twigs of both healthy and weak trees. Since *Cytospora* is a common secondary invader and the cirri are common on dead twigs, no attempts were made to isolate the organism from the injured trunk tissues. However, in view of the recent work by Clayton (1), *Cytospora* should be examined as 1 of the possible factors involved in short-life and as 1 of the factors interacting with time of pruning.

*Clytocybe* root rot was extensive in roots of only 3 dead trees which were counted alive for the analysis. *Clytocybe* kills many trees in the Southeast, but since the symptoms of *Clytocybe* root rot are distinct from those of short life, it is assumed that *Clytocybe* did not interact with time of pruning to cause injury and tree death in this experiment.

**Table 2. Correlations of the 1968 discoloration ratings with tree conditions in July 1969 in Orchard no. 2 and percentage of variation accounted for by the correlations ($r^2 \times 100$).**

<table>
<thead>
<tr>
<th>Pruning dates combined</th>
<th>$r^2 \times 100$</th>
</tr>
</thead>
<tbody>
<tr>
<td>November</td>
<td>34.28</td>
</tr>
<tr>
<td>December</td>
<td>25.09</td>
</tr>
<tr>
<td>January</td>
<td>28.21</td>
</tr>
<tr>
<td>February</td>
<td>0.0001</td>
</tr>
<tr>
<td>Pruning dates combined</td>
<td>21.02</td>
</tr>
</tbody>
</table>

**Correlations significant at 1% level.

The role of other possible factors such as *Pseudomonas*, *Cytospora*, and temp, and their interactions with time of pruning as they affect short-life of peach trees, needs to be determined. However, our results clearly indicate that time of pruning does influence tree longevity and that short-life is site oriented.

**Literature Cited**


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**Effects of (2-Chloroethyl)phosphonic Acid on Rhizome and Tuber Formation in the Potato, *Solanum tuberosum* L.**

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Abstract. Although ethephon did not influence number of primary rhizomes on potato cv. Katahdin in growth chambers, the 500 and 1000 ppm treatments significantly increased the number of secondary rhizomes. Length of primary rhizomes was increased by the 50 ppm treatment. Number of primary tubers per plant decreased with increasing ethephon concn. Total tuber wt per plant was significantly reduced by all ethephon treatments, except 10 ppm which did not differ from controls.

Normal tuber formation in the potato (*Solanum tuberosum* L.) depends upon 2 distinctly different, although closely related processes: development of the rhizome and tuberization of the rhizome tip. Both processes are thought to be controlled by environmental factors, mainly photoperiod and temp, which govern levels of endogenous growth regulators. For example, rhizome elongation has been shown to be enhanced under long day conditions (8) and Okazawa (22) detected higher gibberellin levels in plants grown under long days. Okazawa (23) showed that the onset of tuberization was associated with a decrease in gibberellin content. Relatively high levels of auxin (IAA) have been reported in rhizome tips, as well as the appearance of a growth inhibitor concomitant with tuberization (3). Inhibitor levels have been shown to increase in plants grown at lower temp, a condition favoring tuberization (22). The existence of a specific tuberization hormone has been suggested (12, 17, 24) which might be similar to the cytokinins (9). Recent studies by Palmer and Smith (25, 26) have shown that kinetin induces tuber formation on isolated rhizomes in *vitro*.

With increasing awareness that ethylene, a natural plant product, participates in endogenous regulation of plant growth and development, it is possible that a compound capable of regulating ethylene production within the plant could be useful in altering its morphology. Auxins, such as IAA (1, 29), and gibberellic acid (27) have been reported to stimulate ethylene evolution by plant tissue and several growth responses previously attributed to auxin have been related to auxin-induced ethylene formation (4).

Ethephon ([2-chloroethyl]phosphonic acid)] has been observed to give plant responses similar to those produced by exogenously applied ethylene (2). This is not surprising since degradation of ethephon to ethylene has been reported (10, 13, 18, 31, 32). Plant responses attributed to ethylene include stimulation of lateral bud growth, including rhizome buds (10). Working with the lowbush blueberry, Kender et al. (15) were able to increase rhizome production with ethephon applied as a foliar spray.

When ethephon and IAA were applied in combination,
Langille (16) observed that rhizome growth was stimulated from buds on daughter tubers of potato plants exhibiting “little tuber” symptoms. Singh (28), who applied ethephon to curtail foliar expansion of potato after “optimum” leaf area was achieved, found that number of rhizomes decreased with increasing ethephon concn but tuber number was unaffected. Catchpole and Hillman (6) were able to stimulate sub-apical rhizome swelling in potatoes by direct application of ethephon. Unlike the cytokinin-induced tubers of Palmer and Smith (25) however, they displayed no evidence of starch accumulation.

Since the rhizome serves as a potential site for tuber formation, it seems that within limits, increased tuber yields could be achieved by stimulating rhizome initiation. The following study was undertaken in an attempt to increase rhizome number through use of (2-chloroethyl)phosphonic acid.

Materials and Methods

In study 1, seedpieces of cv. Katahdin were placed in moist perlite in the dark until sprouts measured approx 10 to 15 cm. Seedpieces were then transferred to inverted 1-gal cans which had been partially filled with perlite and were supported on aluminum pie plates. Each can had been drilled with 3 holes: an 8 cm diam observation hole in the side which served to introduce the seed and 2 smaller holes in the bottom of the inverted can: 1 for the emerging sprout and the other for addition of water and nutrient solution. Light was excluded by covering the observation hole with a wide rubber band which could be rolled back to permit regular observation. Molding clay was used to seal the sprout where it emerged from the can and the watering hole was stoppered. Plants were watered regularly and given weekly applications of Hoagland’s complete nutrient solution (14).

In study 2, ‘Katahdin’ seedpieces were planted in 1-gal crocks filled with 4 parts garden soil and 1 part peat moss (pH 5.4). This study was repeated and the data combined.

For both study 1 and study 2, containers were placed in a growth chamber adjusted to 20°C ± 2° with a 14-hr photoperiod. Light intensity at soil level measured 650 ft-c supplied by 8 fluorescent tubes and 8 60-watt incandescent lamps.

Following emergence and expansion of 5 to 6 leaves, plants were removed from the chamber and freshly prepared solutions of ethephon were applied at concn of 0, 10, 50, 100, 500 and 1000 ppm to the point of foliar runoff with a hand atomizer. All treatments included the surfactant Tween 20 at the rate of 1 ml/1. The 6 treatments were replicated 5 times and after the leaves had dried, plants were returned to the chamber and arranged in a randomized complete block design. Harvests were made after control plants had flowered or approx 6 weeks after spray treatment. Plant roots were washed and the number and length of primary and secondary rhizomes and tuber number and wt per plant were ascertained.

Data were subjected to analysis of variance, and Duncan’s Multiple Range Test was used to test significance of observed differences between means.

Results

In study 1, plants receiving the higher ethephon treatments displayed typical ethylene exposure symptoms (i.e. shortened internodes, swollen nodes, and lateral bud release). Ethephon also influenced rhizome initiation (Fig. 1).

The 500 and 1000 ppm ethephon treatments increased number of secondary rhizomes per plant compared with other concn (Table 1). Number of primary rhizomes, however, was not influenced by ethephon at any concn used. Number of tubers per plant decreased with increasing ethephon concn, with the 500 and 1000 ppm treated plants producing fewer tubers than other treatments. Although plants treated with 100 ppm ethephon produced more tubers than those receiving the higher concn, they were still less productive than control plants (Table 1).

Fig. 1. Comparison of secondary rhizome growth and tuber set between ethephon treated plant (1000 ppm) on right and control plant on left (study 1).
Several rhizome tips of plants grown in inverted cans appeared darkened, either due to desiccation or mechanical injury through contact with the sides of the container.

In an attempt to more closely simulate actual field conditions, soil was used as a growth medium in study 2. Again, ethephon had no effect on number of primary rhizomes, but secondary rhizome number was significantly increased with higher ethephon concn (Table 2). Greatest response occurred with 500 and 1000 ppm concn. Below 500 ppm, however, only 50 ppm ethephon produced significantly more secondary rhizomes than controls.

Total length of primary rhizomes was increased by 50 ppm ethephon over the 0, 500, and 1000 ppm treatments. There was no significant difference between total length of primary rhizomes of plants treated with 10, 50 and 100 ppm ethephon.

Reflecting the increase in number of secondary rhizomes, total length of secondary rhizomes was increased by the 500 and 1000 ppm ethephon treatments when compared to the control. The promotional effect on primary rhizome length noted previously for the 50 ppm treatment was also observed for secondary rhizomes.

Number of tubers produced on primary rhizomes decreased with increasing ethephon concn. The plants receiving 500 and 1000 ppm ethephon produced fewer primary tubers than those treated with 0, 10 and 50 ppm. No significant differences were observed in secondary tuber production for any of the ethephon concn tested. Tuber wt per plant, however, decreased with increasing ethephon concn.

Discussion

Since ethylene-releasing properties for ethephon have been reported (10, 13, 31, 32), it was anticipated that this compound could be useful in modifying growth of the potato plant by controlling processes known to be regulated by ethylene. These include apical dominance and bud dormancy (2, 29).

The foregoing results indicate that ethephon does, in fact, have a profound influence upon these developmental processes. As noted in other species (15) ethephon stimulated bud release in both aerial and below-ground portions. Higher concn of ethephon produced more than a 300 percent increase in number of secondary rhizomes, but had no effect on primary rhizome number. These results differ from those of Singh (28) who found that ethephon concn of 500 and 1000 ppm caused a significant reduction in number of rhizomes for the same cultivar. Unlike the present study, however, he applied the chemical at a more advanced growth stage, certainly after rhizome formation would normally have occurred. Morgan and Gausman (20) have suggested that exogenous ethylene inhibits polar auxin transport which could lead to localized surpluses and shortages of auxin. Since exogenously applied auxin has been shown to increase extensibility of cell walls (11), it is tempting to speculate that auxin accumulating in portions of the rhizomes of 50 ppm treated plants was responsible for their increased elongation. The lack of elongation response at the highest ethephon concn may have been related to phytotoxicity.

Ethylene-stimulated tuber initiation observed by Catchpole and Hillman (6) was not apparent in this study. This discrepancy may be due to length of time between ethephon application and development of rhizomes for tuberization. There is convincing evidence (13, 30) that ethylene evolution from ethephon is increased with increasing pH. Furthermore, Warner and Leopold (30) have shown that pH of plant cells is sufficiently high (pH 4.0-4.6) so that most of the ethephon in plant tissue would have been converted to ethylene in the first 48 hr.

### Table 1. Effect of ethephon concn on rhizome and tuber number per plant grown in perlite.

<table>
<thead>
<tr>
<th>Concen (ppm)</th>
<th>Rhizome no.</th>
<th>Rhizome length (cm)</th>
<th>Tuber no.</th>
<th>Tuber wt. (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary</td>
<td>Secondary</td>
<td>Primary</td>
<td>Secondary</td>
</tr>
<tr>
<td>0</td>
<td>4.9a</td>
<td>7.6a</td>
<td>3.3a</td>
<td>3.7a</td>
</tr>
<tr>
<td>10</td>
<td>4.2a</td>
<td>8.2a</td>
<td>2.8ab</td>
<td>2.3a</td>
</tr>
<tr>
<td>50</td>
<td>4.4a</td>
<td>6.5a</td>
<td>2.7a</td>
<td>4.4a</td>
</tr>
<tr>
<td>100</td>
<td>5.3a</td>
<td>7.0a</td>
<td>1.4c</td>
<td>5.2a</td>
</tr>
<tr>
<td>500</td>
<td>4.5a</td>
<td>35.8b</td>
<td>1.2c</td>
<td>5.0a</td>
</tr>
<tr>
<td>1000</td>
<td>3.7a</td>
<td>35.6b</td>
<td>0.4c</td>
<td>1.9a</td>
</tr>
</tbody>
</table>

2Within each column, means followed by the same letter were not significantly different (p = .05).

### Table 2. Effect of ethephon concn on rhizome number, rhizome length, tuber number, and tuber wt per plant grown in soil. Means are the averages of 10 determinations.

<table>
<thead>
<tr>
<th>Concen (ppm)</th>
<th>Rhizome no.</th>
<th>Rhizome length (cm)</th>
<th>Tuber no.</th>
<th>Tuber wt. (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary</td>
<td>Secondary</td>
<td>Primary</td>
<td>Secondary</td>
</tr>
<tr>
<td>0</td>
<td>7.4a</td>
<td>6.0c</td>
<td>68.1 bc</td>
<td>14.2 c</td>
</tr>
<tr>
<td>10</td>
<td>8.7 a</td>
<td>7.9 bc</td>
<td>88.2 ab</td>
<td>14.0 c</td>
</tr>
<tr>
<td>50</td>
<td>8.2 a</td>
<td>13.1 b</td>
<td>97.2 a</td>
<td>31.5 ab</td>
</tr>
<tr>
<td>100</td>
<td>7.6 a</td>
<td>125 bc</td>
<td>84.9 ab</td>
<td>26.7 bc</td>
</tr>
<tr>
<td>500</td>
<td>8.0 a</td>
<td>20.2 a</td>
<td>62.9 bc</td>
<td>47.2 a</td>
</tr>
<tr>
<td>1000</td>
<td>8.3 a</td>
<td>21.4 a</td>
<td>48.1 c</td>
<td>48.0 a</td>
</tr>
</tbody>
</table>

2Within each column, means followed by the same letter were not significantly different (p = .05).
Reduction in tuber wt and number of primary tubers per plant with increasing ethephon conen appeared to be the result of a reduction in size of certain plant parts. Ethephon has been reported to inhibit leaf expansion in potatoes (2) so that, even though the chemical increased potential sites for tuber formation, the photosynthetic area was sufficiently reduced to prevent adequate carbohydrate production for filling these sites. Furthermore, ethylene has been shown to inhibit growth of roots (7), a proposed site of cytokinin synthesis (21). If cytokinins are required for tuber initiation as indicated by Palmer and Smith (25), ethephon-restricted root growth could have led to a shortage of cytokinin in certain rhizome tips, resulting in reduced tuber yield.

Our data indicate that ethephon did not produce the desired effect on tuber yield. Further testing of rates and times of application should be explored, however, before the chemical is judged to lack potential for commercial potato production.

Literature Cited