Nutriplug™: The Next Generation

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Abstract: Providing an added or residual fertilizer load in the plugs of forest tree seedlings prior to outplanting has been an objective pursued by nurseries and forestry operators through the years. Pacific Regeneration Technologies (PRT) has been actively researching and developing means to enhance the performance of forest tree seedlings by providing a fertilizer load at the time of outplanting with the development of its Nutriplug™ product. We are currently experimenting with a technology to deliver metered amounts of controlled release fertilizer in the seedling plug at time-of-lift.

Keywords: container seedlings, fertilizer incorporation, controlled release fertilizer

Introduction

Although achieved by various techniques, delivering an added fertilizer load in the plug at time-of-lift serves a common objective—to make nutrients available to the seedling after outplanting. It is hypothesized that, on certain sites, this will result in the reduction of "planting check" and enhance growth in the first few years after outplanting. The following is a brief review of the various techniques serving this objective.

Fertilization at Time of Sowing (FAS)

A controlled release fertilizer (CRF) with a long release span is incorporated into the growing medium via the mixing equipment at the time of sowing. Although some nutrients are released during the crop cycle at the nursery, there is a significant residual effect after outplanting. This concept was used to develop the Nutriplug™ and was the object of several trials. These trials are briefly described in this paper.

Fertilization at Time of Planting (FAP)

Incorporation of a CRF at time-of-planting involves the tree planters placing fertilizer near the seedling root system at outplanting time. Several commercially available products carry the fertilizers in different chemical and physical forms (for example, "teabags" or planting tabs, polymer-coated or IBDU, and so on).

This concept has been the object of numerous field trials in British Columbia over the past 25 years. Some forestry practitioners use it operationally. Results have been inconsistent, although some very positive results have been reported. Adequate soil moisture seems to be a key factor in obtaining a positive growth response.

Nutrient Loading

Nutrient loading involves growing seedlings in the nursery using extremely high fertilizer levels, enabling the uptake of more nutrients than needed (that is, luxury consumption). After outplanting, the seedlings have the capability to relocate some of these excess nutrients from the older tissues to the new growth. Some forestry practitioners outplant operationally nutrient loaded trees grown by PRT with the Exponta™ regimen. Some studies clearly indicate significantly higher growth of these trees when compared to non-nutrient loaded control seedlings the first year after outplanting.

Brief Overview of the Work and Development Done With Nutriplug™

As previously mentioned, we undertook to develop a value-added product that would enhance field performance and provide a cost effective alternative to fertilization at time-of-planting. The results gathered since the early 1990s using the FAS concept have demonstrated some interesting results, and led us to the development of the Fertilization at Time-of-Lift (FAL) concept.

Although the FAS Nutriplug™ has the advantage of being cost effective when compared to FAP techniques, we are still facing some sizable constraints.

Prill Distribution

It has been challenging to achieve a uniform prill distribution from plug to plug using our existing medium mixing equipment in the nursery (Figure 1). This has proven particularly difficult with batch mixers.

Prill Integrity

If the mixing time is too short, the variation in prill distribution increases; if it is too long, we risk damaging the coating of some of the prills, generating high salt levels in the growing medium.

Release

The controlled release mechanism of most fertilizers is generally triggered by temperature or moisture (or a combination of both) (Figure 2). Given the fact that the seedlings are exposed to moist and warm conditions during the nursery cultural cycle, a fair amount of fertilizers are released at the nursery.

Outplanting Trials

With these limitations in mind, PRT has been working on the development of the FAS and FAP Nutriplug™. Several trials have been done through the years; some with very positive results. The following are some excerpts of selected trials.

Spring Outplanted Interior Spruce FAS/FAP—

Locations: The Tahtsa Reach trial was established on 2 cutblocks approximately 100 km (62 mi) SW of Houston, BC (latitude 53°43', longitude 127°58'). Both sites are in the Moist Cold Subzone of the Sub-Boreal Spruce (SBSmc2).

The Whitesail and Nadina trials were established near Houston, BC (approximately 100 km [62 mi] SE of Smithers). Interior spruce was spring outplanted in 1997. The Whitesail site is a low vegetation, dry site. The Nadina West site is a wet site, making it difficult for the planters to identify acceptable microsites. This resulted in a low overall survival.

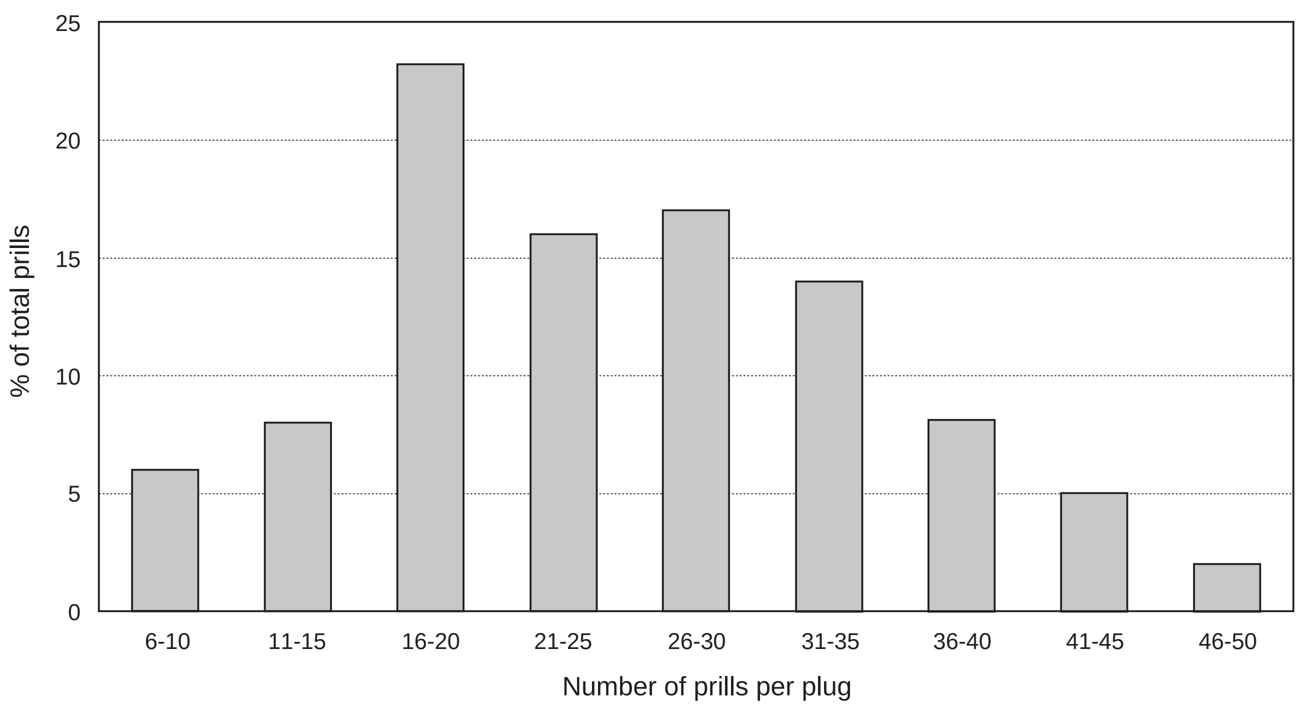

Figure 1—Typical prill distribution from plug to plug for the PRT 99-NT410 prill distribution. Target is 24; average is 25.

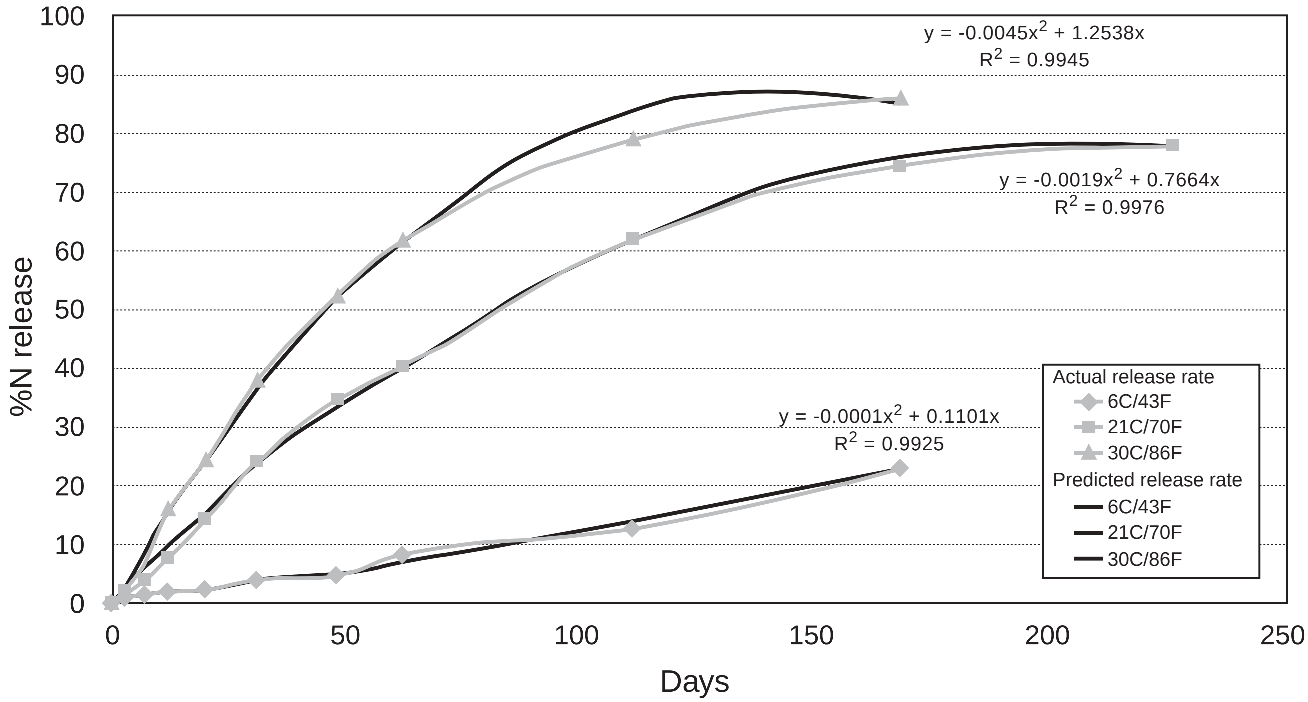

Figure 2—Actual nitrogen-release curve compared to the predicted release rate for the controlled release fertilizer Multicote 18N:6P_2O_5:12K_2O (5- to 6-month formulation) at 3 different temperatures.

Treatments: A commercially available CRF was tested in conjunction with a control and the "tea bag."

1. Control. The control seedlings were those produced under operational culturing procedures.
2. Nutriplug™ FAS. Nutricote 16N:10P_2O_5:10K_2O CRF with a 12-month release formulation (at 25 °C [77 °F] soil temperature) was incorporated into the growing media. Approximately 30% was released while seedlings were still in the nursery.
3. "Tea Bag." Silva-Pak™ 26N:12P_2O_5:6K_2O (10 g [0.35 oz]) polymer-coated urea with a 12-month release formulation (at 21 °C [70 °F] soil temperature) was placed in the planting hole at mid-plug depth approximately 2 cm (0.8 in) from the plug.

Results: Results after 3 years of measurements for the Tahtsa Reach trial are shown in Figure 3. Initial seedling height was significantly greater for the Nutriplug™ treatment at outplanting. However, annual height growth was significantly greater in the "tea bag" treatment following the second and third growing seasons (Figure 3A). Initial diameter measurements were significantly greater in the "tea bag" treatment at outplanting. Annual diameter growth was also significantly greater in this treatment following the second and third growing seasons (Figure 3B).

Results after 5 years of measurements for the Whitesail trial are shown in Figure 4. Initial seedling height was significantly greater for the Nutriplug™ treatment at outplanting. Annual height growth was significantly greater in both the Nutriplug™ and "tea bag" treatments as compared

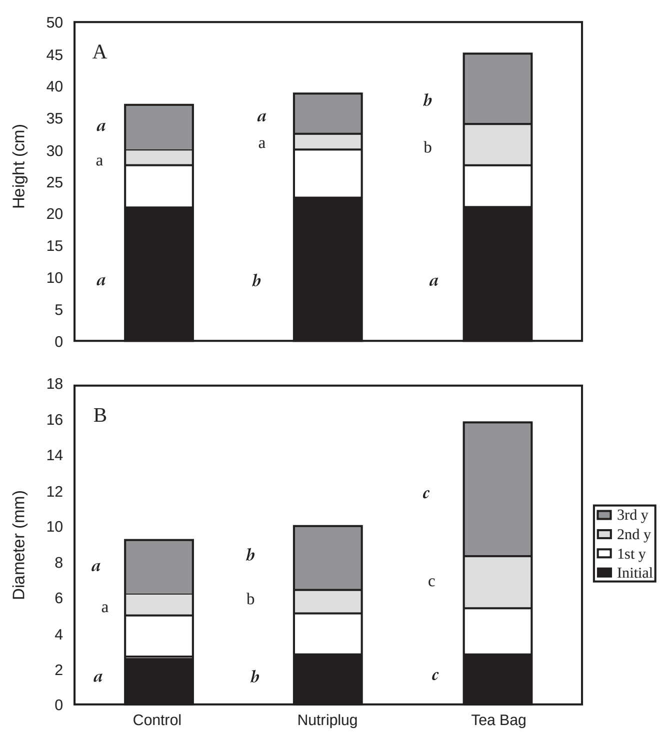

Figure 3—Height measurements (A) and diameter measurements (B) for the Tahtsa Reach trial after 3 seasons.

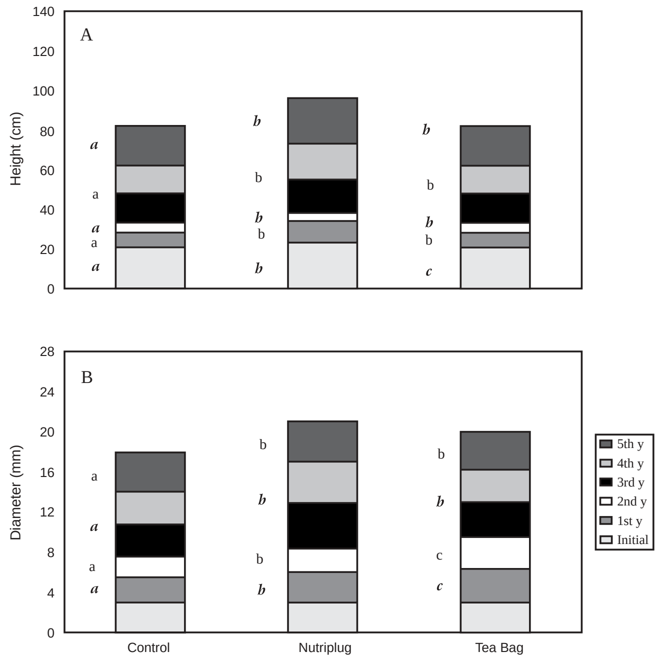

Figure 4—Height measurements (A) and diameter measurements (B) for the Whitesail trial after 5 seasons.

to the control throughout each of the first 5 growing seasons; no significant difference in height growth was found between the Nutriplug™ and "tea bag" treatments (Figure 4A). Initial diameter measurements were significantly greater in the "tea bag" treatment at outplanting and following the first and second growing seasons. Annual diameter growth was significantly greater for both the Nutriplug™ and "tea bag" treatments as compared to the control through the third, fourth, and fifth growing seasons, but no significant differences were found between the 2 treatments during these periods (Figure 4B).

Summer Outplanted Interior Spruce FAP—

Location: This trial was located near Dennis Lake in BC.

Treatments: Various commercially available CRFs were tested in conjunction with a control and the "tea bag."

1. Control. The control seedlings were those produced under operational culturing procedures (C).
2. Nutriplug™ FAS. Nutricote 16N:10P_2O_5:10K_2O CRF with a 12-month release formulation (at 25 °C [77 °F] soil temperature) (NT15).
3. Polyon 13N:13P_2O_5:13K_2O CRF with an 8- to 9-month release formulation (at 20 °C [68° F] soil temperature) (P13).
4. Polyon 17N:5P_2O_5:11K_2O CRF with a 10- to 12-month release formulation (at 20 °C [68° F] soil temperature) (P17).
5. "Tea Bag." Silva-Pak™ 26N:12P_2O_5:6K_2O (10 g [0.35 oz]) polymer-coated urea with a 12-month release formulation (at 21 °C [70 °F] soil temperature) (TB).

Results:

As reflected by the data in Figure 5, the use of fertilizer at the time of outplanting has an impact on survival. Most fertilizer treatments, with the exception of the P13 treatment, tended to lower overall seedling survival. This clearly displays the necessity of using the proper product and dosage in order to minimize the impact on survival and determine the point at which the gains outweigh the losses.

Results of height and diameter growth after 4 years for the Dennis Lake trial are shown in Figure 6. Initial seedling height was significantly greater in both the Polyon treatments as compared to the control and other treatments at

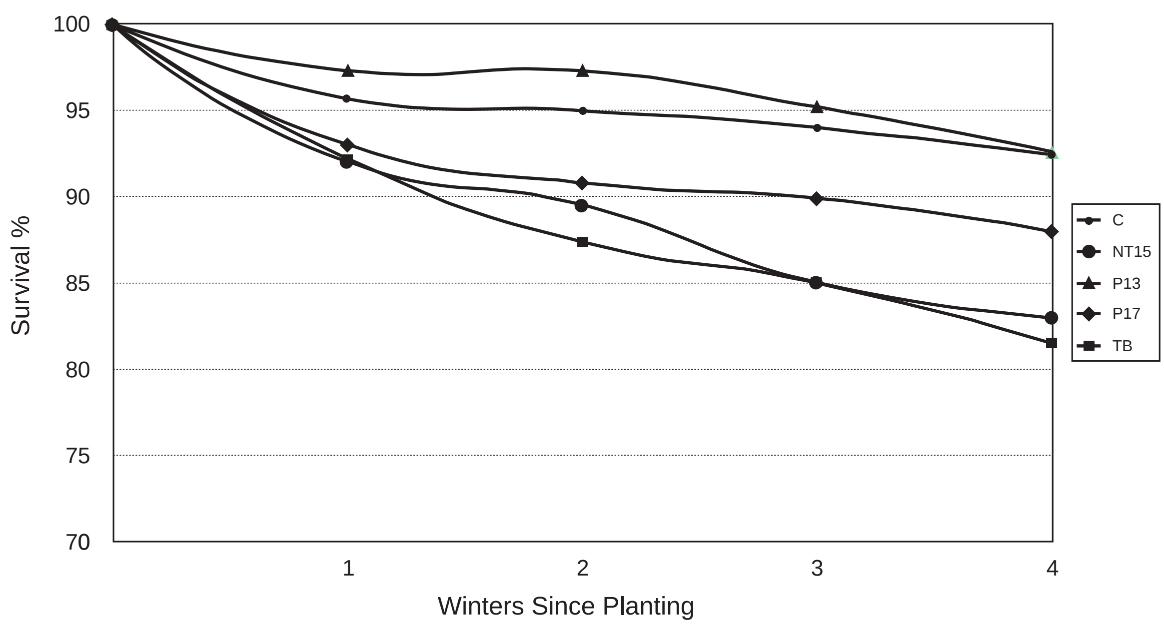

Figure 5—Survival after 5 years for the Dennis Lake trial.

outplanting. However, by the end of the third growing season, the 2 Polyon treatments differed, but there was no significant difference between the control and the other treatments in annual height growth (Figure 6A). Initial diameter measurements were significantly greater in both the Polyon treatments as compared to the control and other treatments at outplanting, and the P17 treatment resulted in significantly greater diameter growth at the end of the first season. At the end for the fourth growing season, annual diameter growth was significantly greater for the P17 treatment as compared the NT15 and TB treatments, but did not significantly differ from the control (Figure 6B).

Fertilization at Time-of-Lifting (FAL) Approach

In order to minimize the problems associated with the FAS Nutriplug™, PRT decided to develop a means to incorporate CRF into the plug at time-of-lift. The main objectives we are pursuing are:

1. Reduce the variation in the number of prills from plug to plug to enable us to increase the target average dose without generating undesirable salinity levels.
2. Ensure that all the fertilizer release takes place after outplanting in the field.
3. Identify new CRF products that would maximize the duration of the release time in the field.
4. Develop a mechanical means of incorporation consistent with our existing lifting equipment.
5. Target nutrient uptake via the root mass of the seedling and minimize feeding the surrounding vegetation.
6. Provide a cost effective alternative to fertilization at the time of outplanting to our customers.
7. Ensure that the intellectual property is adequately protected.

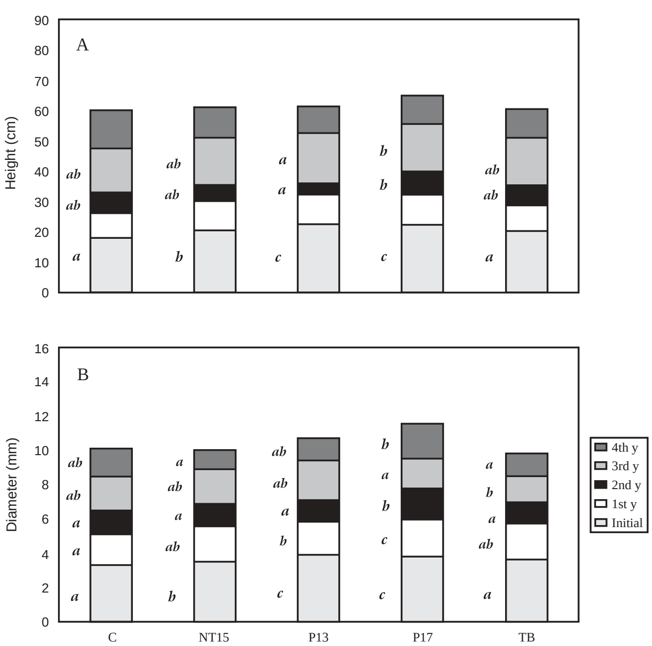

Figure 6—Height measurements (A) and diameter measurements (B) for the Dennis Lake trial after 4 seasons.

Initial Incorporation Trial

In the spring of 2000, a large trial was implemented to evaluate the impact of various types and rates of CRF placed directly in the seedling root plug. The primary objective was to evaluate at which rate the various fertilizers would start to generate undesirable salt levels and thus negatively impact seedling survival. Ten products (or combination of products) were tested at 3 doses representing 0.5, 1.0, and 2.0 g N/80 ml (5 in^3) plug (Styroblock® PSB410A) interior spruce root-plug. The resulting 31 treatments (including the control) were outplanted as an operational trial on a forestry cutblock. All fertilizer treatments were individually weighed and inserted into small paper envelopes. At the time of outplanting, the envelopes were opened and the fertilizer was placed directly into contact with the root plug, then placed into the planting hole along with the opened envelope. The seedlings were assessed for survival after flushing in the spring of 2001. The high mortality rates anticipated for some of the treatments did not materialize and survival was good (Table 1).

Second Incorporation Trial

In order to validate the results obtained from the original trial, a second incorporation trial was implemented using the same fertilizer treatments. However, this trial was different in that the fertilizers were pre-incorporated in a manually created cavity from the bottom of the plug during fall lifting at the nursery. The seedlings were then packaged and cold stored for the duration of the winter (–2 °C [28 °F]) as per our current practices. Outplanting took place in the spring of 2002, which was much drier than average. Survival was evaluated in the fall of 2002. Although we still have missing data, the survival rates were much more in line with our original expectations, demonstrating the negative impact of extended (that is, cold) storage and a dry year on fertilizer salts within the root plug. Increased mortality was as expected, and was correlated with the increasing doses (Table 2). This trial is still providing us with valuable information as to the maximum fertilizer rate of the various products that would remain safe even in an exceptionally dry year. Our preliminary results indicate a positive growth response for most of the treatments. Statistics will be compiled after measurement in fall 2003.

Development of a Mechanized Means of Incorporation (FAL)

Concurrent to this trial work, PRT has been working on the development of a mechanized means of incorporating fertilizer in root plugs at the time of lifting. In fall 2001, a prototype was developed to inject seedlings on a semi-operational basis. A field trial was replicated in an operational setting in BC and Saskatchewan. The treatments

Table 1—Survival evaluation of different fertilizer treatments with hot lifting, spring outplanting, and fertilizer incorporation into the planting hole on 3 different sites.

Fertilizer mix number	Fertilizer application rate (g of fertilizer per plug)	Fertilizer application rate (g of N per plug)	Survival on site 1	Survival on site 2	Survival on site 3
			- - - - - - - - - - *percent*	- - - - - - - - - -	
1	1.3	0.5	100	100	100
2	2.5	1	100	100	93
3	5.1	2	99	93	88
4	2.9	0.5	100	100	100
5	5.7	1	100	100	99
6	11.4	2	99	100	93
7	2.9	0.5	100	100	99
8	5.9	1	100	100	97
9	11.8	2	100	100	97
10	3.7	0.5	100	100	100
11	7.4	1	100	100	100
12	14.8	2	100	100	97
13	2.2	0.5	100	100	100
14	4.3	1	100	100	100
15	8.6	2	97	97	97
16	3.1	0.5	100	100	100
17	6.3	1	100	100	100
18	12.5	2	100	100	99
19	1.4	0.5	100	100	99
20	2.9	1	100	100	100
21	5.8	2	100	100	92
22	1.6	0.5	100	100	99
23	3.2	1	100	100	100
24	6.5	2	99	100	97
25	2.3	0.5	100	100	100
26	4.6	1	100	100	100
27	9.1	2	99	100	100
28	2.4	0.5	100	100	100
29	4.7	1	99	100	100
30	9.5	2	100	100	99
			100	100	97

were refined and considerably narrowed down. The doses were readjusted in the range of 0.2 to 0.5 g N/plug (1.0 to 3.0 g of fertilizer) for the 80 ml (5 in^3) plug of a 410A block (Table 3).

Although spring 2002 was mostly dry, survival was in a much more acceptable range for all treatments (Figure 7A). Early measurement in fall 2002 indicated a positive effect on growth (Figures 7B and 7C). A thorough statistical analysis will be done when measurement takes place in fall 2003.

Conclusion

Although in its early stages, we believe the FAL Nutriplug™ technology has the potential to become a very useful silvicultural tool by helping tree seedlings overcome any "planting check" experienced during their first 2 or 3 seasons, thus quickly achieving optimal growth. Although the doses and suitable products have been narrowed down considerably, more research is needed to further define what fertilizer is best suited for a given combination of species, containers, and outplanting sites.

The development of a fully automated injection machine is also part of our current agenda, so that we will be able to fill high-volume orders through a technology fully compatible with our existing lifting equipment.

We see FAL technology (patent pending) taking the Nutriplug™ to the next generation. As a cost effective and versatile alternative to FAP, it also has the flexibility of being able to deliver various products in a range of doses directly to the root plug. This opens the door to a multitude of applications and outplanting sites, with seedling fertilizer effectively customized for each application.

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Table 2—Survival evaluation of different fertilizer treatments with fall lifting, fertilizer incorporation into the plug, cold storage, and spring outplanting on 2 different sites.

Fertilizer mix number	Fertilizer application rate (g of fertilizer per plug)	Fertilizer application rate (g of N per plug)	Survival on site 1	Survival on site 2
			- - - - - percent - - - - - -	
1	1.3	0.5		46
2	2.5	1		0
3	5.1	2		2
4	2.9	0.5		32
5	5.7	1		8
6	11.4	2		0
7	2.9	0.5		50
8	5.9	1		16
9	11.8	2		2
10	3.7	0.5		42
11	7.4	1	8	
12	14.8	2	58	
13	2.2	0.5	75	
14	4.3	1	33	
15	8.6	2	50	
16	3.1	0.5	50	
17	6.3	1	8	
18	12.5	2	25	
19	1.4	0.5	25	
20	2.9	1	8	
21	5.8	2	58	0
22	1.6	0.5	92	100
23	3.2	1	75	100
24	6.5	2	92	60
25	2.3	0.5	50	93
26	4.6	1	8	3
27	9.1	2	42	0
28	2.4	0.5	75	97
29	4.7	1	58	43
30	9.5	2	67	10
			92	100

Table 3—Treatments for mechanized incorporation for fertilization at time of lifting.

Mix number	Fertilizer	Nitrogen
	- - - - - - g per plug - - - - - -	
1	1.029	0.180
2	1.487	0.260
3	2.002	0.350
4	1.000	0.170
5	1.500	0.255
6	2.000	0.340
7	1.554	0.202
8	2.077	0.270
9	3.108	0.404
10	1.000	0.160
11	1.500	0.240
12	2.500	0.400
13	1.000	0.310
14	0.000	0.000
15	0.000	0.000

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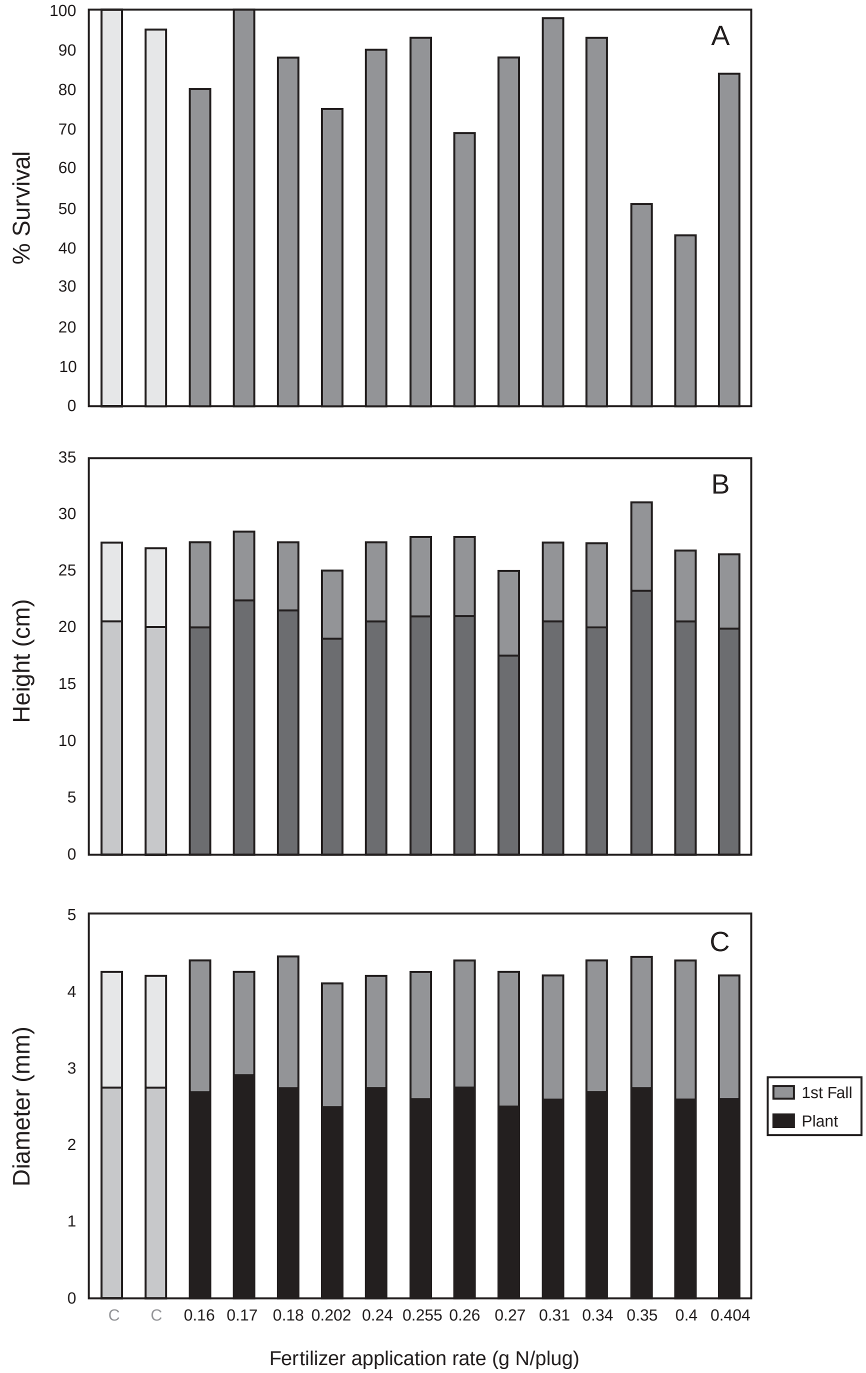

Figure 7—Survival percent (A), height measurements (B), and diameter measurements (C) for interior spruce at the Telkwa site after 1 growing season for the mechanized FAL trial.