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Wilthin Effective in Thinning Mississippi Apples

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Abstract

'Royal Gala', 'Ultra Gold', and 'Blushing Golden' on M7A were treated two years with Wilthin (monocarbamide dihydrogensulfate) at 0 $ml \cdot l^{-1}$, 5 $ml \cdot l^{-1}$, 10 $ml \cdot l^{-1}$,and 15 $ml \cdot l^{-1}$ when trees were at 70 to 80 percent bloom. Wilthin at 5 $ml \cdot l^{-1}$ and 15 $ml \cdot l^{-1}$ resulted in satisfactory thinning of all cultivars. Yield was not affected as a result of thinning with Wilthin. Fruit weight and size were increased, firmness and individual sugars were increased, acidity was reduced, and juice pH was increased as a result of thinning with Wilthin.

Introduction

Wilthin has been shown to be an effective apple blossom thinner in Washington, U.S.A. and Australia (14). In Idaho, Wilthin at 3.75 $ml \cdot l^{-1}$ thinned and increased fruit size, but there were unacceptable fruit markings in one of four years. However, Wilthin at 2.5 $ml \cdot l^{-1}$ plus Regulaid (surfactant) showed commercially acceptable thinning (7) and no adverse effects on fruit. Byers (3) reported that Wilthin inhibited fruit set of 'Campbell Redchief Delicious'/seedling apple trees. High rates caused more fruit thinning and russet was increased with the higher rates of Wilthin. No published results on the effect of Wilthin on apples has been reported in Mississippi or surrounding states. The objective of this study was to determine the effect of Wilthin on thinning, fruit size, yield and fruit quality indices of 'Royal Gala', 'Blushing Gold', and 'Ultra Gold' grown in Mississippi.

Materials and Methods

In 1997 and 1998, 'Royal Gala', 'Blushing Gold', and 'Ultra Gold Delicious' grafted on M7A rootstock were sprayed with Wilthin at 0 $ml \cdot l^{-1}$, 5 $ml \cdot l^{-1}$, 10 $ml \cdot l^{-1}$, and 15 ml•l-1 when trees were at 70 to 80 percent bloom (March 29, 1997, April 3, 1997 and April 5, 1997, respectively). In 1998, treatment dates for 'Royal Gala', 'Blushing Golden', and 'Ultra Gold' were April 8, April 13, and April 16, respectively. Tween 20 at 0.1 percent was used as a wetting agent and trees were sprayed to the point of drip with an 11.34 liter Hudson backpack hand spayer. Trees were six years old and received 3.78 liters of spray solution of a given concentration.

Experiments were conducted at the Pontotoc Ridge-Flatwoods Research and Extension Center located seven miles south of Pontotoc, MS. Trees were planted in 1991 at a spacing of 6.1m x 4.3m and trained to a modified central-leader system.

Standard cultural practices and pest management as recommended by the MS Cooperative Extension Service were used. The experimental design was a completely randomized design with four treatments and three single tree replications per treatment. Data was analyzed in a 4 x 3, factorial arrangement with repeated measurements. The factors were four chemical thinner concentrations and three apple cultivars. Measurements taken in 1997 were repeated in 1998. Data were analyzed with SAS (SAS Institute, Cary, NC) using Proc ANOVA and subjected to regression analysis to evaluate possible linear and quadratic effects of Wilthin concentration. Due to various interactions, data was analyzed by cultivar and by year.

Before application of Wilthin, four randomly selected limbs from each of three trees receiving a given dosage (12 limbs per treatment) were tagged on each tree and the total numbers of flowers per limb counted. The number of flowers per limb ranged from 35-75. Limb diameter ranged from 2 cm to 3 cm. Fruit were counted 45 days after treatment application. Fruit set

was expressed as the number of fruit per limb 45 days after treatment, divided by the initial flower count per limb multiplied by 100. Yield per tree was expressed as fruit weight per tree (kg) divided by the trunk cross-sectional area (TCSA). Fruit weight was determined by dividing the weight of 20 randomly selected fruit per tree at harvest time by 20.

To determine fruit length and diameter, 10 randomly selected fruit per tree at harvest were measured using a metric caliper. An Instron Universal Testing Machine, Model 1011 (Canton, Mass) was used to measure fruit firmness from fifteen randomly selected fruit from each replication. Fruit was placed on a flat steel washer in the center of the load cell and punctured with a 24 mm diameter cylindrical probe at a cross-head with chart speed of 50 mm/min and a load range of 20 Newton.

For quality analysis, ten randomly selected fruit per tree at harvest time were homogenized in a Mullinex juice extractor. Juice pH was measured using an Accumet pH meter model 925 (Fisher Scientific). Juice titratiable acidity was determined using 5 ml of juice in 50 ml distilled water by titrating in 0.1 N NaOH to the end point of 8 pH. Juice soluble solids concentration (SSC) was measured using a Bausch & Lomb Abbe 3L refractometer. Juice fructose, glucose, and sucrose, were measured using HPLC analysis as follows; extracted juice was filtered through a 0.45 micron filter (Micron Separations Inc.). A 5 micro liter sample was injected into the HPLC system in which double distilled water was used as the solvent. Standard samples of fructose, glucose, and sucrose were made and injected into the system for the development of standard curves for each sugar. The liquid chromatography system was equipped with a Model 110 pump (Beckman, Fullerton, California), a Rheodyne injector fitted to a 10 micro liter sample loop, and Varian RI - 4 refractive index detector (Varian Instrument Group, Walnut Creek, California). The detector signal was recorded using an Ominiscribe recorder (Houston Instrument model D5137-5, Austin, TX.). Sugars were separated at 85C with a 100 x 7.8 mm, Bio-sil, Biorad fast carbohydrate column (Bio-Rad, Richmond, California).

Results and Discussion

Wilthin reduced fruit set of all three cultivars both years. There was a concentration x cultivar interaction. The reduction in percentage fruit set for 'Royal Gala' and 'Blushing Golden' was linear both years. However, the guadratic response of 'Ultra Gold' both years suggest that fruit set reduction was maximized between 10 $ml \cdot l^{-1}$ and 15 $ml \cdot l^{-1}$. The thinning effect of Wilthin is in agreement with previous studies on apple (1,15,16). In this study, thinning did not influence yield per tree which ranged from .06 kg/cm^2 TCSA to .27 kg/cm^2 TCSA. Fruit weight was increased in all cultivars as a result of thinning. The quadratic increase in fruit weight of 'Royal Gala' in 1998 suggests that maximum fruit weight occurred between 5 $ml \cdot l^{-1}$ and 10 $ml \cdot l^{-1}$ Wilthin. For 'Blushing Gold', the same year, fruit weight was maximized at 10 $ml \cdot l^{-1}$ Wilthin. Increase in apple fruit weight as a result of thinning has been reported by others (10,11). Greater Fruit weight and size has been shown to be due to increases in cell division and cell enlargement (8).

With respect to fruit length and diameter, there was a cultivar response, and a year x concentration interaction. 'Royal Gala' fruit length and diameter increased linearly both years. The quadratic response in diameter of 'Ultra Gold' both years shows that diameter was maximized between 5 $ml \cdot l^{-1}$ and 10 $ml \cdot l^{-1}$. These data are not presented, since increases in fruit length and diameter are functions of increased fruit size. Increase in fruit length and diameter with thinners has been reported (9, 10, 13, 14, 17). Such increase has been attributed to the direct influence of benzladenine (BA) on cell division and cell size. In 'Gala' reduction in fruit set by carbaryl (1-maphthyl N-Carbanate) was consistently followed by an increase in fruit size and return bloom and NAA (naphthalene actic acid) was not consistent in causing fruit size increase(6).

Table 1. Effect of Wilthin on fruit set, weight, and firmness of three apple cultivars in 1997 and 1998.

Year	Wilthin (ml·l^{-1})	Fruit Set (%)	Weight (g)	Firmness (N)
		'Royal Gala'		
97	0	12.0	149.2	63.3
	5	6.0	150.3	70.3
	10	4.0	153.0	79.2
	15	3.0	159.0	84.4
	Significance[Y]	L*	L**	L*
98	0	12.0	144.4	60.6
	5	7.0	170.7	85.0
	10	4.0	169.8	87.4
	15	3.0	164.7	85.8
	Significance	L*	L*Q*	L*Q*
		'Ultra Gold'		
97	0	9.0	147.6	71.2
	5	5.0	218.3	80.4
	10	2.4	227.3	87.7
	15	2.0	228.6	88.0
	Significance	L*Q*	L**Q**	L*
98	0	10.0	147.3	69.4
	5	7.0	203.0	83.0
	10	3.0	227.0	85.0
	15	3.0	216.0	8
	Significance	L*Q*	L*	L**
		'Blushing Golden'		
97	0	10.0	136.5	76.6
	5	8.0	156.0	82.2
	10	4.0	167.6	83.7
	15	3.0	171.3	86.0
	Significance	L*	L**	L**
98	0	12.0	156.0	76.8
	5	6.0	157.0	80.0
	10	4.0	171.0	86.8
	15	3.0	163.0	91.0
	Significance	L*Q*	L**Q**	L**

[Y]significant linear (L) or quadratic (Q) response at P=0.05 (*) or 0.01 (**); NS=not significant.

Fruit firmness of all cultivars was increased linearly with increasing concentrations of Wilthin both years, except in 1998 when maximum fruit firmness of 'Royal Gala' occurred at 10 ml•l^{-1} Wilthin. A review on factors affecting apple fruit firmness was recently published by DeEll et al. (4). Crop density appears to be a factor in the case of fruit thinning. The example presented was the increase of fruit firmness of 'Gala' from trees with a small crop load. Elfving and Cline (5) showed that fruit thinning with BA increased flesh firmness of 'Empire' and the response was concentration dependent. Greene and Autio (6) reported that BA and Daminozide increased fruit flesh firmness of several apple cultivars. In such cases, the chemicals had a direct effect on fruit firmness. It is not likely that Wilthin would have a direct effect on the fruit firmness since it's mode of action is to kill blossoms. Increase firmness might be more related to crop load as previously suggested (4).

Soluble solids concentration increased quadratically for all cultivar except 'Royal Gala' in 1998. Maximum SSC occurred at 5 ml•l^{-1} Wilthin in both years and for all cultivars

Sucrose concentration was increased by Wilthin. There was a year x cultivar x concentration interaction. In 'Blushing Golden', the quadratic response shows that sucrose was maximized at 5 ml•l^{-1} Wilthin both years. In 'Royal Gala' and 'Ultra Gold' sucrose increased linearly with concentration, except in 1997 when sucrose in 'Royal Gala' was reduced at 5 ml•l^{-1} Wilthin and increased by higher concentrations.

Glucose concentration of 'Royal Gala' was increased quadratically both years. In 'Ultra Gold' glucose increased linearly with increasing Wilthin concentrations. Wilthin did not effect glucose concentration in 'Blushing Golden'. Fructose was increased linearly and quadratically for all cultivars depending on the year. The quadratic response of 'Royal Gala' in 1998 shows that fructose was minimum at 5 ml•l^{-1} and increased with the higher concentrations. However, fructose peaked at 5ml•l^{-1} in 'Ultra Gold' in 1998 and at 10ml•l^{-1} for 'Blushing Golden' the same year. Several researchers have reported an increase in SSC as a result of thinning (2,

Table 2. Effect of Wilthin on fruit juice SSC, sucrose, glucose, fructose, acidity, and pH of three apple cultivars in 1997 and 1998.

Year	Wilthin (%)	SSC (%)	Sucrose (%)	Glucose (%)	Fructose (%)	Acidity (%)	pH
				'Royal Gala'			
97	0	10.00	3.40	2.70	8.20	3.05	3.36
	5	12.00	2.60	3.00	8.30	2.94	3.84
	10	12.00	3.40	2.90	8.40	2.75	3.88
	15	12.00	4.00	3.70	9.10	2.89	3.92
	Significance[Y]	L*Q*	L*Q*	L*Q*	L*	L*Q*	L*
98	0	11.00	3.10	2.50	8.70	3.36	3.66
	5	12.00	3.40	2.40	8.30	2.88	3.81
	10	12.00	3.50	3.10	8.90	3.00	3.78
	15	12.00	3.80	3.20	9.60	3.03	3.37
	Significance	NS	L*	L*Q*	L*Q*	L*Q*	NS
				'Ultra Gold'			
97	0	12.20	2.64	2.97	8.19	3.32	3.38
	5	13.70	3.06	3.62	9.86	2.94	3.79
	10	12.90	3.34	3.79	10.12	2.88	3.89
	15	13.70	3.46	3.94	10.82	3.09	3.75
	Significance	L*Q*	L**	L*	L**	L*Q*	L*Q*
98	0	11.92	1.91	2.95	8.10	3.31	3.37
	5	13.00	3.17	3.84	10.20	3.07	3.79
	10	13.30	3.32	3.80	9.51	2.94	3.86
	15	13.00	4.10	4.38	9.96	2.89	3.87
	Significance	L*Q*	L**	L**	L*Q*	L*	L*Q*
				'Blushing Gold'			
97	0	11.88	1.23	3.84	9.79	3.43	3.26
	5	13.10	1.74	3.94	9.41	3.06	3.46
	10	12.45	1.54	4.23	9.54	3.03	3.60
	15	11.70	1.26	3.94	10.47	3.05	3.55
	Significance	L**Q**	L**Q**	NS	L**Q**	L*Q*	L*Q*
98	0	11.10	0.92	3.42	8.42	3.44	3.26
	5	13.20	1.41	3.18	9.92	3.01	3.59
	10	12.90	1.18	3.61	9.99	2.98	3.62
	15	12.5	1.21	3.80	9.62	2.97	3.84
	Significance	L*Q*	L*Q*	NS	L*Q*	L*Q*	L*

[Y]significant linear (L) or quadratic (Q) response at P=0.05 (*) or 0.01 (**). NS=not significant.

3, 9, 12, 13) and often times the response was cultivar dependent. In this experiment, there was an increase in individual sugars as a result of thinning with Wilthin. This increase in sugars is likely due to an increase in the leaf/fruit ratio.

Acidity was decreased in all cultivars both years and the reduction was concentration dependent. A decrease in acidity would be expected with an increase in sugars. Juice pH of all cultivars was increased linearly or quadratically, in both year, except in 'Royal Gala' in 1998 when juice pH was not influenced by Wilthin. In thinning experiments with Accel and Carbaryl, fruit juice pH was increased in 'Braeburn' and

'Jon-A-Red' (13). An increase in juice pH is consistent with a decrease in acidity as a result of thinning.

Conclusions

Wilthin at 5 $ml \cdot l^{-1}$ to 15 $ml \cdot l^{-1}$ resulted in satisfactory thinning of 'Royal Gala', 'Ultra Gold', and 'Blushing Golden'. According to regression analysis the amount of thinning was concentration dependent. Enhanced fruit quality as a result of thinning was evident by an increase in sugars, reduced acidity, and increased pH. In addition, yield was not affected indicating that the increase in fruit weight and size compensated for the reduction in fruit load by Wilthin.

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Temp Effects on Apple Fruit Growth

Fruit setting potential of 'Queen Cox' and 'Golden Delicious' was severely reduced at 20°C compared to 15°C. Fruit set was highest at ambient temp but fruit size was reduced. The largest fruit were obtained from 'Golden Delicious' trees initially growing at 20°C however fruit set was lowest on these trees. Despite higher temperatures producing larger fruit, measurements of cortical cell size showed that increasing the temp induced larger cells not more cells per apple. In summary temp increase to 20°C post antithesis had negative effects on number of fruit retained by the tree but positively stimulated fruit growth rate and fruit size. From Atkinson et al J. Hort. Sci. and Biotech 2001 76(6):721-731.