QUANTIFICATION OF ORCHARD SEED PRODUCTION
EFFICIENCIES AND ABSOLUTE SEED LOSSES
FROM THE TIME OF FLOWERING THROUGH
TO SEED GERMINATION

Seed Orchard Management Study

Progress Report for
Section 3ii(d) entitled:

Evaluation of Nylon Mesh Sacks for the
Storage of Seed Orchard Cone Collections

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TITLE Evaluation of Nylon Mesh Sacks for the Storage of Seed Orchard Cone Collections

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Introduction

In June of 1982 the Technical Planning Committee of the Coastal Tree Improvement Council (CTIC) hosted a tour of coastal seed orchards for seed orchard researchers/managers from Washington and Oregon. During the tour Dr. Roy Silen, Principle Plant Geneticist – PNW Forest and Range Experimental Station, stated that nylon mesh cone sacks may be preferable to the burlap sacks used traditionally in B.C. for operational seed orchard and natural stand cone collections.

Acting on this input the Silviculture Branch purchased 500 60 cm x 90 cm nylon mesh sacks for use in seed orchards¹. These sacks were first employed operationally in 1983 in CTIC orchards and on a limited basis in natural stands. Because these sacks were new in B.C. it was decided that their performance should be evaluated in comparison to the standard burlap sacks.

A single index of sack performance was chosen -- weight loss during cone storage. This parameter was selected because it could be easily assessed and should correlate well with cone moisture content. The following trial objective was thus formulated:

To ascertain if weight loss differences exist between nylon mesh sacks and burlap sacks when used for the storage of seed orchard cone collections.

¹These sacks were fabricated by:
Deluth Lighthouse for the Blind
2701 West Superior St.
Deluth, Minnesota
USA  55086

An additional 1000 30 cm x 60 cm sacks were purchased for seed orchard trial work and parent tree cone collections.
Methods

The trial was carried out at one coastal Douglas-fir seed orchard - #1 Quinsam, near Campbell River. Procedures were as follows. Cones were representatively sampled from throughout the orchard each collection day and placed into one of three sack types: nylon mesh, light burlap and heavy burlap. The sack type employed each day was selected randomly within three day replications. Each sack type was thus equally represented throughout the collection period.

The collection period lasted from August 23, 1983 to September 21, 1983. During this time cone collections were undertaken on twenty-two separate days and this number of sacks were therefore included in the trial: seven nylon, eight heavy burlap and seven light burlap.

Total weight of each sack was measured when filled with fresh cones (Day 0) and throughout the term of storage -- sacks were individually measured at seven day intervals (e.g. Day 7, Day 14 etc.) for fifty-six days (eight weeks) after Day 0. The contents of each sack were left intact throughout the trial and all sacks were stored under cover in a common storage facility.

Two types of analyses were performed. Sack weight loss was first examined over six different storage intervals using the following ANOVA model:

\[ Y_{ij} = \mu + T_j + E_{ij} \]

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2 Both light and heavy burlap cone sacks have been used in B.C. and were thus included in the trial. Light burlap sacks, consist of '7.5 ounce' weave; heavy burlap sacks a tighter '10.5 ounce' weave.

3 Because a late change to trial procedures the initial, Day 0, sack weight was not measured for the first six sacks included in the trial. All other weights were measured as planned.
where \(Y\) = sack weight loss, \(u\) = overall mean, \(T\) = sack type effect and \(E\) = random error.\(^4\) Weight loss to Day 56, 35 and 14 were each examined to determine if differences existed near the end of and during the storage period. Weight losses were calculated starting from Day 0 and from Day 7 because the latter day yielded six more observations.

The rate of sack weight loss over the 56 day storage period was also analyzed. Weight loss curves were fitted for each sack type using least squares regression techniques. These curves were then tested for parallelism (i.e., different rates of weight loss).

Results

1. Comparison of sack weight loss over six storage intervals.

   The ANOVA results are presented in Figure 1. In all six cases the sack type differences were found to be nonsignificant (PR>F values all greater than 0.05). However the nylon mesh sacks consistently exhibited greater mean weight loss than both the burlap sack types. Weight loss superiority was most pronounced from Day 7 to Day 35 and Day 7 to Day 14. The corresponding F values for these intervals did approach significance (PR>F = 0.1877 and 0.2361 respectively). Light and heavy burlap sack weight losses were on average near identical in most cases.

   The greatest weight losses were achieved for the storage intervals ending at Day 35. Inspection of the data revealed that most sacks did in fact gain weight at some point after this day.

\(^4\)If replication effect had been included in the model only a single observation would have remained in each cell.
FIGURE 1: Mean sack weight loss for the three sack types over various storage intervals.

a. Day 0 to Day 56

- Mean Sack Weight Loss (kg)
- NYLON MESH: PR>F = 0.9039
- HEAVY BURLAP
- LIGHT BURLAP

b. Day 7 to Day 56

- Mean Sack Weight Loss (kg)
- PR>F = 0.6729

- NYLON MESH
- HEAVY BURLAP
- LIGHT BURLAP

c. Day 0 to Day 35

- Mean Sack Weight Loss (kg)
- PR>F = 0.8020

- NYLON MESH
- HEAVY BURLAP
- LIGHT BURLAP

d. Day 7 to Day 35

- Mean Sack Weight Loss (kg)
- PR>F = 0.1877

- NYLON MESH
- HEAVY BURLAP
- LIGHT BURLAP

e. Day 0 to Day 14

- Mean Sack Weight Loss (kg)
- PR>F = 0.6356

- NYLON MESH
- HEAVY BURLAP
- LIGHT BURLAP

f. Day 7 to Day 14

- Mean Sack Weight Loss (kg)
- PR>F = 0.2381

- NYLON MESH
- HEAVY BURLAP
- LIGHT BURLAP
2. Comparison of the rate of sack weight loss

Inspection of scatter diagrams showing the relationship between sack weight and length of storage revealed a curvilinear relationship. Sack weights dropped for five to six weeks after Day 0 and then increased slightly. A quadratic curvilinear model was thus tested:

\[
Y = B0 + B1(X1) + B2(X2) + E
\]

where \(Y\) = total sack weight in kg
\(X1\) = storage interval in days
\(X2 = X1 \times X1\)
\(E\) = random error

for each sack type. The regressions were all highly significant and exhibited a good fit. The contribution of \(X2\) proved highly significant for both the light burlap and nylon mesh sack types and approached significance for the heavy burlap sack types (Table 1). The above model was thus adopted.

The least squares regression lines are shown for each sack type in Figure 2. Together, these curves show that the initial rate of weight loss (Day 0 to Day 14) was the sharpest. It also required about 42 days to reach maximum weight loss. Weight gain near the end of storage is also again evident. The low \(R^2\) values (0.14 - 0.43) revealed that much residual variation was unexplained by the model. This fact is further shown by nylon sack type observations (\(\cdot\)'s) plotted on Figure 2.
FIGURE 2: Least squares curvilinear regression of total sack weight over length of storage by sack type

<table>
<thead>
<tr>
<th>SACK TYPE</th>
<th>REGRESSION</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>NYLON MESH</td>
<td>$Y = 11.7994 - 0.1353X + 0.0017X^2$</td>
<td>0.429</td>
</tr>
<tr>
<td>LIGHT BURLAP</td>
<td>$Y = 11.4570 - 0.0963X + 0.0012X^2$</td>
<td>0.200</td>
</tr>
<tr>
<td>HEAVY BURLAP</td>
<td>$Y = 11.8990 - 0.0802X + 0.0010X^2$</td>
<td>0.139</td>
</tr>
</tbody>
</table>
Table 1. Test of curvilinear relationship between sack weight and storage interval ns = not significant ** = P ≤ 0.01

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>SS</th>
<th>NS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>* *<em><strong>LIGHT BURLAP</strong></em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression due to X1, X2</td>
<td>2</td>
<td>105.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression due to X1</td>
<td>1</td>
<td>73.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>1</td>
<td>32.2</td>
<td>32.2</td>
<td>4.4</td>
</tr>
<tr>
<td>Residual</td>
<td>58</td>
<td>426.3</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td>* <em><strong>NYLON MESH</strong></em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression due to X1, X2</td>
<td>2</td>
<td>194.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression due to X1</td>
<td>1</td>
<td>128.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>1</td>
<td>66.8</td>
<td>66.8</td>
<td>12.1</td>
</tr>
<tr>
<td>Residual</td>
<td>59</td>
<td>326.5</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>* <em><strong>HEAVY BURLAP</strong></em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression due to X1, X2</td>
<td>2</td>
<td>137.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression due to X1</td>
<td>1</td>
<td>110.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>1</td>
<td>27.2</td>
<td>27.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Residual</td>
<td>67</td>
<td>855.9</td>
<td>12.8</td>
<td></td>
</tr>
</tbody>
</table>

Individually, these curves first indicate that the rate of sack weight loss throughout the storage period was comparable between the two burlap sack types. The nylon mesh sacks appeared to lose weight initially (Day 0 to Day 28) at a faster rate. A test of regression curve parallelism described by Kozak (1970) revealed however that these curves were not statistically different (Table 2). Similar tests for parallelism over shorter storage intervals (Day 0 to Day 14 and Day 0 to Day 28) were also not significant.  

5To reduce the unexplained residual variation in the model (and increase the power of the test for parallelism) the contribution due to total sack weight differences was removed by calculating sack weight changes and fitting a new set of curves. These curves were again statistically the same.
Table 2. Analysis of variance to test for parallelism of the weight loss curves for the three sack types -- Day 0 to Day 56

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual for models with</td>
<td>187</td>
<td>1552.028</td>
<td></td>
<td></td>
</tr>
<tr>
<td>common slopes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual for unrestricted</td>
<td>183</td>
<td>1541.969</td>
<td>8.4261</td>
<td></td>
</tr>
<tr>
<td>models</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>4</td>
<td>10.059</td>
<td>2.514</td>
<td>0.298 NS</td>
</tr>
</tbody>
</table>

Discussion

The index of sack type performance used in this simple trial: total sack weight, was considered to be a reasonable measure of sack quality. Since the cones within each sack were left intact during storage, sack weight changes were principally due to moisture diffusion through the sacking material. The magnitude of the weight loss should have thus equated closely to changes in cone moisture content, an important cone storage parameter.

The weight loss curves demonstrated in general that the early cone storage interval (Day 0 to Day 28) yielded the greatest sack weight reductions. This fact suggested that proper cone handling procedures are especially important for Douglas-fir collections in the first weeks of storage to ensure that high initial cone moisture levels do indeed dissipate quickly. These curves also showed that the maximum sack weight loss was achieved by about the sixth week of storage. This suggested that a storage interval of this length would be

6High cone moisture content during storage is undesirable. Section 3.86 of the MOF Silviculture Manual states, "As cones lose moisture, they expand and generate heat which, if not dispersed, may damage the seeds. If this moisture is not dispersed, molds will also appear which, with the heat, can "case harden" the cones and create difficulty at the extractory".
required for Douglas-fir collections if the objective was to minimize cone moisture content prior to extraction. The increases in sack weight observed after six weeks demonstrated that longer storage intervals will not guarantee a continual cone moisture reduction for Douglas fir orchard collections. ⁷

Although no statistical differences were detected among the three sack types, nylon mesh sacks consistently exhibited the greatest mean weight loss and the quickest average rate of weight loss (and a corresponding lower cone moisture content in storage). Sample sizes in this trial were small and it is suggested that a nylon sack superiority trend was thus found.

Storage environment was a confounding factor because the sacks were not all monitored starting at the same date. Although the storage intervals tested were the same for each sack (e.g. Day 0 to Day 35) the actual dates of storage differed according to when the sacks were first filled. This problem was not considered a major obstacle however since all sack types were used evenly through the collection period and should have thus experienced, on average, a comparable storage environment.

The purchase of additional nylon sacks of this type for operational use is not recommended at this time. They were more expensive than burlap sacks ($3.50 each versus $0.50). The index of superiority used in this trial was also an indirect one, and considering this increased cost, a clearer demonstration of nylon sack superiority (e.g. improved seed yield) is deemed necessary. In addition, a recent evaluation of extraction efficiency (EE) showed burlap sacks showed performance to be acceptable. ⁸ Three seed

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⁷The sack weight increases measured near the end of storage was surprising since the cones were stored in a covered facility. The shelter was however open-sided and increases in atmospheric humidity were deemed responsible (T. Crowder, pers. comm.).

⁸
orchard collections were evaluated in 1982 and EE values were on average 0.96 following cone storage in burlap sacks (OSL Progress Report 1982).

The following procedural modifications are suggested if a further evaluation of sack type performance is considered. Additional indices of performance should be evaluated. Cone condition (e.g. mold incidence), within-sack temperature, sack durability, and seed yield are attributes of interest. Sample sizes should also be increased and all sacks should be monitored starting at the same time. Other promising sack types and/or methods of storage (e.g. tray storage) could be considered.

Conclusions
1. Using a single and indirect index of sack performance, nylon mesh sacks look to be superior to burlap sacks for storage of Douglas-fir seed orchard cone collections.
2. The purchase of additional nylon mesh sacks at this time for use in seed orchards would be premature.
3. If a further sack type comparison trial is attempted additional performance indices and larger sample sizes should be considered.

Reference


Acknowledgement

I would like to thank J. Konishi and D. Wallinger for helping to initiate this section of the trial, M. Crow for refining the methods used, and T. Crowder for carrying out the procedures.

\[ EE = \frac{\text{Number filled seed extracted/cone}}{\text{Total number of filled seed}} \]