18. Root, D.A. 1971. Effect of undercutting and wrenching on growth of *Pinus radiata* D. Dan. seedlings. J. Appl. Ecol. 477–490.
19. Sharma, D.P. 1974. Effects of pesticides on photosynthesis of apple (*Malus sylvestris* Mill.). PhD Thesis, Ohio State Univ. Columbus, Ohio.
20. Short, K.C. and J.G. Torrey. 1972. Cytokinins in seedling root of pea. Plant Physiol. 49:155–160.
21. Stansell, J.R., B. Kleppe, V. Browning, and H.M. Taylor. 1974. Effect of root pruning on water relations and growth of cotton. Agron. J. 66:591–592.
22. Wilcox, H. 1955. Regeneration of injured rootsystems in Noble fir. Bot. Gaz. 116:221–234.

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Quality of *Euvitis* Hybrid Bunch Grapes after low Temperature Storage with Sulfur Dioxide Generators

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Additional index words. table grapes, sulfur dioxide injury, appearance, flavor, decay

Abstract. **Eighteen lines of *Euvitis* grapes in 1980, and 30 in 1981, were stored for 9 weeks at 0°C in 5.7-liter telescoping, corrugated cardboard shipping containers with polyethylene liners, with and without commercially available sulfur dioxide (SO_2) generators (1 in 1980; 2 in 1981). Decay during storage without SO_2 varied greatly among lines (2% to 81% in 1980 and 0% to 62% in 1981). The generator producing SO_2 for the entire 9 weeks in 1981 eliminated decay of most grape lots. By comparison, the generators producing SO_2 for only 2 weeks permitted 4 times as much decay. Two weeks of SO_2, however, permitted only one-fifth as much decay as that associated with no SO_2 during storage. Both generators reduced degradation of appearance and flavor of the grapes. The long-term generator was associated with more SO_2 damage to the fruit than was the short-term generator. The lines varied widely in tolerance to SO_2. SO_2 damaged the fruit by entering openings in their surfaces caused by stem tears and cracks.**

In recent years, efforts by grape breeders in the eastern United States have been directed toward development of high quality, high-yielding fresh market grapes comparable in quality to table grapes from other sources. For these grapes, including *Euvitis* hybrids, to be marketed competitively, high quality fruit must be available on the marketplace for a period of at least 2 months.

The storage life of other types of grapes has been lengthened appreciably by the use of low temperature storage and exposure to SO_2 so that decay is minimized and quality degradation is slowed (1, 4, 5, 6, 7, 8, 9, 10). Excellent reviews of the subject are available (2, 3).

The objective of this study was to determine the influence of low temperature storage and SO_2 generators upon the storage quality of *Euvitis* hybrid grapes.

Materials and Methods

The tests included fruit of 18 lines in 1980 and 30 lines in 1981 of *Euvitis* hybrid cultivars from Arkansas, Florida, and New York, plus selections originating from the grape breeding program of the N.C. Agricultural Research Service (Tables 1, 2). These *Euvitis* lines included green/yellow, red, and dark-blue grapes grown at the Central Crops Research Station located at Clayton, N.C.

Two types of commercially-available Grape Guard sheets (Uvas Quality Packaging, Inc., P.O. Box 369, Antioch, CA 94509) were used to generate CO_2: (A) Quick Release sheets (released SO_2 for 2 weeks) which were 20 × 40 cm sheets of craft paper coated with a SO_2 emmitter on one side; and (B) Combination sheets (releasing SO_2 for 10 weeks) which were Quick Release sheets attached to Slow Release sheets (2 pieces of 20 × 40 cm paper each lined with a thin film of plastic and joined together on the plastic sides to provide a number of pockets containing a crystalline SO_2 emitter).

All grapes were harvested from late July to mid-August, early in the morning. An effort was made to select ripe, but not overripe grapes. After transport to Raleigh, uniform clusters of grapes were selected and placed on 39 × 46 × 3 cm fiberglass trays. Split, decayed, or otherwise visibly low quality berries were cut from each cluster.

Storage units were 5.7-liter (12 pint) shipping flats (corrugated cardboard, telescoping top, blueberry type). Each flat was fitted initially with a 76 × 122 cm, 2-mil polyethylene sheet. The cardboard divider/supporter was recut to form a cross, thus dividing the flat into 4 equal chambers. About 1.2 kg samples of each of 4 grape lines were placed in each flat. Except for the "control" flats, one appropriate Grape Guard sheet was placed in the center of the top of each shipping flat. The exposed emulsion side of the Quick Release as well as of the Combination Grape Guard sheets was placed up, away from the surface

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Table 1. Ratings of appearance and flavor, plus percentage of decay of *Euvitis* grapes stored for 9 weeks at 0°C with and without a sulfur dioxide generator in 1980.[z]

Grape	Appearance[y]			Flavor[x]			Incidence of decay (% by no.)[w]	
		After storage			After storage			
	Before storage	SO_2 treatment[v] 0	QRG	Before Storage	SO_2 treatment[v] 0	QRG	SO_2 treatment[v] 0	QRG
ARK 118	1.0	3.5	3.5	1.0	1.0	1.0	69	1
ARK 1163	2.0	3.5	2.5	1.0	1.0	1.0	42	13
ARK 1600	1.0	4.0	1.5	2.0	2.0	2.0	47	5
Canadice	2.0	4.0	2.5	2.0	2.3	2.0	45	7
FLA 9-68	3.0	4.0	4.0	2.0	4.0	2.0	80	28
Glenora	3.0	4.0	3.0	3.0	3.0	3.0	37	1
Lakemont	2.0	4.0	3.5	1.0	1.0	1.0	72	12
Moored	2.0	2.0	2.0	1.0	1.0	1.0	2	1
NC 655048-13	1.0	4.0	4.0	1.0	3.4	1.0	78	24
NC 74B029-9	2.0	3.6	3.3	1.0	2.2	1.0	49	3
NC 74B030-14	2.0	3.7	2.0	1.0	1.0	1.0	7	1
NC 74B030-22	1.0	3.5	3.5	3.0	3.0	3.0	18	2
NC 74B030-48	4.0	4.0	4.0	1.0	4.0	1.0	81	21
NC 74C039-1	3.0	4.0	4.0	3.0	4.0	3.0	69	17
Romulus	1.0	4.0	1.0	1.0	1.0	1.0	37	1
Suffolk-Red	2.0	4.0	3.3	1.0	1.0	1.0	20	3
Venus	1.0	4.0	3.7	1.0	1.0	1.0	56	0
NC 67B040-84	1.0	4.0	3.3	1.0	1.0	1.0	10	0
Mean	1.9	3.8[u]	3.1 b	1.5	2.1 a[u]	1.5 b	46 a[u]	9 b
LSD 0.05 Grape × SO_2 treatment		0.6			0.6		15.5	

[z] Ratings made before storage were not replicated; ratings for "after storage" as well as for percentage of decay were averages for 4 replications.
[y]Appearance ratings: 1 = excellent; 2 = good; 3 = fair; 4 = unacceptable.
[x]Flavor ratings: 1 = good; 2 = flat or average; 3 = off or poor; 4 = unacceptable.
[w]Decay noted after storage.
[v]SO_2 treatments: 0 = no treatment; QRG = Quick Release Grape Guard.
[u]Means within a data set not followed by the same letter are significantly different at the 5% level (LSD).

of the grapes. The polyethylene sheet ends then were folded over the top of the flat, and the flat was lidded. The completed storage units (flats) were held for 9 weeks at 0°C and 70% to 80% RH.

In 1980, 18 *Euvitis* lines were exposed to 2 SO_2 treatments (control and Rapid Release Grape Guard sheets) in 4 replications (completely randomized block design). In 1981, 30 *Euvitis* lines were exposed to 3 SO_2 treatments (control, Rapid Release and Combination Grape Guard sheets) in 4 replications (completely randomized block design). The total number of experimental units was 144 in 1980 and 360, in 1981. "Filler" grapes were added to flats containing less than 4 experimental samples to maintain the same fruit volume in each flat.

Before storage, each line of grapes was rated for overall appearance (1 = excellent; 2 = good; 3 = fair; and 4 = unacceptable) and flavor (1 = good; 2 = flat or average; 3 = off or poor; and 4 = unacceptable). No decay was detected, since decayed fruit had been removed before the evaluations were made.

After removal from storage, each line of grapes was rated by a research analyst for appearance and flavor. The total number of berries and number of berries exhibiting decay in that cluster were used to calculate the percentage of decay (by number). Decay was indicated either by visual presence of fungal fruiting bodies on the surface of the berries or by deterioration of the skin. The number of berries exhibiting visible SO_2 damage and the total berry number were used to calculate the percentage of damage (by number) due to SO_2. The data were subjected to analysis of variance.

Results and Discussion

1980 test. The appearance of grapes in all lines except 'Moored' and NC 74B030–48 (for which there was no change) degraded during storage without SO_2. (Table 1). The latter line was judged unacceptable before storage. Grapes of ARK 1163, ARK 1600, 'Canadice', NC 74B030–14, and 'Romulus' benefitted from the SO_2 treatment.

The flavor of grapes of FLA 9–68, NC 655048–13, NC 74B029–9, NC 74B030–48, and NC 74C039–1 deteriorated in storage without SO_2. Only these 5 lines benefitted from the SO_2 treatment. Overall, flavor deteriorated less than appearance during storage.

Without the use of SO_2, the 1980 grapes developed an average of 46% decay; only 3 lines had decay <10%; 2 lines had >80%. When SO_2 was used, decay averaged only 9%; 2 lines had no decay; 5 lines had only 1%, 2 lines had 3%, and 11 lines had 5%. ARK 1600 and 'Moored' were the only lines of grapes that exhibited SO_2 damage after storage with SO_2 generators in 1980, 10% and 1%, respectively, (data not shown). The data indicated that the 2-week exposure to SO_2 was not adequate for long-term (9 weeks) storage of 7 lines of grapes.

1981 test. The appearance of grapes in all lines degraded to an "unacceptable" or nearly unacceptable level in storage with

Table 2. Ratings of appearance and flavor, plus percentage of decay of *Euvitis* grapes stored for 9 weeks at 0°C with and without a sulfur dioxide generator in 1981.[z]

	Appearance[y]				Flavor[x]				Incidence of decay (% by no.)[w]			Incidence of SO_2 damage (% by no.)[v]	
		After storage SO_2 treatment[u]				After storage SO_2 treatment[u]			SO_2 treatment[u]			SO_2 treatment	
Grape	Before storage	0	QRG	CG	Before storage	0	QRG	CG	0	QRG	CG	QRG	CG
ARK 1105	1.0	4.0	4.0	1.0	1.0	1.0	1.0	1.0	27	1	0	11	12
ARK 1118	1.0	4.0	3.0	1.0	2.0	2.0	2.0	2.0	20	0	0	0	1
ARK 1346	1.0	3.5	2.7	1.0	1.0	1.0	1.0	1.0	2	0	0	1	2
ARK 1380	1.0	4.0	4.0	1.0	1.0	1.0	1.0	1.0	11	4	0	0	0
ARK 1393	2.0	4.0	4.0	2.0	1.0	2.0	2.0	2.0	21	1	0	0	0
ARK 1415	1.0	4.0	4.0	1.0	1.0	1.0	1.0	1.0	26	3	0	0	0
ARK 1508	1.0	4.0	4.0	1.0	1.0	1.0	1.0	1.0	10	0	0	0	0
Canadice	4.0	4.0	4.0	3.7	1.0	2.0	1.0	1.0	23	12	2	0	0
Century I	1.0	4.0	4.0	1.0	1.0	4.0	1.0	1.0	41	0	0	1	7
FLA 9-68	4.0	4.0	4.0	4.0	1.0	4.0	1.0	1.0	62	33	10	0	0
Glenora	3.0	4.0	3.0	3.0	3.0	3.0	3.0	3.0	18	23	0	0	0
Lakemont	2.0	4.0	4.0	2.0	1.0	1.0	1.0	1.0	12	1	0	16	1
Moored	2.0	3.0	2.0	2.0	1.0	2.0	1.0	1.0	0	0	0	0	0
NC 645091-9	2.0	4.0	4.0	2.0	1.0	1.0	1.0	1.0	5	2	0	0	1
NC 655048-13	1.0	4.0	4.0	2.3	1.0	1.0	1.0	1.0	41	16	0	0	11
NC 66B149-29	1.0	4.0	4.0	1.0	1.0	1.0	1.0	1.0	16	4	0	0	9
NC 72B021-58	2.0	3.0	2.0	2.0	1.0	1.0	1.0	1.0	0	0	0	0	0
NC 72B021-99	2.0	4.0	4.0	2.0	1.0	1.0	1.0	1.0	7	3	0	1	0
NC 73C027-2	4.0	4.0	4.0	4.0	3.0	3.0	3.0	3.0	29	6	3	0	5
NC 74B025-19	1.0	4.0	4.0	1.0	1.0	1.0	1.0	1.0	48	1	0	0	1
NC 74B025-21	3.0	4.0	4.0	3.0	1.0	1.0	1.0	1.0	27	2	0	0	1
NC 74B026-18	2.0	4.0	4.0	4.0	1.0	2.5	1.0	1.0	0	0	0	0	28
NC 74B029-9	1.0	4.0	4.0	1.0	1.0	1.0	1.0	1.0	13	0	0	3	3
NC 74B030-14	1.0	4.0	4.0	1.0	1.0	1.0	1.0	1.0	4	1	0	1	0
NC 74B030-22	2.0	4.0	3.3	2.0	1.0	1.0	1.0	1.0	4	3	0	5	5
NC 74B030-48	1.0	4.0	3.5	1.0	1.0	1.0	1.0	1.0	21	2	0	3	7
NC 74C039-1	2.0	3.5	2.7	2.0	3.0	3.5	2.0	2.0	9	2	0	0	0
Ramley	1.0	4.0	3.5	1.0	1.0	1.0	1.0	1.0	4	2	0	5	2
Suffolk-Red	2.0	3.5	2.3	2.0	1.0	1.0	1.0	1.0	8	0	0	0	0
Venus	1.0	4.0	3.0	1.5	2.0	2.0	1.5	2.0	12	1	0	2	4
Mean	1.8	3.9 a[t]	3.6 b	1.8 c	1.3	1.7 a[t]	1.2 b	1.2 b	17 a[t]	4 b	1 c	2 b[t]	4 c
LSD 0.05 Grape × SO_2 trt.			0.61				0.61			17		4	

[z]Ratings made before storage were not replicated; ratings for "after storage" as well as for percentage of decay were averages for 4 replications.
[y]Appearance ratings: 1 = excellent; 2 = good; 3 = fair; and 4 = unacceptable.
[x]Flavor ratings: 1 = good; 2 = flat or average; 3 = off or poor; and 4 = unacceptable.
[w]Decay noted after storage.
[v]SO_2 damage noted after storage.
[u]SO_2 treatments: 0 = no treatment; QRG = Quick Release Grape Guard; CG = Combination Grape Guard.
[t]Means in a data set not followed by the same letter are significantly different at the 5% level (LSD).

no SO_2 in 1981 (Table 2). Only 9 lines of grapes benefitted from the use of the Quick Release Grape Guard, while 26 lines benefitted from the use of the Combination Grape Guard; use of the Combination Grape Guard, compared to storage with no SO_2, improved appearance for 12 lines from "unacceptable" to "excellent".

The flavor of ARK 1393, 'Canadice', 'Century I', FLA 9–68, 'Moored', NC 74B026–18, NC 74C039–1, and 'Venus' deteriorated during storage with no SO_2. Use of the Quick Release or the Combination Grape Guard was associated with the deterioration of only one line, ARK 1393.

Decay, in the abscence of SO_2 in 1981, ranged from 0% ('Moored') to 62% (FLA 9–68) with an average of 17%. Only 8 lines had < 5% decay. With the use of the Quick Release Grapeguard, 25 of the 30 lines had < 5% decay. The combination Grape Guard was associated with decay in only 3 lines: 'Candice' (2%), FLA 9–68 (10%), and NC 73C027–2 (3%). Thus, SO_2 released throughout the 9–week storage period was extremely effective in reducing grape decay.

Sulfur dioxide damage resulted from the use of both Grape Guard types in 1981. Quick Release Grape Guards damaged 11 of the 30 lines; damage for individual lines ranged from 1% to 16%. Combination Grape Guards damaged 17 of the 30 lines; damage ranged from 1% to 28% of the fruit. A wide range of response of grape types to SO_2 damage was observed. Damage generally occurred wherever there was exposure of internal grape tissue to the gas (torn stem scars, cracks, tears, etc.). Damage was characterized by bleaching of color of the skin of the affected area. In most cases, SO_2 injury was accompanied by a SO_2 flavor of the tissues.

Euvitis bunch grapes responded more favorably to SO_2 treatments than did *V. rotundifolia* Michx. grapes (1). *Euvitis* grapes had reduced decay and tissue damage resulting from the presence of SO_2. These studies indicated that those *Euvitis* lines that maintain good attachment of stems to the fruit during handling would store well for 9 weeks at 0°C when full-term SO_2 generators are used.

Literature Cited

1. Ballinger, W.E. and W.B. Nesbitt. 1982. Quality of muscadine grapes after storage with sulfur dioxide generators. J. Amer. Soc. Hort. Sci. 107(5):827–830.
2. Ginsburg, L., J.C. Combrink, and A.B. Truter. 1978. Long and short term storage of table grapes. Intl. J. Refrig. 1:137–142.
3. Harvey, J.M. and M. Uota. 1978. Table grapes and refrigeration: fumigation with sulfur dioxide. Intl. J. Refrig. 1:167–171.
4. Lutz, J.M. and R.E. Hardenburg. 1968. The commercial storage of fruits, vegetables, and florist and nursery stocks. USDA Agr. Handbk. No. 66.
5. Nelson, K.E. and M. Ahmedullah. 1972. Effect of in-package sulfur dioxide generator and packaging materials on quality of stored grapes. Amer. J. Enol. Viticult. 23:78–85.
6. Nelson, K.E. and M. Ahmedullah. 1976. Packaging and decay-control systems for storage and transit of table grapes for export. Amer. J. Enol. Viticult. 27:74–79.
7. Pentzer, W.T., C.E. Abur, and K.C. Hamner. 1932. Effects of fumigation of different varieties of *Vinifera* grapes with sulfur dioxide gas. Proc. Amer. Soc. Hort. Sci. 29:339–344.
8. Pentzer, W.T., C.E. Asbury, and K.C. Hamner. 1933. The effect of sulfur dioxide fumigation on the respiration of Emperor grapes. Proc. Amer. Soc. Hort. Sci. 30:258–260.
9. Safran, B. 1977. The behavior of conventional table grape varieties. Proc. Commission C2, Intl. Inst. Refrig., and Commissions I and III, Intl. Vine and Wine Office, Paris, France.
10. Smit, C.J.B., L. Cancel, and T.O.M. Nakayama. 1971. Refrigerated storage of muscadine grapes. Amer. J. Enol. Viticult. 22:227–230.

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The Effect of European Red Mite Feeding on the Fruit Quality of 'Miller Sturdeespur' Apple

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Abstract. **Trees of *Malus domestica* (Borkh.) 'Miller Sturdeespur' were hand thinned to achieve light, medium, and heavy fruit loads. A heavy European red mite (ERM), *Panonychus ulmi* (Koch), infestation was encouraged by mite seeding and predator elimination in half the trees for each fruit load. The effect of these treatments were determined on fruit number, number and percentage of drops, fruit size, color, soluble solids, titratable acidity, pH, firmness, and percentage of foliar concentration for 5 macronutrients. Mite feeding increased the percentage of drop and reduced red pigmentation, soluble solids, and leaf phosphorus and calcium. Deleterious effects of mite feeding increased with increasing fruit load. With light fruit loads, heavy mite feeding had a negligible effect on fruit quality.**

Previous mite-apple research has concentrated on the effects of mite feeding from a quantitative point of view; e.g., harvest, fruit size, trunk girth, terminal shoot growth, and leaf chlorophyll content (1, 3, 4, 9, 11, 13, 22). Although mite effects on fruit quality have been scrutinized individually (1, 11, 22), a broad range of fruit qualities — firmness, color, percent soluble solids, titratable acid content, and pH — has yet to be addressed in a single, comprehensive experiment.

The effects of tree fruit load on fruit quality and quantity have been examined thoroughly (2, 5, 8, 12, 14, 15, 18, 21), and routine cultural practices include thinning to insure optimum quality fruit. However, the effects of mites at different fruit load levels, which could have an impact on management decisions, have not been investigated adequately. The current research addressed the interactive effects of mite feeding and fruit load on fruit quantity and quality.

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Materials and Methods

Twenty-four 'Miller Sturdeespur' trees on clonal rootstocks MM 104, MM 106, and MM 111 were chosen from a 12-year-old block at the Univ. of Arkansas Fruit Substation at Clarksville. Two plots, each with 12 trees, were selected for uniformity of size, canopy density, and fruit load via the previous year's foliar and harvest data. The plots were separated by a buffer zone of approximately 33 m, to minimize the chance of spray drift or mite dispersal between the 2 plots.

In late April of 1982, all 24 trees were hand-thinned to attain light, medium, or heavy fruit loads. The heavy-load trees were left unthinned, the medium-load trees were thinned to leave 50% of the spurs with one or 2 fruit per spur, and the light-load trees were thinned to leave 25% of the spurs fruiting with one or 2 fruit per spur. Each of the 2 plots (high-mite and low-mite plots) contained 4 trees thinned to each of the 3 fruit load levels.

Several methods were used to obtain the desired mite levels and to keep the trees free of disease and insect damage. In the