branching isogeneic lines of *Lycopersicum esculentum* have been conducted (19). The onset or release of axillary bud growth was found to be regulated by the shoot portion of the plant, which differs from this study, while the magnitude of axillary shoot growth was controlled by the root system, which is in agreement with findings of this study. However, root systems of tomato lines having a greater degree of apical dominance facilitated axillary shoot growth to a greater degree than did root systems of lines with weak apical dominance. This is quite different from the results obtained with poinsettias and further implies that control of axillary bud growth and shoot growth is variable between plant species. Further experiments should investigate these differences and determine if branching is being regulated in shoots by altering levels of auxin and cytokinin as a result of grafting genetically dissimilar shoots and roots with different degrees of branching.

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J. Amer. Soc. Hort. Sci. 108(3):422–424. 1983.

Postharvest Decay of Blueberries as Influenced by Water Dips and Captafol

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Additional index words. *Vaccinium corymbosum, Glomerella cingulata, Colletotrichum gloeosporioides, Alternaria* sp., *Botrytis* sp.

Abstract. **Blueberries can be handled in water if 10 mg/liter of captafol is added to the water and the berries are immersed for at least 30 minutes. Addition of 100 mg/liter and immersion for 3 or 10 minutes produced similar control of decay. Captafol controlled decay due to *Colletotrichum gloeosporioides* [the imperfect stage of *Glomerella cingulata* (Ston.) Spauld. & Shrenk] better than it did decay due to *Alternaria* and *Botrytis* spp.**

The shelf-life of blueberries is commonly shortened by decay organisms after harvest (1, 2, 3, 4, 5). Mechanization of harvesting or sorting, grading, and packaging of blueberries can expose these fruits to increased levels of postharvest inoculation with *Colletotrichum gloeosporioides* (the imperfect stage of *Glomerella cingulata*) and *Alternaria* and *Botrytis* spp. (2, 4, 7). Use of water as a cushioning (catching) medium during mechanical harvesting or in a sorting–grading line for washing or sorting-for-ripeness (specific gravity) can also potentially aggravate the spreading of decay organisms. Ceponis and Cappellini (3) reported that dipping blueberries from New Jersey in water did not increase subsequent decay; dips of blueberries in 1000 and 5000 mg/liter solutions of several fungicides, including captafol, reduced postharvest decay but left undesirable visible residues.

The objectives of this study were a) to determine if dipping harvested blueberries from North Carolina in water increases subsequent decay and b) to determine the lowest concentration of captafol that would control postharvest decay of these blueberries.

Received for publication October 14, 1982. Paper No. 8103 of the Journal Series of the North Carolina Agricultural Research Service (NCARS), Raleigh. The use of trade names in this paper does not imply endorsement by NCARS of products named, nor criticism of similar ones not mentioned. Thanks are due R.D. Milholland, Dept. of Plant Pathology, for his identification of decay organisms, advice during the test, and review of the manuscript; and E.P. Maness for her technical assistance during the experiments. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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Materials and Methods

Seven tests were conducted over a 3-yr period with blueberries grown and harvested in commercial plantings in eastern North Carolina. Treatments with captafol (Ortho Difolatan 4F) fungicide were made in the field at harvest (1973) or in packing sheds after harvest (1974, 1975). Data were subjected to an analysis of variance.

In 1973, three replications of 'Jersey' berries were picked directly into 3.8-liter (1-gal) plastic containers filled with 3.3 liters of 0, 2500, 5000, or 10,000 ml/liter aqueous suspensions of captafol. Berries for dry controls were picked directly into 1-pint (475-ml) cardboard cartons with an acetate window on one board side. Berries used as wet controls were treated similarly and dipped for 1 min in buckets of water. Both sets of controls plus the treated berries were transported in ice chests to Raleigh. The berries were removed from their containers 4 hr after harvest and placed one layer deep on 1 × 15 × 21 cm trays lined with cotton lab towels. When dry, the samples were placed in new pint cartons, held at 21°C and 90–95% relative humidity for 7 days, and sorted for decay (6).

In 1974 and 1975, pint samples of berries were sorted to remove off-quality fruit, placed in plastic-mesh bags, sealed, weighted, and submerged in 11-liter plastic buckets filled with various concentrations of captafol for different periods of time. The berries were then removed and spread on towels as in 1973. When dry, the berries were placed in paperboard boxes. Pint samples of fruit used as dry controls were not treated but were poured directly on the towels and boxed. Samples were transported to Raleigh in ice chests, stored at 21°C, and sorted for decay.

Two tests were conducted in 1974. 'Jersey' berries were dipped in 0, 2500, 5000, or 10,000 mg/liter suspensions of captafol for 0, 30, 60, or 120 min. Each treatment was replicated 5 times. Tap water was used as a medium in one test and 0.5% Agrifoam (a foam-generating liquid; Foam Products Division, Waukesha Foundry Co., Inc., Waukesha, Wis.) was added to water before addition of captafol in the 2nd test. Some researchers have postulated that a foam might be of potential use in cushioning the fall of blueberries during harvesting with innovative mechanical harvesters. All treatments were made within 3 hr of harvest.

In 1975, tap water was used with the fungicide in all tests. Concentrations of captafol were 0, 10, 100, 200, 400, 800, 1200, and 2400 mg/liter with dip times of 0, 3, 10, and 30 min. All treatments were made 30 to 45 min after harvest and replicated 5 times. The cultivars Wolcott (with some resistance to *C. gloeosporioides*) and Jersey (susceptible) were used in these studies. Two tests were conducted with each cultivar. Their data were combined for analysis.

Since symptoms of *C. gloeosporioides* decay were obvious in 1974 on 'Jersey' fruit after 7 days of storage, separate counts were made in 1975 for sound fruit, fruit with *C. gloeosporioides*, and fruit with decay due to other fungi (*Alternaria tenuissima* and *Botrytis* sp.).

Results

In 1973, decay of 'Jersey' fruit at harvest was 11.9%. Dipping the fruit for 1 min into water did not increase decay significantly (wet control, 12.5%). However, transport of blueberries in a container of water for 4 hr significantly increased decay to 18.6%. Addition of 2500, 5000, or 10,000 mg/liter captafol was phytotoxic.

The 1974 results were similar to those of the previous year (Table 1). Concentrations of 2500, 5000, or 10,000 mg/liter captafol significantly reduced decay of 'Jersey' berries as compared to decay of berries in the dry control or those dipped in water (wet control). Time of dip in captafol solutions containing 0.5% Agrifoam were as effective as those without. No indications of phytotoxicity were observed from either captafol or the Agrifoam.

Table 1. Effect of time of immersion (dip time) and concentration of captafol upon development of decay of 'Jersey' blueberries in 1974.

Treatment		Decay (%)	
Dip time (min)	Captafol (mg/liter)	Water base	Agrifoam liquid base[z]
0 (dry)	0	44[y]	44
30	0	33	51
60	0	28	38
120	0	55	39
30	2500[x]	4	8
60	2500	5	5
120	2500	4	7
LSD 5% for treatment/test:		11	8

[z]A 0.5% solution of Agrifoam in water.
[y]Mean percent decay of 5 replications.
[x]Data for 5000 and 10,000 mg/liter of captafol were not significantly different from those for 2500 mg/liter of captafol.

In general, dry fruit of 'Wolcott' had more total decay than fruit of 'Jersey' in 1975 (Table 2). However, compared to the dry-control treatment, submersion in water did not increase decay of 'Wolcott' fruit, whereas decay of 'Jersey' fruit was significantly increased from 33 to 72%. Very little evidence of *C. gloeosporioides* was observed in the 'Wolcott' samples after 7 days storage.

Ten mg/liter of captafol for 30 min significantly reduced fruit decay below that of blueberries dipped in water (wet controls)

Table 2. Effect of time of immersion (dip time) and concn of captafol upon decay in 'Wolcott' and 'Jersey' blueberries in 1975.

Treatment		Decay (%)[z]			
		Jersey			Wolcott[y]
Dip time (min)	Captafol (mg/liter)	*Colletotrichum gloeosporioides*	*Alternaria* and *Botrytis* spp.	Total	Total
0	0	14	19	33	58
3	0	46	24	70	62
10	0	46	26	72	66
30	0	40	24	64	47
3	10	39	20	59	50
10	10	19	19	38	47
30	10	7	16	23	37
3	100	7	15	22	35
10	100	6	11	17	31
30	100	3	9	12	28
3	1200	3	8	11	21
10	1200	4	8	12	23
30	1200	4	9	13	20
3	2400	2	8	10	21
10	2400	4	8	12	23
30	2400	3	7	10	20
LSD 5%		10	6	13	13

[z]Means of 2 tests, replicated 5 times each (or, 10 replications overall).
[y]Little if any *C. gloeosporioides* present.

(Table 2). Dip time had no effect at higher concentrations. Consequently, considering averages of concentrations of 100 mg/liter and greater, decay was much better controlled by treatment on 'Jersey' than on 'Wolcott' fruit. Decay of 'Jersey' fruit was reduced as much by a concentration of 100 mg/liter as by 2400 mg/liter.

Increase in decay caused by *C. gloeosporioides* (14 to 46%) upon wetting of 'Jersey' fruit was almost 2-fold over increased decay by other fungi (19 to 26%) (Table 2). As little as 10 mg/liter captafol for 30 min significantly reduced decay caused by *C. gloeosporioides*. This decay was reduced to very low levels (3%) when concentrations of 100 mg/liter or greater were used. Concentrations of 200, 400, or 800 mg/liter captafol were not more effective in reducing decay than 100 mg/liter. For control of decay due to *Alternaria* and *Botrytis* spp., treatment with 2400 mg/liter resulted in very little extra control (8% decay) beyond that resulting from treatment with 100 mg/liter (10–15% decay).

When effects of dip time (Table 2) were averaged over concentration effects, it appears that length of dip time increases the effects of captafol upon control of *C. gloeosporioides,* but not decay due to other fungi. Percent decay due to *C. gloeosporioides* at 3, 10, and 30 min dip times was 14, 11, and 8, respectively.

Discussion

These tests confirm that 'Jersey' blueberries are more susceptible to decay by *C. gloeosporioides* than are 'Wolcott' blueberries (8, 9). Initial infection of susceptible blueberry fruit occurs in the field at or shortly after fruit set. When infected ripe fruit were immersed in water during treatment, spores from these initial infections undoubtedly contaminated sound berries. Ten mg/liter of captafol added to the water with 30-min exposure appears effective in preventing these spores from causing decay of additional berries. Concentrations of 100 mg/liter or greater reduced dip time to 3 or 10 min for similar results.

Captafol also appeared to control decay due to *Alternaria* and *Botrytis* spp.; however, the degree of effectiveness varied from year to year on 'Wolcott' fruit. This variation may be related to the fact that the 2 lots of fruit came from different farms, or they may have been of different degrees of ripeness (1).

These data indicate that *C. gloeosporioides* can be a more severe disease than *Alternaria* and *Bortrytis* spp. if the berries of cultivars susceptible to *C. gloeosporioides* are wetted during or after harvest. However, lower concentrations of captafol are required for control of *C. gloeosporioides* than for control of *Alternaria* and *Botrytis* spp. These low levels of captafol (10 and 100 mg/liter) left little visible residue compared to residue left by levels of 1000 mg/liter and higher as found in this study and as reported elsewhere (3).

Wetting of these blueberries increased decay in 2 of the 6 tests. The increase in decay in these 2 tests was associated with the presence of *C. gloeosporioides* in 1975. In 1974, *C. gloeosporioides* was also present in the fruit after storage but was not determined separately. Its presence was not associated with an increase in total decay subsequent to wetting of the fruit. This indicates perhaps that these 'Jersey' fruits had been inoculated with *C. gloeosporioides* prior to wetting—either on the bush or after harvest and prior to wetting. Typical symptoms of the disease were present on fruits on the bushes prior to harvest in 1974. All this indicates that a similar circumstance might have existed with fruit in a study in New Jersey reported earlier (2) in which decay of harvested 'Jersey' and 'Bluecrop' fruit did not increase subsequent to wetting even though they contained decay due to *C. gloeosporioides*. Thus, if berries susceptible to *C. gloeosporioides* are to be wetted for any reason after harvest, or, if these berries are wet at harvest, they apparently should be treated with a fungicide as soon as possible.

The fact that the presence of 0.5% Agrifoam liquid in the treatment solution had no discernible effect upon the efficacy of captafol indicates that fungicides such as captafol can be used potentially to control decay of blueberries that are harvested into tanks of water or foam until they are received in a washing, sorting, grading, and packaging line.

Captafol is not cleared for use in controlling postharvest decay of blueberries. The fungicide was selected for our studies because of its effectivenes as a preharvest spray for controlling *C. gloeosporioides*.

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