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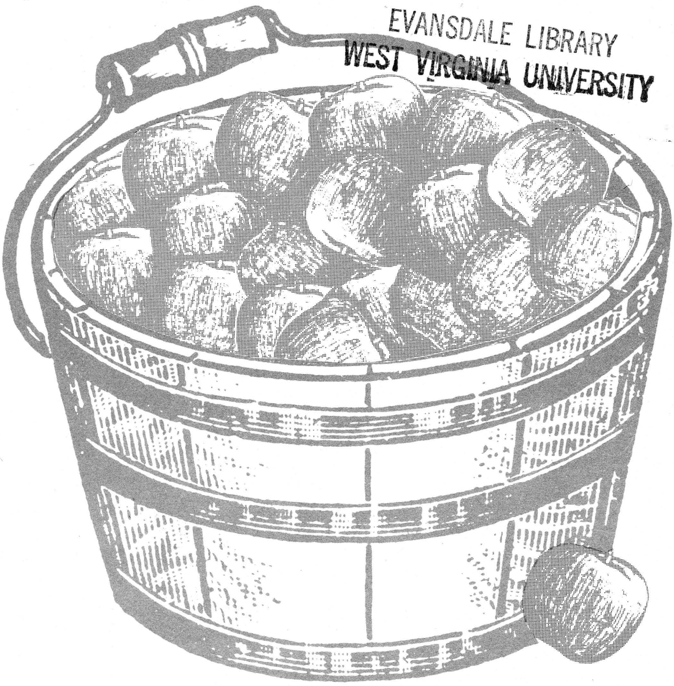

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A Comparison of Inhibitor Treatment Systems for Controlling Superficial Scald on Four Apple Cultivars

by

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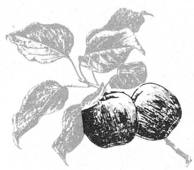

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investigators (Smock, 1961; Ingle, 1966; Johnson et al., 1980; Porritt and Meheriuk, 1968, 1970; Little et al., 1980 a, b) have studied application methods and rates for several apple cultivars.

Results reported in this bulletin are from experiments performed over several years to compare the effects of two concentrations of DPA and EQ—alone and in combinations—on the losses ascribable to scald on four of the most important apple cultivars grown in West Virginia and surrounding areas. The combinations were suggested by the experience of two commercial storage operators. As with all agricultural chemicals, there are always questions about the continued availability and tolerance of DPA and EQ, making it imperative to develop their most efficient uses.

METHODS AND MATERIALS

'Red Delicious,' 'York,' and 'Rome' apples were picked simultaneously from several trees and combined in a 300-kg (22-bushel) bin. Fruit from five 'Stayman' trees was picked and placed in separate, marked, 20-kg (1-bushel) boxes. Replicates were formed from the bins by picking about 20 apples at random and placing them in the treatment containers. A replicate of about 20 fruit was taken from each 'Stayman' tree.

All of the 'Red Delicious' and 'Rome' apples were collected from standard trees at the West Virginia University Experiment Farm, Kearneysville, West Virginia. For the 1984/85 experiments, 'York' fruits were collected from trees on a 3-wire trellis at the Experiment Farm, while the apples for 1985/86 experiments came from three commercial orchards in the Kearneysville vicinity. 'Stayman' for 1981/82 and 1982/83 came from an orchard 5 km to the east of Kearneysville. In 1984, 'Stayman' were picked 157 days after full bloom in an orchard 8 km west of Kearneysville and 161 days after full bloom in an orchard 72 km southwest. The latter orchard was 245 m higher in elevation than Kearneysville. Because of the difference in altitude and hence temperature, the two lots of fruit should have been about equally mature.

Prior to 1983, treatments were applied by dipping. Fruits were placed in 10-liter plastic pails with perforated bottoms for drainage. These pails were dipped in 11 liters of mixture contained in a larger pail. After 1983, fruits were placed in plastic milk bottle crates and drenched for 1 minute (about the standard time in local commercial systems) in an apparatus that circulates about 12 l/min through a flood pan with 1-cm-diameter holes on 2.5-cm centers and back to a sump. Commercial emulsifiable concentrate formulations containing 15% or 30% DPA or 30% EQ (Pennwalt or Shieldbrite) were used. After draining for at least 1 minute, the fruits were transferred from pails or crates to paper bags that then were placed in bins for storage. The 1982/83 and 1986/87 experiments were kept in grower-operated refrigerated storage at 0–3°C. The 1984/85 and 1985/86 experiments were placed in commercial controlled atmosphere storage at 0°C, 2.5% O_2 and 5% CO_2. Treatment and storage were completed within 48 hrs of picking.

After removal from 0°C refrigerated or controlled atmosphere storage, bags were removed from the bins and fruit was evaluated after one or seven days at 20°C.

The amount of scald on individual fruits was classified as none, slight (less than an estimated 10% of the surface affected), medium (10–50% of surface affected), or severe (50–100% of surface affected). The slight level required very close examination and would not be seen by inspectors or consumers. Since medium and severely affected fruits were considered "unmarketable," the percent of fruit in those two classes was combined as a measure of scald incidence. A "scald score" was used to estimate scald severity and was computed as (1 × no. of slight) + (3 × no. of medium) + (5 × no. of severe)/total no. of fruit. There were always at least 10 fruits per replication.

The maturity of three 'Red Delicious' strains was compared in 1985 by internal ethylene concentration. An 18-gauge needle was inserted into the core, cleaned with a wire, and a 1-ml sample was drawn into a 1-ml syringe. Ethylene concentration in the sample was estimated with a Varian 3700 gas chromatograph fitted with an alumina column and flame ionization detector. DPA residue was extracted from peel with high performance liquid chromatography (HPLC) grade hexane by steam distillation. Concentrations of DPA were determined by HPLC in a commercial laboratory.

Duncan's New Multiple Range Comparisons were made of untransformed data. Arcsine transformation did not affect mean separations.

RESULTS

The percentage of fruit too badly affected to be acceptable for sale and the scald severity estimation systems used in these studies are highly related and furnish much the same information, since the scald score is derived from the incidence rating. Correlation coefficients between the percent unmarketable because of scald and the scald scores shown on Tables 1–4 were 0.87–0.98, all $p < .0001$. Because the two scoring methods are essentially identical, the "percent unmarketable" has been used predominantly in this report.

Table 1 shows that percent unmarketable fruit and scald score tended to increase during storage at 20°C after storage at 0°C, but the differences were rarely significant. The increase after 7 days was most prominent when scald was relatively low after 1 day at 20°C. Although the two strains of 'Red Delicious' were picked 7 days apart they were of about equal maturity (Ingle, 1972). Percent unmarketable of untreated fruit was very high at the end of refrigerated storage and after 1 day and did not change very much during 6 more days at 20°C, but severity of existing scald did increase from medium to severe. Inhibitor treatment reduced the initial percent unmarketable significantly, but there were large increases during 7 days at 20°C, except for when control was poor (2000 mg/l DPA on Sturdeespur). In most experiments, evaluations were made only after 7 days at 20°C, a simulated shelf life, when there was the maximum amount of scald.

Two thousand mg/l DPA or 2700 mg/l EQ have been considered the standard treatments since their introduction in 1955 and 1957 (Smock, 1955, 1957). Sometimes neither treatment provides adequate control (Tables 1, 4, 5, 6, 11, 13). In some cases, scald has been further reduced by a combination of the two inhibitors. In Table 1, scald on Sturdeespur 'Red Delicious' after 7 days at 20°C was reduced only slightly by the addition of 2000 mg/l DPA to 2700 mg/l EQ. Scald was slightly less severe on the Bisbee picked 1 week later, and the combination was significantly more effective than either inhibitor alone, particularly after 7 days at 20°C. In 1984/85, Starkrimson 'Red Delicious' picked 143 days after full bloom developed a high incidence of scald (Table 3). The greatest reduction was achieved with combinations, but there was no satisfactory control (less than 5% unmarketable). Untreated fruit picked 7 days later had about 60% less scald, and all treatments except 1000 mg/l DPA provided adequate protection (Table 3). In Table 4 (1985/86), combinations provided more scald reduction than DPA or EQ alone on the Maehara and Dietrich strains. Untreated Topred developed less scald than the other untreated strains. Two thousand mg/l provided effective control.

In 1984/85 scald was severe on 'York' picked 157 or 164 days after full bloom (Table 5). Combination treatments generally reduced scald more than DPA or EQ alone, but the differences were too small to be significant and no treatment provided sufficient protection. The untreated 'York' fruit used in the 1985/86 experiments developed about half as much scald as in 1984/85, and all of the treatments were sufficiently effective (Table 6).

In 1981/82, 'Stayman' fruit treated with combinations of DPA and EQ had about half as much scald as that treated with either 2000 mg/l DPA or 2700 mg/l EQ (Table 7). In 1982/83, the combinations were no more effective than EQ, which in turn was superior to DPA (Table 8). In 1984/85, the incidence of scald on untreated fruit was lower, and all of the treatments were equally effective (Table 9).

The 'Rome' apples for all the 1982–86 experiments came from the same three rows of visually uniform trees at the Kearneysville experiment farm. Untreated fruit in the first (1982/83) experiment scalded extensively (Table 10). All treatments of fruit picked 160 days after full bloom had nearly 30% scald except for 2000 mg/l plus 2700 mg/l EQ, and even that 15% may be an unacceptable loss. Fruit picked 167 days after full bloom still scalded extensively, but was reduced to 0–4% unmarketable by all three treatments except 1000 mg/l DPA. In 1983/84, a relatively low 37% of the untreated fruit developed excessive scald during storage (Table 11). There was a great deal of variation among replications and no treatment showed outstanding scald control. The more mature fruit collected 10 days later had only 6% scald on the untreated fruit, and all treatments reduced scald to an acceptable level (Table 11). Scald was again comparatively low in 1985/86, but the differences between rows help to demonstrate how erratic the occurrence of scald can be (Table 12). It should be recalled that controlled atmosphere storage was used in 1985/86 and refrigerated storage in the other years. In 1986/87, when the level of scald was again high, the combination of 1000 mg/l DPA plus 2700 mg/l EQ gave better scald reduction than either 2000 mg/l DPA or 2700 mg/l EQ, the highest labeled concentrations (Table 13).

Increasing the DPA above the highest labeled concentrations failed to further reduce scald on three strains of 'Red Delicious' (Table 4), 'York,' or 'Rome' (Tables 6, 12, 13). Apples treated with 3000 or 4000 mg/l DPA did not contain higher residues than those treated with the labeled rates (Table 14). The Environmental Protection Agency tolerance for DPA is 10 ppm.

DISCUSSION

There is some experimental evidence (Smock, 1961; Meir and Bramlage, 1988) and considerable commercial experience indicating that incidence and severity of scald decrease with increasing maturity. Since these experiments were designed to compare several scald inhibitor treatments, maturity was not studied systematically. For some experiments fruit was collected from the same trees or blocks on successive dates, or differences in maturity were suggested by internal ethylene concentration or accumulated heat units. Delaying harvest of Starkrimson 'Red Delicious' for 7 days reduced scald on untreated fruit from 62% to 21% and also increased the effectiveness of scald inhibitor treatments (Table 3). On the fruit picked 143 days after full bloom, which would be considered immature (Ingle, 1972), scald was reduced by less than 50% (62% to 37%) by the most effective treatment, while on the fruit picked later, scald was reduced to zero by the same treatment. The three 'Red Delicious' strains used in 1985/86 were in adjacent rows but differed in maturity as judged by the mean internal ethylene concentration of 20 fruits. The less mature Maehara (42%) and Dietrich (66%) strains appeared to have more scald on the untreated fruits, and there was less reduction by any treatment than on the more mature Topred (30%) strain (Table 4). A maturity difference of 7 days had little effect on incidence of scald on 'York' in 1984/85 or on the effectiveness of any scald inhibitor treatment (Table 5). Scald incidence was high on untreated 'Stayman' fruit picked on both 153 and 160 days after full bloom (early and late maturity, respectively); good and essentially identical control was obtained on both groups of fruit (Table 8).

In 1982/83, maturity as days after full bloom had little effect on the incidence of scald on untreated 'Rome' apples (Table 10); however, the inhibitor treatments were much more effective on the more mature fruit. In 1983/84 more mature fruit was used. Even on fruit picked 171 days after full bloom, near the latest recommended picking date (Haller et al., 1950), there was still considerable scald (31%), and there was only limited reduction by any treatment (Table 11). By 181 days after full bloom, when the fruit should have been over mature, so little scald developed on the untreated fruit that the reductions on the inhibitor-treated fruits were insignificant.

A review of the data in this report and many others (Smock, 1961; Merritt et al., 1961; Ingle, 1966; Ingle and D'Souza, 1989; Porritt and Meheriuk, 1969, 1970; Little et al., 1980) shows that the incidence of scald depends on cultivar, harvest date, and growing-season weather conditions, which cause appreciable year-to-year differences. For instance, in 1982/83 94% of 'Rome' apples picked 167 days after full bloom were too badly affected by scald to be marketed as fresh fruit (Table 10). In 1983/84, trees from the same row produced fruit 37% unmarketable when picked 171 days after full bloom (Table 11). Controlled atmosphere storage as well as maturity in 1983/84 may have been partly responsible for differences between 1982/83 and 1983/84. The untreated fruit from three adjacent rows picked 161 days after full bloom in 1985/86 was 4–20% unmarketable (Table 12). Sometimes low scald inhibitor concentrations provided sufficient reduction (Table 6), while other blocks were so recalcitrant that even 2000 mg/l DPA plus 2700 mg/l EQ failed to provide acceptable control (Tables 5 and 11).

If the incidence and severity of scald could be predicted quantitatively and related to scald inhibitor concentrations, minimal effective concentrations could be prescribed, reducing costs and residues. Because data collection for a number of variables would be necessary for many years, few people have been able to commit the time and resources. A system based on temperature distribution in the latter part of the growing season was suggested for 'Stayman' by Merritt et al. (1961), but has not been thoroughly developed. The concentration of α-farnesene or conjugated trienes may be related to scald development in storage (Anet, 1974; Meir and Bramlage, 1988). Both approaches need to be studied much more extensively. But until reliable predictive systems become available, scald inhibitors applied at concentrations that have been shown to satisfactorily suppress high incidence of scald will be the principal control tools. In essence, scald inhibitors are used as insurance against worst-case scenarios.

In the majority of these experiments, combinations of DPA and EQ performed better than either inhibitor alone on 'Red Delicious,' 'Stayman,' and 'Rome' (Tables 1-4, 7, 10, 13). Rarely was there an advantage to using the highest rates of DPA and EQ together. Two thousand mg/l DPA plus 1350 mg/l EQ or 1000 mg/l DPA plus 2700 mg/l did as well as 2000 mg/l DPA plus 2700 mg/l EQ; indeed, a treatment of 1000 mg/l DPA plus 1350 mg/l EQ should not afford much more risk of scald than the higher rates together except with very immature fruit (starch index < 2 or internal ethylene concentrations < 0.5 ul/l or ppm). Lower concentrations would reduce costs and residues.

Not many experiments were done with 'York' because until recently that cultivar has been used mostly for processing after a short storage period. There is increasing utilization of 'York' after extended refrigerated and controlled atmosphere storage, necessitating more information about the cultivar's storage disorders. In 1984/85 no treatment provided satisfactory control. There was the same amount of scald reduction with all treatments (Table 5). In 1985/86 the incidence of scald on untreated fruit was unacceptably high but lower than the previous year (Table 6). All treatments provided satisfactory control.

Neither inhibitor alone seemed consistently better than the other. DPA probably gives somewhat better control of scald on 'Red Delicious' but there would seem to be little risk in using 2700 mg/l EQ. Since 'Stayman,' 'York,' and 'Rome' may be harvested during the same time, 2700 mg/l EQ might be the single best inhibitor for those three cultivars. Superficial injury attributed to DPA has been seen in commercial lots of those three strains, although none was observed in these experiments.

Pending the development of very reliable predictive methods, the use of scald inhibitors as protection against an unknown future will be unavoidable, although there is always a possibility of only limited control.

Both DPA and EQ can injure the peel of apples. Like scald itself the injury is superficial and cosmetic. Inhibitor injury was not observed in any of the experiments described in this report. From samples provided by storage operators, it appears that injury is most common when suspension accumulates between fruits or in the bottom of containers. Thorough drainage before storage is probably desirable.

SUMMARY

Superficial scald was observed to develop during the storage of 20 of 22 lots of apples. The conventional treatments of 2000 mg/l diphenylamine or 2700 mg/l ethoxyquin usually reduced incidence to less than 10%. Combinations of the two inhibitors were slightly more effective than either alone. One thousand mg/l diphenylamine plus 1350 mg/l ethoxyquin was as effective as the higher rates of either compound alone. The combinations may reduce fruit residues.

LITERATURE CITED

Anet, E. F. L. J. 1969. Autoxidation of α-farnesene. *Austral. J. Chem.* 22:2403–2410.

Anet, E. F. L. J. 1972. Superficial scald, a functional disorder of stored apples IX. Effect of maturity and ventilation. *J. Sci. Food Agr.* 23:763–769.

Anet, E. F. L. J. 1974. Superficial scald, a functional disorder of stored apples. XI. Apple antioxidants. *J. Sci. Food Agr.* 25:299–304.

Chen, P. M., K. L. Olsen, and M. Meheriuk. 1985. Effect of low-oxygen atmosphere on storage, scald and quality preservation of 'Delicious' apples. *J. Amer. Soc. Hort. Sci.* 110:16–20.

Gough, R. E., V. G. Shutak, C. E. Olney, and H. Day. 1973. Effect of butylated hydroxytoluene on apple scald. *J. Amer. Soc. Hort. Sci.* 98:14–15.

Hardenburg, R. E. 1965. Review of literature on harvesting, handling, storage and transportation of apples. USDA/ARS Res. 51-4:194–215.

Hardenburg, R. E. and R. E. Anderson. 1965. Postharvest chemical, hot water, and packaging treatments to control scald on 'Stayman' apples. *Proc. Amer. Soc. Hort. Sci.* 90:484–490.

Ingle, M. 1966. Storage scald of apples—causes and control. West Virginia Univ. Agr. Exp. Sta. Current Report 47. 9 p.

Ingle, M. 1972. Studies on the maturity and storage behavior of 'Red Delicious' budsports. West Virginia Univ. Agr. Exp. Sta. Bull. 609T. 13 p.

Ingle, M. and M. C. D'Souza. 1989. Physiology and control of superficial scald of apples. A review. *HortScience* 24:28–31.

Johnson, D. S., J. G. Allen, and T. S. Warman. 1980. Post-harvest application of diphenylamine and ethoxyquin for control of superficial scald on Bramley's Seedling apples. *J. Sci. Food Agr.* 31:1189–1194.

Little, C. R., H. J. Taylor, and I. D. Peggie. 1980a. Multiformulation dips for controlling storage disorders of apples and pears. I. Assessing fungicides. *Scientia Hort.* 13:213–219.

Little, C. R., H. J. Taylor, and I. D. Peggie. 1980b. Multiformulation dips for controlling storage disorders of apples and pears. II. Assessing scald inhibitors. *Scientia Hort.* 13:315–321.

Little, C. R. and I. D. Peggie. 1987. Storage injury of some fruit caused by stress levels of oxygen, carbon dioxide, temperature, and ethylene. *HortScience* 22:783–790.

Meir, S. and W. J. Bramlage. 1988. Antioxidant activity in 'Cortland' apple peel and susceptibility to superficial scald after storage. *J. Amer. Soc. Hort. Sci.* 113:412–418.

Merritt, R. H., W. C. Stiles, A. V. Havens, and L. A. Miterling. 1961. Effects of preharvest air temperature on storage scald of 'Stayman' apples. *Proc. Amer. Soc. Hort. Sci.* 78:24–34.

Porritt, S. and M. Meheriuk. 1968. Application of chemicals for control of apple scald. *Can. J. Plant Sci.* 50:313–315.

Porritt, S. W. and M. Meheriuk. 1970. Chemical control of scald on waxed apples. *Can. J. Plant Sci.* 50:313–315.

Scott, K. J., R. B. H. Wills, and W. McBailey. 1980. The action of phorone and other compounds in controlling superficial scald of apples. *Scientia Hort.* 13:9–14.

Smock, R. M. 1955. A new method for scald control. *Amer. Fruit Grower* 75:20.

Smock, R. M. 1957. A comparison of treatments for control of apple scald disease. *Proc. Amer. Soc. Hort. Sci.* 69:91–100.

Smock, R. M. 1961. Methods of scald control on the apples. Cornell Univ. Agr. Exp. Sta. Bull. 970.

Wills, R. B. H., K. J. Scott, and W. McBailey. 1977. Reduction of superficial scald in apples with monoterpenes. *Austral. J. Agr. Res.* 28:445–448.

Table 1.
Effect of time at 20°C on incidence and severity of scald on two strains of 'Red Delicious' apples, 1982/83. Evaluated after 179 or 186 days at 0°C.

	% Unmarketable (Scald)		Scald Score	
	Days at 20°C			
Treatment	1	7	1	7
	Sturdeespur picked 139 days after full bloom			
Not dipped	78 a*	88 a	1.4 ab	2.7 a
Fungicide only**	80 a	82 ab	1.8 a	2.4 a
Diphenylamine (DPA), 2000 mg/l	52 b	55 bc	1.3 b	1.2 b
Ethoxyquin (EQ), 2700 mg/l	16 c	30 cd	0.8 b	0.9 b
DPA, 2000 mg/l + EQ, 2700 mg/l	0 d	20 d	0.6 b	0.7 b
	Bisbee picked 146 days after full bloom			
Not dipped	62 a	80 a	1.6 b	2.0 a
Fungicide only	78 a	85 a	2.1 a	2.1 a
Diphenylamine (DPA), 2000 mg/l	17 b	28 b	0.9 c	1.1 b
Ethoxyquin (EQ), 2700 mg/l	12 b	32 b	0.7 c	1.1 b
DPA, 2000 mg/l, EQ, 2700 mg/l	0 c	4 c	0.8 c	0.8 c

*Means for % unmarketable or scald score within a column and strain of a picking date followed by same letters are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

**All dip treatments contained 1.2 g/l captan and 0.6 g/l benomyl.

Table 2.
Effect of scald inhibitor dip treatments on incidence and severity of scald on 'Red Delicious' apples, 1982/83. Evaluated after 186 days (Sturdeespur) or 179 days (Bisbee) at 0°C and 7 days at 20°C.

	% Unmarketable (Scald)			Scald Score		
Diphenylamine	Ethoxyquin, mg/l					
mg/l	0	1350	2700	0	1350	2700
	Sturdeespur picked 139 days after full bloom					
Not dipped	88 a*			2.7 a		
0**	82 ab		30 de	2.4 a		0.9 b
1000	85 ab	38 cd	23 de	2.7 a	1.1 b	0.8 b
2000	55 bc	23 de	20 e	1.2 b	0.8 b	0.7 b
	Bisbee picked 146 days after full bloom					
Not dipped	80 a			2.0 a		
0	85 a		32 b	2.1 a		1.1 c
1000	94 a	4 d	6 d	1.6 b	0.8 c	1.0 c
2000	28 c	2 d	4 d	1.1 c	0.9 c	0.8 c

*Means for % unmarketable or scald score within a picking followed by same letters are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

**All dip treatments contained 1.2 g/l captan and 0.6 g/l benomyl. Fruit from several trees combined in a bin and five replications for each treatment drawn from around bin.

Table 3.
Effect of scald inhibitor drench treatments on incidence of scald on 'Red Delicious' apples, 1984/85. Evaluated after 166 and 173 days at 0°C controlled atmosphere and 7 days at 20°C.

Diphenylamine mg/l	% Unmarketable (Scald) Ethoxyquin, mg/l 0	1350	2700
	Picked 143 days after full bloom		
Undrenched	78 a*		
0**	62 ab	57 ab	39 de
1000	52 bc	30 e	37 e
2000	46 cd	52 bc	34 e
	Picked 150 days after full bloom		
Undrenched	15 ab		
0	21 a	5 bc	4 c
1000	10 bc	1 c	0 c
2000	0 c	5 bc	0 c

*Means within a picking followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

**All drenches contained 1.2 g/l captan and 0.6 g/l benomyl.

Table 4.
Effect of scald inhibitor drench treatments on incidence of scald on 'Red Delicious' apples, 1985/86. Fruit picked 136 days after full bloom and evaluated after 163 days at 0°C controlled atmosphere and 7 days at 20°C.

	% Unmarketable (Scald)		
Diphenylamine	Ethoxyquin, mg/l		
mg/l	0	1350	2700
	Maehara strain (0.1 ul/l internal ethylene)		
0*	42 b**		68 a
1000	49 b	48 b	29 bc
2000	14 cd	20 cd	3 d
3000	9 d		
4000	7 d		
	Dietrich Strain (1.8 ul/l internal ethylene)		
0	66 a		33 bc
1000	46 b	29 c	8 de
2000	21 cd	5 e	20 cd
3000	9 de		
4000	7 de		
	Topred strain (6.1 ul/l internal ethylene)		
0	30 a		16 ab
1000	10 b	5 b	1 b
2000	5 b	5 b	0 b
3000	1 b		
4000	1 b		

*All drenches contained 1.2 g/l captan and 0.6 g/l benomyl.

**Means within a strain followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

Table 5.
Effect of scald inhibitor drench treatments on incidence of scald on 'York' apples, 1984/85. Evaluated after 203 days at 0°C controlled atmosphere and 7 days at 20°C.

	% Unmarketable (Scald)		
Diphenylamine	Ethoxyquin, mg/l		
mg/l	0	1350	2700
	Picked 157 days after full bloom		
Not drenched	89 a*		
0**	92 a	37 cd	56 bc
1000	49 bcd	46 bcd	46 bcd
2000	28 d	34 cd	40 bcd
	Picked 164 days after full bloom		
Not drenched	81 a		
0	78 a	39 bcd	37 bcd
1000	32 cd	42 bc	22 d
2000	40 b	33 cd	27 cd

*Means within a picking followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

**All drenches contained 1.2 g/l captan and 0.6 g/l benomyl.

Table 6.

Effect of scald inhibitor drench treatments on incidence of scald on 'York' apples, 1985/86. Fruit harvested and treated 152–155 days after full bloom and evaluated after 149 days at 0°C controlled atmosphere and 7 days at 20°C.

Diphenylamine mg/l	% Unmarketable (Scald) Ethoxyquin, mg/l 0	1350	2700
		Orchard A	
0*	53 a**		7 b
1000	7 b	3 b	6 b
2000	7 b	6 b	10 b
3000	9 b		
4000	8 b		
		Orchard B	
0	56 a		1 b
1000	0 b	0 b	0 b
2000	0 b	1 b	2 b
3000	0 b		
4000	0 b		
		Orchard C	
0	44 a		2 b
1000	3 b	0 b	3 b
2000	1 b	3 b	0 b
3000	0 b		
4000	1 b		

*All drenches contained 1.2 g/l captan and 0.6 g/l benomyl.

**Means within a orchard followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

Table 7.
Effect of scald inhibitor dip treatments on incidence of scald on 'Stayman' apples, 1981/82. Evaluated after 152 days at 0°C and 7 days at 20°C.

Diphenylamine mg/l	% Unmarketable (Scald) Ethoxyquin, mg/l 0	 1350	 2700
	Picked 155 days after bloom		
0*	36 a**	—	12 c
1000	30 ab	2 c	8 c
2000	16 abc	7 c	6 c

*All dip treatments contained 1.2 g/l captan and 0.6 g/l benomyl.

**Means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

Table 8.

Effect of scald inhibitor dip treatments on incidence and severity of scald on 'Stayman' apples, 1982/83. Evaluated after 175 days at 0°C and 7 days at 20°C.

	% Unmarketable (Scald)			Scald Score		
	Ethoxyquin, mg/l					
Diphenylamine mg/l	0	1350	2700	0	1350	2700
	Picked 153 days after full bloom					
Not dipped	82 a*			2.9 a		
0**	98 a		4 b	3.0 a		0.7 b
1000		3 b	3 b		0.7 b	
2000	15 b	4 b	0 b	0.8 b	0.6 b	0.8 b
	Picked 160 days after full bloom					
Not dipped	85 a			2.5 a		
0	80 a		0 b	1.9 b		
1000		0 b	0 b		0.6 c	0.6 c
2000	0 b	0 b	0 b	0.5 c	0.5 c	0.5 c

*Means for % unmarketable or scald score within a picking followed by the same letters are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

**All dip treatments contained 1.2 g/l captan and 0.6 g/l benomyl.

Table 9.
Effect of scald inhibitor drench treatments on incidence of scald on 'Stayman' apples, 1984/85. Evaluated after 173 or 179 days at 0°C controlled atmosphere and 7 days at 20°C.

Diphenylamine mg/l	% Unmarketable (Scald) Ethoxyquin, mg/l 0	1350	2700
	Orchard A—Picked 157 days after full bloom		
Not drenched	33 a*		
0**	26 a	0 b	0 b
1000	1 b	0 b	0 b
2000	0 b	0 b	0 b
	Orchard B—Picked 161 days after full bloom		
Not drenched	48 a		
0	50 a	2 b	0 b
1000	0 b	0 b	0 b
2000	0 b	0 b	0 b

*Means within a picking followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

**All drenches contained 1.2 g/l captan and 0.6 g/l benomyl.

Table 10.

Effect of scald inhibitor dip treatments on incidence and severity of scald on 'Rome' apples, 1982/83. Evaluated after 178 days at 0°C and 7 days at 20°C.

	% Unmarketable (Scald)			Scald Score		
Diphenylamine	Ethoxyquin, mg/l					
mg/l	0	1350	2700	0	1350	2700
	Picked 160 days after full bloom					
Not dipped	89 ab*			2.6 ab		
0**	94 a			2.7 a		
1000	62 c	29 de	75 abc	1.9 cd	1.9 cd	2.4 abc
2000	38 de	35 de	15 e	1.3 de	1.1 e	1.3 de
	Picked 167 days after full bloom					
Not dipped	94 a			2.8 ab		
0	100 a			3.1 a		2.6 b
1000	14 b	4 b	92 a	0.8 c	0.7 c	0.7 c
2000	2 b	0 b		0.6 c	0.6 c	0.7 c

*Means for % unmarketable or scald score within a picking followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

**All dip treatments contained 1.2 g/l captan and 0.6 g/l benomyl.

Table 11.
Effect of scald inhibitor drench treatments on incidence of scald on 'Rome' apples, 1983/84. Evaluated after 210 and 203 days at 0°C and 7 days at 20°C.

	% Unmarketable (Scald)		
Diphenylamine	Ethoxyquin, mg/l		
mg/l	0	1350	2700
	Picked 171 days after full bloom		
Not drenched	37 a*		
0**	31 ab	20 bcd	12 cd
1000	23 bc	24 bc	17 cd
2000	5 d	20 bcd	22 bcd
	Picked 181 days after full bloom		
Not drenched	6 ab		
0	8 a	3 ab	2 b
1000	3 ab	1 b	0 b
2000	4 ab	3 ab	0 b

*Means within a picking followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

**All drenches contained 1.2 g/l captan and 0.6 g/l benomyl.

Table 12.
Effect of scald inhibitor drench treatments on incidence of scald on 'Rome' apples, 1985/86. Picked and treated 161 days after full boom and evaluated after 138 days at 0°C controlled atmosphere and 7 days at 20°C.

	% Unmarketable (Scald)		
Diphenylamine	Ethoxyquin, mg/l		
mg/l	0	1350	2700
		Row A	
0*	4 a**		1 b
1000	0 b	0 b	0 b
2000	1 b	0 b	0 b
3000	0 b		
4000	0 b		
		Row B	
0	11 a		1 b
1000	5 ab	2 b	1 b
2000	2 b	1 b	1 b
3000	5 ab		
4000	1 b		
		Row C	
0	20 a		2 b
1000	0 b	0 b	7 b
2000	2 b	0 b	2 b
3000	1 b		
4000	3 b		

*All drenches contained 1.2 g/l captan and 0.6 g/l benomyl.

**Means within a row followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

Table 13.
Effect of scald inhibitor drench treatments on incidence of scald on 'Rome' apples, 1986/87. Harvested and treated 154 days after full bloom and evaluated after 150 days at 0°C and 8 days at 20°C.

	% Unmarketable (Scald)		
Diphenylamine mg/l	Ethoxyquin, mg/l 0	1350	2700
0*	75**		55 ab
1000		44 bc	13 d
2000	43 bc	38 bc	
3000	23 cd	33 bcd	
4000	10 d		
2000 + 4% $CaCl_2$	22 cd		
2000 + Stopit	88 a		

*All drenches contained 1.2 g/l captan and 0.6 g/l benomyl.

**Means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

Table 14.
Diphenylamine residues after storage on three apple cultivars as a function of drench mixture concentration.

Drench Concentration mg/l	Cultivar 'Red Delicious'	'York'	'Rome'
	mg/Kg (fresh weight)		
		1985/86	
0	0.79	0.75	0.64
1000	0.53	1.15	1.70
2000	1.15	0.69	1.33
3000	0.83	1.60	1.60
4000	1.32	1.06	1.59
		1986/87	
0		0.07	0.03
2000	0.11	0.11	0.04
3000			0.14
4000	0.14	0.11	0.10

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