WORKING PLAN

SX85605V

OPERATIONAL FLOWER INDUCTION OF DOUGLAS-FIR

USING GIBBERELLIN A 4/7

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MINISTRY OF FORESTS
COASTAL SEED ORCHARDS
DUNCAN, B.C.

JUNE 1985

(Revised August 1985 - M. Crown)
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1.0 INTRODUCTION

A primary objective of seed orchard management is the production of 'broadly adapted' seed. Given the genetic pool which exists within each orchard (families and/or clones), 'broadly adapted' seed will be produced when there is an evenly distributed parental balance of trees contributing to seed production.

To date most Douglas-fir seed has been produced on a relatively low number of seed orchard trees (Crown, 1985). The need for this project is this parental imbalance and the presence of recalcitrant trees in coastal seed orchards.

Studies have shown that application of gibberellic acids (GA 4/7) will promote flowering in Douglas-fir (Ross, 1985; Ross et al, 1985; Webber et al, 1985; Owens et al, 1985). This project looks at operational flower induction treatment in using GA 4/7 in an underproducing orchard - Snowdon Douglas-fir Seed Orchard #15 at Campbell River, B.C.

The use of GA 4/7 as a flower induction treatment is expected to benefit the seed orchard program by;

1. Increasing the proportion of clones and families which contribute to the orchard seed production to provide seed of complete parental balance.

2. Increasing the seed yield of 'low producing' and recalcitrant orchard trees.
2.0 OBJECTIVES

The objectives of this study are:

2.1 To develop operational procedures for the ultra low volume (ULV) spray applications of gibberellin in Douglas-fir orchards.

2.2 To develop productivity data for flower induction of Douglas-fir using GA 4/7.

3.0 FLOWER INDUCTION

The study will be located at the B.C. Ministry of Forests Snowdon Seed Orchard in Campbell River. The Douglas-fir orchard trees are open-pollinated seedlings (and a few clones and full-sib seedlings) planted in 1969 and 1970. The treatments involve the application of gibberellin A4 and A7 mixture (GA 4/7).

Hands on experience gained through these studies will provide the basis of the operational procedures and productivity estimates which will be compiled as part of this project.

3.1 Problem Statement:

What is the effect of operational GA 4/7 application on flower, cone, and pollen production of trees with a previous record of poor seed and pollen production at Snowdon S.O.?

3.2 Responses to be measured:

- Number of seed-cones per tree.
- Intensity of pollen-cones per tree.
- Hectolitres of cones per tree (with a sub-sample to determine number of cones/ha and seed statistics)
- Length of shoot elongation at each GA 4/7 application and final shoot elongation length.

3.3 Factors:

There are two factors in this study. The first is FAMILY and the second is TREATMENT - the application of GA 4/7.
3.4 Design:

This is a "family crossed with treatment" design to study the effect of GA 4/7 treatment of fertilized half-sib family pairs. Thirty families with lowest flower production history were selected for this study. Pairs in each family will be selected by visually matching tree height, diameter, and crownform.

The TREATMENT factor, GA 4/7, will be applied at two levels:

<table>
<thead>
<tr>
<th>TO</th>
<th>0 mg/litre</th>
<th>30 trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>200 mg/litre</td>
<td>30 trees</td>
</tr>
</tbody>
</table>

Thirty trees (one seedling per family) will not receive any GA 4/7 (TO). These are paired and matched to thirty T1 trees. Selection of the TO tree in the pair was randomly made by the flip of a coin.

The thirty treated (T1) trees will receive GA 4/7 application as follows: weekly application with 800 mg GA 4/7 per litre for 6 weeks commencing when 50% of the trees reach vegetative bud burst. The GA 4/7 will be applied with a ULV backpack sprayer. The conditions of the test to be met during GA 4/7 application are specified in Appendix I.

All 60 trees (2 seedling x 30 families) will be fertilized prior to vegetative bud burst with 400 kg/ha nitrogen applied to the equivalent area within their crown diameter. All trees were root-pruned in the fall of 1984 as part of the orchard management regime.

This study will be repeated for 3 years in order to develop and refine the OPERATIONAL experience pending further research results. Each year the study trees will be repeated on the same families in the rotating 'induction' section of Snowdon Seed Orchard for the same families. Thus individual trees will not receive GA 4/7 application in consecutive years.

The map in Figure 1 shows the location of the study trees at Snowdon Seed Orchard #15.
3.5 Data Collection

The following information will be collected for each ramet in each study year:

1. An historical record of pollen and flower cone production (yes/no) assessed for each study tree. i.e. how many years in ? years has the tree produced cones and/or pollen.

2. Average shoot elongation for each ramet at time of each GA 4/7 application, and final average shoot elongation at the end of the current growing season.

3. Number of female flowers per tree (collected by sub-sample) in the spring following GA 4/7 application.

The flower counts per tree will be assessed by a subsample. A procedure for sub-sampling individual tree seed-cone counts will be developed prior to the first year of flower assessment by C. Bartram, Ministry of Forests, and G. Miller, Canadian Forestry Service. The sub-sampling procedure should be accurate to 10% of total flower count at 90% confidence.

4. Intensity of pollen crop as rated operationally i.e. LOW, MEDIUM, AND HEAVY pollen crop.

This will be assessed once the first year's pollen crop is visible.

5. Volume of cones per ramet.

6. A sub-sample (10 cones/tree) will be collected by hand and forwarded to Cowichan Lake Research Station (CLRS) for seed extraction to determine the number of filled seeds/cone and number of seed/gm.

3.6 Analysis

Pollen-cone production, seed-cone production and cone & seed yield data for each tree and each clone will all be subjected to two way analysis of variance (ANOVA) models at two levels.

Table 1 provides the ANOVA model for this study.

The treatment effect and any interaction between treatment families will be determined in the analysis. The error is expected to be minimized by selecting matched (homogeneous) pairs of half-sib families.
The flower production for each family will be combined for the two observations per family. The production for each family will then be ranked and plotted on a bar graph. This will provide a graphic demonstration of family variation in cone production.

Crop production for all seedlings will be correlated to timing of GA 4/7 application in relation to shoot elongation. This information may help in narrowing down the 6 week treatment period.

Repeated studies over several years and sites will also be analyzed separately. The variability between years cannot be quantified and conclusively explained to allow for meaningful combination of data or results.

TABLE 1  ANALYSIS OF VARIANCE TABLES FOR FLOWER INDUCTION STUDY

Two Way ANOVA (two levels)  F-test at 0.05 
Total number of observations = 60

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gibberellic Acid (T)</td>
<td>1</td>
<td>MS1</td>
<td>MS1/MS3</td>
</tr>
<tr>
<td>Family (F)</td>
<td>29</td>
<td>MS2</td>
<td>(a)</td>
</tr>
<tr>
<td>T x F = Error</td>
<td>29</td>
<td>MS3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>59</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) The significance of the effect of the factor FAMILY cannot be tested in this mixed model where there is only one observation per cell.
4.0 PROCEDURES

Once experience is gained following the first season of GA 4/7 application operational procedures will be documented which describe 'How to Apply Gibberellic Acids Using A ULV Application'. This will be an expansion of "How To Apply Gibberellic Acids", (Colangeli, 1985).

5.0 PRODUCTIVITY

Baseline productivity data on the application of gibberellic acids will be collected for each application over the 6 week period. This information includes:

1) Time required to prepare stock and working solutions and calibrate & test equipment.
2) Volume of working solution applied to individual trees (by size of tree and application method).
3) Amount of GA 4/7 (grams) required per tree (by size of tree and application method).
4) Time required (hours or minutes) for application (by size of tree).
6.0 SCHEDULE OF ACTIVITIES

6.1 1985 Activities

SPRING FIELD WORK

- fertilize & root-prune trees (part of operations) 2.0
- select, identify & tag flower induction trees 1.0
- calibrate ULV sprayer 2.0
- prepare GA 4/7 stock solution 6.0
- GA 4/7 application & shoot elongation measurements-6weeks Subtotal 11.0

FALL FIELD WORK

- final shoot elongation 0.5

DATA ANALYSIS & REPORT WRITING

- Interim progress report (T. Crowder) 3.0
- How To Apply Gibberellic Acids procedures using ULV sprayer (T. Crowder) 1.0
- Subtotal 4.0

6.2 1986 Activities

SPRING FIELD WORK

- identify, select & tag flower induction trees 2.0
- fertilize & root prune all 1986 induction trees (part of operations) 8.0
- prepare & apply GA 4/7 collect data (pollen & flower production) on 1985 induced trees 0.5
- Subtotal 10.5

FALL FIELD WORK

- cone collection (1985 induced trees) (operational) 1.0
- record cone vol/tree 5.0
- ship cone samples to C.L.R.S. Subtotal 6.0

DATA ANALYSIS & REPORT WRITING

- first progress report including analysis of results of 1985 induced trees 10.0
6.3 1987 Activities

SPRING FIELD WORK

identify, select & tag 1987 flower induction trees 2.0
fertilize & root prune all 1987 induction trees (part of operations) 7.0
prepare & apply GA 4/7 7.0
collect data (pollen & flower production) on 1986 induced trees 0.5
Subtotal 16.5

FALL FIELD WORK

cone collection (1986 induced trees) (operational)
- record cone vol/tree 1.0
- ship cone samples to C.L.R.S. 5.0
- C.L.R.S. extraction and seed stats 5.0
Subtotal 11.0

DATA ANALYSIS & REPORT WRITING

Second progress report including analysis of results of 1986 induced trees 10.0

6.4 1988 Activities

SPRING FIELD WORK

collect data (pollen & flower production) on 1987 induced trees 0.5

FALL FIELD WORK

cone collection (1987 induced trees) (operational)
- record cone vol/tree 1.0
- ship cone samples to C.L.R.S. 5.0
- C.L.R.S. extraction and seed stats 5.0
Subtotal 11.0

DATA ANALYSIS & REPORT WRITING

final report including analysis of results of 1987 induced trees 15.0
7.0 COST ESTIMATES

<table>
<thead>
<tr>
<th></th>
<th>Man-days</th>
<th>m.d. $</th>
<th>Materials $</th>
<th>Total Direct $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Spring</td>
<td>11.0</td>
<td>$1500</td>
<td>$2000</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>0.5</td>
<td>$ 75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analysis &amp; Reporting</td>
<td>4.0</td>
<td>$ 600</td>
<td>$1500</td>
<td></td>
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<tr>
<td>Subtotals</td>
<td>15.5</td>
<td></td>
<td>$2325</td>
<td>$3500</td>
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<tr>
<td>1986</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>10.5</td>
<td>$1575</td>
<td>$2000</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>6.0</td>
<td>$ 900</td>
<td>$ 100</td>
<td></td>
</tr>
<tr>
<td>Analysis &amp; Reporting</td>
<td>10.0</td>
<td>$1500</td>
<td>$2000</td>
<td></td>
</tr>
<tr>
<td>Subtotals</td>
<td>26.5</td>
<td></td>
<td>$3975</td>
<td>$4100</td>
</tr>
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<td>1987</td>
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<tr>
<td>Spring</td>
<td>10.5</td>
<td>$2100</td>
<td>$2000</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>6.0</td>
<td>$ 900</td>
<td>$ 100</td>
<td></td>
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<tr>
<td>Analysis &amp; Reporting</td>
<td>10.0</td>
<td>$1500</td>
<td>$2000</td>
<td></td>
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<tr>
<td>Subtotals</td>
<td>26.5</td>
<td></td>
<td>$3975</td>
<td>$4100</td>
</tr>
<tr>
<td>1988</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>0.5</td>
<td>$ 600</td>
<td>$ 200</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>6.0</td>
<td>$ 900</td>
<td>$ 100</td>
<td></td>
</tr>
<tr>
<td>Analysis &amp; Reporting</td>
<td>15.0</td>
<td>$2250</td>
<td>$2000</td>
<td></td>
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<tr>
<td>Subtotals</td>
<td>21.5</td>
<td></td>
<td>$3225</td>
<td>$2300</td>
</tr>
</tbody>
</table>

GRAND TOTALS | 90.0 | $13,500 | $14,000 | $27,500.00 |
8.0 RESPONSIBILITIES

6.1 Silviculture Branch - Coastal Seed orchard Office - A. Wolfe

- Develop data collection and productivity sheets for;
  - ULV GA and N application
  - cone/flower monitoring
  - cone collection
- Coordinate materials
- Apply treatments (T. Crowder)
- Collect data (T. Crowder)
- Develop yield and production figures (A. Wolfe, C. Bartram)
- Analysis interpretation (A. Wolfe, C. Bartram)
- Author reports, procedures (A. Wolfe, T. Crowder)

6.2 Research Branch

- Treatment recommendations and technical advice (Physiologists)
- Assist in interpretation of data analysis (D. Errico)
- Seed extraction (CLRS)

6.3 Review Committee

- S. Ross – MOF Research Branch
- M. Crown – MOF Silviculture Branch
- C. Bartram – MOF Silviculture Branch

9.0 ACKNOWLEDGEMENTS

The author appreciates the technical advise provided by C. Bartram, M. Crown, D. Errico, S. Ross & J. Webber in preparing this working plan.

A. Wolfe
Seed Orchard Projects Coordinator
Coast

June 1985

(Revised August 1985, M. Crown)
10.0 REFERENCES


APPENDIX 1

CONDITIONS OF THE TEST (APPLICATION OF GIBBERELLIC ACIDS)

1. All trees will receive the same treatment. Sufficient solution will be used for adequate coverage of each tree without dripping excess solution off trees. Care will be taken to avoid double spraying of individual trees during one application.

2. No precipitation 8 hours following application.

3. No wind at all during ULV application.

4. Proper calibration of equipment to accommodate variation in tree size within each site.

5. Document weather conditions at day of application
   - wind
   - sun/cloud
   - next precipitation (time)
Optimum conditions for application are either early morning (6-9 a.m.) or evening (5-9 p.m.) when stomata are open for maximum uptake and minimum evaporative loss, or windless evening when temperature is cooling and there is minimal chance of precipitation.

6. Document phenological state of vegetative buds/shoots
   - bud burst, flush
   - shoot elongation.

7. Complete data collection sheet at each application.

8. Precautions in handling GA 4/7 and safety gear as necessary.