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Reduction in Russeting of 'Golden Delicious' Apples with Silicon Dioxide Formulations and Gibberellins A_{4+7} [1]

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Abstract: **A 2-spray treatment of Apasil, a formulation containing silicon dioxide, applied at petal fall and at petal fall + 7 to 10 days reduced russeting 20 to 30% in apple (*Malus domestica* Borkh.). The application of gibberellins 4+7 (GA_{4+7}) at 25 to 50 ppm also reduced russet in these trials. The application of GA_{4+7} at 25 ppm with silicon dioxide formulation improved control over that obtained with either material alone. The addition of chlorothaonil as a surfactant with the combination provided additional benefit.**

Russeting on the surface of apple fruits detracts from the appearance and economic value of the crop. 'Golden Delicious' is particularly susceptible to fruit russeting and in many fruit districts where it is grown this places it at an ecomonic disadvantage. Russet develops from the activity of the phellogen in the hyperdermis of the young fruit following injury and disruption of normal cells (2, 7). The injury can occur as the result of rapid growth of the young fruit during the post-bloom period of rapid cell division. Surface moisture and humidity are presumed to be one of the principal causal factors for the disruption of the cells in the hyperdermis (4, 9), and the subsequent phellogen development. Several other physical and physiological factors such as spray materials, water balance, and nutrition have been associated with russet formation (4).

It has been reported that the post-bloom application of Apasil, a commercial formualtion containing silicon dioxide, reduced russet development (3, 6). The deposit of silicon dioxide acting as a gel on the young fruit surface during this period was presumed to form a protective barrier to the external environment. Our trials with Apasil alone have given only partial or erratic control of russet on this cultivar (3).

Other possible practical solutions to the disorder have been explored. One such consideration would be to inhibit or delay the development of phellogen. Arzee et al. (1) reported a significant delay in development of phellogen with applications of gibberellic acid (GA_3). Subsequently Taylor (8) found that GA_{4+7} applied post-bloom on 'Golden Delicious' reduced russet. The best control resulted with the application at 200 ppm with some slight reduction at concentrations as low as 25 ppm. Unacceptable side effects of the high concentrations such as long, spindly shoots and reduced flower bud formation would limit this rate as a commercial practice. However, in our effort to improve control without the undesirable side effects we combined the lower concentrations of GA_{4+7} with the Apasil. Orchard trials with this and other combinations have been carried on in New York in 1976 and 1977 and during the 1976-77 season in Victoria, Australia.

Treatments were applied in New York in May, 1976, with a pressure sprayer and hand gun at the petal fall stage, followed by a repeat application 10 days later. Leaf and fruit surfaces were wet thoroughly to point of run off. Similar repeat applications were made in 1977, with the initial treatment applied May 26 two weeks after petal fall. In addition one test was conducted in a commercial orchard in 1977 with the Apasil and GA_{4+7} applied with an air-blast, fixed-outlet sprayer at the rate of 1800 liters/hr.

In the Victoria trials during the 1976-77 season the materials were applied with a small power sprayer on large unit limbs. Good coverage of leaf and fruit surfaces was obtained, with the first application timed at petal fall, October 26, and the second application 10 days later. Each treatment in the various experiments in both areas was replicated on 4 to 8 trees or unit branches.

Treatments included Apasil at 2.5% alone and in combination with GA_{4+7} at 25 ppm. In several tests GA_{4+7} was applied alone or in combination with chlorothalonil at 25 and 50 ppm. Samples were collected at harvest for examination and grading. Generally a 50-fruit sample was harvested at random from each replicate unit. These were graded into five russet categories and the data expressed as % of the fruit in each class. The classes were as follows: I = no russet; II = 0 to 5%; III = 5 to 10%; IV = 10 to 20%; V = over 20% surface area russeted.

The Apasil applications significantly reduced russet in 1976 (Table 1) and 1977 (Table 2). GA_{4+7} applied alone at 25 ppm in 1976 did not reduce russet as much as the Apasil treatment but performed somewhat better in 1977

Table 1. Effect of post-bloom applications of Apasil and GA_{4+7} on 'Golden Delicious' apples, Ithaca, New York, 1976.

Treatment[z]	Fruit in each russet class (%)[y] I	II	III	IV	V	Fruit wt (g)
Control	0 A[x]	13 A	50 A	30 BC	7	131
Apasil (2.5%)	15 B	37 B	26 B	17 ABC	5	130
Apasil (2.5%) + GA_{4+7} (25 ppm)	17 B	38 B	26 B	18 ABC	1	127
GA_{4+7} (25 ppm)	0 A	22 AB	63 A	13 A	2	130
GA_{4+7} (100 ppm)	2 A	40 B	50 A	7 A	1	124
Chlorothalonil (200 ppm)	0 A	12 A	46 A	34 C	8	127
GA_{4+7} (25 ppm) + chlorothalonil (200 ppm)	0 A	20 AB	50 A	27 BC	3	132
	**	**	**	**	N.S.	N.S.

[z]Treatments applied May 22; the first 2 treatments involving Apasil were repeated May 31.
[y] I = no russett; V = > 20% russett.
[x]Mean separation in columns by Duncan's multiple range test, 1% level.

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Table 2. Effect of Apasil and GA_{4+7} alone and in combinations with surfactants on 'Golden Delicious' fruit russet, Ithaca and Albion, New York, 1977.

Location and treatment[z]	Fruit in each russet class (%)[y] I	II	III	IV	V	Fruit weight (gm)
Ithaca						
Control	2 A[x]	37	33 B	24 C	4	156
Apasil (2.5%)	14 B	44	19 A	21 BC	2	149
GA_{4+7} (50 ppm)	17 B	45	23 B	13 AB	2	150
GA_{4+7} (50 ppm) + chlorothalonil (250 ppm)	29 C	40	27 B	4 A	0	156
Apasil 2.5% + GA_{4+7} (25 ppm) + chlorothalonil (250 ppm)	38 C	38	14 A	10 AB	0	157
	**	N.S.	**	**	N.S.	N.S.
Albion (Kirby Orchard)						
Control	9	45	38	7	1	128
Apasil (2.5%)	21	67	10	2	0	131
Apasil (2.5%) + GA_{4+7} (25 ppm) + chlorothalonil (250 ppm)	32	55	13	0	0	133

[z]Ithaca applications May 26, repeated June 5.
Albion applications with air blast sprayer May 14, repeated May 22.

[y]I = no russett; V = > 20% russett.

[x]Mean separation in columns (Ithaca Orchard) by Duncan's multiple range test, 1% level.

at both 25 and 50 ppm. Two factors may have had a bearing on these responses. Rainfall at Ithaca during the 4-week post-bloom period in 1977 was 4.6 cm less than during this period in 1976 and russet was in general more severe in 1976. Also the initial application in the 1977 test was applied May 26, two weeks after petal fall, as indicated above.

The application of Apasil and GA_{4+7} as a tank mix provided the best control of russet both years (Tables 1 and 2). Fruit weights were not affected by the treatment either year.

The response in Victoria was similar, with varying degrees of russet control depending on the treatment (Table 3). In these tests the GA_{4+7} was applied as a post-bloom spray, followed by an application of Apasil 10 days later. Apasil applied at 1.25% in combination with GA_{4+7} at 25 ppm provided some control of russet but was inferior to the full rate (Table 3).

The addition of chlorothalonil as a surfactant to the Apasil plus GA_{4+7} treatments provided some additional control. Previous work had demonstrated that chlorothalonil can enhance the effectiveness of certain growth regulators (5). The Albion test with the combination is of particular interest as it was applied with a airblast sprayer in a commerical orchard. The increase in % of russet-free and fancy fruit was consistently better than the Apasil alone or in the control plots (Table 2).

Based on the results in these trials and earlier reports (4, 7) it is apparent that several factors can cause the proliferation of the phellogen in 'Golden Delicious' fruits which gives rise to the russet disorder. The protection provided by the silicon dioxide and by the GA_{4+7} would presumably be through different mechanisms, and hence could be additive. However, since this combination has not provided complete control of fruit russeting, even in seasons where only moderate russet occurs, it is likely that other conditions may also contribute to phellogen activity and ultimate fruit russet. More versatile timing and coverage with either or both of the present materials or different concentrations may provide further reduction. Other materials that might influence the development of the cuticle and the phellogen layer are being investigated. Additional research will be needed to develop an economical and effective method for russet control.

Table 3. Effect of post-bloom applications of Apasil, GA_{4+7}, and chlorothalonil on 'Golden Delicious' apples, Victoria, Australia, 1976-1977.

Treatments[z]	Fruit in each russet class (%)[y] I	II	III	IV	V
Control	8	29	31	18	14
Apasil (2.5% x1)	12	42	28	18	0
Apasil (2.5% x 2)	25	58	15	2	0
Apasil (2.5% x 2) + GA_{4+7} (25 ppm) + chlorothalonil (250 ppm) (tank mix)	31	53	11	5	0
GA_{4+7} (25 ppm) + chlorothalonil (250 ppm)[x] Apasil (2.5% x 2)	26	69	3	2	0
Apasil (1.25% x 1)	6	53	25	12	4
Apasil (1.25% x 2)	3	55	30	11	1
Apasil (1.25% x 2) + GA_{4+7} (25 ppm) + chlorothalonil (250 ppm) (tank mix)	19	58	29	4	0
GA_{4+7} (25 ppm) + chlorothalonil (250 ppm)[x] Apasil (1.25% x 2)	18	63	15	3	1

[z]Single applications (x 1), and first application of 2-spray treatments was Oct. 26; repeat application in 2-spray treatments (x 2) Nov. 5. (Full bloom was Oct. 19).

[y]I = no russett; V = > 20% russett.

[x]In these 2 treatments, the GA_{4+7} and chlorothalonil were applied Oct. 26, with the first Apasil spray applied separately 24 hr later.

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