Forest Research Branch

# PRELIMINARY RESULTS OF A FIELD TEST OF BULLET PLANTING IN ALBERTA

by

R. F. ACKERMAN, D. I. CROSSLEY,

L. L. KENNEDY AND J. CHEDZOY

*Sommaire et conclusions en français*



DEPARTMENT OF FORESTRY PUBLICATION NO. 1098

1965

## ABSTRACT

Field tests of ball planting, using plastic, bullet-shaped containers, were initiated on a variety of sites in the High Foothills Section of west-central Alberta. Preliminary survival results indicate that unfertilized lodgepole pine and white spruce seedlings, eight weeks of age and older, can be successfully planted throughout the frost-free season on a wide range of sites and seedbeds. Further development of the technique is recommended and may result in a fast, low cost regeneration method of wide application.

**Published under the authority of**

**The Honourable Maurice Sauvé, P.C., M.P.,**

**Minister of Forestry**

**Ottawa, 1965**

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1965

Catalogue No. 47-1098

## CONTENTS

# Preliminary Results of a Field Test of Bullet Planting in Alberta[1]

by

R. F. Ackerman[2], D. I. Crossley[3],
L. L. Kennedy[4] and J. Chedzoy[5]

## INTRODUCTION

The development by Walters (1961, 1963) of a planting "gun" designed to set out seedlings grown in bullet-shaped, plastic containers has "triggered" a resurgence of interest in ball planting. Although much of the interest is presently focussed on the planting gun, the significant question at this time is field survival and development of seedlings grown and planted out in the plastic containers.

In 1962 and 1963 the Alberta Department of Lands and Forests, North Western Pulp and Power Limited, Alberta Department of Agriculture and the Department of Forestry co-operated in the establishment of experiments to determine the following:

1. Is survival and growth of bullet-planted stock sufficiently good to warrant further development of the technique?
2. Can bullet planting be successfully employed throughout the frost-free season?
3. What minimum age of stock will give a reasonable level of survival?
4. Is the method applicable to a variety of sites and seedbeds?

The economic feasibility of mass production of these units was not studied. Nevertheless, the possibility of continuous planting throughout the frost-free season, and the rate of turnover at the nursery, as controlled by the age of stock required, have a direct bearing on this question.

## REVIEW OF THE LITERATURE

Interest in ball planting (defined as the lifting, transporting and planting of stock with a larger or smaller "ball" of soil attached to the roots (Heiberg, 1934) is justified, for the technique offers a number of important advantages over conventional, exposed-root planting (Anon. 1958; McLean 1959; Heiberg 1934; Oramas 1942; Petre 1949; Pato 1940; Walters 1961). Some advantages are:

1. Increased seedling survival and juvenile growth, attributable to the fact that:
   (a) seedlings are planted in the soil to which they are accustomed,
   (b) there is no mechanical or climatic injury to roots,
   (c) interruption of growth (planting check) is reduced to a minimum and the seedlings can more quickly adapt to the new environment,
   (d) a uniform high standard of planting, and
   (e) the method facilitates location of seedlings in favorable microsites.

[1]Department of Forestry, Canada, Forest Research Branch Contribution No. 666
[2]Research Officer, Forest Research Branch, Department of Forestry, Calgary, Alberta
[3]Chief Forester, North Western Pulp and Power Limited, Hinton, Alberta
[4]Forester, Silviculture, Forest Management Branch, Department of Lands and Forests, Edmonton, Alberta
[5]Superintendent, Provincial Tree Nursery, Department of Agriculture, Edmonton, Alberta

2. The possibility of extending the planting season throughout the entire frost-free period.
3. With an extended planting period a semi-permanent, trained planting crew can be organized rather than the makeshift crews normally employed in spring and fall planting.
4. The method lends itself to a variety of treatments designed to promote growth and survival in the nursery and after planting out e.g. special soils, fertilizers, auxins, containers adapted to different field conditions.

In addition to the advantages listed for ball planting, the proposed use of a small container and planting by dibble or gun should result in a high planting rate and a corresponding reduction in field costs.

Ball planting is not a new procedure in world forestry. The literature contains many references to the practice for a variety of species and regions. A few examples are cited below.

1. Tools for lifting and replanting natural seedlings where regeneration is overabundant (Anon. 1953).
2. Machines for the use and manufacture of soil or peat" briquettes", pots of organic soil, peat pots, soil blocks and bricks (Anon. 1954, 1959a; Heiberg 1934; Frohlich 1959; Roosen and Thurnau 1957; Wake 1947).
3. Use and manufacture of containers made from paper, cardboard, tar paper, roofing paper etc. (Anon. 1959b; Dopper 1959; Beltram 1946; Heiberg 1934; Kimbrough 1949; Oramas 1942; Petre 1949; Veiga 1946).
4. Containers of plastic (Anon. 1958; Clauzure 1956; McLean 1959; Walters 1961, 1963).
5. Containers of tin, galvanized iron, jam tins etc. (Anon. 1946, 1947a, b, 1958; Spafford 1948).
6. Leaf baskets e.g. palm leaf, banana leaf (Anon. 1947c).
7. Planting tubes of bamboo, sunflower stem etc. (Anon. 1948; Kith 1949).

Generally, seedling survival has been higher with ball planting in its many forms than with conventional planting, particularly on dry, difficult sites. Planting costs however have also been somewhat higher. The higher costs reported in the literature probably result from failure to develop the technique beyond the experimental stage. Certainly, if methods and containers similar to those employed by either Walters or McLean prove successful, field costs will be substantially lower than for conventional planting.

## METHODS AND MATERIALS

### Description of the Area, Site and Climate

The study was conducted in the Upper Foothills Section of the Boreal Forest Region of west-central Alberta (Rowe 1959), on the pulpwood lease area of North Western Pulp and Power Ltd., Hinton, Alberta. Characteristic topography is a series of high hills (4,000 to 6,000 feet) and deep valleys underlain by Mesozoic and Palaeozoic sandstones and shales. Soils are normally glacial, colluvial or alluvial in origin and show podzolic development.

All planting areas are located on 10-chain clear-cut strips or large clear-cut blocks which carried either pure, even-aged, merchantable white spruce (*Picea glauca* (Moench) Voss var. *albertiana* (S. Brown) Sarg.) or lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) of fire origin.

The significant features of each site planted in 1962 and 1963 are shown in Table 1.

TABLE 1.—DESCRIPTION OF PLANTING SITES.

| Item | 1962 Planting | 1963 Planting | | |
|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 |
| Cover Type | lodgepole pine | lodgepole pine | white spruce | white spruce |
| Productivity—Cords/acre | 60–80 | 20–40 | 40–60 | 40–60 |
| Logging date | 1957–58 | 1960–61 | 1956–57 | 1961–62 |
| Seedbed treatment | scarified | scarified and undisturbed | scarified and undisturbed | scarified and undisturbed |
| Topog. position | top and upper slopes of secondary ridge | mid-upper slope | main valley bottom | plateau top |
| Slope | 0–15% | 20% | nil | 3% |
| Aspect | N and S | S 20° W | nil | N 30° E |
| Exposure | variable | exposed | normal | normal |
| Soil origin and fabric | sandy loam till | sandy loam till | coarse alluvium | stony till |
| Depth to water table | — | — | — | 6′ |
| Depth to bedrock | 6′ | 3′–4′ | — | — |
| Organic horizons | 3″ mor | 1″ mor | 1–2″ mor | 4″ feather moss |
| Soil moisture | fresh | dry | very dry | moist |
| Veg. competition | moderate | light | light | — |

The four sites are fairly representative of the Foothills Section. Surface soil moisture regimes vary from very dry to moist. Surface organic horizons vary from a thin mor to four inches of feather moss. Site 3, in particular, has a history of regeneration failure; mechanical scarification, seeding and planting have all been largely unsuccessful.

Vegetative competition, although generally not a severe problem affecting regeneration after logging in this area, is a definite consideration on the more productive sites. The four sites in this study vary in this regard from a light herbaceous and grass cover on Sites 2 and 3 to a rich shrub and grass cover on Site 1 and include a fairly deep feather moss on Site 4.

Mean temperature and precipitation for the Hinton area during the summer months of 1962 and 1963 are given in Table 2. Since there are no long term weather records available for Hinton, long term averages and 1962 and 1963 data are also shown for Edson, located approximately 50 miles east of Hinton.

TABLE 2.—MEAN TEMPERATURE AND PRECIPITATION—1962, 1963.

| Location | Year | Mean Temp. ° F. | | | | Precipitation—inches | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | May | June | July | Aug. | May | June | July | Aug. | Total |
| Hinton | 1962 | 45 | 54 | 57 | 56 | 2.22 | 2.62 | 3.48 | 1.83 | 10.15 |
| | 1963 | 46 | 53 | 59 | 59 | 1.12 | 0.28 | 2.59 | 3.24 | 7.23 |
| Edson | 1962 | 46 | 55 | 58 | 57 | 3.60 | 2.00 | 6.60 | 2.80 | 15.00 |
| | 1963 | 46 | 55 | 60 | 59 | 1.30 | 0.80 | 2.19 | 2.52 | 6.81 |
| | Long Term | 48 | 54 | 60 | 57 | 1.52 | 3.15 | 3.21 | 2.97 | 10.85 |

The climate of the region is characterized by winter-low, summer-high precipitation, with approximately 3 inches each month in June, July and August. The 1962 season was abnormally wet, owing primarily to abundant rainfall during May and July. The 1963 season was abnormally dry due to somewhat low precipitation during all months but most particularly during June. The drought condition during June 1963, preceded by a relatively dry May, is of particular interest.

## Experimental Design

*1962 Planting*

In 1962 the following treatments were applied for lodgepole pine and white spruce on each of a north, level and south aspect of a secondary ridge (Table 1, Site 1).

| Date of Planting | Age of Seedlings (Weeks from seeding) | | | | | Transplants |
|---|---|---|---|---|---|---|
| May 15 | 4 | | | | | 1-0 |
| June 15 | -- | 8 | | | | 1-0 |
| July 15 | 4 | 8 | 12 | | | 1-0 |
| August 15 | 4 | 8 | 12 | 16 | | 1-0 |
| September 15 | 4 | 8 | 12 | 16 | 20 | 1-0 |

The design was not orthogonal because there was insufficient time to produce the older seedlings for spring planting. For each species, a block containing 20 cells (15 × 15 feet) was located on each of the north, level and south aspects of the site. Twenty age X date treatments were assigned randomly to the cells in each block.

It was originally intended to set out 100 seedlings, at a minimum spacing of 1 foot in each cell. This was not possible in a number of treatments because of difficulties encountered at the nursery.

The site of the 1962 planting, previously scarified by tractor, offered a variety of seedbed conditions. An attempt was made to place one-half of the seedlings in each cell in a mineral soil seedbed and the other half in undisturbed organic seedbed. However, this procedure was not entirely effective for in some cells scalping or digging was required to obtain mineral soil while in other cells truly undisturbed organic seedbed was absent.

Tallies of seedling survival were made once each month during 1962 and in the spring and fall of 1963.

*1963 Planting*

In 1963 an orthogonal, factorial design was possible and the following treatments were applied:

1. *Species*—
   - (a) white spruce
   - (b) lodgepole pine
2. *Site*—(see Table 1)
3. *Seedbed Treatment*—
   - (a) scarified
   - (b) not scarified
4. *Date of planting*—
   - (a) June 1-7
   - (b) July 1-7
   - (c) August 1-7
   - (d) September 1-7

5. *Age of seedlings*—

(a) 8 week seedlings (from seed) grown and planted out in bullets

(b) 16 week seedlings grown and planted out in bullets

(c) 1-0 seedlings transplanted into bullets

(d) 2-0 conventional, exposed-root stock lifted immediately prior to planting

A block containing 32 cells (30 × 30 feet) was located on each site X seedbed unit (a total of 6 blocks). The 32 species X age of stock X planting month treatments were assigned randomly to the cells in each block. It was intended to plant 50 seedlings within each cell, at a spacing of approximately 4 feet. As in the 1962 planting, this objective was not attained for all treatments owing to germination and survival difficulties at the nursery. Seedling survival was tallied each month during the 1963 season.

In the 1962 planting a mineral soil seedbed was created where necessary by scalping. In the 1963 experiment, repeated on scarified and unscarified areas, no scalping was undertaken. Seedlings were placed in what were considered to be the most favourable situations available, with due regard to maintenance of a reasonable spacing. Thus on the unscarified areas, nearly all seedlings were planted in undisturbed organic seedbeds while on the scarified areas advantage was taken wherever possible of the mineral soil and disturbed seedbeds created by this treatment.

## Planting Materials and Methods

The plastic bullet developed by Walters (1961) was used in 1962. This is of molded styrene plastic 1/16-inch thick and measures $2\frac{1}{3}$ inches long by $\frac{7}{8}$-inch outside diameter. The wall of the bullet is weakened by a narrow slit extending from the rim to a hole near the tip (Fig. 2). The container was modified slightly in 1963. The dimensions of the new container remained the same but the thickness of the plastic shell was reduced to 1/20-inch and three additional holes were added near the tip of the bullet.

The planting stock was provided by the Provincial Tree Nursery of the Department of Agriculture, Edmonton, Alberta. Germination, using seed of Hinton origin, was accomplished in the bullets in the nursery greenhouse with a water-misting system. The seedlings in the bullets were then moved outside to sheltered flats until needed. The 1-0 stock, also of Hinton origin, was lifted from the nursery seedbeds and transplanted into the bullets in the spring and used, as required, throughout the summer. The stock employed is illustrated in Figures 1, 2 and 3.

The soil used in the bullets was a black nursery loam capped with a sand mulch. No nutrients were added to the soil or irrigation water.

Planting of the seedlings contained in the plastic bullets was done with a dibble or punch designed to make a hole in the ground exactly large enough to accommodate the bullet.

The 2-0 conventional stock was lifted as required and taken to the planting site with as little delay as possible. Lifting in May and holding in cold storage was considered as an alternative procedure. However, a very large storage period would have been necessary in this experiment and past experience with cold storage, with the facilities then available, had been less than satisfactory. Lifting the stock as required was adopted as the lesser of two evils.

The 2-0 conventional stock was set out with a planting bar, the method currently in use in the area.

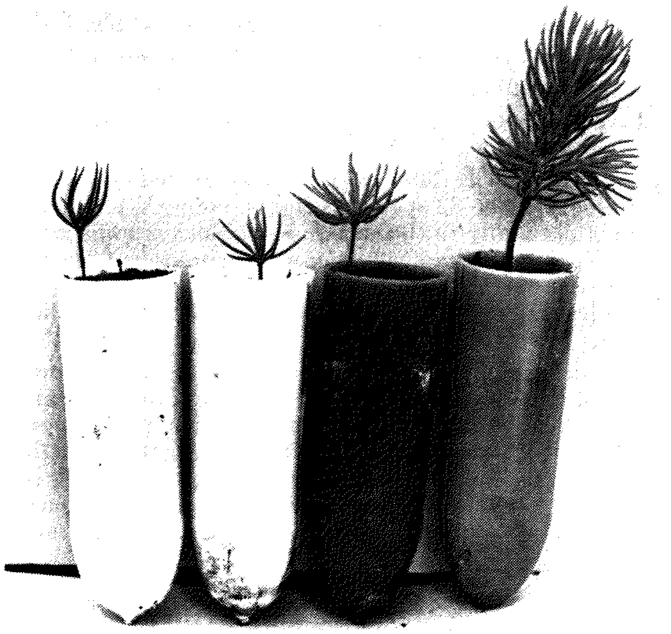

FIGURE 1. White spruce seedlings used in 1962 planting. Ages from left to right, 4 weeks, 8 weeks, 12 weeks and 1-0 transplants, 3/5 natural size.

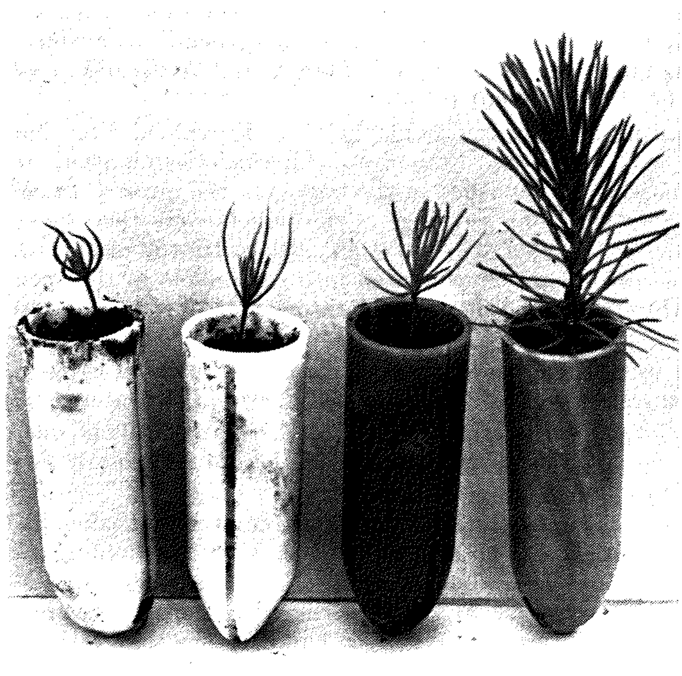

FIGURE 2. Lodgepole pine seedlings used in 1962 planting. Ages from left to right, 4 weeks, 8 weeks, 12 weeks and 1-0 transplants, 3/5 natural size.

FIGURE 3. 1-0 lodgepole pine transplant in bullet planted in mineral soil seedbed.

# RESULTS

## 1962 Planting

The numbers of white spruce and lodgepole pine planted, together with percentage survival to September 1963 and probable causes of mortality are given in Tables 3 and 4 respectively. These data combine all three aspects and both mineral and organic seedbeds.

Seedling survival of both spruce and pine for most planting months and ages, except 4 week, ranged between 70 and 90 per cent after two seasons in the field. These results are most encouraging. They indicate that young seedlings can be employed successfully and that planting throughout the frost-free season is entirely feasible.

The main causes of seedling mortality in the 1962 planting were rodent feeding, frost and smothering. Spring losses from rodent feeding were not distinguishable from frost injury at the initial inspection, one month after planting, and are therefore included with climatic losses in Tables 3 and 4. It was later observed however that rodent feeding was largely confined to 4-week-old seedlings immediately after planting. Seedlings older than 4 weeks are apparently no longer palatable.

Both the May and August plantings were subjected to frost shortly after planting. This is clearly seen in the mortality figures of the 4-week-old seedlings. Seedlings 8 weeks and older were not so susceptible and although some damage occurred, mortality seldom resulted.

Frost heaving adversely affected 20 per cent of all the seedlings set out in 1962 (17 per cent partially heaved, 3 per cent totally heaved). Although heaving has not, as yet, contributed significantly to mortality, the process may act as a check on root development and growth. Since heaving is most severe on large patches of unsheltered mineral soil, this situation should be avoided in future planting of bullets.

TABLE 3.—WHITE SPRUCE SURVIVAL TO SEPTEMBER 1963
1962 PLANTING—ALL ASPECTS AND SEEDBEDS

| Age of Stock | Planting Month | Number Planted | Percentage Survival | Apparent Cause of Mortality—Percentage of Total Planted | | | |
|---|---|---|---|---|---|---|---|
| | | | | Climatic | Smothering | Heaving | Total |
| 4 week | May | 216 | 26 | 62 | 12 | — | 74 |
| | July | 300 | 56 | 29 | 13 | 2 | 44 |
| | August | 300 | 14 | 66 | 20 | <1 | 86 |
| | September | 282 | 49 | 42 | 8 | 1 | 51 |
| 8 week | June | 216 | 71 | 21 | 8 | <1 | 29 |
| | July | 180 | 86 | 7 | 7 | <1 | 14 |
| | August | 300 | 83 | 9 | 8 | <1 | 17 |
| | September | 97 | 57 | 23 | 16 | 4 | 43 |
| 12 week | July | 216 | 86 | 5 | 9 | — | 14 |
| | August | 180 | 84 | 5 | 10 | 1 | 16 |
| | September | 292 | 92 | 3 | 3 | 2 | 8 |
| 16 week | August | 216 | 64 | 25 | 9 | 2 | 36 |
| | September | 180 | 86 | 4 | 9 | 1 | 14 |
| 20 week | September | 216 | 82 | 9 | 7 | 2 | 18 |
| 1-0 Bullet Transplants | May | 300 | 70 | 20 | 9 | 1 | 30 |
| | June | 300 | 84 | 10 | 6 | <1 | 16 |
| | July | 300 | 92 | 5 | 3 | — | 8 |
| | August | 300 | 90 | 5 | 5 | — | 10 |
| | September | 294 | 90 | 8 | 2 | — | 10 |

TABLE 4.—LODGEPOLE PINE SURVIVAL TO SEPTEMBER 1963
1962 PLANTING—ALL ASPECTS AND SEEDBEDS

| Age of Stock | Planting Month | Number Planted | Percentage Survival | Apparent Cause of Mortality—Percentage of Total Planted | | | |
|---|---|---|---|---|---|---|---|
| | | | | Climatic | Smothering | Heaving | Total |
| 4 week | May | 78 | 20 | 76 | 4 | — | 80 |
| | July | 282 | 61 | 26 | 13 | — | 39 |
| | August | 30 | 23 | 67 | 10 | — | 77 |
| | September | 256 | 46 | 43 | 10 | 1 | 54 |
| 8 week | June | 78 | 70 | 22 | 8 | — | 30 |
| | July | 30 | 77 | 17 | 6 | — | 23 |
| | August | 282 | 75 | 17 | 8 | — | 25 |
| | September | 34 | 82 | 18 | — | — | 18 |
| 12 week | July | 78 | 72 | 20 | 8 | — | 28 |
| | August | 30 | 87 | 7 | 7 | — | 13 |
| | September | 282 | 92 | 6 | 2 | <1 | 8 |
| 16 week | August | | Insufficient Data | | | | |
| | September | 30 | 83 | 10 | 7 | — | 17 |
| 20 week | September | | Insufficient Data | | | | |
| 1-0 Bullet Transplants | May | 300 | 89 | 9 | 2 | — | 11 |
| | June | 300 | 92 | 5 | 3 | — | 8 |
| | July | 300 | 93 | 6 | 1 | — | 7 |
| | August | 300 | 88 | 9 | 2 | 1 | 12 |
| | September | 278 | 95 | 4 | — | 1 | 5 |

Smothering by litter killed 7 per cent of all the seedlings set out in 1962 and adversely affected the development of an additional 19 per cent. However, these losses were to a large extent avoidable, for more than 50 per cent of all mortality due to smothering was a direct result of the creation of depressions or holes in the effort to obtain a mineral soil seedbed. It is safe to assume that survival would have been approximately 5 per cent higher had this practice been avoided. The effect of smothering was most pronounced on the smaller, younger seedlings and provides strong argument for the use of large vigorous stock.

Significant differences between the survival of spruce and pine are not evident in the 1962 experiment. Both species were subject to the same major causes of mortality and in most cases, to a similar degree. One possible exception—lodgepole pine, a larger more vigorous seedling than spruce was less subject to smothering. This is most evident for the 1-0 transplants.

It has not been possible to demonstrate significant effects of aspect or seedbed on seedling survival in the 1962 experiment. The soil was fresh and the 1962 season was moist with frequent and abundant rainfall during all months (Table 2). Both factors tend to obscure an independent effect of aspect on survival.

The effect of seedbed was confounded by several factors: (a) the study area had been previously scarified, (b) truly undisturbed organic seedbed was either scarce or absent in some cells and (c) the scalping and resultant abnormal mortality (smothering) associated with the mineral seedbed. The significance of a mineral soil seedbed with regard to frost heaving has been noted.

## 1963 Planting

The analysis of variance of percentage survival to September 1963 is presented in the Appendix. Owing to the preliminary stage of the investigation no attempt has been made to interpret results beyond the first-order interactions. In addition, all variance beyond first-order interactions has been employed as error term. This procedure, although questionable statistically emphasizes the main trends in the data which is all that can be reasonably expected at this time.

All main effects in this experiment except seedbed are involved in a significant first-order interaction, indicating that the effects on survival of all factors except seedbed are dependent upon the level of one or more of the other factors.

Three first-order interactions are significant; *age* X *month*, *species* X *age* and *site* X *month*. The *age* X *month* and *species* X *age* interactions are shown in Table 5; the presentation of percentage survival by species, month of planting and age of stock.

TABLE 5.—1963 PLANTING—PERCENTAGE SURVIVAL OF SPRUCE AND PINE TO SEPTEMBER 1963—ALL SITES AND SEEDBED TREATMENTS

| Age of Stock | Planting Month | | | |
|---|---|---|---|---|
| | June | July | August | All |
| Spruce—Percentage Survival to September 1963 (Number Planted) | | | | |
| 8 week bullets | 38(300) | 70(82) | 92(120) | 67(502) |
| 16 week bullets | 72(300) | 76(299) | 91(300) | 80(899) |
| 1-0 bullet transplants | 28(300) | 83(300) | 94(300) | 68(900) |
| mean—all bullets | 46(900) | 76(681) | 92(720) | 72(2301) |
| 2-0 conventional stock | 36(300) | 44(300) | 98(300) | 59(900) |
| mean—all stock | 43(1200) | 68(981) | 94(1020) | 68(3201) |
| Pine—Percentage Survival to September 1963 (Number Planted) | | | | |
| 8 week bullets | 74(78) | 74(222) | 98(131) | 81(431) |
| 16 week bullets | 49(300) | 93(56) | 99(290) | 80(646) |
| 1-0 bullet transplants | 32(300) | 84(300) | 86(250) | 67(850) |
| mean—all bullets | 52(678) | 84(578) | 94(671) | 76(1927) |
| 2-0 conventional stock | 34(300) | 52(300) | 96(300) | 61(900) |
| mean—all stock | 47(978) | 76(878) | 95(971) | 73(2827) |

The best overall survival (approximately 80 per cent) was obtained with 8 and 16 week seedlings grown and set out in bullets. Any advantage gained by the use of 16 week seedlings rather than 8 week, is evident only for spruce planted during the extremely dry month of June.

Mean survival of the 1-0 transplants was well below that of 8 and 16 week seedlings. The data in Table 5 show that this results from the very poor survival of the June planting. Survival of 1-0 transplants set out in July and August was excellent. The severe mortality of 1-0 transplants set out in June is attributed largely to the drought. Also, the June transplants may not have had time to establish themselves in the bullets before planting, making them particularly sensitive to moisture stress.

The conventional, exposed-root planting of 2-0 stock was the least successful of all treatments. Many trees of the June and July planting were badly wilted when set out and simply failed to recover. The effect of lifting and planting during the spring growth period, aggravated by the June drought can be held responsible. The August and September plantings more closely resemble a "normal" operation and will provide a better basis for comparison with bullet planting when long-term survival records are available.

The *site* X *month* interaction is shown in Table 6 for 8 and 16 week-old seedlings grown and set out in bullets.

TABLE 6.—1963 PLANTING—PERCENTAGE SURVIVAL TO SEPTEMBER 1963 OF 8-WEEK AND 16-WEEK SEEDLINGS BY SITE AND MONTH OF PLANTING—ALL SPECIES AND SEEDBED TREATMENTS.

| Site | Month of Planting | | | |
|---|---|---|---|---|
| | June | July | August | All |
| | Percentage Survival (Number Planted) | | | |
| No. 2 | 62(326) | 70(224) | 89(284) | 74(834) |
| No. 3 | 42(326) | 76(217) | 99(274) | 72(817) |
| No. 4 | 72(326) | 90(218) | 97(283) | 86(827) |
| All | 59(978) | 79(659) | 95(841) | 77(2478) |

Averaging all months, survival was highest on Site 4 (moist till) and lowest on Site 3 (dry alluvial gravel). The very low survival of the June planting on Site 3, the result of the combined effects of dry site and low precipitation, is the source of most of the interaction variance in these data. Survival on all sites was relatively good for the July and August plantings.

Seedbed treatment is the only variable in the experiment not involved in an interaction. Survival of 8 and 16-week seedlings, for all treatments, averaged 9 per cent higher on the scarified blocks than on the unscarified blocks (Table 7).

TABLE 7.—1963 PLANTING—PERCENTAGE SURVIVAL TO SEPT. 1963 OF 8-WEEK AND 16-WEEK SEEDLINGS ON SCARIFIED AND UNSCARIFIED BLOCKS.—ALL SPECIES, SITES, AGES AND PLANTING MONTHS.

| Seedbed Treatment | Percentage Survival (No. Planted) |
|---|---|
| Scarified | 82(1234) |
| Not Scarified | 73(1244) |

These preliminary data suggest that tractor scarification, as practised on the lease area of North Western Pulp and Power Ltd. may be a favourable pre-planting treatment. It should be noted, however, that the effects of frost heaving, which will be most severe on the scarified blocks, cannot be evaluated for another year.

The principal causes of mortality in the 1963 planting have been:

(1) lack of precipitation in June affecting all ages of stock.

(2) the use of 2-0 conventional stock lifted and planted during the period of active growth.

(3) planting out 1-0 transplants before they were properly established in the bullets.

To date, none of the major causes of mortality noted in the 1962 planting have been important in the 1963 planting. Loss to rodents was largely avoided by the use of seedlings 8 weeks and older while frost did not occur during the planting period in 1963. Smothering and heaving losses have yet to be determined.

The undisturbed seedbed on Site 4 is a feather moss. Mortality may occur on this site due to envelopment of the bullets by the moss. A longer container may be useful on this particular seedbed.

## DISCUSSION

Eight-week-old seedlings were the youngest used successfully in the planting trials. This stock, grown without nutrient amendments, must be considered the minimum development obtainable in that period of time. The size of spruce stock that can be grown in 8 weeks with nutrient amendments is shown in Figure 4 and should be compared with the 8-week seedling in Figure 1, grown without amendments. The use of such vigorous stock in future trials should certainly increase survival and lower the minimum age required for success. It is anticipated that with the use of fertilizers 4-week-old seedlings, or younger will be satisfactory.

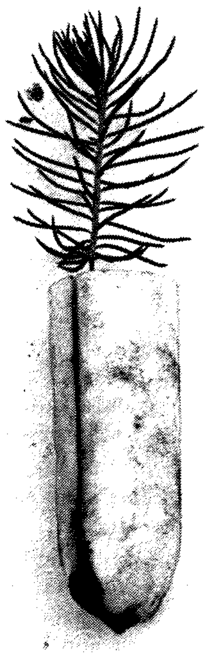

FIGURE 4. 8-week-old white spruce seedling grown with nutrient amendments. 3/5 natural size.

No data are available as yet on top or root growth. Seedling growth is slow in the High Foothills Section of Alberta under the best of conditions and it is anticipated that the earliest practical date for growth measurements will be 1965. During September 1963 several spruce and pine seedlings planted out in May, 1962 were excavated to observe root development. As might be expected root development varied as much as top development. In some instances the roots had not grown beyond the container while in others well developed root systems were in evidence (Figures 5 and 6).

The suitability of the plastic container used in these trials has not been established for the possibility remains of mortality or a severe growth check as a result of restricted root development. Observations to date indicate that the roots will grow out of the plastic container provided there is a suitable substratum. It is questionable, however, whether the roots will break the container when they become confined by the exit holes. Further root development in plastic containers will be followed closely. In the meantime field tests have been initiated to investigate a number of other container materials and designs.

It is difficult at this time to comment on the problems and costs of mass production of seedlings grown in small containers. As yet, little or no research has been undertaken on the many problems that will be encountered in the culture of these units. Nevertheless, if fairly young seedlings are successful, summer long planting is feasible and if advantage is taken of mechanization there appears to be no reason why these units could not be mass produced economically and with a fraction of the establishment presently associated with forest nurseries.

The main objective of the field trials described in this report is to determine if the technique of bullet planting has sufficient promise to warrant further development. The preliminary survival results indicate that such is indeed the case and research will be initiated on seedling culture as rapidly as staff and facilities permit.

## SUMMARY AND CONCLUSIONS

In 1962 and 1963 field testing of bullet planting was initiated in the High Foothills Section of the Boreal Forest Region of Alberta. White spruce and lodgepole pine seedlings, varying in age from 4 weeks to 1 year were grown and planted out in plastic, bullet-shaped containers each month of the frost-free seasons of 1962 and 1963, on a variety of representative site and seedbed conditions.

With the exception of the planting in June 1963, an abnormally dry month, 70 to 90 per cent survival is indicated for all stock older than 4 weeks and for all planting months. In addition, these data indicate little or no advantage in the use of unfertilized stock older than 8 weeks from seed.

The results to date, although preliminary, indicate that the technique will have wide application, for survival has been satisfactory on a wide range of site and seedbeds characteristic of the region.

The results provide a strong argument for further research and rapid development of bullet planting. Additional research is urgently required in nursery greenhouse techniques for mass production, in the use of fertilizers and in the design and testing of improved containers. The reward, a fast, low cost planting method that can be employed throughout the frost-free season is manifestly worthwhile.

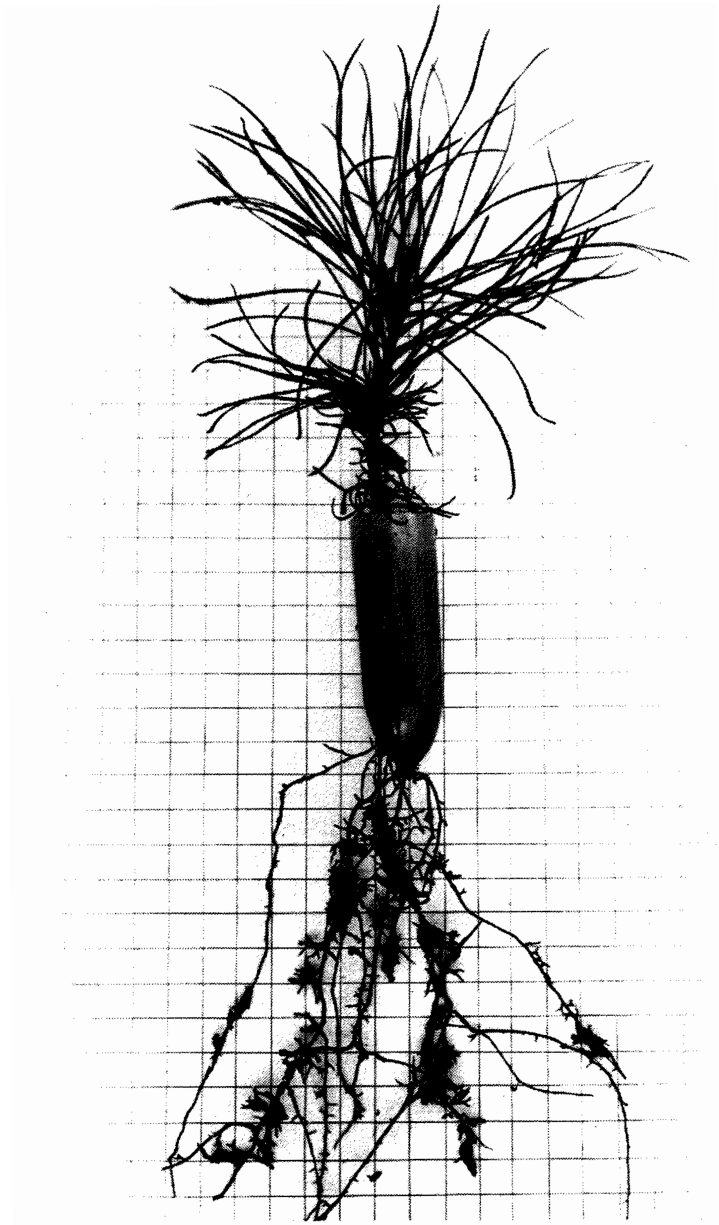

FIGURE 5. Root development of 1–0 lodgepole pine seedling planted in May 1962 and excavated in September 1963. ½ natural size.

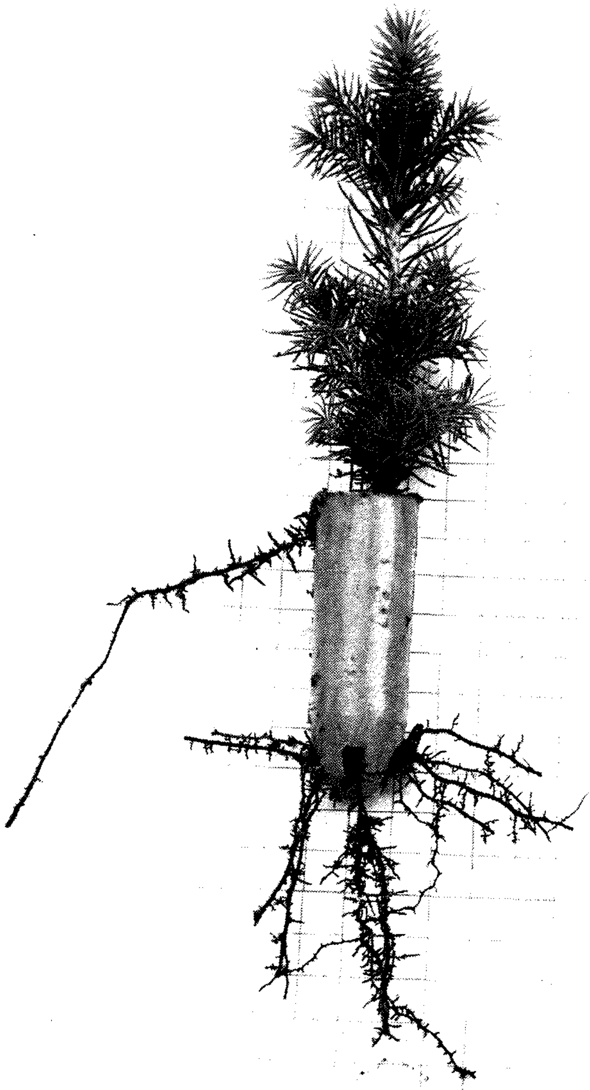

FIGURE 6. Root development of 1–0 white spruce seedling planted in May 1962 and excavated in September 1963. 3/5 natural size.

## SOMMAIRE ET CONCLUSIONS

En 1962 et 1963, on a commencé à faire des tests de plantage dans la section des hauts contreforts des Rocheuses de la forêt boréale de l'Alberta. Des semis d'épinette blanche et de pin de Murray, dont l'âge variait entre 4 semaines et 1 an, et qui étaient contenus dans des cartouches de plastique où ils avaient poussé, ont été plantés, au cours des mois exempts de gel des années 1962 et 1963, dans diverses conditions typiques de station et de terrain de germination.

A l'exception des semis plantés en juin 1963, alors que le temps fut anormalement sec, de 70 à 90 p. 100 des plants qui avaient au moins 4 semaines ont survécu, et ceci s'applique à tous les autres mois où on a fait du plantage. De plus, les données recueillies indiquent qu'il est peu ou pas avantageux de planter des sujets de plus de 8 semaines semés en terrain non engraissé.

Les résultats obtenus jusqu'à ce jour ne sont que préliminaires, mais ils indiquent que la méthode de plantage en cartouches de plastique est destinée à acquérir une grande vogue, car les plants ont survécu en forte proportion dans une vaste gamme de stations et de terrains de germination qui sont caractéristiques de la région où les essais ont eu lieu.

Les résultats des essais militent fortement en faveur de recherches plus poussées afin de mettre au point la méthode de plantage de semis en cartouches. Il y aurait lieu de poursuivre sans tarder les expériences en serre de pépinière sur la production en masse, sur l'emploi d'engrais, ainsi que sur la conception et la mise à l'essai de contenants perfectionnés. Parvenir, comme fruit de telles recherches, à mettre au point une méthode de plantage peu coûteuse et applicable durant toute la période exempte de gel, serait un grand succès.

## APPENDIX

**Analysis of Variance-Percentage Survival to September/63—1963 Planting**

| Source | Degree of Freedom | Sum Squares | Mean Square | F. Ratio |
|---|---|---|---|---|
| Total | 143 | 68,709.4 | | |
| Main Effects | | | | |
| Species | 1 | 344.0 | 344.0 | 2.60 |
| Site | 2 | 3,479.4 | 1,739.7 | 13.17** |
| Seedbed Treatment | 1 | 1,277.2 | 1,277.2 | 9.67** |
| Seedling Age | 3 | 4,615.4 | 1,538.5 | 11.65** |
| Planting Month | 2 | 34,373.9 | 17,186.9 | 130.10** |
| First Order Interactions | | | | |
| Species x Site | 2 | 37.7 | 18.8 | 0.14 |
| Species x Seedbed | 1 | 15.3 | 15.3 | 0.12 |
| Species x Age | 3 | 1,004.8 | 334.9 | 2.54* |
| Species x Month | 2 | 292.0 | 146.0 | 1.11 |
| Site x Seedbed | 2 | 49.0 | 24.5 | 0.19 |
| Site x Age | 6 | 1,518.6 | 253.1 | 1.91 |
| Site x Month | 4 | 2,208.5 | 552.1 | 4.18** |
| Seedbed x Age | 3 | 200.2 | 66.7 | 0.50 |
| Seedbed x Month | 2 | 27.5 | 13.8 | 0.10 |
| Age x Month | 6 | 5,662.3 | 943.7 | 7.14** |
| Error | 103 | 13,603.6 | 132.1 | |

*Significant @ 5% level
**Significant @ 1% level

## REFERENCES


ANON. 1946. Vegetative propagation of Pinus radiata. Rep. For. Timb. Bur. Austr. (12).

———1947. (a) Vegetative propagation of Pinus radiata. Rep. For. Timb. Bur. (13).

———1947. (b) Tube planting in Hong Kong. Rep. For. Off. Hong Kong (3). *Cited from* For. Abst. Vol. 11 No. 2 (1008).

———1947. (c) Casuarina sumatrana planting stock. Rep. For. Dept. Sarasak (5). *Cited from* For. Abst. Vol. 10. No. 3.

———1948. Bamboo planting tubes. Malay Forester, 11 (3) (126–7). *Cited from* For. Abst. Vol. 10. No. 2.

———1953. The Engel balled planting procedure. F.A.O. Equip. Note A.1.53.

———1954. Equipment news. Unasylva 8 (2) (85–6).

———1958. Growing planting stock in tubes in the greenhouse. Extr. from Rep. For. Res., Glendon Hall, Fac. For., Univ. Toronto. (9–11).

———1959. (a) "Melap" device for balling planting stock. For. Equip. Note, F.A.C. No. A. 15.59.

———1959. (b) Nursery research. Extr. from Rep. For. Dept. Uganda 1957/58 (25). *Cited from* For. Abst. Vol. 21 (437).

BELTRAM, V. 1946. Afforestation of the Korst is no problem. Gosd. Vestn. 5 (1, 2) (9–18) (Sloven.) *Cited from* For. Abst. Vol. 11 (270).

CLAUZURE, P. 1956. Utilization des godets en polyethylene pour les reboisemonts dans la region mediterranienne. Revue Forestiere Francais 11: 769–784. *Cited from* McLean, M. M. 1959 Experimental planting of tubed seedlings.

DOPPER, A. 1959. Paper cones for forest planting. Allg. Forstztg. 70 (5/6) (61–2) (G). *Cited from* For. Abst. Vol. 20 (4502).

FROHLICH, H. J. 1959. The uses of peat pots in forestry. Forst-u. Holsw. 14 (6) (122–9) (G). *Cited from* For. Abst. Vol. 20 (4485).

HEIBERG, S. O. 1934. Briquette planting. Journal of For. Vol. 32, No. 3. PP. 333–336.

KIMBROUGH, E. F. 1949. Making paper tubes for plant propagation. For. Res. Notes Calif. Range Experiment Station No. 59, PP. 5.

KITH Y. TASSARA, M. 1949. A method of protecting seedlings in the formation of forest stands in Granada province. Montos, Madrid 5 (26) (102–4) (Span). *Cited from* For. Abst. Vol. 11 (256).

McLEAN, M. M. 1959. Experimental planting of tubed seedlings. Ont. Dept. of Lands and Forests, Tech. Series Res. Dept. No. 39, 13 PP.

ORAMAS, J. M. 1942. Planting with tar-paper pots on different sites in Puerto Rico. Carib. For. Vol. 3 (158–63). *Cited from* For. Abst. Vol. IV. No. 3.

PATO, M. 1940. Relative efficiency of earth-balled and bare rooted methods of transplanting Fili seedlings. Philipp J. For. 3 (425–9). *Cited from* For. Abst. Vol. 3 No. 2.

PETRE, A. 1949. A lost opportunity, Skogen 36 (5/6) (74) (G) *Cited from* For. Abst. Vol. 11 (255).

ROOSEN, J. W. & THURNAU, H. 1957. Planting out conifer seedlings in soil blocks. Allg. Forstzeitschr. 12 (14/15) (191–2) (G). *Cited from* For. Abst. Vol. 19 (4131)

ROWE, J. S. 1959. Forest regions of Canada, Can. Dept. Northern Affairs and Nat. Res., For. Br. Bull. 123.

SPAFFORD, W. J. 1948. Breakwinds and shelters for farms with calcareous soils. Jour. Dept. of Agric. of South Australia, Adelaide 51 (9) (439–46). *Cited from* For. Abst. Vol. 11 (287).

VEIGA, A. DE A. 1946 Eucalyptus citriodera Rev. Agric., Piraciacaba 21 (3/4) (154–7) (Port.). *Cited from* For. Abst. Vol. 11 (257).

WAKE, G. R. 1947. The pot planting of Eucalypts. Bull. Minist. Agric. Lands. S. Rhod. No. 1382, pp. 5. *Cited from* For. Abst. Vol. 11 (258).

WALTERS, J. 1961. The planting gun and bullet. A new tree-planting technique. For. Chron. 37:2 (94–95).

———1963. A new planting gun. F.A.O. For. Equip. Notes A-29-63.