THE USE OF METASYSTOX-R FOR CONE AND SEED INSECT CONTROL
IN SEED ORCHARDS

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Introduction

Cone and seed insects are a major detriment to conifer seed production in the Province of British Columbia (B.C.) (Hedlin, 1974; Hedlin, et al. 1980; Miller, 1980). In seed orchards, it is possible to control their damage through the use of insecticidal sprays (Fogal and Lopushanski, 1985; Hedlin, 1966; Miller, 1980; 1983; 1984; Overhulser and Sandquist, 1985; Stein and Markin, 1986; Summers and Miller, 1986; ). In B.C., systemic insecticides are preferred over contact insecticides for cone and seed insect control. Systemic insecticides penetrate cone tissue and are translocated within the cone to sites where the insects feed. If applied after the insect oviposition period, the material will penetrate the cones and kill the newly emerged larvae. This allows orchard managers to sample insect populations (using egg counts) to determine whether treatment is required or not (Miller, 1983; 1984; 1986; ). At the present time, two systemic insecticides are registered in Canada for cone and seed insect control: dimethoate (on Douglas-fir and spruce) and oxydemeton-methyl (on Douglas-fir).

It is useful to have at least two alternative insecticides registered for each conifer species. In a seed orchard, one formulation may work very well on most families or clones but may be phytotoxic to others (Miller, 1982). Having an alternative insecticide allows an orchard manager to protect the seed crops on those sensitive trees. Alternatives are only available for Douglas-fir orchards. For some orchard tree species such as western redcedar, there is no registered material for cone and seed insect control.

Systemic insecticides can also offer a method with which to reduce the amount of off-target pesticide residue in a seed orchard. Pesticide spray operations are always associated with spray drifting off target. In recent years, numerous studies have shown that systemics, injected directly into the trunk of a tree, can be effective in controlling cone and seed insects (Dale and Frank, 1981; Fogal and Lopushanski, 1989; Johnson, et al., 1984; Koerber, 1976; Koerber and Markin, 1984; Merkel and DeBarr, 1971; Reardon, et al., 1985; Summers and Miller, 1986; ). This method of application is not registered in Canada at present, but it may offer a feasible alternative to conventional spray operations in
environmentally sensitive areas.

The purpose of this paper is to outline the results of several recent studies done in B.C. to test the efficacy of one systemic insecticide, Metasystox-R, as an control for cone and seed insects of Douglas-fir, spruce and western redcedar. These trials were focused on the following:

1. the use of MSR trunk injections against cone pests of Douglas-fir and spruce.
2. the use of foliar applications of MSR against cone pests of spruce and western redcedar.

Methods

In general, the methods used in the trials were similar and an outline is provided here. All trials were conducted in provincial seed orchards or in test plantations at the Cowichan Lake Research Station, near Duncan B.C. (Appendix 1).

Cone bearing trees were selected early in the spring by assessing the numbers of cone buds present. Once selected, the trees were randomly assigned to treatments. Candidate trees were chosen either from the entire population of crop trees at a site or, where necessary, from a selection of crop trees provided by the orchard manager for our use.

Treatments were applied after insect oviposition in the spring. For Douglas-fir and spruce, this was when the conelets had begun to turn from upright to horizontal and before they had reached the pendant stage (Anon, 1986; Miller, 1983;). For western redcedar, the end of oviposition was estimated through field and laboratory observations. Sprays (early sprays, Table 6) were applied at the first sign of egg hatch in the cones. This timing would coincide with operational timing, should egg sampling be used to estimate insect populations. On cedar, an additional test (late spray, Table 6) was made approximately 2 weeks after oviposition.

Sprays of MSR (PCP 7882) were applied by backpack sprayer at rates of 0.125, 0.25, and 0.50 % a.i. (volume) in water. The cone bearing areas of trees were sprayed to run-off. The injections were made in one of two ways. The first method was to use Mauget injectors (J.J. Mauget Co., Burbank, Calif. U.S.A. 91504). These are packaged, plastic containers containing 3ml of Metasystox-R (50% a.i.) each. The containers are attached to small feeder tubes that are inserted into the sapwood of the tree. The second injection method was to apply MSR (PCP 7882; 25% a.i.) by syringe, directly into holes drilled in the trunk of the tree. The same rates of application were used with either method- 3ml of MSR (product) every 10, 15 or 30cm of tree circumference, applied below the first lateral branches. In these tests, this varied from breast height to about a 30cm from the ground.
Cones were collected for assessment at about the time of operational cone harvest (August-September). Where possible, 20 cones were sampled from each tree and bagged separately. Samples were stored at 0°C until they could be assessed for insect damage. Insect damage was assessed by either dissecting the cones scale by scale (full cone counts), one-half cone counts of insect damage made on a longitudinally cut face of a cone, or both. Assessments included one or more of the following, depending on the host tree and the insect being studied: filled seed, hollow seed, seed destroyed by insects, number of larvae, number of galls (for the Douglas-fir gall midge). The insects that were studied were:

**Douglas-fir**
- *Contarinia oregonensis* Foote
  - Douglas-fir cone gall midge
- *Megastigmus spermatrophius* Wachtl
  - Douglas-fir seed chalcid

**Spruce**
- *Strobilomyia neanthracinum* (Czerny)
  - spruce cone maggot

**Western redcedar**
- *Mayetiola thujae* (Hedlin)
  - western redcedar cone midge

Germination tests were done on seed from most trials and followed the appropriate procedure as outlined by Edwards (1987). Data analysis was performed through SAS Procedures (SAS Institute Inc., Cary, North Carolina, USA, 27511).

A short description of each trial accompanies the tables in this paper. Tables 1, 2, 5 and 6 include results for treatments using other insecticides. These treatments were included in the trial designs at the time and are therefore included here for information.

**Results and Discussion**

Douglas-fir (Table 1; Table 2; Fig 1; Fig 2)

The major pest of Douglas-fir cones in coastal B.C. is the cone midge (*C. oregonensis*). Injections of MSR reduced damage by this midge in all tests when applied at a rate of 3ml/15cm or 3ml/10cm of tree circumference. The percentage of cones attacked was also reduced in at least two of the tests (Table 1; Table 2). Efficacy appears to drop at the 3ml/30cm rate using the Mauget injectors.
(Table 1). Although the treatments were not statistically different, injections did not appear to be quite as effective as sprays of MSR or dimethoate (Cygon) in 1984 (Table 2). However, they were possibly more effective than dimethoate sprays in 1987 (Fig 1).

MSR injections did not affect the numbers of filled or hollow seed per cone in Douglas-fir. Losses by the gall midge are usually due to the seed being fused in the cone by the gall that the insect forms on the scale tissue. This hinders seed extraction and results in seed losses even though the numbers of seed/cone may be high. Reducing the number of gall midge galls in a cone will increase the number of extractable seed /cone. While the number of filled seeds/cone was increased by an operational spray of dimethoate in 1984 (Table 2), this is not consistent on a year to year basis (Summers and Miller, 1986). There are many physiological and environmental factors that affect the number of filled seed in conifer cones (Owens, 1973).

The effect of MSR on the seed chalcid (M. spermatrophus) remains unclear because of the low populations in the trials but there is a trend in the data that suggests that damage may be reduced by injections. Damage was reduced in 1987 (Fig 2) and the percentage of cones attacked was reduced in 1983 (Table 1). Also, in 1983, the percentage of seed infested with the seed chalcid was reduced from 6.4% in the checks to between 2.14 and 2.6% in treated cones (data on file). The operational significance of the latter data remains uncertain and should be checked in a year with more insects.

Spruce (Table 3; Table 4)

The major pest of spruce cones in the orchards is the spruce cone maggot (S. neanthracinum). This insect tunnels through the cone, feeding on scale tissue and seeds.

Both sprays and injections of MSR reduced damage by this insect (Table 3; Table 4), however the efficacy of sprays begins to drop at 0.125% a.i. (Table 4). The number of filled seed/cone was increased by all treatments. The number of hollow seed/cone was also increased (Table 4). The increase in hollow seed is probably not a treatment effect on the developing seed, but rather an artifact that appears because of the lack of damage in the cones. With insects in the cones, both hollow and filled seeds would be eaten and would not show up in the dissections. The data does indicate that there is potential for increasing the number of seeds/cone in spruce seed orchard crops through pollen management, frost protection, etc. (Faulkner, 1975).

MSR appeared to reduce seed germination at some rates in 1989 at Skimikin Seed Orchard, however the effect was not consistent with the rates used (Table 4). Germination for the 3ml/10cm injection was higher than the germination for the 3ml/15cm injection and the .5% spray had higher germination than the .25% spray. Why this should occur is not clear. If the sprays were having an effect on the seed, a higher rate of application would be expected to have more of an effect than a lower rate. Even with a slight reduction
in germination, the seed return from the treatments is almost double that of the checks (Table 3; Table 4).

Western redcedar (Table 5; Table 6)

MSR sprays (as well as the other insecticides tested) reduced damage by the cedar cone midge (M. thujae) (Table 5). There was a dramatic difference in damage between sprayed and unsprayed cones when the they were dissected. This midge moves through the cones feeding on the developing seeds so the damage is quite noticable. The data in Table 6 indicates that the percentage of filled seed in the cones was increased by early sprays of Orthene or MSR. This may be so, however the situation would be the same as it was above for spruce. The lack of damage in the cones meant that there was more seed uneaten by the insects, whether that seed was filled or empty.

Germination was apparently not reduced by the treatments. The results were quite variable due to the small sample size available for testing. The trial was conducted in a poor seed year and the number of seed available for testing was small. In an associated study within the same orchard, the average number of seeds/cone was only 0.88 with 24.8% of those seed being filled (Summers and Crowder, 1987).

There were no obvious signs of foliar phytotoxicity caused by MSR in any of the above tests. While the possibility does exist that some families or clones will be susceptible to damage, this can be minimized by testing the material on trees before using it operationally. A similar situation exists for the use of dimethoate on Douglas-fir (Miller, 1982). Where dimethoate sensitivity is known to occur in Douglas-fir, orchard managers have used MSR successfully as an alternative, without phytotoxic effects (C. Cook, Fletcher Challenge Canada, pers. comm.).

Conclusions

1. Injections of MSR are a feasible alternative to sprays for controlling cone and seed insects on Douglas-fir and spruce.

MSR can be applied using either Mauget injectors or a direct injection via syringe. Rates of application should be 3ml per 10-15cm of tree circumference. The actual rate of active ingredient used will vary with the product used, but these tests resulted in consistent control irrespective of the product differences.

2. Sprays of MSR are effective against cone and seed insects of spruce and western redcedar.

In the case of spruce, MSR offers an alternative to dimethoate and in the case of western redcedar, MSR would be a candidate insecticide for operational use.
Sprays should be applied to run-off at rates between 0.25 and 0.50% a.i. in water. They should be applied to spruce after pollination but before the cones are pendant (May-June). On western redcedar, sprays should be applied after oviposition has occurred and at the first sign of egg hatch (March-April). The 0.25% rate was not tested on cedar however this rate is effective on both Douglas-fir and spruce so there is no reason to expect that it would not work on cedar.

The injection technique requires that workers handle concentrated products, however this risk can be managed through the use of protective clothing. The environmental risks with this method of application appear to be minimal as the material is applied to and contained by the trees.

Drilling holes does damage the trees, but the holes heal quickly and the healed wounds would be no worse that the wounds caused by cone induction techniques such as girdling. Most orchard plans call for cone production to be rotated through the orchard such that each tree would produce cones only once every two to three years. This would allow time for treated trees to heal between treatments.
REFERENCES CITED


Table 1: Effects of stem injections of acephate and Metasystox-R on Douglas Fir seed at Lake Cowichan, British Columbia, in 1983

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Spacing of Injectors</th>
<th>Number of Cones</th>
<th>Mean number of seeds/cone*</th>
<th>% cones attacked**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hollow</td>
<td>Filled</td>
</tr>
<tr>
<td>acephate</td>
<td>1/15 cm</td>
<td>100</td>
<td>18.0a</td>
<td>38.3a</td>
</tr>
<tr>
<td></td>
<td>1/30 cm</td>
<td>80</td>
<td>17.1a</td>
<td>44.1a</td>
</tr>
<tr>
<td>Metasystox-R</td>
<td>1/15 cm</td>
<td>140</td>
<td>15.8a</td>
<td>43.6a</td>
</tr>
<tr>
<td></td>
<td>1/30 cm</td>
<td>140</td>
<td>16.7a</td>
<td>39.2a</td>
</tr>
<tr>
<td>Check</td>
<td></td>
<td>138</td>
<td>15.5a</td>
<td>40.2a</td>
</tr>
</tbody>
</table>

* Means within a column followed the same letter are not significantly different, P=0.05; Duncan's Multiple Range Test.

** Percentages within a column followed by the same letter are not significantly different, P=0.05; x² - test.

(After Summers and Miller, 1986)
Table 2: Effects of two systemic insecticides applied via two methods on seed production at Quinsam Seed Orchard, Campbell River, British Columbia, in 1984.

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Method</th>
<th>Rate</th>
<th>Number of Cones</th>
<th>Hollow Seeds</th>
<th>Filled Seeds</th>
<th>Gall midge galls</th>
<th>Seed Chalcid</th>
<th>% Cones Attacked by gall midge**</th>
<th>Seed Germination (%)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimethoate</td>
<td>Spray</td>
<td>0.75%</td>
<td>131</td>
<td>37.9a</td>
<td>18.2a</td>
<td>1.8a</td>
<td>1.8a</td>
<td>19.8a</td>
<td>87.0ab</td>
</tr>
<tr>
<td>Metasystox-R</td>
<td>&quot;</td>
<td>0.25%</td>
<td>139</td>
<td>33.0a</td>
<td>8.7b</td>
<td>1.5a</td>
<td>3.1a</td>
<td>12.2ab</td>
<td>88.5a</td>
</tr>
<tr>
<td>Metasystox-R</td>
<td>&quot;</td>
<td>0.5%</td>
<td>169</td>
<td>29.8a</td>
<td>2.8bc</td>
<td>1.3a</td>
<td>1.7a</td>
<td>17.8a</td>
<td>88.0a</td>
</tr>
<tr>
<td>Metasystox-R</td>
<td>&quot;</td>
<td>1.0%</td>
<td>64</td>
<td>49.4b</td>
<td>6.4bc</td>
<td>0a</td>
<td>1.1a</td>
<td>0b</td>
<td>83.0ab</td>
</tr>
<tr>
<td>Check</td>
<td>-</td>
<td>-</td>
<td>193</td>
<td>35.5a</td>
<td>2.0c</td>
<td>39.8b</td>
<td>2.6a</td>
<td>100d</td>
<td>81.5b</td>
</tr>
</tbody>
</table>

* Means within a column followed the same letter are not significantly different, P=0.05; Duncan's Multiple Range Test.
+ Means followed by the same letter are not significantly different, P=0.05; \( \chi^2 \)-test.

**1 injector/15 cm of circumference, 0.1 gm a.i./cm

(After Summers and Miller, 1986)
FIGURE 1. GALL MIDGE GALLS FOUND ON 1/2 CONE SLICE--COLLECTED 1987 DEWDNEY S.O

FIGURE 2. MEAN MEGASTIGMUS FOUND ON 1/2 CONE SLICE--COLLECTED 1987 DEWDNEY S.O
Table 3: Effects of sprays of Metasystox-R on the cone maggot in an initial test on Spruce cones at Skimikin Seed Orchard, Tappen, B.C. in 1988

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>TOTAL* FILLED CONES</th>
<th>TOTAL FILLED SEED/CONE</th>
<th>% FILLED SEED</th>
<th>% CONES INFESTED</th>
<th>MEAN % GERMINATION</th>
<th>MEAN NO. SEED DESTROYED PER CONE (1/2 CONE COUNTS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td>3672/3671</td>
<td>379</td>
<td>10</td>
<td>15</td>
<td>65</td>
<td>97</td>
</tr>
<tr>
<td>0.5% a.i.</td>
<td>3581/3576</td>
<td>165</td>
<td>22</td>
<td>38</td>
<td>0</td>
<td>95</td>
</tr>
</tbody>
</table>

*Two counts were made of each seedlot. Calculations (filled seed/cone) are based on the larger number.
Table 4. Effects of sprays or injections of *Metasystox-R* on the spruce cone maggot in spruce cones at Skimikin Seed Orchard, Tappen, B.C., in 1989. Down columns, means followed by the same letter are not significantly different, $P=0.05$, Duncan's Multiple Range Test.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Hollow Seed</th>
<th>Filled Seed</th>
<th>Seed Destroyed</th>
<th>% Germ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td>5.87a</td>
<td>1.73a</td>
<td>10.52a</td>
<td>96.24a</td>
</tr>
<tr>
<td>Spray 0.125% a.i.</td>
<td>7.36a</td>
<td>3.86b</td>
<td>5.63b</td>
<td>91.99abc</td>
</tr>
<tr>
<td>Spray 0.25% a.i.</td>
<td>9.97b</td>
<td>5.17b</td>
<td>2.50c</td>
<td>89.49c</td>
</tr>
<tr>
<td>Spray 0.5% a.i.</td>
<td>10.94b</td>
<td>4.16b</td>
<td>1.89c</td>
<td>95.23ab</td>
</tr>
<tr>
<td>Injection 3ml/10cm</td>
<td>11.98b</td>
<td>5.87b</td>
<td>0.31c</td>
<td>96.25a</td>
</tr>
<tr>
<td>Injection 3ml/15cm</td>
<td>11.28b</td>
<td>4.12b</td>
<td>0.48c</td>
<td>90.93bc</td>
</tr>
</tbody>
</table>

* Metasystox-R (PCP 7882) sprayed or applied directly into holes via syringe.

** Data based on one-half cone counts.
Table 5. The effect of sprays on the western redcedar cone midge at Mt. Newton Seed Orchard, Saanichton, British Columbia in 1987. Means followed by the same letter in a column are not significantly different (P=.05).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of cones</th>
<th>Mean/cone Damaged ovules</th>
<th>Midge</th>
</tr>
</thead>
<tbody>
<tr>
<td>check</td>
<td>240</td>
<td>5.6a</td>
<td>4.5a</td>
</tr>
<tr>
<td>Orthene late</td>
<td>240</td>
<td>1.5b</td>
<td>1.2b</td>
</tr>
<tr>
<td>Orthene early</td>
<td>229</td>
<td>0.9bc</td>
<td>0.9bc</td>
</tr>
<tr>
<td>dimethoate early</td>
<td>230</td>
<td>0.3c</td>
<td>0.3bc</td>
</tr>
<tr>
<td>MSR early</td>
<td>231</td>
<td>0.4c</td>
<td>0.2bc</td>
</tr>
<tr>
<td>MSR late</td>
<td>240</td>
<td>0.2c</td>
<td>0.2bc</td>
</tr>
<tr>
<td>dimethoate late</td>
<td>240</td>
<td>0.1c</td>
<td>0.1c</td>
</tr>
</tbody>
</table>

1 early= spray applied at the end of oviposition, late= applied approximately 2 weeks later.
Table 6. The effect of sprays on the germination and filled seed count for seed from western redcedar cones treated in 1987 at Mt. Newton Seed Orchard, Saanichton, British Columbia. Means followed by the same letter in a column are not significantly different (P = .05).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean % filled seed</th>
<th>Mean % germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthene early</td>
<td>37.6a</td>
<td>81.3a</td>
</tr>
<tr>
<td>MSR early</td>
<td>29.1ab</td>
<td>90.6a</td>
</tr>
<tr>
<td>dimethoate early</td>
<td>27.8abc</td>
<td>75.0a</td>
</tr>
<tr>
<td>dimethoate late</td>
<td>27.8abc</td>
<td>87.5a</td>
</tr>
<tr>
<td>Orthene late</td>
<td>23.8bc</td>
<td>93.8a</td>
</tr>
<tr>
<td>MSR late</td>
<td>17.5cd</td>
<td>65.6a</td>
</tr>
<tr>
<td>check</td>
<td>10.7cd</td>
<td>81.3a</td>
</tr>
</tbody>
</table>

1 early= spray applied at the end of oviposition, late= applied approximately 2 weeks later.
GENERAL LOCATION OF CENTRAL SAANICH SEED ORCHARDS