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Manual Seeding With Pre-Seeded Peat Pellets: Field Trials at Malcolm Knapp Research Forest

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1. INTRODUCTION

Many sites in coastal B.C. have difficult planting conditions as a result of their remote mountainous terrain and helicopter- or boat-only access. The logistical challenges associated with planting containerized stock – seedling ordering and delivery logistics, stock thawing and handling requirements, time constraints, etc. – coupled with the difficulty of access, make reforestation in these remote sites a cumbersome and costly operation.

Reforestation through the use of “seed pucks” or “seed wafers” – seeds encapsulated in a pelletized growing medium – has been suggested as an alternative method for streamlining reforestation logistics in remote areas. If successful, this method could also eliminate or greatly reduce reforestation costs. Past studies have tested the concept of seed pucks in a forestry context with promising results (Adams, et al, 1990; Wennström, 2014). However, the potential of using this alternative method has not yet been explored in B.C. FPInnovations has set out to explore the concept with a series of laboratory and field trials aimed at testing product materials and operational issues. A laboratory trial resulted in moderate success, with the best pellet configuration reaching 56% establishment (Matute, 2016). The field trial component tested these pellets in a natural setting and explored their optimal position relative to mineral soil, effects of seed predation and the germination and survival of different conifer species.

2. OBJECTIVES

The objectives of the field trial were to:

- Assess the germination and survival of different tree species grown in peat pellets under field conditions.
- Identify the best seed puck placement on the soil for increased germination and survival.
- Assess the effect of seed predation by birds and rodents through the testing of physical barriers and repellents.
- Assess the effects of sowing season and seed stratification on germination.
- Assess the feasibility of large-scale implementation.

3. METHODS

A spring trial and a winter replicate trial were installed in the UBC Malcolm Knapp Research Forest in early April and mid-December, 2015, respectively. The site is situated in the CWHdm1 biogeoclimatic subzone and has gentle slopes (0–20%) with westerly aspects. It was harvested in winter 2014 and had minimal slash, minimal brush development and extensive mineral soil disturbance at the time of trial installation.

A modified version of the Jiffy 50 x 60 mm Carefree Horticulture Mix pellet was used as the growing medium. A deep indentation was drilled in the centre of the pellet, in which seeds were placed and covered with fine vermiculite (Figure 1). A vermiculite cover not only protects the seeds against the elements and predators, but also aids in moisture retention and provides a regulated micro-environment for successful germination. The vermiculite and seed were held in place with the use of calcium activated seed tacker, a specialized seed glue manufactured by Geonics LLC.

Four coastal conifer species were tested: Douglas-fir (*Pseudotsuga menziesii),* western hemlock (*Tsuga heterophylla)*, western redcedar (*Thuja plicata)* and amabilis fir (*Abies amabilis)* (Table 1). For the spring trial, the seeds were stratified and planted in the field within two days of stratification. Winter trial seeds were unstratified. Two seeds per pellet were used for seedlots with high germination capacity (> 90%). For the amabilis fir pellets, four seeds were used per pellet.

Figure 1. Pre-seeded peat pellets used in the field trial

Table 1. Seed specifications

Species	Seedlot	Germination capacity (%)	Peak value	Seed class	Genetic gain
Douglas-fir	62254	95	87%/10 days	A	G+02
Western hemlock	06766	94	82%/14 days	A	G+02
Western redcedar	53724	92	81%/16 days	B	NA
Amabilis fir	39826	57	44%/21 days	B	NA

Trial treatments are described in Table 2. All species were tested at four different placements: Pellet placed on the litter layer (LFH), pellet embedded in mineral soil at 2–4 cm, but not buried (MIN) (Figure 2), pellet embedded in mineral soil with chemical animal repellent (Critter Ridder) treatment (REP) and pellet embedded in mineral soil with a physical barrier (custom-made mesh cylinders) (BAR) (Figure 3). Seven pellets for each placement and species were outplanted with a planting shovel and identified with coloured pin flags. Two plots with 112 pellets each were established for the spring and winter trial, for a total of 448 pellets.


Figure 2. Mineral soil placement


Figure 3. Physical barrier

Table 2. Number of pellets per treatment and species

Treatment	Number of pellets			
	Douglas-fir	Western hemlock	Western redcedar	Amabilis fir
LFH	7	7	7	7
MIN	7	7	7	7
REP	7	7	7	7
BAR	7	7	7	7

The pellet establishment rate was measured during germination assessments throughout the first and second growing seasons.

4. RESULTS AND DISCUSSION

Spring Trial

The first germination measurement took place eight weeks after trial installation on June 5, 2015. Table 3 shows the percentage of germinated pellets per treatment. During measurement, pellets placed on the LFH layer were observed to be drier than those planted in mineral soil. However, there was no difference in germination between moist and dry pellets.

Table 3. Spring trial germination results after eight weeks

Treatment	Germination (%)				Establishment by treatment (%)
	Douglas-fir	Western hemlock	Western redcedar	Amabilis fir	
LFH	21.4	0.0	7.1	14.3	10.7
MIN	21.4	0.0	0.0	21.4	10.7
REP	14.3	0.0	0.0	28.6	10.7
BAR	35.7	7.1	0.0	14.3	14.3
Establishment by tree species (%)	23.2	1.8	1.8	19.6	**Total: 11.6**

At the eight-week mark, 11.6% of all pellets had germinated. Establishment rates were comparable across treatments in both replicates, indicating that placement and predation may have had no effect on pellet germination at this stage. Similarly there was no significant difference at $\alpha = 0.05$ in germinant height among treatments. The average germinant height was 3.5 cm. The Douglas-fir and amabilis fir pellets did much better than their counterparts: 23.2% of Douglas-fir pellets and 19.6% of amabilis fir pellets germinated, compared to 1.8% of western redcedar and western hemlock pellets.

A second germination measurement took place seven months after trial installation to capture any late germination or mortality during the first growing season (Table 4). Losses from germinant mortality reduced the percentage of established seed pellets to 4.5% from the previous measurement of 11.6%.

Table 4. Spring trial germination results at the end of the first growing season

Treatment	Germination (%)				Establishment by treatment (%)
	Douglas-fir	Western hemlock	Western redcedar	Amabilis fir	
LFH	14.3	0	0	7.1	5.4
MIN	7.1	0	0	0	1.8
REP	7.1	0	0	0	1.8
BAR	28.6	0	0	7.1	8.9
Establishment by tree species (%)	14.3	0	0	3.6	**Total: 4.5**

There were no significant differences in establishment rates between the different placements in the soil ($\alpha = 0.05$). Of the tested species, only Douglas-fir and amabilis fir germinants survived the first growing season. A possible reason for the poor performance of western redcedar and western hemlock might be the negative effect of small seed size in field germination potential, as large-seeded species have access to larger seed nutritional reserves that help them weather short periods of stress during the germination phase (St-Denis, et al., 2013). Douglas-fir germinants were found to be more vigorous than those of amabilis fir, with average heights of 6.7 cm and 2.6 cm, respectively (Figure 4).

Winter trial

A replication of the spring trial was installed in December 2015 with unstratified seed from the same seedlots, with the objective of testing the effect of seeding season on establishment rates. Germination was measured after the first growing season, in March 2017. Results were poor, with a total establishment of 2.2% of pellets (Table 5). Establishment results were not significantly different from first-year results at the spring trial at $\alpha = 0.05$, so it is unlikely that seeding season had an effect on establishment.

Figure 4. Douglas-fir pellet at the seven-month mark

Table 5. Winter trial germination results at the end of the first growing season

Treatment	Germination (%)				Establishment by treatment (%)
	Douglas-fir	Western hemlock	Western redcedar	Amabilis fir	
LFH	0	0	0	0	0
MIN	14.3	0	0	0	3.6
REP	7.1	0	0	0	1.8
BAR	7.1	0	7.1	0	3.6
Establishment by tree species (%)	7.1	0	1.8	0	**Total: 2.2**

Predation was not deemed to be an issue as establishment was equally low in protected and unprotected pellets, and ungerminated seeds were observed within the pellets after the first growing season. The two main causes of low establishment and survival were likely the rapid development of competing grass vegetation (Figure 5) and, in the case of the spring trial, the unseasonally hot and dry weather experienced during the 2015 growing season.

Figure 5. Heavy grass cover two years after initial spring trial installation

While careful site selection may reduce the risk of seeding failure from vegetation competition, uncontrollable factors, such as moisture deficits and high summer temperatures, remain a major determinant of seed germination and establishment in the field. The pellets' relative establishment success in the laboratory trial is owed to the constant high moisture and light conditions they were grown under. Yet in the field, the variability in conditions means that seeds might not get a chance to germinate before their reserves are depleted. Future work should focus on exploring pellet materials with higher moisture retention capabilities to ensure constant moisture supply during dry periods and to reduce risk from environmental factors.

5. CONCLUSION

FPInnovations installed two field trials, one in the spring and one in the winter, to determine establishment rates from pre-seeded pellets under natural, coastal B.C. conditions. Seeding season and pellet placement had no effect on results. However, Douglas-fir and amabilis fir had better germination and survival than western hemlock and western redcedar. Establishment results were poor (4.5% and 2.2% establishment in the spring and winter trials, respectively) after a dry summer in 2015, confirming that, as with direct seeding, weather can be an unpredictable and uncontrollable variable in germination success. While opportunities for pellet improvement were identified, the level of risk involved in reforestation from seed in its current configuration makes manual seeding an unviable option on sites with access issues in particular, as the fill-planting costs resulting from a potential plantation failure far outweigh the initial cost savings from seeding with pellets.

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