significantly increased total yields for the first 2 harvests, however, by September 17 all daminozide treatments had greatly increased the total amount of fruit harvested. High daminozide concentrations tended to further increase yields. Ethephon alone had no effect but, when applied with daminozide, tended to increase the effectiveness of the daminozide. These increases in yield resulted entirely from greater numbers of fruits. After the first harvest date, fruit size was decreased by daminozide. On September 2, control fruits and daminozide-treated fruits weighed 4.0 g and 4.5 g respectively but, by September 17, the comparable fruit weights were 3.5 g and 2.9 g.

First signs of flower bud formation were seen in the buds from the 10–12 node section. This occurred when the primocanes were about 50 cm tall. At that time the 10–12 bud section was only 7–18 cm above the soil surface. About 50% of the buds in the section were showing initial flattening of the apical meristem. All buds closer to the shoot tip were vegetative. Within 3 weeks all buds, 1–12, were showing some floral development. By then the primocanes were about 75 cm tall. From that time on development of the upper buds was rapid and at the end of the fourth week the stage of development of the upper buds was at least as advanced as lower buds.

Other workers found a similar relation between position of the axillary buds on the cane and the time of flower initiation (1, 4). They observed that axillary buds in the region 5–15 below the terminal buds were the first to develop flower initials in both floricane — and primocane — fruiting cultivars. Flower initials develop in the terminal bud just prior to axillary flower bud formation (2, 4).

The stage of primocane growth when we applied the growth regulators (12–16 nodes) corresponds closely with the time when cold treatment has the greatest effect on early flowering (3). It appears, therefore, that treatments must be applied during the beginning stages of flower initiation to be most effective. Similar growth regulator treatments applied last year at a later stage of primocane growth did not significantly increase yields.

Literature Cited

1. Mather, B. A. 1952. A study of fruit-bud development in *Rubus idaeus*. J. Hort. Sci. 27:266–272.
2. Vasilakakis, M. D. 1978. Physiology of flowering in red raspberries (*Rubus idaeus* L.). PhD Thesis, Univ. of Wisconsin, Madison.
3. Vasilakakis, M. D., B. H. McCown, and M. N. Dana. 1980. Low temperature and flowering of primocane-fruiting red raspberries. HortScience 15:750–751.
4. Williams, I. H. 1959. Effects of environment on *Rubus idaeus* L. IV. Flower initiation and development of the inflorescence. J. Hort. Sci. 34:219–228.

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Ericoid Mycorrhizas Stimulate Fruit Yield of Blueberry[1]

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Additional index words. inoculation, field trial, *Vaccinium corymbosum*

Abstract. **Two-year-old blueberry plants (*Vaccinium corymbosum* L.) of 6 cultivars were planted into a peat soil with or without ericoid mycorrhizal fungi inoculation. At the first fruit season, inoculation increased fruit yield by 11 to 92% among the six cultivars.**

The roots of heath plants in natural ecosystems are normally infected with ericoid mycorrhizal fungi (1, 3, 5) which stimulate N and P uptake (4, 6) and plant growth (4, 7). Blueberries are a new horticultural crop for New Zealand. Farmers are now planting 2-year-old nursery-grown stock onto former grass and clover paddocks which have never been vegetated by heath plants. As there are no reports on the incidence and effect of ericoid mycorrhizas on the growth and fruiting of highbush blueberry, we decided to root sample plants from nurseries and growers' plantations to see whether blueberries were becoming mycorrhizal under New Zealand conditions.

Root samples (5g) were taken at 0-100 mm soil depth underneath randomly chosen blueberry bushes in 12 nurseries and plantations. A total of 289 samples were taken from the cultivars 'Jersey', 'Dixi' and 'Atlantic'.

The root samples (1 per plant) were washed, cleared in 10% KOH for 40 min. (at 9°C), 20 volume H_2O_2 for 10 min. (at 20°), 1.0 N HCl for 2 min. (20°) and stained in 0.05% trypan blue in lactoglycerol. Infection level was determined as the percentage of randomly chosen root segments (0.5 mm long) which were mycorrhizal. Nursery plants sampled (3 to 24 months old), were growing in mixtures of pumice sand and unsterilised (U) or partially sterilised (S) peat cut from bogs vegetated by native heath plants. Field grown plants sampled were 3 to 15 years old.

None of the 61 blueberry plants sampled had become mycorrhizal within the first year of growth in potting mix, whether or not partially sterilised peat was used (Table 1). For the 2-year-old plants raised in partially sterilised peat (S), mycorrhizal infection levels were very low (3%) and only present in a third of the sampled roots. Where unsterilised peat (U) was used the incidence and degree of mycorrhizal infection were higher (Table 1). The data suggest that the potting mixes used are low in ericoid mycorrhizal fungi capable of infecting *V. corymbosum*, and that mycorrhizal infectivity is further reduced in the heat sterilising process.

After 3–7 years growth in the field, 28–42% of blueberry plants sampled were still nonmycorrhizal, and only after 15 years growth were all the sampled bushes infected (Table 1). A field trial was laid down on a peat soil under pasture in September 1977 to see whether artifical inoculation could stimulate

Table. 1. Mycorrhizal infection levels in roots of nursery and field grown blueberry plants.[z]

Age of plants	No. of plants sampled	Plants mycorrhizal (%)	Roots infected in mycorrhizal plants (%)
Nursery grown			
3 months S & U[y]	5	0	-
6 month S & U	43	0	-
12 month S & U	13	0	-
24 month S	64	34	3
U	23	56	15
Field grown			
3 year	32	72	52
5 year	47	60	34
7 year	19	58	27
15 year	43	100	36

[z]Cultivars samples were Jersey, Dixi and Atlantic.
[y]Nursery plants grown in sterilised (S) or unsterilised (U) peat.

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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]

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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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