METHODS FOR CONTROLLING MATURITY (ACIDITY) OF CITRUS

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INTRODUCTION

Lead arsenate (LA) has been the only plant growth regulator (PGR) chemical legally available for increasing Ratio of citrus fruits (red and white grapefruit only). Its history and use are summarized in the attached publication by Wilson (3). LA was a "grandfather clause" chemical which was the property of no particular commercial company. In addition, no toxicology data is available for LA. Therefore, the Federal Environmental Protection Agency (EPA) did not renew registration of LA. The cancellation does not affect stocks of the PGR manufactured before the cancellation date, hence, it is legal for growers to use up their existing stocks . For a number of years, the Florida Department of Citrus (FDOC) has had a research project aimed at replacing LA.

Recently, a new natural product sold as Citrus Ten^{tm} (or Brix Plus^{tm}) (C-10) has been available to Florida citrus growers to increase Ratio of most oranges and specialty fruits.

Arsanilic Acid (AA) as a Replacement for LA for Grapefruit

The attached paper by Wilson (3) summarizes research studies with AA. It is an effective LA substitute for grapefruit acidity reduction. Application rates and timing are very similar to LA. Additional (unpublished) data for the 1986-87 season indicate that AA is not as easily washed off by rains immediately following spraying as originally believed. Also, Red grapefruit respond to increased concentrations similarly to that observed for White

grapefruit. The FDOC is cooperating with the manufacturer trying to obtain EPA clearance for use on Florida grapefruit.

As previously mentioned, the remaining stocks of LA may be used up. Recommendations for use are printed on the label and are listed in the Florida Citrus Spray Guide (1).

Other Citrus Acidity Adjustment Chemicals

C-10

In the spring of 1987, the FDOC tested a natural product for Bio-Organics, Inc. of New York. This natural plant extract, when applied 3 times, significantly reduced % acid, therefore, increasing Ratio and, to some extent, raised the ^{o}Brix of Valencia oranges (Table 1). The material later received a Florida registration (274-0670) and is marketed under the trade name Citrus Ten (C-10).

Triacontanol

The FDOC is currently conducting experiments with TRI and it is hoped it may become an additional product for use by the Florida Citrus Industry. This natural product is active at extremely low levels (parts per billion), but has a history of being inconsistent in activity (see attached paper (2) by Ries, et al., 1982). However, it, as well as C-10, are completely safe to use. TRI is patented for plant growth regulator use by Michigan State University and worldwide sales are licensed to the Teijin Limited of Japan.

Observations and Use

Since these original tests with C-10, additional experiments were conducted during the fall of 1987. These are summarized in Table 2. In the first series of tests conducted at the Shinn Grove, north of Lake Alfred, the C-10 results produced only a 0.5 point increase in Ratio when Hamlin oranges were sprayed 4 times with a FMC Speed Sprayer. However, a hand spray (dilute application) produced almost a full point Ratio increase. Single triacontanol (TRI) sprays also produced Ratio increases. TRI was furnished by Michigan State University.

Results of experiments conducted at LaBelle showed that 4 applications of C-10 applied by fixed-wing aircraft or handspray or both produced Ratio increases of more than 3 points. The single sprays of TRI also substantially increased Ratio, particularly the higher level (1.33 ppb) which increased Ratio by 4.56 points.

C-10 applied to 'Marsh' grapefruit produced only a slight (if any) increase in Ratio. In its present form, C-10 does not appear to be effective for use on grapefruit. TRI has not been tested on grapefruit at this time.

Although the actual mechanism of action of these chemicals is unknown, C-10 reduced % acid significantly (Tables 1,3) and can significantly increase Brix (Table 3), but did not do so in all tests (Table 1). TRI appears to affect these properties in a similar manner (Table 3), but experiments with it have, so far, been limited. Most of the effect of increasing Ratio by both chemicals is, however, their ability to reduce fruit acidity.

Except for grapefruit, the use of Citrus Ten on most orange and tangelos or tangerine hybrids will probably result in a Ratio increase of 1 to 2 points. (Although the FDOC has not tested C-10 on this latter group of cultivars, a number of growers have reported excellent results from its use.) However, C-10

is not an inexpensive chemical to use, particularly as it requires 4 applications. A copy of "General Instructions" prepared by Bio-Organics, Inc. for use of Citrus Ten - Brix Plus is attached (Table 4). In addition, the company now recommends that spray tank pH be adjusted to between 6 and 7 for maximum chemical effectiveness. Our own experience measuring spray water pH has shown most to be from pH 8-10, although this may vary greatly with location. Aircraft application is as effective as a hand spray.

References

1. Knapp, J. L., D. P. H. Tucker, J. W. Noling, and V. V. Vandriver, Jr. 1987. Florida Citrus Spray Guide. Florida Cooperative Extension Service (Revised Annually).
2. Ries, S., V. Wert and J. Biernbaum. 1982. Factors altering the efficacy of triacontanol applications to plants. Proceedings of the Plant Growth Regulator Society of America 9: 80.
3. Wilson, W. C. 1987. Results of experiments using arsanilic acid to reduce acidity of grapefruit in Florida. Proceedings of the Plant Growth Regulator Society of America 14: 490-502.

TABLE 1. SUMMARY OF BIO-AGRO RESULTS: VALENCIA ORANGES
Fruit tested 4/23/87

Control	Med. (10 ml/100 gal)	High (20 ml/100 gal)	Very High (40 ml/100 gal)
		Ratio	
12.98	16.58	16.59	15.72
13.03	14.78	13.81	13.78
12.39	14.31	13.13	14.32
13.18	14.61	13.74	16.45
14.56	14.22	15.02	14.09
13.79	14.85	14.99	14.26
13.32 ± 0.75	14.89 ± 0.86	14.55 ± 1.25	14.77 ± 1.06
		°Brix	
13.37	14.26	14.10	14.15
13.03	14.34	13.67	13.64
12.76	13.00	13.65	13.09
13.44	13.59	13.33	13.49
14.20	13.61	13.67	13.67
13.83	14.11	14.09	13.97
13.44 ± 0.52	13.80 ± 0.52	13.75 ± 0.30	13.67 ± 0.37
		Acid %	
1.03	0.83	0.85	0.90
1.00	0.97	0.99	0.99
1.03	0.97	1.04	0.97
1.02	0.93	0.97	0.82
1.03	0.95	0.91	0.97
0.95	0.95	0.94	0.98
1.01 ± 0.03	0.93 ± 0.05	0.95 ± 0.07	0.94 ± 0.07

Three sprays applied, Orange-Co, Ft. Pierce (Block B-2)
April 6, 1987 (10 - 12 a.m.)
April 8, 1987 (10 - 12 a.m.)
April 9, 1987 (10 - 12 a.m.)
Harvest - April 20, 1987
Fruit held at 40°F until run on April 23.

Table 2. - Results of Field Tests with Citrus Ten and Triacontanol on 'Hamlin' orange (HA) and Citrus Ten applied to 'Marsh' grapefruit (GPFT)[z]

Treatment and Cultivar	Spray Date (1987)	Location	Application Method	Ratio & SD
C-10 (HA)	Sept. 23, 25, 29, Oct. 12	LA	Speed Sprayer (100 gal/acre)	8.72 ± 0.61
Control (HA)	-	LA	-	8.22 ± 0.90
C-10 (HA)	Sept. 29, Oct. 2, 5, 8	LA	Handspray (dilute)	8.46 ± 0.71
Control (HA)	-	LA	-	7.53 ± 0.46
Triacontanol (0.67 ppb)	Oct. 9	LA	Handspray (dilute)	8.19 ± 0.52
Triacontanol (1.33 ppb)	Oct. 9	LA	Handspray (dilute)	9.81 ± 0.39
C-10 (HA)	Oct. 2, 5, 14, 19	LB	Fixed-wing Air	12.73 ± 0.85
C-10 (HA)	Oct. 1, 5, 13, 16	LB	Handspray (dilute)	12.62 ± 0.59
Control (HA)	-	LB	-	9.30 ± 0.25
Triacontanol (HA) (0.67 ppb)	Oct. 9	LB	Handspray (dilute)	12.35 ± 0.51
Triacontanol (HA) (1.33 ppb)	Oct. 9	LB	Handspray (dilute)	13.86 ± 0.43
C-10 (GPFT)	Sept. 15, 17, 22, 25	FP	Handspray (dilute)	6.64 ± 0.22
Control (GPFT)	-	FP	Handspray (dilute)	6.45 ± 0.25

[z] LA - Shinn Grove, n. of Lake Alfred; LB - A. Duda & Sons Grove, s. of LaBelle; FP - Orange Co., Inc. Grove w. of Ft. Pierce; Citrus Ten was applied at 10 ml/100 gal of water. Ortho X-77 Surfactant (0.1%) was added to all sprays and pH was adjusted to between 6 and 7; SD - Standard Deviation. Fruit from the Shinn Grove was harvested 10-29; Duda Grove 11-5; the grapefruit were harvested 10-27. Speed Sprayer Application was 100 gal/acre containing 20 ml of C-10; Fixed-wing air application was 20 ml of C-10/acre; Hand spray applications were 10 ml/100 gal of C-10 sprayed to tree run-off. TRI was furnished by Dr. Stanley Ries, Dept. of Horticulture, Michigan State University, E. Lansing, MI.

Table 3. Effect of Sprays Containing Citrus Ten (C-10) and Tricontanol (TRI) on °Brix, % Acid, and Ratio of 'Hamlin' Oranges at LaBelle, FL[z]

Treatment	Application Method	°Brix + SD	% Acid + SD	Ratio + SD
C-10	Fixed-wing Aircraft	10.08 ± 0.28	0.79 ± 0.04	12.73 ± 0.85
C-10	Hand Spray	9.51 ± 0.20	0.75 ± 0.03	12.62 ± 0.59
Control	-	8.97 ± 0.26	0.97 ± 0.03	9.30 ± 0.25
TRI (0.67 ppb)	Hand Spray	10.48 ± 0.21	0.85 ± 0.02	12.35 ± 0.51
TRI (1.33 ppb)	Hand Spray	10.39 ± 0.08	0.75 ± 0.02	13.86 ± 0.43

[z] Additional information concerning concentration, spray dates, etc. are shown in Table 2 footnote.

Table 4. Manufacturers Instructions for the Use of C-10

CITRUS TEN - BRIX PLUS

General Instructions

Storage:	A.	Citrus Ten is very sensitive to extreme temperatures, store between 45 degrees F and 85 degrees F.
	B.	Do not store in direct sunlight.
	C.	Do not leave in a vehicle without proper cooling.
Timing:	A.	Start spraying 6 weeks prior to normal harvest
	B.	Spray every 3 to 4 days for 4 applications.
Mixing:	A.	Shake packet well before opening.
	B.	Mix 20 ml with 100 gallons of water per acre. (One packet per 500 gallons).
	C.	Use 1/2 to 1 Pt. of a Non-Ionic Surfactant per 100 gallons of spray mix.
	D.	Injection by irrigation (micro-jets or drip) -- mix one packet per 2 gallons of water.
Application:	A.	Spray between 6:00 AM and 11:00 AM.
	B.	Injection through irrigation between 6:00 AM and 11:00 AM. (Inject during last of irrigation cycle leaving 1/2 hour for flushing).
	C.	Material should be used within 3 hours of mixing.
Harvesting:	A.	Do not harvest earlier than 10 days after last application for maximum benefit.