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Items of Interest for Storage Operators
in
New York and Beyond

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SmartFresh™ (1-methylcyclopropene; 1-MCP) is registered for use on New York-grown apples.

This has been an exciting year for the New York apple industry. The ethylene-binding inhibitor, SmartFresh (1-methyl cyclopropene, 1-MCP), was finally approved by the EPA for use on a range of horticultural crops. Moreover, because of the tremendous supportive efforts by the New York Horticulture Society and a rapid turnaround of information by the DEC, New York had the chemical available for use for the 2002 season. Therefore, New York was not left at a competitive disadvantage compared with other states. Attendance at a workshop run by AgroFresh was required before purchase of SmartFresh, but participation at the workshops was very good and the use by New York storage operators far exceeded supplier expectations. At the time of printing of this newsletter, most fruit were still in storage, but preliminary results highlight the effects of SmartFresh on apple fruit quality. A lot more information will be available for the industry by the time of the 2003 harvest, and the Storage Workshop in Ithaca will focus on Smartfresh.

A summary of conclusions about use of SmartFresh on New York-grown apples

1. **Varietal effects:** Most varieties tested so far respond well to SmartFresh as assessed by slower ripening rates - reduction of internal ethylene concentrations (IEC), and maintenance of firmness and ground color. Fruit look fresh after storage, often almost as if they have just been picked. Variety, however, affects the magnitude of the responses of fruit in both air and CA storage. Cortland, Delicious, Empire, Jonagold and McIntosh harvested at optimum maturity appear to be especially responsive to SmartFresh application, especially after 2 months air storage and up to 8 months of CA storage. McIntosh, an important variety for New York, is one that can respond very well to SmartFresh applications. However, if IEC of McIntosh is high at harvest, then SmartFresh may be ineffective. McIntosh fruit from the Champlain growing region appear to respond most consistently to SmartFresh.

   Our recommendations are that SmartFresh should be used cautiously on McIntosh. It should not be used unless it is known that IEC in the fruit is low, especially as variable IEC in fruit from the same orchard lot can result in variable firmness maintenance. SmartFresh should not be used on ethrel-treated fruit.

   If a particular variety does not soften significantly during storage, e.g. Honeycrisp, then effects on softening cannot be measured and SmartFresh will have no benefit.
2. **Maturity of fruit at harvest** affects the response of fruit to SmartFresh. In general later harvested fruit are less responsive to SmartFresh because of higher ethylene pro-

duction by the fruit. Preliminary recommendations are that Smart-Fresh should not be used to extend harvest periods of New York apples. It is suggested that the same harvest periods appropriate for CA storage will apply for the new technology. Overall results indicate that late harvest reduced the effectiveness of SmartFresh treatment in McIntosh. However, with Empire and Delicious, later harvested fruit may also be highly responsive at least for shorter-term storage. One big concern about Smart Fresh is that fruit that are harvested too early may fail to develop flavor. *Overly early harvest of fruit of any variety should be avoided*.

3. **Timing of SmartFresh application** after harvest may affect its effectiveness. A preliminary recommendation for the industry is that storage operators should aim for a 4-day loading period for many varieties when long term CA storage is the goal. In some instances, SmartFresh may be a substitute for CA storage, but the effects on firmness of SmartFresh and CA often are additive. Variability in fruit response across seasons and harvests may occur and therefore the additional "insurance" of CA storage is recommended. *However, the data clearly indicate that SmartFresh markedly improves quality of fruit stored for at least two months in air, and therefore has the potential to improve the quality of air-stored fruit presented to the consumer in December.* SmartFresh treatment effects on quality of air-stored fruit may be influenced more by harvest date and delays before application than CA-stored fruit.
4. **Treatment temperature:** Overall, no marked effect of treatment temperature has been identified. The industry trials carried out as part of the Grow New York program (see last year's Newsletter <http://www.hort.cornell.edu/department/faculty/watkins/Newsletter2001.pdf>) indicated that better responses to SmartFresh often were obtained when fruit were treated warm on the day of harvest. Our recommendation, however, is to cool fruit before applying SmartFresh, but further research is required.
5. **Storage temperature:** A tentative recommendation is made to maintain current storage temperatures when using Smart-Fresh.
6. **SmartFresh and DPA:** Caution must be taken in substituting SmartFresh for diphenylamine (DPA) to control superficial scald. In many varieties, DPA has the additional advantage of eliminating risk of carbon dioxide injury. Therefore, care must be taken to avoid factors that increase risk of this disorder developing. SmartFresh does not appear to do a sufficiently good job of controlling superficial scald development in Cortland. Caution should be taken by the industry in substituting chemicals for long term storage. Remember that even a little scald is equivalent to all fruit having scald in the fruit trade, because buyers assume that scald develops rapidly in fruit lots that show just a bit of scald.
7. **Fruit quality monitoring:** A comprehensive sampling program must be implemented by storage operators for any treated varieties.

What are the risk factors for SmartFresh use?

1. SmartFresh doesn't work on all fruit lots, especially if there is variability in harvest maturity or if preharvest stress factors cause advanced fruit maturity. Use CA as "insurance" for quality maintenance, if you are uncertain about fruit maturity at the time of treatment.
2. SmartFresh-treated fruit may show a higher incidence of other postharvest disorders. These include CO_2 injury if DPA has not been used. One way to reduce the risk of CO_2 injury is to maintain low CO_2 levels during the first 4 weeks in sensitive varieties such as McIntosh, Cortland, and Empire.
3. Although SmartFresh can control superficial scald, the degree of control is uncertain across varieties and storage periods. Therefore you should try some lots, not the entire room without DPA, if long storage periods are anticipated for scald-susceptible varieties.

Effect of CA at different storage temperatures on fruit quality

A major goal of the 2001/2002 research program was to investigate whether SmartFresh (1-MCP) might permit the use of higher storage temperatures during CA storage. If temperatures could be raised, the risk of chilling injury, a major limitation to storability of several NY cultivars, could be reduced.

McIntosh

At harvest, firmness and IEC of fruit from the Champlain (9/18/01) and Western NY (9/19/01) were 14.8 lb and 48 ppm, and 14.9 lb and 87 ppm, respectively.

Overall, fruit from Champlain were firmer than fruit from Western NY after storage. However, fruit from both regions, treated with 1-MCP, softened little during the shelf life period after storage at either 33 and 38^{o}F for 4 months. After 10 months of storage, 1-MCP treated fruit had similar firmness at 1 day after removal, but fruit that had been stored at 38^{o}F softened much faster than those that had been stored at 33^{o}F.

For Champlain-grown fruit, no differences among any factors were found for senescent breakdown (overall 2.8%), core browning (3.2%) and superficial scald (0.4%). However, flesh browning, which is a chilling-related injury averaged 31% at 33^{o}F compared with 0% at 38^{o}F. External CO_2 injury was affected by treatment and temperature (P=0.05), with no differences between treatment at 33^{o}F (0.6%), but 3.7% in 1-MCP treated fruit compared with 0.4% at 38^{o}F.

For Western NY-grown fruit, an interaction between treatment and temperature (P=0.013) was found for

senescent breakdown; surprisingly, 1.9% occurred at 33°F, but only in the control fruit. None was found at 38°F. Core browning was 3.9% and 10.7% at 33°F and 38°F respectively, but was not affected by 1-MCP application. Flesh browning incidence was less than 1% and was not affected by treatment. Superficial scald occurred only in untreated fruit that were stored at 33°F, averaging 4.3%. No external CO_2 injury was detected in these fruit.

Overall, while there was a small advantage in firmness for 1-MCP treated fruit stored at the 33°F compared with 38°F during the shelf life period, the sensitivity of Champlain-grown fruit to flesh browning suggests that the lower temperature should not be used for long-term storage. The only disorder that was exacerbated by 1-MCP application was external CO_2 injury, and only in fruit stored at 38°F.

Cortland

At harvest, firmness and IEC of fruit from the Champlain (9/24/01) and Western NY (9/27/01) were 14.1 lb and 3.8 ppm, and 13.9 lb and 11ppm, respectively.

1-MCP treated fruit were firmer than untreated fruit for both regions, storage periods and temperatures, and shelf life periods (Table 2). Champlain fruit treated with 1-MCP softened between 4 and 10 months of storage at 33 °F, but only during the shelf life period in fruit stored at 38 °F. Overall, however, there was little difference between firmness of 1-MCP treated fruit at both temperatures. Similar results were found in Western NY fruit except that greater softening of 1-MCP treated fruit stored at 33 °F occurred during the shelf life, and over the storage period in fruit stored at 33 °F.

Champlain fruit had a slightly higher incidence of bitter pit in 1-MCP treated fruit (2.5%) than in untreated fruit (0%). Senescent breakdown was not affected by any factor. Rots were affected by 1-MCP treatment, but effects were inconsistent and affected by orchard – in one orchard it was higher, in another, lower, and a third orchard had no detectable rots. Scald was greatly affected by all factors, but overall was reduced by 1-MCP treatment (32%) compared with untreated (60%) and was higher at 33°F (69%) than at 38°F (22%).

Western NY fruit also developed a number of disorders. Rots were only affected by temperature. Senescent breakdown was not affected by treatment (P=0.059) although 1-MCP treated fruit had 0.6% compared with 4.5% in the untreated fruit. The incidence of scald was 74% and 31% in untreated and 1-MCP treated fruit respectively, but in this region scald was higher at 38°F (78%) than at 33°F (30%).

Empire

At harvest, firmness and IEC of fruit from the Hudson Valley (10/3/01) and Western NY (10/4/01) were 16.9 lb and 7.4 ppm, and 16.1 lb and 0.36 ppm, respectively.

After 9 months of storage, 1-MCP treated fruit were firmer than untreated fruit from both regions, storage periods and temperatures, and shelf-life periods (Table 3). Hudson Valley fruit were slightly firmer than Western NY fruit. Fruit from both regions were firmer at 33°F than at 38°F, and fruit at the higher storage temperature lost condition particularly after 4 months of CA storage. Treatment with 1-MCP reduced this loss of firmness, but fruit were softer at 38°F than at 33°F.

Decay incidence was a major factor in fruit from both growing regions, but was affected only by temperature: 5 and 20% for fruit stored at 33°F and 38°F (Western NY), respectively, and 10 and 38% for fruit stored at 33°F and 38°F (Hudson Valley), respectively. Core browning was also affected by temperature, being 32% at 38°F compared with 14% at 33°F in fruit from Western NY, although orchard factors also interacted – orchard 2 had low incidence at both temperatures. Core browning incidence was 9% and 24% at 33 and 38°F, respectively in fruit from the Hudson Valley.

Flesh browning was affected by 1-MCP treatment and temperature in fruit from both regions (Table 4). 1-MCP treatment markedly increased the incidence of flesh browning at 38°F.

External carbon dioxide injury was detected only in Western NY-grown fruit (2 out of 3 orchards). It was higher at 38°F (5.2%) than at 33°F (0.2%), but was not affected by 1-MCP treatment.

Senescent breakdown was found only in untreated Hudson Valley-grown fruit and only at 38°F (30%). 1-MCP and/or storage at 33°F prevented disorder development.

Table 1: Firmness of 'McIntosh' harvested in two regions and treated with air or 1ppm 1-MCP for 24 hours after overnight cooling of fruit. Fruit were evaluated after 4 and 10 months of storage at 33 and 38°F plus 1 or 7 days at 68°F.

Growing region	**Storage period (months)**	**Firmness (lb)**							
		33°F				**38°F**			
		-MCP		**+ MCP**		**-MCP**		**+ MCP**	
Champlain		***1 d***	***7 d***	***1 d***	***7 d***	***1 d***	***7 d***	***1 d***	***7 d***
	4	13.9	12.6	15.1	15.1	12.3	11.5	15.0	14.6
	10	13.0	11.0	14.5	13.2	11.0	10.2	14.5	11.6
	Average	*12.6*		*14.5*		*11.2*		*13.9*	
Western NY		***1 d***	***7 d***	***1 d***	***7 d***	***1 d***	***7 d***	***1 d***	***7 d***
	4	12.8	12.4	13.7	13.6	12.6	12.1	13.9	13.6
	10	12.0	10.9	13.2	12.4	12.0	10.5	13.6	11.7
	Average	*12.0*		*13.2*		*11.7*		*13.2*	

Table 2: Firmness of 'Cortland' harvested in two regions and treated with air or 1ppm 1-MCP for 24 hours after overnight cooling of fruit. Fruit were evaluated after 4 and 10 months of storage at 33 and 38°F plus 1 or 7 days at 68°F.

Growing region	**Storage period (months)**	**Firmness (lb)**							
		33°F				**38°F**			
		-MCP		**+ MCP**		**-MCP**		**+ MCP**	
Champlain		***1 d***	***7 d***	***1 d***	***7 d***	***1 d***	***7 d***	***1 d***	***7 d***
	4	13.2	10.7	14.6	14.8	12.6	11.4	14.1	14.4
	10	11.6	10.6	13.8	14.3	10.9	10.2	14.1	13.0
	Average	*11.5*		*14.4*		*11.3*		*13.9*	
Western NY		***1 d***	***7 d***	***1 d***	***7 d***	***1 d***	***7 d***	***1 d***	***7 d***
	4	12.9	11.8	14.5	13.9	12.4	11.8	13.8	13.9
	10	10.8	10.7	13.9	12.9	9.9	9.5	12.8	12.8
	Average	*11.5*		*13.8*		*10.9*		*13.3*	

Table 3: Firmness of 'Empire' harvested in two regions and treated with air or 1ppm 1-MCP for 24 hours after overnight cooling of fruit. Fruit were evaluated after 4 and 9 months of storage at 33 and 38°F plus 1 or 7 days at 68°F.

Growing region	**Storage period (months)**	**Firmness (lb)**							
		33 °F				**38 °F**			
		-MCP		**+ MCP**		**-MCP**		**+ MCP**	
Hudson Valley		***1 d***	***7 d***	***1 d***	***7 d***	***1 d***	***7 d***	***1 d***	***7 d***
	4	16.6	15.3	16.8	16.7	15.1	13.1	16.5	16.8
	10	15.0	14.2	16.3	16.8	8.9	7.9	14.5	12.7
	Average	*15.2*		*16.7*		*11.3*		*15.1*	
Western NY		***1 d***	***7 d***	***1 d***	***7 d***	***1 d***	***7 d***	***1 d***	***7 d***
	4	15.9	15.2	15.9	15.8	14.1	13.3	15.4	15.5
	10	14.6	14.1	15.0	15.3	11.4	10.2	14.3	13.2
	Average	*14.9*		*15.5*		*12.3*		*14.6*	

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Table 4: Flesh browning (%) in Empire apples from the Hudson Valley and Western NY either untreated or treated with 1-MCP and stored under CA conditions at 33 °F or 38°F for 10 months plus 7 days at 68°F.

	Hudson Valley		**Western NY**	
Storage temperature (°F)	**-MCP**	**+MCP**	**-MCP**	**+MCP**
33	6	2	12	14
38	0	54	21	41

Recommendations for storage of Honeycrisp

The development of soft scald (Fig. 1.) and the internal disorder, soggy breakdown (Fig.2), during storage continues to be a concern for this variety. A special issue of the New York Fruit Quarterly that will summarize all pre- and post-harvest research on the variety to date is being planned for summer 2003. However, the current recommendations are:

1. Do not allow fruit to become over-mature on the tree. The risk of soft scald increases greatly as fruit maturity advances.
2. Fruit should be stored at 38^{o}F in air storage because lower storage temperatures can result in development of off-flavors and a higher incidence of postharvest disorders, even in early harvested fruit. Where the risk is extremely high, e.g. very late harvest, even a higher storage temperature may not be effective in preventing disorder development.
3. Holding fruit for one week at 50^{o}F before they are moved to 38°F can minimize risk of soft scald development without loss of fruit quality. However, bitter pit development may be higher if fruit are susceptible.

Fig. 1. Soft Scald

Fig. 2. Soggy Breakdown

Reviewing Causes of Postharvest Decays in Apples

Dave Rosenberger

Postharvest decays in apples can be caused by many different fungi. Where decays have caused significant losses, corrective measures for the next season can be prescribed only after the cause of the decays has been identified.

The two most common postharvest pathogens on apples are *Penicillium expansum*, the cause of blue mold, and *Botrytis cinerea*, the cause of gray mold. Blue mold decay is very soft, watery, and has a musty or earthy odor and taste. Fruit with blue mold develop blue or bluish-white spore masses in the oldest part of the infections (Fig. 1). However, development of spores is suppressed in CA storage and may not become apparent until a week to 10 days after CA rooms are opened.

Fig. 1. Apple fruit decayed by *P. expansum* showing blue sporulation around the wound where the infection was initiated.

Penicillium expansum invades wounds on fruit or the abscission layer on fruit stems during or after harvest. In New York, the primary source of inoculum involves spores that are carried over from season to season on contaminated bins or on storage walls. (See the article on inoculum cycling in the 2001 Storage and Handling Newsletter <http://www.hort.cornell.edu/department/faculty/watkins/Newsletter2001.pdf>). These spores are effectively dispersed by postharvest drenches or by air movement in CA rooms when rooms are being filled or emptied. A high incidence of blue mold in fruit coming out of a long-term CA storage is an indicator that better sanitation will be needed to prevent similar losses in the future.

Fruit with gray mold often emerge from CA storage looking like baked apples (Fig. 2). They have a uniformly light tan skin, fairly firm flesh, and a cider-like odor. Fruit with gray mold may develop a cottony gray-white mass of mycelium at the wound site if the decay was initiated at a wound (Fig. 3). *Botrytis cinerea* can invade fruit at wounds created during or after harvest. However, *Botrytis* may also infect fruit in the field. In other crops such as strawberries and kiwi, researchers have shown that *B. cinerea* infects fruit during or shortly after bloom, then remains quiescent until fruit begin to ripen. We have noted that gray mold often seems to originate at the calyx ends of fruit (Fig. 2), a location that would be consistent with field infections of the calyx shortly after bloom. However, the existence or prevalence of such quiescent infections in apples has not been determined.

Fig. 2. Apple fruit decayed by *B. cinerea* showing the typical “baked apple” appearance.

Fig. 3. Apple fruit decayed by *B. cinerea* showing gray sporulation around the wound where the infection was initiated.

Postharvest treatment with thiabendazole plus diphenylamine are still very effective for controlling *B. cinerea*, but as noted earlier, postharvest drenches may contributed to a higher incidence of decays caused by fungicide-resistant strains of *P. expansum*. Little is known about weather conditions that might promote infection of fruit during late bloom or petal fall, so the incidence of quiescent gray mold infections is unpredictable. Most of our apple scab fungicides have little activity against *B. cinerea*, so routine sprays for apple scab will not necessarily prevent infections in the field. Mancozeb and SI fungicides (Nova, Rubigan, Procure) are completely ineffective for controlling *B. cinerea*. Captan is moderately effective for controlling *B. cinerea* in other crops such as strawberries, so using captan either alone or in combinations with SI fungicides during bloom and at petal fall might help to suppress calyx infections of *B. cinerea.*

Other postharvest diseases that can be initiated in the field prior to harvest include bitter rot caused by *Colletotrichum* species, white rot cause by *Botryosphaeria dothidea*, and black rot (Fig. 4) caused by *Botryosphaeria obtusa*. These same pathogens cause the summer fruit rots that sometimes appear in the orchard prior to harvest, especially in southeastern United States. Bitter rot, black rot, and white rot have accounted for as much as 41% of the postharvest decays in Empire fruit in some New York storages. However, in most cases these pathogens account for a relatively small percentage of postharvest decays.

The summer fruit rots cause the greatest postharvest losses in New York in years with hot, wet summers and/or years in which heavy rains in late August or September remove fungicide residues, thereby allowing fruit infections to occur during warm rainy periods in September. Fruit can become infected shortly before harvest, escape detection at harvest, and then develop into visible decays as the harvested fruit are cooled in storage rooms. These pathogens grow slowly at temperatures below 40° F, especially during the early stages of infection, so rapid cooling to below 40° F can prevent infected fruit from developing decays.

Fig. 4. Black rot fruit decay caused by *Botryosphaeria obtusa*. Fruit with black rot remain firm and sometimes develop bull's eye patterns with dark pycnidia in circular patterns radiating from the oldest part of the infection.

The fungi causing bitter rot, black rot, and white rot must be controlled by applying fungicides during the growing season. Fungicides applied as postharvest treatments do not eradicate infections of these field-initiated diseases. Benlate and Topsin M applied during late summer provide good control of black rot and white rot, but will not control bitter rot. Under conditions in northeastern United States, captan applied at rates of 2-3 lb active ingredient per acre at 10-day intervals can suppress bitter rot, although higher rates are needed for complete control under heavy disease pressure. Sovran and Flint control all three of these diseases and may be the best choice for late-summer sprays in blocks where the summer fruit rots have caused losses in previous years.

Development of New Postharvest Fungicides for Apples

Dave Rosenberger

For nearly 30 years, apples have been protected from *P. expansum* and *B. cinerea* by treating fruit after harvest with a benzimidazole fungicide (first with Benlate or Topsin M, now with Mertect 340F). Benzimidazole-resistant strains of *P. expansum* and *B. cinerea* were detected in storages several years after the fungicides were introduced in the mid-1970's. However, postharvest treatments continued to provide excellent control of these pathogens throughout the 1980's. Pathogens with resistance to benzimidazole fungicides showed increased sensitivity to diphenylamine (DPA) and were therefore controlled when benzimidazole fungicides and DPA where combined in postharvest drenches. Eventually, the repeated exposure of *P. expansum* to the DPA/benzimidazole combination selected for strains of this pathogen that were resistant to both components of the postharvest drench. Today postharvest treatment with the DPA/benzimidazole combination no longer controls *P. expansum* in many apple storages. Treatment solutions applied to fruit after harvest may actually spread spores and make the disease worse.

Fludioxonil is a new fungicide that is being developed and marketed by Syngenta under the trade name of 'Scholar.' Scholar has been used for several years under an emergency use label to control postharvest brown rot on stone fruits in California and New Jersey. Currently IR-4, the agency charged with developing data packages for minor-use registrations, is working with Syngenta to gather the data required for getting Scholar labeled on apples. A postharvest label for Scholar on apples may be issued in time for the 2003 harvest season, although it seems likely that New York State approvals for Scholar may not be available until 2004.

Scholar is a phenylpyrrole fungicide with a different mode of action than any of the other fungicides currently registered for apples. We evaluated fludioxonil in more than ten different trials over the past five years and found it extremely effective for controlling both benzimidazole-resistant and benzimidazole-sensitive isolates of *P. expansum* (Table 1). It is also effective for preventing stem-end invasion of fruit by *P. expansum* during long-term CA storage (Table 2). Registration of fludioxonil would provide packinghouses with an effective new tool for reducing losses to blue mold and gray mold during storage. It would also

help to reduce the incidence of decays that develop in packaged apples after they are shipped from the packinghouses to retail stores.

Scholar was priced at $38/oz in California during the 2001 growing season. Postharvest drenching of apples will require at least 8 oz of formulated product per 100 gallons of water. At that price and usage rate, the fludioxonil needed for a 1000 gallon tank of drench solution would cost about $3000. Current cost for a similar tank of thiabendazole (Mertect 340F) is only about one-tenth as much.

Will Scholar be cost-effective? The answer to that question depends largely on whether sanitation alone can provide adequate control of blue mold, and also on costs involved in implementing better sanitation. Scholar, if labeled on apples, would probably provide better control than could be achieved using sanitation alone. However, sanitation measures that reduce available inoculum for postharvest decays might prove more cost effective even if sanitation provided less than 100% control.

A number of biological controls are also being developed and promoted as options for controlling postharvest apple decays. Biological controls often qualify for fast-track approval by EPA, but an EPA registration does not mean that these products are actually effective in commercial practice. So far, all of the biological controls tested on apples under commercial conditions have been inconsistent and/or less effective than traditional fungicides such as Scholar. Biological controls may prove useful in the future as supplements for other fungicides, but there is still no evidence that biological controls will displace the need for traditional fungicides and/or postharvest sanitation in apple storages and packinghouses.

Table 1. Effectiveness of Mertect 340F (thiabendazole) and Scholar (fludioxonil) for controlling *Penicillium expansum* in Empire apples that were harvested in 1999, uniformly wounded, inoculated with a 1:1 mixture of benzimidazole-resistant and benzimidazole-sensitive spores, and held in air storage for the intervals indicated.

Material and rate of formulated product per 100 gal*	% apples with decay following incubation for: 45 days	90 days	115 days
Control	55 b**	100 b	100 c
Mertect 340F 8 fl oz	59 bc	100 b	100 c
Mertect 340F 16 fl oz	65 c	100 b	100 c
Scholar 50W 4 oz	0 a	1 a	4 b
Scholar 50W 8 oz	0 a	<1 a	1 ab
Scholar 50W 16 fl oz	0 a	0 a	<1 a

* Diphenylamine at 1000 ppm (Shield Liquid DPA 86.5 fl oz/100 gal) was added to all treatments.

** Mean separations: Fisher's Protected LSD, P 0.05. The angular transformation was used for statistical analyses.

Table 2: Effectiveness of various fungicides for controlling stem-end infections of Empire apples during CA storage.

Material and rate of formulated product per 100 gal*	% fruit with *Penicillium* sporulating on the stem: 26 June	3 July	% fruit with stem-end decay: 26 June	3 July
Control	32 b**	34 b	8 c	8 b
Captan 50W 2.5 lb	16 b	19 b	2 ab	5 b
Mertect 340F 16 fl oz	27 b	28 b	6 bc	9 b
Scholar 50W 8 oz	0 a	0 a	0 a	0 a

*Shield Liquid DPA at 1000 ppm was included in all treatments. Non-wounded fruit were dipped into fungicide solutions that also contained 50,000 conidia/ml of a benzimidazole-resistant isolate of *Penicillium expansum.* Fruit were harvested and treated on 1 Oct. 2001, were held in a commercial CA room from 7 Oct 2001 to 30 May 2002, were held in air storage at 34 F until 26 June, and were then held for an additional 7 days at 60-70 F prior to the final evaluation on 3 July

**Mean separations were determined using Fisher's Protected LSD (P 0.05).

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