SILVICULTURE

Forest Renewal Section

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Regeneration Note 7

GROMAX™ AND FERTILIZATION AT TIME OF PLANTING:

A Provincial Summary of Operational and Research Experience

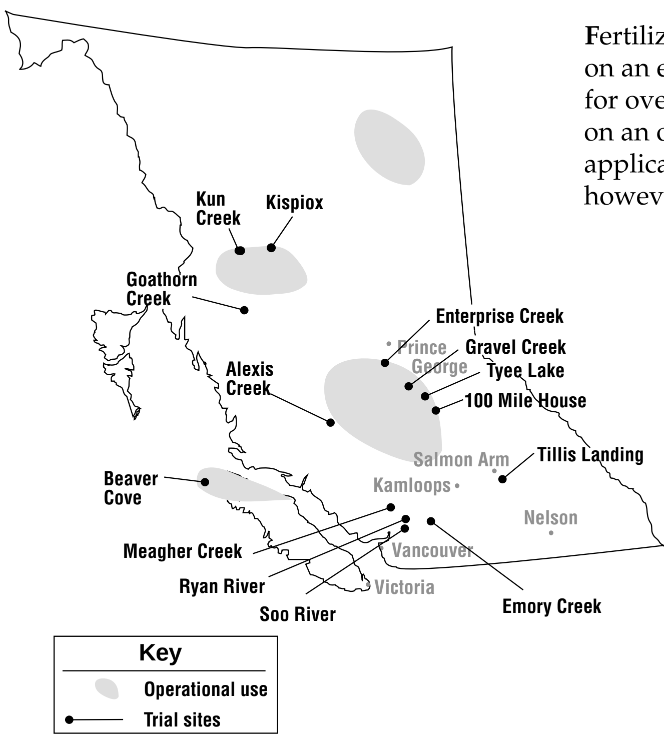

FIGURE 1. Location of FAP trials.

Problem

Fertilization **a**t the time of **p**lanting (FAP) has been applied largely on an experimental basis to forest plantations in British Columbia for over 20 years. FAP has been increasingly considered and used on an operational scale. Different products, rates, timing, and application methods and placements have been examined. Results, however, have not been consistent.

Objectives

To review the operational use and experimental results of GROMAX™ in British Columbia and provide recommendations on the prescription and use of this method of FAP.[1]

Background

Until recently, GROMAX™ has been the only commercially available FAP delivery system favoured by the silviculture community. Typically, one bag of GROMAX™ is placed in the planting hole at planting. In some areas of the province, forest companies are now routinely using GROMAX™ or other fertilizer products for operational planting—particularly for reclamation projects.

1 Mention of a trade name does not constitute endorsement to the exclusion of other or similar products. Official certification of some products mentioned in this Regeneration Note are pending and material is only available for experimental purposes.

Province of British Columbia
Ministry of Forests

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Reasons for Fertilization at Time of Planting (FAP)

Operationally, FAP has been prescribed to alleviate general planting check and a variety of site limiting factors at establishment, including:

- vegetation competition, and
- nutrient deficiency.

FAP, with a hydrophilic polymer amendment, has also been prescribed for sites with a soil moisture deficit.

Methodology

All Ministry of Forests SX trials and licensee trials with designated controls were included in the review. In addition, silviculturists prescribing FAP were surveyed for their experience, cost, and results.

Trial Sites

Trial results were obtained from 20 different sites (Figure 1). There were 91 different site/treatment combinations. In some cases, results were available for up to five years of growth (Figures 4 and 5). The trials cover the complete range of GROMAX™ products (Table 1), six different species, several stocktypes, and a wide range of moisture/nutrient conditions in ten biogeoclimatic subzones. Although this is an extensive set of data it should be noted that the direct comparison of GROMAX™ products are confounded by these factors.

Survey of Operational Users

There were four major areas of operational use of FAP (Figure 1).

Few of these operational projects included controls or firmly established trial designs. Operational experience from these areas was solicited in interviews with prescribing silviculturists. This operational experience has been included as anecdotes throughout this summary as "operational experience."

Product Formulation

Five GROMAX™ products have been used (Table 1). The oldest trials (Tyee Lake, Beaver Cove, Enterprise Lake, Gravel Creek) are only five years old and used GROMAX™ #2, which includes a superabsorbant hydrophilic acrylic polymer for increasing water holding capacity around the seedling. By itself the polymer has been shown to be beneficial in terms of survival and growth in agricultural applications. The benefits of the polymer for forestry seedlings, either by itself or in combination with fertilizers, has not been proven. One note of reference is the rate of N-application (< 2 g N per seedling) in all the trials except Tillis Landing, and operational experience is considerably less than the utilized rates previously reported by others (Brockley 1988).

Application

Generally only one bag of GROMAX™ (1x) has been placed directly in the planting hole at planting. However, in some experimental trials double (2x) and quadruple bags (4x) were used. In a number of cases the

TABLE 1. Range of commercially available GROMAX™ products with content and release specifications

Product	Formulation	Total fert. (g)	N-source	Total gel[1] (g)	Total wt. (g)	Total N (g)	Release period [2]
GROMAX™ #2	12–5–8 w gel	5	6.4% NH_4/ 5.6% NO_3	2	7	0.6	360–420 day
GROMAX™ #3	17–7–12 wo gel	7	9.1% NH_4/ 7.9% NO_3	0	7	1.19	360–420 day
GROMAX™ #4	17–3–5 w gel	6	4.6% NH_4/ 4.2% NO_3 8.2% NH_4NO_3	2	8	1.02	360–420 day
GROMAX™ #5	24–4–7 wo gel	7	6.6% NH_4/ 5.9% NO_3 11.5% NH_4NO_3	0	7	1.68	360–420 day

1 Weight in grams per bag of hydrophilic polymer gel.

2 Release period is the manufacturers suggested release period under standardized temperature and moisture conditions. For the most part, the listed release periods are much shorter than is expected under field conditions.

fertilizer was placed into a separate hole beside the seedling (side placement). Operationally only one bag is used.

Costs

The cost of the product has varied since its introduction and depends upon the quantity ordered as well as the shipping costs. A number of licensees routinely use FAP and are convinced of its cost effectiveness for their operations and conditions. In operations where the sites have been well prepared, the planters have received between 2 and 4¢/installation. For fill planting the cost is 6 to 7¢ per seedling. Under more difficult conditions the cost of installation has been as high as 30% of the cost of planting the seedling. Cost of side placement in a separate hole as opposed to in the planting hole can be as high as 11¢ per seedling.

Results: Survival

Trials – In the first year, over all trials, the average survival of GROMAX™ treated seedlings was about 7% less than the controls. Only 12% of the different site/treatment combinations had survivals greater than the controls. Where the survival of the fertilized treatment exceeded that of the control, it was on average, only 5% greater than the control. There were no noticeable differences between formulations with or without hydrophilic polymer gel.

In almost all cases where the fertilizer had lower survival compared to controls, the cause was due to indirect fertilizer effects:

- Preferential browsing by rodents (Fdc at Emory Creek), deer (Fdc at Soo River, Cw at Beaver Cove), or cattle (Fdc at Enterprise Creek), and
- Delayed dormancy and lammas growth leading to frost damage or over-winter desiccation (Fdc at Ryan R).

Similar causes of damage have been reported by operational users for these and other species. There were no reports of GROMAX™ causing an increase in vegetation competition.

Operational Experience – Similar survival to that observed in the trials has been noted in operational experience. In the early operational experience there were direct losses due to fertilizer burn (Figure 2). All species can be damaged by a fertilizer if the rate and time are not appropriate – there is no clear evidence that some species are more tolerant than others. Fertilizer burn can occur on dry sites, with poor placement, improper handling, or dry conditions at planting. Effects of fertilizer burn are evident within a

FIGURE 2. Example of direct mortality due to FAP on Sx PSB 313B. Foliage damage results and dead roots are evident at point of contact with tea bag fertilizer.

week of application and are characterized by loss of foliage and damaged roots. Due to the risk of fertilizer burn, some applications have prescribed placement in a separate hole beside the seedling (side placement).

Results: Growth

Trials – In nearly all trials, the growth of GROMAX™ treated seedlings was slightly greater than the controls. The fertilizer effect occurs early, generally the first and second year after planting. It then decreases, depending on the site, after the second or third year. In addition to the slightly increased growth, the height growth was more variable than the unfertilized seedlings.

Averaging all site treatments and expressing the results relative to the control, the increases appear to be significant (Figure 3). However, in absolute terms, height reponse is quite small, averaging, over all treatments: 2 cm after the first year; 4 cm after the second year; 6 cm after the third year; and 9 cm after the fifth growing season – only a fraction of the total height of the seedling. Increasing the application rate did not appear to increase growth or mortality.

The largest relative increase in height and diameter was seen under the following conditions:

- Site prepared conditions (Kispiox, Beaver Cove),
- Wetter moisture regimes (Tillis Landing),
- Wetter biogeoclimatic zones (Beaver Cove, Kispiox), and
- Poor site nutrient status (Beaver Cove).

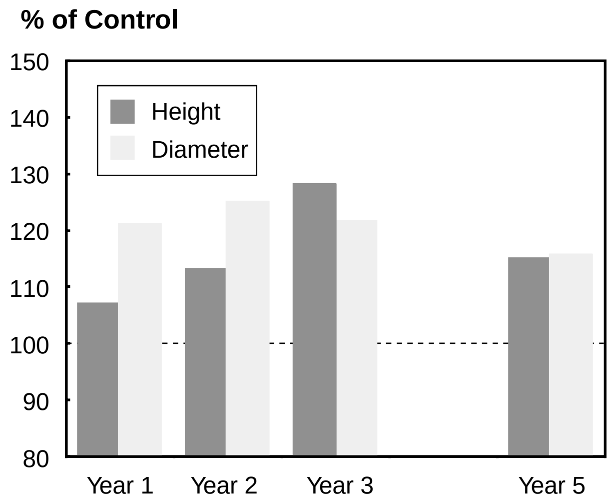

FIGURE 3. Average seedling response, expressed as a % of the control, for height and growth to FAP of all species, all treatments, from all reported trials. If the treatment was equal to the control, it would read as 100.

Some Specific Examples for Oldest Trials

Figure 4 illustrates a typical response to FAP on an unprepared interior site (Tyee Lake – Sx). Figure 5 is an example of superior performance when combined with site preparation on a coastal site (Beaver Cove – Hw, Mitsui Miki Rotoclear). Details of these sites are provided in Table 2, Locations and applications, on page 7.

Both examples illustrate the early height and diameter growth differences between the fertilized and unfertilized treatments. However, expressed as a percent of the control, the differences are slight at the Tyee Lake trial. The largest differences between the treated and untreated seedlings occur over the first two years and then decline. The fertilizer effect occurs early, persists for a few years, then declines. Diameter growth was more responsive to fertilization than height growth. **These early differences may, depending on site conditions (Beaver Cove – Hw), persist for many years.**

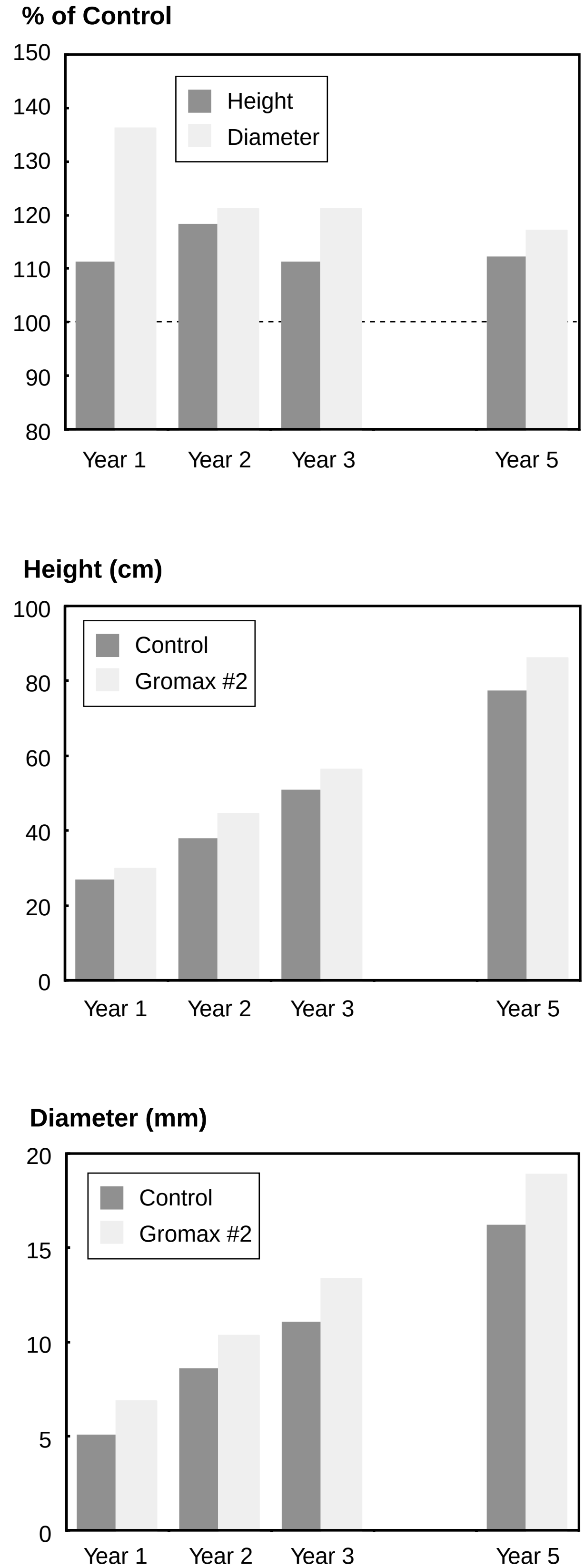

FIGURE 4. Interior spruce response to FAP with GROMAX™ #2 (12-5-8) on an unprepared interior site at Tyee Lake.

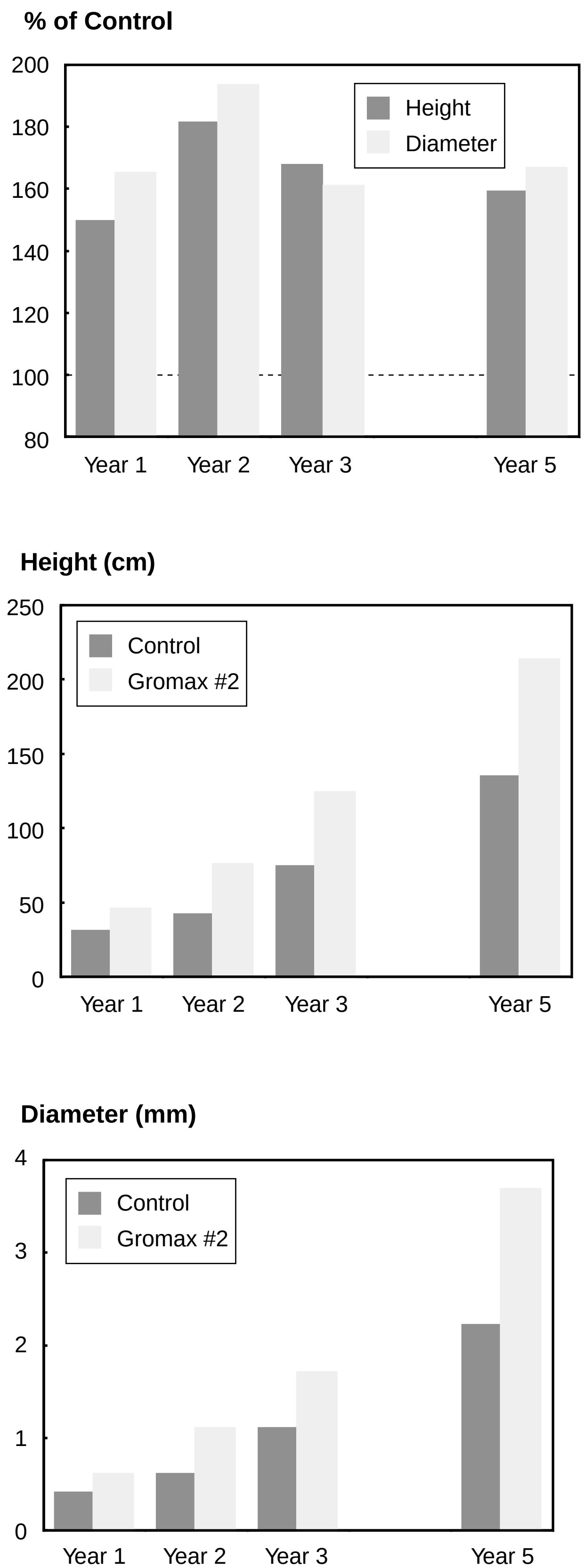

FIGURE 5. Western hemlock response to FAP with GROMAX™ #2 (12-5-8) when combined with site preparation (Mitsui Miki Rotoclear) on a coastal site at Beaver Cove.

Operational Experience – Operational experience, unfortunately, has rarely included controls to allow an assessment of growth. Where controls were established, the FAP seedlings were slightly larger than the unfertilized seedlings. Licensees acknowledged a positive fertilizer effect largely on the basis of the "look" of the seedling. Some of the best fertilizer benefits are reported to be on mechanically site prepared spots, wetter sites, poorer nutrient regimes, and special planting projects (i.e., fill planting, fill slopes, road and landing rehabilitation).

Conclusions

Although FAP with GROMAX™ is slightly more productive than unfertilized treatments, its overall performance is more variable than unfertilized seedlings. Better information is required concerning the reasons for the inconsistency in performance. Currently, FAP has only been reported to be of value for sites with identifiable poor nutrient regimes and special rehabilitation projects. Developments in new formulations and release characteristics may fulfill the promise of increased growth and survival improvement beyond those indicated by the reported trials.

In developing FAP prescriptions it is recommended that all operational uses of GROMAX™ or other FAP be accompanied by site-specific unfertilized controls and a detailed cost analysis. The benefits of "better looking" seedlings have yet to be quantified in terms of substantial growth improvement and survival. These controls will allow the quantification of the increases in productivity and reliability of FAP, permitting operational users to better define the prescription of FAP on a site-specific basis. As well, trials should be maintained to free growing assessment to determine the effect fertilization has on the achievement of free growing.

Conclusions: Risks

FAP with GROMAX™ is not without risks. These risks are both direct and indirect:

- Increased succulence, predisposing seedlings to desiccation or frost damage;
- Preferential browsing by rodents and ungulates; and
- Fertilizer burn.

Conclusions: Other Issues

Formulations – There appears to be no clear indication that any one formulation is preferable over another. Kispiox is the only location where the formulations are being directly compared and the results are inconsistent across the sites.

Hydrophilic polymers – It has not been possible to identify any advantage of these additives to FAP in the trials because fertilizer formulation differs between products with and without the hydrophilic polymers. Like many other moisture retaining materials these additives may only provide a "short-term insurance policy" under extreme conditions.

Stock type size – The only trials that directly compared stock type sizes were for Fdc at Emory Creek and Soo River. For unbrowsed seedlings in these trials, it was more economical to plant a larger stock type than fertilize a smaller stock type.

Duration of effect – The largest effect of FAP appears to be by the third year. Although the effect persists into later years, it is always smaller than the third year and the performance of the fertilized seedlings become increasingly variable with increasing age.

Timing – Meagher Creek and Emory Creek trials considered time of planting. There were no differences between spring- and fall-planted stock (Fdc at Meagher Creek). Nor were there differences between cold-stored and hot-lifted stock (Fdc at Emory Creek). Timing of application did not seem to increase the incidence of lammas growth.

Dose – Tillis Landing directly compared different dosages. The performance of the double-fertilized and quadruple-fertilized seedlings were nearly identical to the single-fertilized seedlings.

Acknowledgements

The Ministry of Forests expresses appreciation to Rob Scagel of Pacific Phytometric Consultants for his contribution to this regeneration note and to Steve Chambers and MacMillian Bloedel, Port McNeill Division for providing the data on the trial at Beaver Cove.

For More Information

Detailed statistical analyses and summaries of individual SX trials are being compiled and will be available from:

Regeneration Specialist
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Recommended Reading:

Brockley, R.P. 1988. The effects of fertilization on the early growth of planted seedlings: a problem analysis. Min. For. and For. Can., Victoria, B.C. FRDA Report 011.

Carlson, W.C. and C.L. Preisig. 1980. Effects of controlled-release fertilizers on the shoot and root development of Douglas-fir seedlings. Can.J. For. Res. Vol 11. pp. 230–242.

Chambers, S.C. and B.T. Smestad. 1995. Beaver Cove individual seedling fertilization trial, third year results. MacMillian Bloedel Ltd., Port McNeill Division. Internal Report. 17 p.

van den Driessche, R. 1988. Response of Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) to some different fertilizers applied at planting. New Forests 2:89–110.

van den Driessche R. 1991. Effects of nutrients on stock performance in the forest. *In* Mineral nutrition of conifer seedlings. R. van den Driessche (editor). CRC Press. pp. 229–260.

TABLE 2. Locations and applications

Location	Trial type	BGCSZ	Unit	Years since planting	Fertilzer rate x product[1]	Season	Other treatment	Species
Kispiox	SX – district	ICHmc1	3–4/C	1	1x(GROMAX™ #2) 1x(GROMAX™ #3) 1x(GROMAX™ #4) 1x(GROMAX™ #5)	Spring	Patch scarification	Hw, Cw, Sx, Pli
Alexis Creek	SX – Branch	IDFdk4	3/C	3	1x(GROMAX™ #2) 2x(GROMAX™ #2)	Spring	None	Pli
Meagher Creek	SX – branch	CWHds1	3/B–C	1	1x(GROMAX™ X)	Spring/ Fall	None	Fdc
Emory Creek	SX – branch	CWHds1	3–4/C	2	1x(GROMAX™ #2)	Spring/ Fall	Stocktype	Fdc
			2–3/C		1x(GROMAX™ #2)	Spring/ Fall	Stocktype	Fdc
Tillis Landing	SX – branch	ICHmw3	4–5/D	5	2x(GROMAX™ #2) 4x(GROMAX™ #2)	Spring	None	Fdi, Pli, Sx
			4/C–D		2x(GROMAX™ #2) 4x(GROMAX™ #2)	Spring	None	Fdi, Pli, Sx
			3–4/C		2x(GROMAX™ #2) 4x(GROMAX™ #2)	Spring	None	Fdi, Pli, Sx
			4/C		2x(GROMAX™ #2) 4x(GROMAX™ #2)	Spring	None	Fdi, Pli, Sx
Soo River	SX – district	CWHds1	3/C	2	1x(GROMAX™ #2)	Spring	Stocktypes	Fdc
100 Mile House	Weldwood	SBSwk1	3/C	2	1x(GROMAX™ #4)	Spring	None	Pli
			3/C		1x(GROMAX™ #4)	Spring	None	Pli
			2–3/B		1x(GROMAX™ #4)	Spring	None	Pli
			5/C		1x(GROMAX™ #4)	Spring	None	Pli
Ryan River	Terminal	CWHms1	4–5/D	2	1x(GROMAX™ #2)	Spring	Brushmats	Fdc, Se
Beaver Cove	MB	CWHvm1	3–4/C	3	1x(GROMAX™ #5)	Spring	None	Fdc, Hw, Cw
			4/C		1x(GROMAX™ #5)	Spring	Mitsui Miike	Fdc, Hw, Cw
Tyee Lake	SX – region	SBSdw1	3–4/C	5	1x(GROMAX™ #2)	Spring	None	Fdi, Lw, Pli, Sx
Enterprise Creek	SX – region	IDFdk3	3/C	5	1x(GROMAX™ #2)	Spring	None	Fdi, Lw, Pli
Gravel Creek	SX – region	SBSdw1	3/C	5	1x(GROMAX™ #2)	Spring	None	Fdi, Pli

1 1x – standard application rate; 2x – double standard application rate; 4x quadruple standard application rate.