difficult to harvest mechanically can be picked more easily and with less damaged fruit than unsprayed vines. Undesirable side effects such as defoliation did not occur in any Florida tests, but premature berry drop can be serious within 30 hr after applying ethephon (4). For this reason, harvest should be scheduled the day after spraying. Experience has shown that rainfall after spraying nullifies the ethephon abscission effect.

Spraying of ethephon on grapevines is not yet cleared by the Environmental Protection Agency for grower use on muscadine grapes.

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EFFECT OF AMINOETHOXYVINYLGLYCINE, CARBOXYMETHYLCELLULOSE AND GROWTH REGULATORS ON LONGEVITY OF FRESH RABBITEYE BLUEBERRIES

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Additional index words. L-2-amino-4-(2-aminoethoxy)-*trans*-3-butenoic acid hydrochloride, ethylene inhibitors, bioregulators, coating mixture, sodium carboxymethylcellulose, CMC, ethephon, daminozide, blueberry storage, texture, quality, *Vaccinium ashei*.

Abstract. **Rabbiteye blueberries** [Vaccinium ashei **Reade cvs. 'T-19' (E. C. Lott) and 'Tifblue'] sprayed before harvest with daminozide [butanedioic acid mono(2,2-dimethlhydrazide)] and/or ethephon at specific stages of berry development and placed in storage at 3°C and 95-100% relative humidity effectively maintained storage quality for 2 1/2 months—a prolongation of their market life. The waxy bloom, which is characteristic of freshly harvested blueberries, was retained throughout storage. Berries with the daminozide/ethephon treatment retained firmness especially well during storage.**

Berries that had been sprayed twice before harvest with ethephon and coated after harvest with a mixture of carboxymethylcellulose, gum tragacanth and citric acid retained firmness and acidity better than berries similarly coated but not sprayed, and berries that had been neither sprayed nor coated.

Immediately after harvest, treating both sprayed and control berries with L-2-amino-4-(2-aminoethyxy)-trans-3-butenoic hydrochloride (AVG) as a dip improved firmness and color retention during storage. Even after 7 months of storage, as much as 62% of the dipped berries appeared fresh and marketable. This marked increase in marketable life of blueberries may mean that AVG, an inhibitor of ethylene, retarded ethylene-induced senescence. Doubling the concentration of AVG from 1000 to 2000 ppm increased the percentage of marketable fruit.

The rabbiteye blueberry (*Vaccinium ashei* Reade), which is native to the southeastern United States, is a cash crop in rural areas of the South. It is one of 3 types of blueberries that are grown commercially.

Since most Southern blueberries are sold in the fresh market, their perishability is a concern. Blueberries have a much shorter shelf life than most other fresh fruits (11); yet, knowledge on ways to prolong their storage life, by use of appropriate packaging, storage conditions and growth regulators, is limited (6, 7). Presently, commercial storage life of blueberries is approximately two weeks.

Studies of various crops have shown that retardation of senescence and deterioration is associated with inhibited respiration and ethylene production (1, 5, 18). Ripening inhibitors prolong the storage life of fruit. Daminozide suppresses ethylene production and delays ripening (14, 15, 16). Also, aminoethoxyvinylglycine (AVG) inhibits ethylene production in pears and other plant tissue, and increases the longevity of various cut flowers (3, 4, 13, 19, 20, 21).

No work has been done to test whether the application of ethylene inhibitors to rabbiteye blueberries would increase their longevity. Previously, I found that a CMC mixture (carboxymethylcellulose, gum tragacanth and citric acid) was effective in retarding the deterioration of frozen rabbiteye blueberries (8). I now report the results of a study I undertook to determine:

1) the effect of preharvest applications of daminozide and/or ethephon on the storage life of the berries;
2) whether the ethylene inhibitor, AVG, applied after harvest, would effectively delay senescence and extend the longevity of fresh berries;
3) whether CMC coated on blueberries would retard their deterioration during storage and extend their life; and
4) whether the chemicals applied on the berries would interact to affect their keeping quality.

Materials and Methods

Plot design and details of growth regulator applications are described in previous papers (6, 9). The rabbiteye blueberry plants, 'T-19' (E. C. Lott) and 'Tiftblue', were grown commercially in Alma, Georgia. Three spray treatments were compared: 1) no spray application (control), 2) one application of 500 ppm ethephon on May 20 plus another

[1]I thank Dr. A. Stempel of the Research Division, Hoffman-LaRoche, Inc., Nutley, New Jersey, for the gift of L-2-amino-4-(2-aminoethoxy)-*trans*-3-butenoic acid hydrochloride. Mention of bioregulators in this paper does not constitute a recommendation for use by the U. S. Department of Agriculture.

on June 23 (2X ethephon) and 3) one application of 500 ppm daminozide on May 20 plus one of 500 ppm ethephon on June 3 (daminozide + ethephon). Immediately after harvest on June 15, 1977, a one-pint sample from each of 4 replicates was analyzed for various quality characteristics (6, 9): size, color, texture, titratable acidity, pH and soluble solids (Table 1). The remaining berries were divided into groups; and these were given different postharvest treatments: 1) no treatment, 2) coated with CMC mixture (see below), 3) dipped in 0.05% Tween-20 (wetting agent) for 3 min and 4) dipped in 0.05% Tween-20 plus 1,000 or 2,000 ppm AVG for 3 min. The groups are identified according to treatments in Table 1.

The CMC coating mixture for 100 lb of berries consisted of 0.25 lb dry sodium carboxymethylcellulose (CMC), 0.1 lb tragacanth gum and 0.025 lb citric acid. The CMC was of high viscosity, was acid-stable and was of a food-approved grade (10). All the hydrocolloids were obtained from commercial sources. The CMC mixture was sprinkled gradually over the berries while they were tumbled in an open bowl. Tumbling was controlled so that the berries were uniformly coated without any damage. Dipping solutions of Tween-20 and Tween-20 plus AVG (as its hydrochloride) were prepared with distilled water.

Twelve pints of 'T-19' and 'Tifblue' blueberries were used for each postharvest treatment, and after treatment, the berries were weighed, placed in commercial 1-pint cartons of molded paper pulp, film capped, and stored at 3°C and 95+% relative humidity. Berries were weighed again upon removal from storage.

Evaluation of keeping quality

The berries were periodically examined during storage. After 75 days, most of them were removed, equilibrated to room temperature and analyzed for their quality characteristics as before. Also, berries were separated into two classes: marketable—those that were attractive, firm and apparently sound—and deteriorated—those that were visibly moldy (decay), shriveled, and leaky (either naturally or when rolled between the fingers). The berries in the two classes were weighed and the weights were expressed as normalized percentages of the original weight before storage.

The rest of the berries were removed after 7 months, examined and separated as marketable and deteriorated.

Results and Discussion

Effects of preharvest sprays on blueberry storage quality

The quality characteristics of the blueberries directly after harvest are reported in Table 2. The important quality characteristic of blueberries—the natural waxy bloom which gives them a freshly harvested appearance—was mostly retained after 75 days' storage by the 'T-19' and 'Tifblue' fruit sprayed with daminozide and/or ethephon, but not by the control berries. The Hunter negative b values, which measure blueness, were significantly higher for the sprayed berries than for the control (Tables 3, 4). All the positive a values, which measure redness, decreased during storage. The b/a values of the stored fruit increased, and were higher for the sprayed berries than for the control. In

Table 1. Grouping of blueberries (A-J) according to treatments.

Cultivar and preharvest treatment	Postharvest treatment: None	CMC coating	Tween-20 dip	Tween-20 + 1,000 ppm AVG	Tween-20 + 2,000 ppm AVG
T-19					
Control	A	E	F	G	H
2 X Ethephon	B	D		I_1	I_2
Daminozide + ethephon	C				J
Tifblue					
Control	A′	E′	F′	G′	H′
Daminozide + ethephon	C′				

Table 2. Influence of daminozide and/or ethephon on size, color, firmness and chemical characteristics of 'T-19' and 'Tifblue' rabbiteye blueberries at harvest, June 15, 1977.[z]

Cultivar & treatment groups	Number of berries/ 100g	Hunter Color Values[y] L	a	b	b/a	Texture (puncture-force in g-cm X 10^3)	pH	Soluble solids (%)	Titratable acidity[x] (%)
T-19									
A Control	62.00	20.85b	+0.34a	−3.13c	− 9.20c	3.24c	3.34	13.50b	0.80a
B 2 X Ethephon	64.00	20.90b	+0.35a	−3.71b	−10.60b	3.60b	3.36	13.90b	0.76b
C Daminozide + ethephon	62.50	21.70a	+0.35a	−4.00a	−11.43a	3.95a	3.43	15.60a	0.70c
Tifblue									
A′ Control	70.00	20.70b	+0.38a	−3.20b	− 8.42b	2.98b	3.20a	15.40b	0.82a
C′ Daminozide + ethephon	71.50	21.65a	+0.39a	−3.85a	− 9.87a	3.70a	3.28a	16.60a	0.73b

[z]Means within a column followed by different letters are significantly different (Duncan's multiple range tests, 5% level).
[y]Hunter L, a, b terms: L, defines lightness or darkness; a, measures redness-greeness; and b, describes yellowness-blueness.
[x]As percent citric acid.

Table 3. Influence of aminoethoxyvinylglycine (AVG), daminozide and/or ethephon, and CMC on color, firmness, chemical characteristics and storage life of 'T-19' rabbiteye blueberries after 75 days at 3°C and 95+% relative humidity, September 1977.[z]

Cultivar and treatment groups	Hunter Color Values[y]				Texture (puncture-force in g-cm X 10^3)	pH	Soluble solids (%)	Titratable acidity[x] (%)	Deteriorated fruit (%)	Marketable fruit (%)
	L	a	b	b/a						
T-19										
A Control	17.49b	+0.16a	−2.50c	−15.56c	2.47c	3.47	13.90b	0.48b	28.14	65.60c
B 2 X Ethephon	19.59a	+0.16a	−3.15a	−19.69a	2.68b	3.34	13.93b	0.64a	7.51	86.19a
C Daminozide + ethephon	20.24a	+0.17a	−3.60a	−21.18a	3.07a	3.44	15.55a	0.63a	3.50	92.10a
D 2 X Ethephon + CMC	19.10a	+0.17a	−2.90b	−17.10b	3.23a	3.39	13.13b	0.65a	7.16	88.48a
E Control + CMC	20.32a	+0.16a	−2.91b	−18.19b	2.80b	3.49	13.60b	0.49b	17.81	76.40b
F Control + Tween-20	16.66c	+0.19a	−2.42c	−10.07d	2.40c	3.37	13.40b	0.53b	35.40	58.10d
G Control + Tween-20 + 1000 ppm AVG	18.19b	+0.22a	−2.69b	−12.23c	2.69b	3.40	12.63c	0.52b	18.32	79.68c
H Control + Tween-20 + 2000 ppm AVG	18.69b	+0.20a	−2.82b	−14.10b	2.77b	3.50	13.20b	0.46b	10.20	85.80b
I_2 2 X Ethephon + Tween-20 + 2000 ppm AVG	18.93b	+0.20a	−2.94a	−14.70a	2.76b	3.34	13.70b	0.60a	4.30	92.20a
J Daminozide+ ethephon + Tween-20 + 2000 ppm AVG	19.53a	+0.20a	−3.03a	−15.15a	3.37a	3.40	14.68a	0.62a	2.00	95.00a

[z]Means within a column followed by different letters are significantly different (Duncan's multiple range tests, 5% level).
[y]Hunter L, a, b terms: L, defines lightness or darkness; a measures redness-greeness; and b, describes yellowness-blueness.
[x]As percent citric acid.

addition the L values, which measure lightness or darkness, indicated that the control berries were considerably darker than the sprayed berries (Tables 3, 4). Lightness of the sprayed berries was partly attributed to a reduction of polyphenoloxidase activity in those berries (12).

Firmness of berries stored for 75 days was greatly influenced by preharvest growth regulator treatments. The daminozide/ethephon treatment was the more effective, drastically suppressing the rate of softening of stored berries (Tables 3, 4). Acidity was maintained better in the sprayed 'T-19' berries than in the control during storage. Acidity was lower in sprayed fruit before storage (Table 3). After storage, acidity was maintained better in sprayed 'T-19' than in control; however, there was no difference between sprayed and control 'Tiftblue'.

The percentage of marketable 'T-19' fruit after 75 days of storage was higher for the daminozide/ethephon-sprayed berries than for the berries sprayed twice with ethephon (Table 3). Ethephon-treated berries were less moldy (predominantly *Botrytis cinerea* Pers.) than controls. Perhaps ethephon has a fungicidal effect.

Daminozide, a growth retardant, decreases ethylene production (2); and this effect may have caused the increase in longevity. If so, the decrease in marketable fruit between 75 days' and 7 months' storage (Table 5) means that the suppression of ethylene production by daminozide declined with time. The correctness of this hypothesis needs to be proven experimentally.

Differences noted at harvest in ripeness, as indicated mainly by color, firmness and other quality parameters were retained to a considerable extent in the 75-day stored berries. Good retention of fruit texture, which appears possible by the application of daminozide/ethephon treatment will not only enhance the immediate fresh market acceptability but also the storage life of the fruit.

Table 4. Influence of aminoethoxyvinylglycine (AVG), daminozide & ethephon, and CMC on color, firmness, chemical characteristics and storage life of 'Tifblue' rabbiteye blueberries after 75 days at 3°C and 95+% relative humidity, Sept. 1977.[z]

Cultivar and treatment groups	Hunter Color Values[y]				Texture (puncture-force in g-cm x 10^3)	pH	Soluble solids (%)	Titratable acidity[x] (%)	Deteriorated fruit (%)	Marketable fruit (%)
	L	a	b	b/a						
Tifblue										
A′ Control	17.78b	+0.26a	−2.45c	− 9.42b	2.21b	3.15	15.23b	0.73a	33.04	57.76c
C′ Daminozide + ethephon	21.29a	+0.24a	−3.38a	−14.08a	3.14a	3.19	16.55a	0.70a	10.50	84.50a
E′ Control + CMC	19.30a	+0.20b	−2.80b	−14.00a	2.95a	3.28	13.20c	0.70a	18.41	75.95b
F′ Control + Tween-20	17.30c	+0.24a	−2.41b	−10.04b	2.15b	3.35	14.23a	0.67a	33.76	57.24c
G′ Control + Tween-20 + 1000 ppm AVG	17.89b	+0.22a	−2.64a	−12.00a	3.17a	3.25	13.60b	0.68a	13.50	79.60b
H′ Control + Tween-20 + 2000 ppm AVG	18.13a	+0.22a	−2.69a	−12.20a	3.19a	3.23	14.00a	0.65a	8.00	87.45a

[z]Means within a column followed by different letters are significantly different (Duncan's multiple range tests, 5% level).
[y]Hunter L, a, b terms: L, defines lightness or darkness; a, measures redness-greeness; and b, describes yellowness-blueness.
[x]As percent citric acid.

Table 5. Influence of aminoethoxyvinylglycine (AVG), SADH and/or ethephon on storage life of 'T-19' and 'Tifblue' rabbiteye blueberries after 7 months at 3°C and 95+% relative humidity, January 1978.

Cultivar and treatment groups	Deteriorated fruit (%)	Marketable fruit (%)
T-19		
A Control	81.27	0
B 2 X Ethephon	46.86	35.50
C Daminozide + ethephon	50.68	37.00
F Control + Tween-20	81.80	0
I_1 2 X Ethephon + Tween-20 + 1000 ppm AVG	39.30	49.50
I_2 2 X Ethephon + Tween-20 + 2000 ppm AVG	28.64	61.00
J Daminozide + ethephon + Tween-20 + 2000 ppm AVG	30.60	60.00
Tifblue		
A' Control	74.24	0
C' Daminozide + ethephon	46.00	40.00
F' Control + Tween-20	74.80	0
G' Control + Tween-20 + 1000 ppm AVG	35.10	49.50
H' Control + Tween-20 + 2000 ppm AVG	25.70	62.00

Table 6. Influence of aminoethoxyvinylglycine (AVG), SADH and/or ethephon, CMC, and storage upon weight loss of 'T-19' and 'Tifblue' rabbiteye blueberries, 1978.

Cultivar and treatment	Fruit characteristic and length of storage: Weight loss after 2½ mos. storage (%)	Weight loss after 7 mos. storage (%)
T-19		
A Control	6.3	19.0
B 2 X Ethephon	6.3	16.7
C Daminozide + ethephon	4.4	12.3
D 2 X Ethephon + CMC	4.4	11.1
E Control + CMC	5.8	17.5
F Control + Tween-20	6.5	18.2
G Control + Tween-20 + 1000 ppm AVG	5.0	14.0
H Control + Tween-20 + 2000 ppm AVG	4.0	11.2
I_2 2 X Ethephon + Tween-20 + 2000 ppm AVG	3.5	9.8
J Daminozide + ethephon + Tween-20 + 2000 ppm AVG	3.0	8.4
Tifblue		
A' Control	9.0	25.2
G' Control + Tween-20 + 1000 ppm AVG	6.5	15.4
H' Control + Tween-20 + 2000 ppm AVG	4.5	12.6

Effects of CMC treatment on storage quality of rabbiteye blueberries

For the CMC-coated 'T-19' and 'Tifblue' control berries, the Hunter L values after 75 days' storage were 20.32 and 19.30, respectively, which indicate a high degree of lightness and brightness (Tables 3, 4). The corresponding L values for the fresh berries were 20.85 and 20.70 (Table 2), respectively. The CMC-coated control berries had a high degree of both blueness and firmness, but not as high as did the sprayed berries without coating. The 'T-19' berries sprayed twice with ethephon and coated with CMC retained firmness and acidity much better than the control berries coated with CMC. Thus, after 75 days of storage, 88.48% of the 'T-19' berries sprayed twice with ethephon and coated with CMC were marketable (Table 3).

CMC promoted the retention of color, texture and pH. Apparently, it was absorbed through the pores of the fruit and maintained firmness and color (8). Tragacanth improves the dispersion of CMC on fruit, and citric acid helps to preserve fruit (17).

Effects of AVG treatment on blueberry storage quality

AVG minimized weight loss (Table 6) of the berries treated with preharvest growth regulators. Although Tween-20 darkened the color of the blueberries (as indicated by the lower L values of 'T-19' and 'Tifblue' controls treated with Tween-20 than of controls not treated), addition of AVG lightened their color (Tables 3, 4). AVG was especially effective in lightening the color of the sprayed berries. The Hunter negative b values were higher for all Tween-20/AVG-treated berries than for the control treated only with Tween-20.

For the 'T-19' cultivar, fruit firmness, as measured by the Instron machine, was lowest for the control treated with Tween-20 and highest for the berries treated with daminozide plus ethephon plus 2000 ppm AVG. In the puncture-force curve (not shown) for each sample, the peaks indicated the puncture-force required to break the skin and penetrate the flesh; they also indicated the total resistance to puncture. The integrated readings were expressed directly in units of work. Values for total puncture-force varied. The values for 'T-19' berries treated with AVG 2000 ppm and for the daminozide/ethephon followed by AVG 2000 ppm were 2.77×10^3 g-cm and 3.33×10^3 g-cm, respectively, while the Tween-20 was 2.40×10^3 g-cm. At 2,000 ppm, AVG tended to enhance the effectiveness of the preharvest sprays in maintaining fruit firmness. The effects of AVG and the sprays on fruit color, firmness and weight were positive and should be of significance to producers, processors and consumers.

Acid concentration and pH are important quality characteristics of blueberries. The soluble solids to acid ratio is related to keeping quality (7). Acidity in 'T-19' and 'Tifblue' during storage did not appear to be affected by AVG. Treatment with AVG did not exert the same degree of inhibition on various ripening reactions. After storage, berries treated with AVG tended to have a lower soluble solids content than corresponding ones without AVG treatment.

The percentage of marketable fruit after 75 days of storage was higher for AVG treated berries than for the corresponding berries without AVG, and was highest for the berries with preharvest spray treatments plus AVG (Tables 3, 4). The daminozide/ethephon-treated berries (with or without AVG) had the highest soluble solids content and the highest percentage of marketable fruit. Doubling the concentration of AVG from 1000 to 2000 ppm increased but did not double the percentage of marketable fruit (Tables 3, 4).

AVG, which was effective in reducing ethylene production from methionine in other tissue (13), extended the postharvest longevity of 61% and 62%, respectively of 'T-19' and 'Tifblue' rabbiteye blueberries to 7 months (Table 5). An informal panel indicated that the AVG-treated berries

had superior taste and retained a fresh appearance. At 2,000 ppm, AVG increased the amount of marketable 'T-19' berries treated twice with ethephon by about 72% and of 'T-19' berries treated with daminozide plus ethephon by about 62%. Also, the amount of marketable 'Tifblue' treated only with 2000 ppm AVG was about 55% greater than that of 'Tifblue' treated only with daminozide plus ethephon. This marked effect of AVG in increasing storage life of berries is probably due to its potential in retarding ethylene-induced senescence. This hypothesis, however, needs to be tested experimentally.

The present study showed that both AVG treatments (1,000 and 2,000 ppm), immediately after harvest, with or without preharvest sprays of daminozide and/or ethephon effectively retarded senescence and deterioration of blueberries during storage at 3°C. A direct effect of AVG on increasing longevity was demonstrated and is of practical significance. This is the first time that longevity of rabbiteye blueberries has been appreciably increased by chemical treatments. Of the compounds tested, AVG, a suppressant of ethylene, was the most effective inhibitor of senescence of rabbiteye blueberries. It maintained firmness and increased the longevity of 'T-19' and 'Tifblue'. The effect of AVG in lengthening the storage life of rabbiteye blueberries was marked. However, it should be recognized that AVG and daminozide have not been released by the EPA for blueberry use. At present the best way to prolong the storage life of blueberries is to keep them at 3°C and 95+% relative humidity. Any other treatment should be considered as a supplement to good temperature and humidity maintenance.

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FIELD EVALUATION OF HEXAZINONE (VELPAR[R]) HERBICIDE IN PECANS[1]

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Abstract. **Postemergence and preemergence weed control effectiveness from hexazinone (Velpar[R]) was evaluated in an 11-year-old pecan** [Carya illinoensis **(Wang.) K. Koch] orchard. Weed control was rated 4, 12, and 20 weeks after an early April application of 0, 0.9, 1.8, and 3.6 lb. ai/acre of hexazinone in 1977. In 1978 rates were changed to 0, 0.45, 0.9, and 1.8 lb. ai/acre. Two applications, once on April 6, the other on July 13, of 0, 0.45, 0.9, and 1.8 lb. ai/acre hexazinone were evaluated 4, 12, 17, and 21 weeks after the initial April treatment in 1979. All treatments included the surfactant WK[R] at .125% (v/v).**

Hexazinone generally provided excellent postemergence weed control at 0.9 and 1.8 lb. ai/acre. Preemergence weed control was excellent at least 21 weeks after treatment with dual applications of 1.8 lb. ai/acre. Treatments did not significantly influence trunk diameter increase from September 1977 to January 1980.

Postemergence or contact herbicides generally result in non-selective but short term weed control. Preemergence or residual herbicides can control selective weeds for several months. The general weed control method for mature pecans in north Florida is to treat with 2 tank mix applications of postemergence and preemergence herbicides, once in early spring and again in mid-summer. Additional treatments with glyphosate (Roundup[R]) are applied as needed,

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