the type used in this study cannot tolerate populations of 1075 pine vole/ha for extended periods. One tree was killed and the productive capacity of the remaining trees was reduced far below the level of economic feasibility. Their survival through another season seems extremely doubtful. It is possible, of course, that plantings of other cultivars, more vigorous rootstocks, older trees, or wider spacings than those used might be more tolerant, but this planting effectively was destroyed in 2 years by the high population. In contrast, there was almost no measurable effect of 269 voles/ha. The medium population (538 voles/ha) did not reduce yield in 2 years, but vegetative growth was significantly reduced in the 2nd year, and a reduction in yield could be expected in succeeding years. Thus, the economic threshold for plantings of this type might be near 269 pine voles/ha. Pine voles are not distributed uniformly throughout the orchard, however, and significantly lower numbers/ha could inflict severe damage if concentrated around a relatively small number of trees. It would be more accurate to express the economic threshold in terms of the number of voles/tree. On this basis, more than 1 vole/3 or 4 trees in any area would constitute an economic problem. This level would be appropriate for trees of the type used in this study only and would, of necessity, change with tree size and planting density.

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Decadienoate Ester Concentrations in Pear Cultivars and Seedlings with Bartlett-like Aroma

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Abstract. **High levels of decadienoate esters were found in the *iso*-octane soluble fraction extracted directly from pureed canned fruit of 'Harvest Queen', HW-606, 'Bartlett', 5 sports of 'Bartlett', 'Surecrop', and 'Laxtons Progress' pear (*Pyrus communis* L.). These cultivars, with the exception of 'Surecrop', had a Bartlett-like aroma. The decadienoate equivalents observed in 19 other cultivars ranged from none to one-half the high group. Higher levels of decadienoate esters were also detected by high pressure liquid chromatography (HPLC) in essences of canned fruit of 'Bartlett', 'Harvest Queen', and HW-606 with a Bartlett-like aroma than in canned fruit of 3 cultivars with aroma unlike 'Bartlett', including 'Harrow Delight', HW-607, and 'Kieffer'. Cultivars with Bartlett-like aroma seem to be characterized by high decadienoate ester level, but high decadienoate ester levels are not necessarily indicative of Bartlett-like aroma. Decadienoate esters were not detected in essences extracted from actively growing or dormant shoots of 'Bartlett'. Thus, early screening of seedlings for Bartlett-like aroma on basis of decadienoate extraction of the shoot or leaves cannot be effective.**

'Bartlett' is the principal pear cultivar used worldwide for canning and puree. It has good texture and appearance and is especially prized for its flavor, but it is susceptible to fire blight. A major objective of many breeding programs is to develop cultivars which are fire blight resistant but similar to 'Bartlett' in quality. Knowledge of the flavor chemistry of 'Bartlett' is important in achieving this objective.

As many as 77 volatile aromatics have been found to contribute to 'Bartlett' flavor (3). Among these aromatics is a group of esters (including the methyl, ethyl, propyl and butyl esters of trans-2, cis-4 decadienoic acid), which is responsible for the main character impact of 'Bartlett' flavor. These compounds contain unconjugated bonds and have an absorption maximum at wavelength 260 nm (2, 3). The decadienoate esters appear to be present in pear cultivars with a Bartlett-like flavor (5, 6). The present study was undertaken to verify the association of decadienoate esters with Bartlett-like aroma in a number of pear cultivars and selections. Another objective was to determine if it was possible to identify seedlings similar in flavor 'Bartlett' based on decadienoate ester content of the leaves and stem tissue.

Fruit were harvested from the pear collection (*Pyrus communis* L.) at the Research Station in Harrow, Ontario, or, in the case of HW-607, from the Harrow seedling evaluation block. Trees in the cultivar collection were topworked on 'Old Home', and the seedling tree of HW-607 was self-rooted. Fruit were collected, stored, ripened, and canned as halves (20% sucrose syrup, w/v) accord-

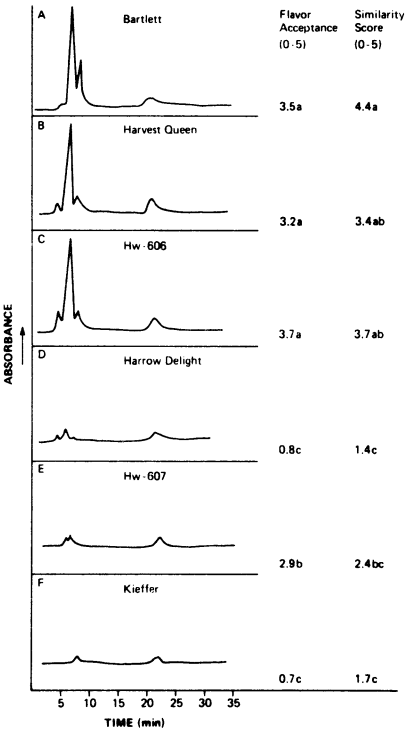

Fig. 1. Typical HPLC profiles of canned fruit essences (A-F), flavor acceptance, and aroma similarity scores for several pear cultivars. The higher mean score indicates higher flavor acceptance and closer similarity to Bartlett. Mean separation in the columns is by Tukey's test, 5% level.

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Table 1. The decadienoate equivalents and Bartlett-like aromas in canned fruit of several pear cultivars.

Cultivar	Decadienoate equivalents (μM/kg) Mean	SE	Percentage of samples rated as being Bartlett on the basis of aroma[z]
Harvest Queen	258	31	55
HW-606	275	5	50
Bartlett	178	48	82
Parbarton[y]	137	40	100
Stewart's Bartlett[y]	126	23	100
Russett Bartlett[y]	125	2	78
Surecrop	114	21	0
Yakima[y]	103	4	66
Maxred[y]	102	15	88
Laxton's Progress	92	11	50
Seckel	41	1	0
Couricelle	24	2	0
Highland	22	4	0
HW-603	22	1	3
Barseck	5	1	11
HW-607	2	1	23
Aurora	0		22
Anjou	0		0
Bosc	0		0
Buerre Superfine	0		0
Clara Fris	0		22
Dr. Jules Guyot	0		0
Ewart	0		22
Kieffer	0		11
Mac	0		11
Magness	0		33
Maxine	0		0
Moonglow	0		0
NY 8760	0		22

[z]Nine to 39 ratings were made.
[y]The cultivar is a mutant of Bartlett.

ing to accepted practice in the industry. Canned fruit were used in taste and aroma panels and for chemical analyses. Fruit were harvested in 1974 for the aroma comparison and direct spectrometric measurement conducted on 29 cultivars, and in 1981 for aroma comparison and high pressure liquid chromatography (HPLC) conducted on 6 cultivars.

Decadienoate ester levels of the 29 cultivars in 1974 were determined by direct spectrophotometry according to the method of Heinz et al. (1). A 20 g sample of drained pear halves was macerated in an equal weight of 0.1 M potassium-phosphate buffer, pH 7.4. The slurry of tissue and buffer was shaken with isooctane (spectral grade) and centrifuged. A spectrophotometer was used directly to measure the absorbance of isooctane fraction at 263 nm. The decadienoate level was expressed as μm equivalents of the methyl ester, the main ester of the decadienoate ester moiety. Three to 6 determinations were made on each cultivar. In the study of the cultivar collection, 3 or 6 trained panelists were asked to score the aroma of marked samples as being the same as or different from the 'Bartlett' standard.

Pear essences were prepared by Nickerson-Likens distillation-extraction (4) using distilled water as the high density layer and pentane (spectral grade) as the low density layer. Syrup was drained from the canned fruit, and a 100-g sample of drained canned fruit was pureed with 100 ml of distilled water in a Waring blender before placing in the distillation flask of the Nickerson-Likens apparatus. Essences of actively growing and dormant shoots also were prepared for measurement by HPLC. Shoot material (50 g/100 ml H_2O) was boiled for 20 min in distilled water and macerated before placement into the distillation flask of the Nickerson-Likens apparatus. An antifoaming agent (BDH aqueous emulsion containing 30% w/w silicone) was added to the boiling flask. Three distillation-extractions were made for each cultivar and type of plant material. After distillation and extraction for 3 hr, the pentane fraction was separated from the aqueous distillate and dried over anhydrous sodium sulfate. The pentane extract was diluted to 15 ml, and 0.1 ml was injected into a high pressure liquid chromatograph connected to an ultraviolet-visible spectrometer. Compounds were separated on a 25 cm × 4.6 mm Partisil 10 u column (Whatman) at 25°C using cholorform and isooctane mixture (15:85 v/v) at a flow rate of 1 ml/min. The spectrometer was set at a wavelength of 263 nm and an absorbance range of 0.08.

Flavor acceptability and Bartlett-like flavor of 1981 samples were evaluated in separate taste panels using 6 trained panelists. Panelists evaluated the similarity to 'Bartlett' and flavor acceptance from high to low by marking the distance on a line of constant length. The distance on the line was measured and converted to numerical scores. Texture and appearance of the fruit were masked by using red light and maceration of the fruit. Taste panels were replicated 6 times for aroma similarity and 4 times for flavor acceptability.

Table 1 lists the decadienoate equivalent of cultivars which were measured by the direct spectrometric method. 'Bartlett', its sports, 'Harvest Queen', HW-606, and 'Laxton's Progress' were characterized by high decadienoate equivalent levels. The aroma of these cultivars were confused with 'Bartlett' by panelists at least half the time. 'Surecrop' was the only cultivar lacking the Bartlett-like flavor found to have decadienoate equivalents equal to the cultivars with Bartlett-like aroma. The decadienoate esters of 'Surecrop' have been observed to differ qualitatively from those cultivars with Bartlett-like aroma (5). The decadienoate ester level of 19 other cultivars ranged none to from one-half of the levels found in cultivars with Bartlett-like aroma. Panelists confused the cultivars which had low decadienoate equivalents with 'Bartlett' in only a few trials.

Ultraviolet-absorbing compounds were present in high levels on the HPLC chromatographs of essences derived from fruit of 'Bartlett', 'Harvest Queen', and HW-606 (Fig. 1). The main group of these compounds was identified previously as decadienoate esters by means of infrared spectrometry (5). The aromas of 'Harvest Queen' and HW-606 were scored as similar to 'Bartlett'. Low levels of the ultraviolet-absorbing compounds were found in 'Kieffer', 'Harrow Delight', and HW-607. The similarity scores of the cultivars and selections with low decadienoate ester levels were significantly different from 'Bartlett'.

'Bartlett', HW-606, and 'Harvest Queen', cultivars in decadienoate ester levels and similar in aroma, were rated significantly higher in flavor acceptance than HW-607 'Kieffer', and 'Harrow Delight' which contianed low decadienoate ester levels and were dissimilar to 'Bartlett' in aroma.

High decadienoate levels appear to be characteristic of 'Bartlett' and cultivars with similar aroma. The high levels of decadienoate esters found in 'Surecrop', which has an aroma unlike 'Bartlett', indicates that the levels of individual decadienoate esters are important to the development of Bartlett-like aroma, or that other unidentified components interfere with expression of the decadienoate esters. The simple extraction with isooctane appears to be useful for identifying cultivars with high decadienoate level, but precise characterization with HPLC or gas chromatography of distilled and concentrated essences is required for exact identification of the flavor type.

The esters were not detected in dormant or actively growing shoots, including the leaves. Thus, early seedling selection before fruiting, based on determination of decadienoate esters in the shoot, does not seem possible.

Among the cultivars studied, only a few had high levels of the decadienoate esters. Breeders may have to rely on 'Bartlett' and a few other closely related cultivars as par-

ents to obtain seedlings with Bartlett-like aroma. All of the cultivars and selections with Bartlett-like aroma in this study had 'Bartlett' as a parent. It may be possible to select seedlings of good processing quality using parents other than 'Bartlett', but the chance of the flavor being similar to 'Bartlett'may be low. Further work is required to determine the inheritance of the 'Bartlett' flavor trait.

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The Effects of Oryzalin Alone and in Combination with Diuron and Simazine on Young Peach Trees

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Additional index words. weed control, herbicides, orchard floor management, *Prunus persica*

Abstract. **Oryzalin (3,5-dinitro-N^4,N^4-dipropylsulfanilamide), simazine (2-chloro-4,6-bis(ethylamino)-*s*-triazine), and diuron (3-(3,4-dichlorophenyl)-1,1-dimethylurea) alone and combinations of oryzalin plus simazine or diuron were applied annually for 4 years to young peach (*Prunus persica* L.) trees. The effectiveness of each herbicide decreased as years of use increased. Weed population shifts occurred with continuous use of the same herbicide. Herbicide combinations resulted in better weed control than did the monoherbicide treatments. Growth and yield were highly correlated with increased weed control.**

Young peach trees are especially vulnerable to weed competition (1, 12). Controlling weeds with herbicides has been shown to be superior to cultivation and has resulted in greater growth and yield (2). Although diuron and simazine have been used successfully in peach culture (4, 5, 6, 7), their effectiveness has decreased with continuous use over a number of years (8). This decreased effectiveness has been associated with a shift in species populations (9, 11). Oryzalin is a safe herbicide for young peach plantings (3, 14); however, it has exhibited weakness in controlling certain weed species (10). Herbicide combinations rather than a single herbicide result in improved control of a broad spectrum of weed species (13).

This study was conducted to evaluate the effect of continuous use of oryzalin, simazine, and diruon applied alone and combinations of oryzalin with simazine or diruon upon weed control, growth and yield of young peach trees.

Peach ('Sun Queen') trees were planted in April 1979 at Cream Ridge, N.J. The soil was a Freehold fine loam (mixed, mesic typic hapludults). The experimental design was a randomized complete block with 3 replications. Each plot was 4 m × 6 m and contained 3 trees. The herbicide treatments were applied in early May in 1979, 1980, 1981, and 1982, with a compressed air sprayer, delivering a volume of 374 liters/ha. Oryzalin was applied alone at 2.2, 4.5, and 9.0 kg/ha, and diuron and simazine were applied at 2.2 kg/ha. Various combinations of oryzalin plus simazine and oryzalin plus diruon also were applied as shown in Table 1.

Visual evaluation of weed control and measurements of trunk circumference of the peach tree were made in August of each year. Weed species present in each treatment were noted in August of 1980 and 1982. There was no crop the 1st fruiting year (1981) due to a freeze. Yield data were obtained in 1982. Data were subjected to an analysis of variance, and treatment mean comparisons were made using Duncan's multiple range test. Correlation coefficients were determined using the method of Snedecor and Cochran.

The effectiveness of single herbicide treatments decreased as years of use increased for each herbicide as expressed in terms of percentage of weed control (Table 1). The weed control obtained with oryzalin at 4.5 kg/ha was 90% in 1979, while in 1982 it was only 53%. Diruon at 2.2 kg/ha resulted in 100% control in 1979, while only 60% control in 1982. The effectiveness of simazine was reduced from 95% control in 1979 to only 35% in 1982. This decline was due mainly to a shift in the weed population (Table 2). With the control of susceptible weeds by a given herbicide, tolerant weed species became established with relative ease. Many of these weeds were biennials and perennials. This type of shift in weed species and

Table 1. Effect of annual herbicide treatments upon weed control.

Treatment	Rate (kg/ha)	Weed control (%) 1979	1980	1981	1982
Oryzalin	2.2	78 c[z]	85 b	45 d	23 e
Oryzalin	4.5	90 b	85 b	72 c	53 d
Oryzalin	9.0	95 ab	90 ab	82 abc	73 bc
Oryzalin + Diuron	2.2 + 2.2	98 a	100 a	90 ab	78 ab
Oryzalin + Diuron	4.5 + 2.2	100 a	100 a	98 a	95 ab
Oryzalin + Diuron	9.0 + 4.5	100 a	100 a	100 a	95 ab
Oryzalin + Simazine	2.2 + 2.2	100 a	100 a	98 a	90 ab
Oryzalin + Simazine	4.5 + 2.2	100 a	100 a	97 a	90 ab
Oryzalin + Simazine	9.0 + 4.5	100 a	100 a	100 a	100 a
Diuron	2.2	100 a	90 ab	75 bc	60 cd
Simazine	2.2	95 ab	67 c	50 d	35 e
Untreated		10 d	0 d	0 e	0 f

[z]Mean separation with columns by Duncan's multiple range test, 5% level, analysis performed on arcsin $\sqrt{x}$ transformed data.

Received for publication 17 Feb. 1984. Mention of a herbicide in this paper does not constitute a recommendation for use by the USDA, nor does it imply registration under FIFRA, as amended.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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