, 0 = none, 1 = light green as in light greasy spot, 3 = 25 to 50% surface burn, 5 = 100% surface burn. Salt concentration was 2700 ppm total dissolved salts.

In late summer when the fruit cuticle was more developed, droplet deposits of Aliette or Morestan did not cause as much damage as earlier. All puncture + chemical injury areas were 1 mm or less in diameter.

Whole grapefruit dips of GA3 + 2,4-D with Herbex showed bottom ringing burn and abscission when the concentration was increased to 8 times the recommended concentration of 20 ppm (8×), but the fruit were completely wetted, a considerably over-sprayed condition. With Induce added, open, circular burns occurred at 2× and abscission by 4× with burns occurring on the exposed side of the fruit at 4× and 8× concentrations.

On-tree spray tests. Aliette caused considerable burn to sun exposed grapefruit when applied in September, 1993 at a standard rate of 4 to 5 mg/ml (Table 3). Without adjuvants, the rating on a 1 to 5 scale increased one unit for salty water and one unit with doubling of the concentration. Cu increased the burn injury grade two units with Aliette in deionized water, but had no effect in salty spray water (2700 ppm total dissolved salts) or if the Aliette concentration was doubled. Salts apparently interfered with copper absorption or activity. The penetrant Induce increased the injury rating about 0.5 units in deionized water, but the salt water stopped the surfactant action even though slightly higher concentrations of surfactant were used. Buffering reduced the injury rating another 0.5 units. Herbex increased the injury from Aliette. The injury level was as high as for Aliette (1Y) with Cu. This surfactant became ineffective in salty water, but for Aliette at 2×, even the injury with salty water was higher than any other combination tested except for the 2× Aliette with Herbex in deionized water. Some fruit in this last treatment were completely burned and turned dark brown on the exposed surface. Buffering the 2× rate of Aliette while using Herbex reduced the injury level to that of the non-adjuvant, non-buffered Aliette.

Morestan resulted in similar rating levels to the Aliette tests for the non-adjuvant controls (Table 4), but the injury rating of the non-sprayed controls was 0.3 units higher on the trees used for these tests. Salty water reduced the injury rating at the 2× concentration by 0.7 units. Cu did not increase injury at the 2× concentration of Morestan, but it did not for Aliette either. The 1× Morestan + Cu combination was not tested. Neither Induce or Herbex alone increased the injury rating for Morestan, but Induce + Cu did increase injury at the 2× Morestan concentration by 0.7+ units. No combinations of Morestan and adjuvants exceeded an injury level of 3.1. Aliette injuries were often more severe. High salt spray water and adjuvants appeared to affect Aliette absorption and activity more than Morestan. This may be because Aliette is much more soluble in water and could respond more to changes in solution surface tension and other factors affecting penetration.

A summary of a combination of tank mix additives with or without Aliette or Morestan is presented in Table 5. The burn rating for Aliette with salty water and Diamond R Citrus Nutritional was 0.7 units higher than Aliette alone, but lime sulfur reduced the injury, presumably by raising the solution pH although the pH was not measured. All of the mixes gave a low grade injury rating that superficially looked very much like greasy spot. The Morestan was again not affected much by what additives were added. Induce with lime sulfur resulted in a noticeable injury that was again like greasy spot. Although the ratings are subjective, replicating the sprayed limb units and getting multiple ratings from several individuals would allow statistical handling of this test method.

GA_3 is another suitable test compound based on occasional burns under grove spray conditions. Limb sprays of GA_3 + 2,4-D alone or with adjuvants resulted in some injury with injury ratings of 0.2, 1.1, 1.8, 1.3, and 1.3 for Controls, Growth Regulators (GRs) alone, GRs + Herbex, GRs + Induce and GRs + Induce + Nutritional N, respectively. Again, as with Aliette, Herbex apparently was more effective in creating burns, probably by increasing absorption, while Induce appeared to be slightly more effective than Herbex when used with Morestan.

In these tests, spray mixes that caused burns in commercial groves also caused burn on some but not all fruit in both the spot

Table 4. Spray burn injury ratings on Ruby Red grapefruit treated with various mixes that included Morestan. Averages of six to nine fruit on three trees sprayed 9 Sept, 1993 and evaluated 6 Jan, 1994.

Main treatment = Additives	Control	Morestan 1×		Morestan 2×	
		DI H_2O	Salt H_2O	DI H_2O	Salt H_2O
	Rating	Rating	Rating	Rating	Rating

Spray concentration relative to 125 gal/acre. ND = no data. 0-5 rating, 0 = none, 1 = light green as in light greasy spot, 3 = 25 to 50% surface burn, 5 = 100% surface burn.

Table 4. Spray burn injury ratings on Ruby Red grapefruit treated with various mixes that included Morestan. Averages of six to nine fruit on three trees sprayed 9 Sept, 1993 and evaluated 6 Jan, 1994.

Main treatment =		Morestan 1×		Morestan 2×	
Additives	Control	DI H_2O	Salt H_2O	DI H_2O	Salt H_2O
No adjuvants	0.4	1.6	1.7	2.5	1.8
Copper		ND	ND	2.2	1.9
Induce		2.0	2.0	1.9	1.5
Induce + Cu		ND	ND	3.1	2.6
Herbex		1.3	1.9	1.8	0.8

Spray concentration relative to 125 gal/acre. ND = no data. 0-5 rating, 0 = none, 1 = light green as in light greasy spot, 3 = 25 to 50% surface burn, 5 = 100% surface burn.

Table 5. Tank mix component effects on spray burn to Ruby Red grapefruit. Treated October 1993 in Vero Beach and rated in January 1994.

Treatments/Chemicals added				
Aliette	Salt	Nutri.-N	Lime sulfur	Rating
-	-	-	-	0.1
-	+	+	-	0.5
-	+	+	+	0.6
1×	-	-	-	1.3
1×	+	+	-	2.0
1×	+	+	+	0.8
Morestan	Induce	Herbex	Lime sulfur	Rating
-	-	-	-	0.4
-	+	-	+	0.9
1×	-	-	-	1.3
1×	+	-	+	1.9
1×	-	+	+	1.8

Spray concentration relative to 125 gal/acre. ND = no data. 0-5 rating, 0 = none, 1 = light green as in light greasy spot, 3 = 25 to 50% surface burn, 5 = 100% surface burn.

and on-tree spray tests. All the primary compounds tested produced at least some burn when tested alone or at the higher concentration of 2× and when combined with one or both surfactants on grapefruit in an Indian River Grove. Concentration, pH, surfactant, and other tank mix compounds affected the level of spray burn.

The combination of methods appeared to be effective in characterizing the phytotoxicity of a potential spray component for citrus. The on-tree spray test may need some adjustment for doing tests that come closer to representing actual concentrations of 125 gal/acre since we sprayed to nearly runoff. Shorter dwell times over the surface and smaller droplet spray would simulate lighter coverage that occurs with commercial speed sprayer applications of 125 gal/acre. These tests which were sprayed to runoff effectively established phytotoxicity potential. We also noted that one sprayer had a 3 mm wide spray band. When held 0.45 m (1.5 ft) from the fruit, line burns developed indicating forced penetration either by injury or stomatal penetration. This phenomenon should be examined with dyes, Scanning Electron Microscopy and x-ray with heavy metals. These tests might be important to evaluate whether air-blast sprayers can drive spray solutions into the stomatal chamber of fruit nearest to the spray nozzles.

We did not test many possible combinations that are suspected to cause spray burns. Our main emphasis was to prove that these

Table 6. Spray burn intensities on oranges or grapefruit sprayed with urea products and mixes containing urea. All sprays mixed at rate of 125 gal/acre except for undiluted urea products as noted.

Cultivar/timing	Product, lb/acre	Additions/acre	Leaf burn	Fruit burn
Oranges/spring	Unocal, 5-10	—	None	—
	Unocal, 10-15	oil, 0.5%	None	—
	Unocal, 15	oil, 1%	Slight	—
	Unocal, undiluted	—	Severe	—
	N-SURE, 5-15	oil, 1%	None	—
	N-SURE, 10-15	oil, 1% + Agrimek 8 oz	Moderate	—
	N-SURE, 5-10	K_3PO_4, 5-10	Moderate-severe	—
	N-SURE, undiluted	—	Slight	—
Grapefruit/early summer	Unocal, 10-20	Aliette, 5	None	None
	Unocal, 10-20	Zn + Mn	None	Slight
	Unocal, 10-20	Zn + Kocide	None	Slight
	Unocal, 30	—	None	Slight
	N-SURE, 10-20	—	None	None
	N-SURE, 30	—	None	Slight
	N-SURE, 10	Aliette, 5	None	None

Table 6. Spray burn intensities on oranges or grapefruit sprayed with urea products and mixes containing urea. All sprays mixed at rate of 125 gal/acre except for undiluted urea products as noted.

Cultivar/timing	Product, lb/acre	Additions/acre	Leaf burn	Fruit burn
	N-SURE, 20-30	Aliette, 5	Slight	None
	Spray grade urea, 10-30	Aliette, 5	None	None
Grapefruit/fall	Unocal, 10-30	—	None	None
	Unocal, 10	Aliette, 5 + buffer	None	None
	Unocal, 20-30	Aliette, 5 + buffer	None	Slight
	N-SURE, 10-30	—	None	None
	N-SURE, 10-30	Aliette, 5 + buffer	None	None
	Trisert KS, 10-30	—	None	None
	Trisert KS, 10-20	Aliette, 5 + buffer	None	None
	Trisert KS, 30	Aliette, 5 + buffer	None	Moderate
	Spray grade urea, 10-30	—	None	None
	Spray grade urea, 10-30	Aliette, 5 + buffer	None	None
	—	Comite, 2.7	None	Slight
	All products, 20	Comite, 2.7	None	Moderate-Severe

methods would indicate phytotoxicity potential. We did not try to prevent burn. New emphasis should be on safe mix formulation. The possible need for dilute spraying with the more phytotoxic chemicals, pH adjustment and combinations that reduce burn potential should be examined more critically. Unfortunately from a spray burn standpoint, there is increased interest in the addition ofurea as a foliar nutritional. This material enhances absorption (Yamada et al., 1965). It can be phytotoxic on its own or if combined with other nutritionals or citrus leafminer spray materials such as oil and Agrimek (Table 6). Leaf burn was more likely to occur on spring, unhardened leaves. In the fall, Trisert KS at 30 lbs N/ac with Aliette caused a moderate fruit burn, and urea products aggravated the tendency of Comite to burn fruit.

Adjuvants of the penetrant grade, intended for enhancing the absorption of herbicides, will increase the likelihood of spray burn if the other spray ingredients can be phytotoxic with sufficient absorption. A given adjuvant may be more or less harmful in the spray mix depending on the specific chemical being absorbed and how it interacts with the surfactant. The real need for a surfactant and determining safe surfactants for standard tank mixes should be evaluated carefully by the grower. Any questionable mixture can be examined rather easily by the limb spray method. The peel disk method is very subjective and requires the most exact tissue culture skills. Suspension culture test is the most precise for evaluating phytotoxicity of a given chemical at the cellular level but required technical equipment and personnel. The techniques using peel infusion or droplet deposit over small punctures on young fruit may be satisfactory alternatives that are fast and easy for anyone to use.

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INSECT-PLANT PATHOGEN INTERACTIONS: PRELIMINARY STUDIES OF *DIAPREPES* ROOT WEEVIL INJURIES AND *PHYTOPHTHORA* INFECTIONS

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Abstract. **It has been speculated that larval injuries by *Diaprepes abbreviatus* L. serve as preferred infection courts for root rot diseases caused by soil pathogens such as *Phytophthora* spp. A completely randomized block experiment was performed in the greenhouse where roots of young Cleopatra mandarin (*C. reticulata* Blanco) and trifoliate orange (*Poncirus trifoliata* L.) were first exposed to *D. abbreviatus* larvae of known density and then later inoculated with *Phytophthora nicotianae* Breda de Haan. Results suggest that the incidence and severity of root rot disease on *Phytophthora*-susceptible seedlings generally increased in relation to the amount of root damage caused by *D. abbreviatus* larvae. *Phytophthora*-tolerant seedlings, however, showed little or no increase in disease severity with increasing insect injury. Infection of root tips dis-**

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