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**Cone and Seed Improvement Program**
**BCMoF Tree Seed Centre**

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## *Abies* sp. Seed Drying Patterns

During the past eight years the BC Ministry of Forests Tree Seed Centre (TSC) has been sampling and determining moisture content of cones and seeds during the pre-conditioning (slow drying) of *Abies* sp. seedlots prior to processing. The cones arrive at the TSC after field or interim storage that usually lasts approximately one month. The cones may arrive intact, partially disintegrated or completely disintegrated depending on moisture content. It should be clear that these patterns reflect drying of cones under controlled conditions (11-15°C with fans providing air circulation) after some amount of drying during interim storage. The objective of this Quality Assurance program has been to 1) assess condition and moisture content of cones upon arrival 2) prioritise seedlots for cone and seed processing and 3) obtain data on the drying rates of cones and seeds of *Abies* during pre-conditioning at the TSC. This article will focus on objective number three.

Initial analysis of data between 1992 and 1995 indicated that cones have a higher moisture content, but large (8.3%) and unpredictable (1.2 to 17.5%) differences exist between the cones and seeds within any seedlot. There were also large differences in moisture content between cones within a seedlot, which can exceed 20% on cone receipt. For these reasons the measurement of <u>seed</u> moisture content has been a priority and this article will only discuss seed moisture content patterns.

Sampling methods have varied slightly over the eight years of this program, but have comprised of between two and four replicates of between 50 and 100 seeds at each time interval. Seedlots were sampled as close as possible to arrival and at approximately two-week intervals, but if cone disintegration was not occurring then sampling may have been delayed. The seed moisture content data is examined relative to the time in preconditioning as no data is available on the conditions each seedlot was exposed to during interim storage immediately following collection.

Seedlot drying rates were estimated by taking the moisture content difference between the initial and final assessments divided by the number of days in preconditioning and presented as a change in moisture content per day. Some seedlots did not have two assessments performed prior to processing which is why the dataset includes only 81 drying rate estimates from 289 sample points. All data points were also analyzed using linear and non-linear regression equations to better understand and enable us to better predict drying of *Abies* sp. seed. Analysis was conducted for all seedlots and for Amabilis fir (Ba) and subalpine fir (Bl) separately, but due to the small sample size with grand fir (Bg) it was only incorporated in the pooled analysis.

### Results

The average estimated drying rate of seedlots sampled over the past nine years was 0.48 % per day and varies by species from 0.39 for subalpine fir to 0.57 for Amabilis fir (Table 1). The difference between these two species was much greater prior to year 2000, but the low volume and co-operative weather resulted in extremely fast seed drying for Bl in year 2000. We would expect faster drying rates in Ba (based on past monitoring), but unfortunately no Ba seedlots were monitored during this year. One might expect that drying rates would be related to the volume of cones in the preconditioning area, but 1996 ,which was the largest crop included, had relatively rapid drying rates.

Table 1. Dehydration rates of *Abies* sp. seed with number of **S**eedlots and **s**amples (#**S**/#**s**) included and total Hl of cones processed by species[1].

| **Year** | Ba (#S/#s) | **Ba (Hl)** | Bl (#S/#s) | **Bl (Hl)** | Bg (#S/#s) | **Bg (Hl)** | **Total Hl** |
|---|---|---|---|---|---|---|---|
| 1992 | -0.50 (1/10) | 214 | +0.04 (1/8) | 295 | | | 509 |
| 1993 | -0.35 (5/17) | 345 | -0.04 (3/7) | 99 | | | 444 |
| 1994 | -0.28 (5/20) | 558 | (0/17) | | | | 558 |
| 1995 | | | -0.14 (13/31) | 404 | | | 404 |
| 1996 | -0.80 (8/22) | 308 | -0.19 (3/12) | 320 | | | 628 |
| 1997 | -0.59 (7/20) | 233 | -0.08 (3/13) | 22 | -0.06 (1/4) | 3 | 255 |
| 1998 | -0.15 (3/24) | 79 | -0.05 (1/9) | 99 | | | 178 |
| 1999 | -0.83 (7/22) | 186 | -0.07 (7/25) | 149 | -0.69 (4/9) | 31 | 366 |
| 2000 | | | -1.38 (9/) | 102 | | | 102 |
| **Mean[2]** | **-0.57** | **214** | **-0.39** | **166** | **-0.56** | **4** | **383** |

All of the data is plotted in Figure 1 to illustrate the variability present between seedlots on any given day after receipt, the high moisture content of some seedlots upon arrival and the preconditioning time some seedlots receive until processing is initiated.

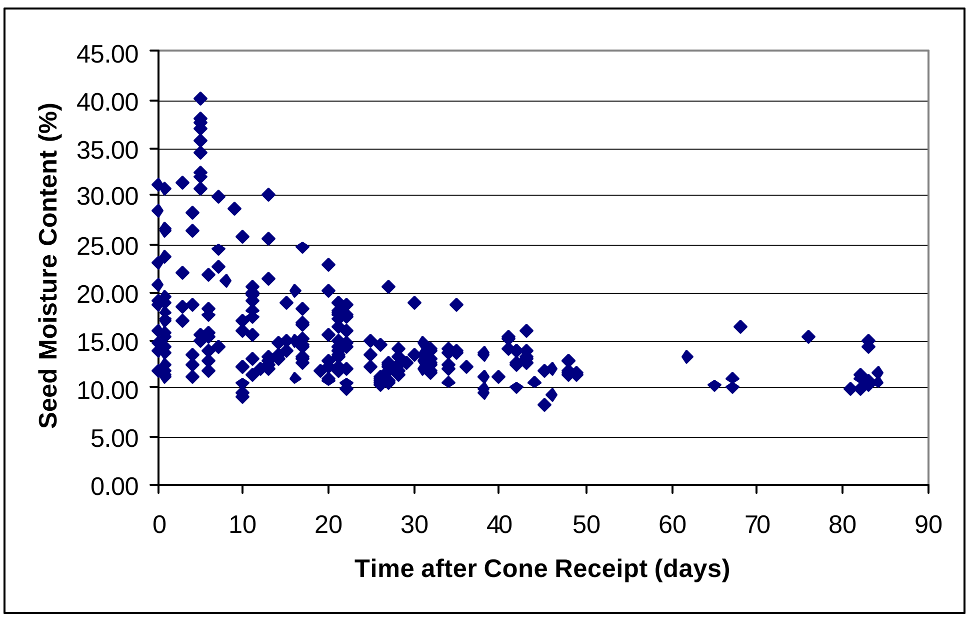


Figure 1. The entire dataset of seed moisture content over time for all *Abies* sp. datapoints obtained in the pre-conditioning area at the BC Ministry of Forests Tree Seed Centre.

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[1] **<u>Species codes</u>**: **Ba** = Amabilis fir ; *Abies amabilis* (Dougl. ex Loud.) Dougl. ex J. Forbes: **Bl** = subalpine fir; *Abies lasiocarpa* (Hook.) Nutt.: **Bg** = Grand fir; *Abies grandis* (Dougl. Ex D.Don) Lindl.

[2] Mean dehydration rates are based on the average of all seedlot estimates across years rather than the average of annual means that can be derived from Table 1.

To obtain a better understanding of seed drying in the preconditioning area simple linear and curvilinear regression equations were fitted to the data with SAS (1996) using **seed moisture content** (MC) as the dependant variable (Y) and **days** as the independent variable (X). The simple linear regression equations (SMC= a + b*DAYS), associated $r^2$ values and Mean Square Error (MSE) are presented below in Table 2. The linear relationships are all statistically significant at $\alpha$ = 0.05, but do not explain a high proportion of the inherent variability. Based on the observed data pattern (Figure 1), non-linear regression equations were fitted using the NLIN procedure in SAS (1996) and curves obtained from Sit and Poulin-Costello (1994). A variety of exponential, logistic, logarithmic, hyperbolic and power functions were explored, but for All results and results for Ba and Bl the Type I Exponential and combined exponential and power functions produced the best equations. The form of the Type I exponential equation is $SMC=ae^{b*DAYS}$ and the form of the combined exponential and power functions is $SMC = a*DAYS^{b}c^{DAYS}$ . The parameter estimates, estimated $r^2$ values, mean square error (MSE), Akaike's information criterion (AIC) and probabilities of best model (Anderson *et al*., 2000) are presented in Table 2 for ALL data and separately for Ba and Bl.

Table 2. Parameter estimates (a, b and c) and descriptive statistics[3] for simple linear and curvilinear regression equations for ALL data, Amabilis fir (Ba) and subalpine fir (Bl).

| **Equation** | **a** | **b** | **c** | **AIC** | **Prob.** | **MSE** | **$r^2$** |
|---|---|---|---|---|---|---|---|
| **ALL (n=289)** | | | | | | | |
| Exponential + Power | 21.664 | -0.0535 | 0.9924 | 943.92 | 50% | 25.85 | 0.25 |
| Exponential | 20.3287 | -0.0113 | | 944.59 | 36% | 26.00 | 0.25 |
| Simple Linear | 19.1641 | -0.1377 | | 955.99 | <1% | 27.14 | 0.21 |
| **Ba (n=135)** | | | | | | | |
| Exponential | 26.3755 | -0.0190 | | 454.21 | 71% | 28.29 | 0.46 |
| Exponential + Power | 26.8914 | -0.0183 | 0.9826 | 456.06 | 28% | 28.48 | 0.46 |
| Simple Linear | 24.2677 | -0.2790 | | 465.93 | <1% | 31.08 | 0.41 |
| **Bl (n=141)** | | | | | | | |
| Exponential | 16.4254 | -0.0056 | | 347.60 | 35% | 11.52 | 0.18 |
| Exponential + Power | 17.3924 | -0.0394 | 0.9964 | 347.94 | 30% | 11.47 | 0.19 |
| Simple Linear | 16.0898 | -0.0690 | | 348.80 | 17% | 11.70 | 0.17 |

**Discussion**

The analysis indicates that the seed drying pattern for Amabilis fir is more predictable than other *Abies* sp. with any of the regression equations. The Type I exponential equation provided the lowest mean square error and had a 71% probability of being the best equation fitted model (Anderson *et al*., 2000). Subalpine fir displayed drying rates that were not as predictable based on $r^2$ values even though the MSE was substantially lower than Ba. Amabilis fir did show greater variability (indicated by higher regression and error mean squares), but subalpine fir had a relatively shallow line or curve which makes prediction more difficult (i.e. compare simple linear regression slopes for Ba and Bl). The simple linear regression for Bl explained the data far better than with Ba or All species combined. The intercepts of Ba and Bl are also very with Ba ranging

[3] AIC= Akaike's information criterion; Prob.= Probability that model is best compared to models evaluated (Anderson et al. 2000); MSE = Mean Square Error; and $r^2$ is the correlation coefficient calculated as [1 – SSError/SSTotalcorrected] for non-linear regressions.

from 24.3 to 26.9 while Bl ranged from 16.1 to 17.4% moisture content experienced on arrival. The combined or All analysis was intermediate between the two species .

The prediction of seed moisture content over time in our preconditioning area was not strong. A significant part of this can be attributed to the differences in drying rates between years (Table 1) that is influenced by current weather conditions, time since harvest (= interim storage), crop maturity and handling practices. The results do validate the observations of different drying rates in Amabilis and subalpine fir. It is interesting that slow drying rates in subalpine fir are also experienced during the dryback procedure used in the stratification of these two species. These models will be tested this coming season for predictive ability and data collection continued to improve moisture content prediction and to prioritize seedlots for processing

**References**

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