the growth of 6 highbush blueberry cultivars. There were 8 inoculated and 4 uninoculated plots arranged in 4 blocks with 1.0 m spacing between plants in rows and 3.0 m spacing between rows. Each plot contained 2 plants of each of 6 cultivars (subplots). Inoculated plants were planted out with a 200 ml layer of mycorrhizal peat in the base of the planting hole. This inoculum peat was dug from under some old established plants (on an unfertilised peat bog) which had become highly mycorrhizal (80% root infection) with native ericoid mycorrhizal fungi. Fruit was protected from bird damage by spraying with mesurol (6 kg ai/ha) and handpicked on 6 occasions from December 1979 to January 1980. Mycorrhizal inoculation increased fruit yield in all 6 cultivars (Table 1) with responses ranging from 92% ('Stanley') to 11% ('Dixi'). Percentage mycorrhizal yield responses were generally smaller for the high producing cultivars, but even with 'Jersey' (a main cultivar for New Zealand) inoculation increased fruit yield by 238 g per plant equivalent to 600 kg/ha at a plant density of 2500 per ha.

Mycorrhizal infection assessed at the first fruit season was 63% with no response to inoculation or cultivar. This suggests that mycorrhizal inoculation stimulated early plant growth and fruit yield and noninoculated plants became infected with the indigenous mycorrhizal fungi in the peat soil during the 2 year period between planting and first fruit harvest.

Table. 2. Effect of mycorrhizal inoculation on fruit yield of 4-year-old plants of 6 blueberry cultivars in the field.

Mycorrhizal[z] inoculation	Fruit yield (g/plant)					
	Stanley	Blueray	Ivanhoe	Herbert	Jersey	Dixi
Without	182	230	453	477	605	1250
With	349	389	534	719	843	1390
Response	92%	69%	18%	51%	39%	11%

LSD (fungi) = 126; LSD (blueberry cultivars) = 218

[z]Mycorrhizal response significant at $P<5\%$. No significant fungus x cultivar interaction.

This is the first report of successful field inoculation and practical application of ericoid mycorrhiza and highlights the need for routine mycorrhizal inoculation of nursery grown plants (2) especially where suitable mycorrhizal fungi are absent or in low numbers in field soils.

Literature Cited

1. Brook, P. J. 1952. Mycorrhiza of *Pernettya macrostigma*. New Phytol. 51:388–397.
2. Gianinazzi-Pearson, V. 1976. Les mycorhizes endotrophes: etat actuel des connaissances et possibilities d'application dans la pratique cultural. Annu. Rev. Phytopath. 8:249–256.
3. Read, D. J. 1978. The biology of mycorrhiza in heathland ecosystems with special reference to the nitrogen nutrition of the Ericaceae. *In:* M. W. Loutit and J. A. R. Miles (eds.) Microbial ecology. Springer-Verlag, Berlin.
4. Read, D. J. and D. P. Stribley. 1973. Effect of mycorrhizal infection on nitrogen and phosphorus nutrition of Ericaceous plants. Nature (New Biol.) 244:81–82.
5. Read, D. J. and D. P. Stribley. 1975. Some mycological aspects of the biology of mycorrhiza in the Ericaceae. *In:* F. E. Sanders, B. Mosse and P. B. Tinker (eds.) Endomycorrhizas. Academic Press, London.
6. Stribley, D. P. and D. J. Read. 1974. The biology of mycorrhiza in the Ericaceae III. Movement of ^{14}Carbon from host to fungus. New Phytol. 73:731–741.
7. Stribley, D. P. and D. J. Read. 1974. The biology of mycorrhiza in the Ericaceae IV. The effect of mycorrhizal infection on uptake of ^{15}N from labelled soil by *Vaccinium macrocarpon* Ait. New Phytol. 73:1149–1155.

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Effects of Cooling Rate on Shelflife and Decay of Highbush Blueberries[1]

Donald E. Hudson and William H. Tietjen[2]

U. S. Department of Agriculture, Science and Education Administration, Postharvest Research Center, New Brunswick, NJ 08903

Additional index words. Vaccinium corymbosum, precooling, storage, quality, handling

Abstract. **Fruit of blueberry (*Vaccinium corymbosum* L.), precooled to 2°C, had 60–80% less decay than non-precooled berries when held for 24 hours at 21° following a 3-day simulated transit period at 10°. When precooled berries were held 48 hours at 21° following a 10-day simulated transit period at 2°, they had 37–46% less decay than non-precooled berries similarly handled.**

Decay is the major factor limiting fresh blueberry (*Vaccinium corymbosum* L.) shelf life (2, 3, 4, 5,), especially from anthracnose (*Gloeosporium* sp.), alternaria rot (*Alternaria* sp.) and gray mold rot (*Botrytis cinera* Pers. ex Fr.). In New Jersey few if any blueberries are precooled. For local markets they are shipped with little or no refrigeration, and for distant markets they are usually shipped at air temperatures of 5–7°C. At retail, blueberries are often displayed without refrigeration.

Temperatures near 0°C are best for storing and handling fresh blueberries (6). However, moisture condenses on the surface of cold blueberries that are exposed to warm temperatures and high humidities. Condensation causes some loss of bloom and many shippers and receivers believe that condensed moisture on berry surfaces also increases the incidence of decay.

Little information is available comparing decay of rapidly precooled berries with that of non-precooled berries under conditions that could be encountered in transit. This study was conducted to determine the effects of precooling on decay development when fruits are subjected to gradual changes in temperature during simulated transit.

Commercially hand-harvested highbush blueberries were obtained in 1976 and 1977 in southern New Jersey and transported at ambient temperatures about 47 km to the Postharvest Research Center, New Brunswick, New Jersey. The first harvest of 'Bluetta' (June 22, 1976 and June 20, 1977) and first and second harvests of 'Bluecrop' (July 9 and July 19, 1976 and July 11 and 22, 1977) were used. Berry temperatures at the packinghouse ranged between 22° and 28°C in 1976 and between 25° and 29° in 1977.

Defective fruit were culled and the remainder were randomized into 1-pint (473 ml) containers. The pints were assembled in 2 lots; 1 lot was precooled (PC) by fan-forced cold air to 2°C in 2 hr; the other lot was not precooled (NPC). The PC and NPC berries were stored at temperatures that initially approximated their respective pulp temperatures. In 1 test, air temperature reached 10° in 24 or 48 hr and that temperature was maintained for the duration of a 3-day simulated domestic transit period. In another test, air temperature for the NPC berries reached 2° in 24 or 48 hr and stayed at 2° until the end of 10 days, simulating transit to a European market. PC berries in this regime were held continuously at 2°. Samples from each temperature regime were visually examined for decay incidence immediately after removal from storage. Other samples were held at 2° and 21° and examined after 24 and 48 hr. Six 1-pint replicates were examined each time in every test, and soft berries were included with ones showing decay.

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[2]Research Horticulturist and Horticulturist, respectively.

Rapidly precooling blueberries to 2°C significantly reduced the amount of decay that developed subsequently during the 21° holding period that followed the 3-day (Table 1) and 10-day (Table 2) simulated transit periods. After 3 days at 10°, despite low incidences of decay, there was significantly less decay in the PC berries than in the NPC berries that took 48 hr to cool to 10° (Table 1). After an additional 24 hr at 21°, the PC berries had 60 to 80% less decay than the NPC berries, even when the latter were cooled to the ambient temperature in 24 hr. When the berries were held 48 hr at 21° after storage, the PC berries still had significantly less decay than NPC berries that had been cooled to 10°. A constant temperature of 2° resulted in substantially less decay than any other treatment after 48 hr at 21°.

Blueberries precooled to 2°C and stored at that temperature for 10 days, to simulate surface transport to prospective European markets, had significantly less decay after cold storage than NPC berries that had been cooled to 2° in 48 hr (Table 2). Slightly less decay was found in the PC berries than in the NPC berries cooled to 2° in 24 hr. Test shipments of fresh blueberries to distant domestic markets conducted by the USDA required 48 hr to reach an average berry temperature of 13.5° from the initial 27° (unpublished data). Thus, in the average container load (1920 trays), berry temperatures probably would not reach 2° in 48 hr and decay could be higher than reported here.

Following the transfer to 21°C, the PC berries had significantly less decay than the NPC berries even when the latter fruits had been cooled to 2° in 24 hr (Table 2). After 48 hr at 21°, the PC berries still had more than a third to nearly a half less decay than the NPC berries. The benefits of precooling probably would have been more striking if we had cooled the NPC berries more slowly, as would occur in an actual commercial shipment. The PC berries were still marketable despite the relatively long storage period and the 48 hr at 21°, since 15% defective fruit is permissible (1). Other researchers have accepted 20% defects as a marketable limit (1). Despite moisture condensation on berries when transferred from 2° to 21° in our tests, the bloom did not appear adversely affected. Whether or not decay was enhanced because of the condensate is questionable (7).

Rapidly precooling fresh blueberries to a temperature just above freezing and maintaining that temperature appears best for suppressing decay development and preserving the marketability of the fruits. Gray mold accounted for most of the decay in blueberries in these tests. Very little alternaria and anthracnose were seen. Rapid precooling and the 2°C storage temperature were especially beneficial in the longer storage tests because the shelf life of this highly perishable commodity was lengthened to 12 days which suggests that surface transport of fresh blueberries to foreign markets may be feasible.

Table 1. Postharvest decay of precooled and non-precooled blueberries following storage at 2° or 10°C, and after holding at 21°.

		Decay (%)					
		Stored 3 days at 10°C		Additional holding at 21°C			
				24 hr		48 hr	
Treatment	Hours to 10°C	1976	1977	1976	1977	1976	1977
NPC	24	2.0 a[z]	3.3 a	6.6 b	9.2 c	24.9 c	26.2 d
NPC	48	3.8 b	4.7 b	15.0 c	17.8 d	32.0 d	32.9 e
PC	24	1.9 a	2.7 a	2.6 a	3.5 a	13.6 b	15.9 b
PC	48	1.5 a	3.0 a	2.9 a	5.4 b	15.4 b	21.9 c
PC[y]		0.9 a	1.8 a	1.8 a	2.5 a	2.5 a	7.4 a

[z]Mean separation within columns by Duncan's multiple range test, 5% level.
[y]Held at 2°C continuously.

Table 2. Postharvest decay of precooled and non-precooled blueberries following storage at 2°C and after holding at 21°.

		(%) Decay					
		Stored 3 days at 10°C		Additional holding at 21°C			
				24 hr		48 hr	
Treatment	Hours to 10°C	1976	1977	1976	1977	1976	1977
PC	2	1.8 a[z]	2.1 a	3.5 a	4.0 a	12.9 a	11.8 a
NPC	24	2.0 ab	4.3 b	6.8 b	6.9 b	21.7 b	18.6 b
NPC	48	4.1 b	4.4 b	7.3 b	8.1 b	23.8 b	21.9 b

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

Literature Cited

1. Ballinger, W. E., E. P. Maness, and W. F. McClure. 1978. Relationship of stage of ripeness and holding temperatures to decay development in blueberries. J. Amer. Soc. Hort. Sci. 103:130–134.
2. Ceponis, M. J. and R. A. Cappellini. 1978. Chemical control of postharvest rots in New Jersey blueberries. Plant Dis. Rptr. 62:154–156.
3. Ceponis, M. J., J. Kaufman, and W. H. Tietjen. 1973. Decays of New Jersey blueberries in marketing channels. Plant Dis. Rptr. 57:487–488.
4. Galletta, G. J., W. E. Ballinger, R. J. Monroe, and L. J. Kushman. 1971. Relationship between fruit acidity and soluble solids levels of highbush blueberry clones and fruit keeping quality. J. Amer. Soc. Hort. Sci. 96:758–762.
5. Harvey, J. M. and W. T. Pentzer. 1960. Market diseases of grapes and other small fruits. U. S. Dept. Agr., Agr. Handb. 189, p. 2–3.
6. Hruschka, H. W. and L. J. Kushman. 1963. Storage and shelf life of packaged blueberries. U. S. Dept. Agr., Mrtg. Res. Rpt. 612.
7. Schulze, C. P., M. J. Ceponis, and R. A. Cappellini. 1981. The influence of "sweating" on postharvest decay of blueberries. Phytopathology 71. (In press)

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Effect of BA and GA on Fruit Drop of Citrus[1]

Wang Dayuan[2]

Institute of Citrus, Chinese Academy of Agriculture Sciences, ChungKing, The People's Republic of China

Additional index words. fruit-set, orange, *Citrus sinensis*, mandarin, *Citrus reticulata*

Abstract. **Application of gibberellic acid (GA) and 6-benzylamino purine (BA) on whole trees of 'Washington Navel' orange (*Citrus sinensis* [L.] Osbeck) during anthesis caused flower thinning and increased leaf size of the spring growth flush. BA sprayed on whole trees at the young fruit stage induced premature initiation of the summer growth flush and resulted in serious fruit drop. Application of BA on the surface of individual young fruit of 'Washington Navel' orange and 'Satsuma' mandarin (*C. reticulata* Blanco) prevented postbloom drop, but not June drop. Neither GA nor BA had any influence on fruit-set of "Jeng" orange.**

Dropping of flowers and fruit is a serious problem in citrus, especially in seedless cultivars. According to Erickson et al. (4), the flower and young fruit drop percentages in 'Washington Navel' orange (based on the total number of flowers) are: flower buds 48.5%; flowers 16.7% young fruit with pedicel (postbloom drop) 31.4%; and young fruit abscised without pedicel (June drop) 3.2%.

Though temperature (3), light intensity (11) and girdling (8) can influence fruit drop of citrus, many researchers suggest that these factors act through plant growth regulators (1, 3, 10). It has been demonstrated that GA plays a significant role in preventing fruit

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[2]Visiting Scientist, Department of Botany, University of Florida, Gainesville, FL 32611.

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