VARIATION IN LOBLOLLY PINE SEEDLING ROOT GROWTH POTENTIAL OVER TWO LIFTING SEASONS1

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ABSTRACT Root growth potential (RGP) was measured on loblolly pine (*Pinus taeda* L.) seedlings lifted at various times during the year beginning in the fall and ending in the spring for the 1984-85 and 1985-86 lifting seasons. General trends in RGP were consistent for both years with RGP being low in the fall, increasing through the late fall and winter, reaching a peak in the late winter/early spring, and then declining when bud activity is imminent. An early autumn RGP peak, measured in the 1985-86 lifting season, was not detected during the 1984-85 lifting season. Spring RGP peaks occurred in early to mid-March for both years.

Additional keywords: *Pinus taeda*, nursery management, root growth capacity.

INTRODUCTION

Root growth potential (RGP) can be used as a measure of seedling quality (Duryea, 1985) and appears to provide a good indication of potential outplanting success (Feret et al., 1985; Feret and Kreh, 1985). Knowledge of the variability in RGP during the lifting season has potential utility for the nursery manager. Seedling quality changes during the fall and winter as the seedling undergoes dormancy induction and release. When these quality changes occur has important implications for best lifting periods and whether to cold store and for how long (DeWald, 1986; Carlson, 1985; Ritchie and Dunlap, 1980). General RGP trends during the lifting season are consistent over a number of species (Ritchie and Dunlap, 1980) and a number of locations for a given species (Feret et al.,1985). RGP typically increases from a low in the fall to a peak in the late winter and decreases again in the spring. This study was undertaken to investigate the variability in loblolly pine RGP over two lifting seasons in order to better understand the trends in RGP over the lifting season and to compare RGP trends for two different years at the same nursery.

MATERIAL AND METHODS

Loblolly pine seedlings from a Virginia Division of Forestry seed orchard/commercial seed mix were grown at the Virginia Division of Forestry's New Kent Forestry Center located at Providence Forge, VA.

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Seedlings were hand lifted beginning in the fall and then periodically during the 1984-85 and 1985-86 lifting seasons. Seedlings were transported to Virginia Tech, Blacksburg, VA, where they were placed in a 15 day hydroponic RGP test system (Dewald et al., 1985). After a full 15 days in the hydroponic system the number of new white roots (> 0.5 cm) and the number of seedlings which showed bud activity was determined on each thirty seedlings sample. Buds were considered active if noticeable greening and swelling, or active elongation was taking place.

RESULTS AND DISCUSSION

Root Growth Potential for the 1984-85 and 1985-86 lifting seasons varied significantly among liftdates. In the 1984-85 season RGP was low for the first lift (11/29/84) then increased to a RGP peak for the 03/19/85 lift after which RGP declined for each succeeding lift to a low on 04/08/85 (Figure 1). Although the 01/31/85 lift also showed a RGP low, it is thought to be an artifact of lifting seedlings from frozen ground. Seedling beds had about 1 inch or less of frozen soil at the time of lifting. All other lifts in both years were made from completely thawed ground. Lifts for 1985-86 season were begun on 10/28/85, a month earlier than the earliest lift for the 1984-85 season. The RGP pattern for 1985-86 season began at a moderate level (4.8 new roots/seedling) but then increased to 11.9 new roots on the next lift (11/07/85). After this, RGP declined to a low on 01/03/86, then increased to another peak on 03/06/86 declining to another low In the final lift.

Changes in RGP during the two lifting seasons were similar to those reported earlier (Feret et al., 1985). However there are some interesting comparisons to be made between the trends of the two seasons sampled in this study.

The November, 1985 RGP peak suggests seedlings Just coming out of the growing season still contain good RGP. When these seedlings were lifted all top growth had ceased and buds had developed. At this point seedlings were going into fall dormancy (Cannell, 1985 and references therein). Although overt stem elongation had ceased, buds were developing and seedlings were still accumulating dry-matter, especially in the roots (DeWald, 1986). In fact, autumn root growth at the VDF nursery extended well into the winter season (DeWald, 1986). This autumn and early winter dry weight increase has been noted in a previous study on loblolly pine seedlings from the same nursery (Garner and Dierauf, 1976), and by other investigators (Munson and Stone, 1984). Active root growth in southern pines during the autumn would be expected if soil temperature is adequate (Cannell, 1985). The high RGP of seedlings lifted in the early autumn may be a feature of the continued fall root growth. When seedlings are put into the RGP test all white roots are removed so the measured RGP is not an artifact of white roots brought in from the field. Evidently roots of a November lifted seedling are sufficiently active to exhibit good new root production in the test system.

Whether autumn RGP should be considered equivalent to spring RGP is a matter for some thought. Seedlings lifted in the autumn are going into dormancy. Loblolly pine grown in Arkansas and brought in from an overwintering site to a greenhouse in late October and mid-November showed very strong bud dormancy (Garber, 1983). The seedlings in this study that showed the high autumn RGP were lifted in early and mid November (11/08/85 and 11/20/85). Few chilling hours were received by these seedlings (107 and 120 chill hours were received by 11/08 and 11/20 respectively) and no bud activity was noted in any of the seedlings at the end of the RGP test period. If RGP is closely linked to seedling dormancy (Ritchie and Dunlap, 1980), then one would not expect to see a high autumn RGP. Ritchie and Roden (1985) noted an autumn and late winter RGP peak in lodgepole pine (Pinus contorts Dougl.) and interior spruce (Picea glauca engelmannii complex). The authors could not interpret the early RGP peak in the context of seedling dormancy because the seedlings which showed the high RGP also exhibited strong dormancy in a forcing environment.

Perhaps the autumn RGP is not equivalent to the late winter RGP. DeWald (1986) determined the sites of new root growth in loblolly pine seedlings lifted periodically throughout the 1984-85 lifting season at the New Kent nursery. New root production can be generalized to arise from either elongating established root tips or from elongating newly generated root tips. DeWald's results indicate that new root production in the autumn and winter is largely from established root tips and that RGP In the late winter/early spring is a function of an increased proportion of newly generated root sites (DeWald, 1986). However, as RGP increases through the autumn and winter, the numbers of roots in both categories increase. That is, the RGP in the late winter-early spring has a larger component of roots arising from primordia that were newly formed or were preformed and induced to differentiate into a root. This difference in composition of root types may be a reason for differences in dormancy relations with autumn and spring RGP peaks. If one assumes that the initiation or development and growth of root primordia formed in the root pericycle and adventitious primordia initiated in callus tissue at the base of stem cuttings (and it may be argued that many of the new root sites in loblolly pine seedling roots in the spring are likely to be adventitious in origin) will react the same to seedling dormancy, then the results on dormancy relations with stem cutting rootability may provide some additional information in answer to this question of the difference between autumn and spring RGP.

Cuttings of narrow leaved evergreens generally root best when taken in late autumn to late winter (Hartmann and Kester, 1975), or when the chilling requirement is being satisfied and dormancy is being broken. Rooting of Douglas fir (Pseudotsuga menziesii (mirb.) Franco) and white spruce (Picea glauca) stem cuttings was lowest during the period of greatest bud dormancy and increased through winter with maximum rootability occurring in late winter/early spring (Bhella and Roberts, 1975; Roberts et al., 1974; Tognoni et al., 1977). Roberts et al (1974) found that the only treatment that succeeded in promoting rooting during greatest bud dormancy were cold storage or long days in combination with auxin. Cuttings which did not respond to auxin treatment in September and October did so in November. Days to bud break were greatest in September and October and began to decrease in November. Even in November, however, buds did not break normally. From this the authors concluded that adventitious root formation and development is strongly affected by dormancy requirements but that the cold requirement for rooting is significantly less than that for bud break.

It is possible that elongation growth of existing root tips is more dependent on soil temperature and less dependent on dormancy mechanisms as compared to initiation and development of new root sites which may be more dependent on seedling dormancy. This is not meant to imply that elongation growth is not affected by physiological conditions associated with dormancy. One can see in Figure 1 that there is a good relationship between decline in RGP during the period when maximum seedling dormancy might be expected. The point to be made is that, if root elongation growth is less influenced by dormancy related mechanisms, and If a larger percentage of RGP in the autumn (as opposed to spring) is comprised of elongating roots, then it may not be surprising that RGP peaks may occur in the fall and be poorly related to the dormancy condition of the seedling. In the winter and spring, the release of seedling dormancy is marked by an increase in root elongation and initiation and development. If elongation and initiation and development are less tightly controlled by the dormancy condition as suggested above, then one would expect to see an RGP peak before buds show a complete loss of the dormancy.

An autumn RGP peak was not detected in the 1984-85 lifting season. This may be due to the peak having been missed. The first lift in the 1984-85 season occurred at the end of November, after the peak occurred in the 1985-86 season. The first lift in the 1984-85 season had received 237 chilling hours, about twice that of the lifts in the 1985-86 season which showed the RGP peak. The lift in the 1985-86 season with an equivalent number of chilling hours also exhibited low RGP suggesting that these lifts from the two years were at about the same point in development.

Spring RGP peaks occurred Just before a large majority of the seedlings In the test system showed bud activity (Figure 2). While this is only an approximate measure of phase change, data are consistent between the two years in showing an inverse relation between bud activity and RGP. Peak RGP occurred one lift before a very large rise in bud activity (compare Figures 1 and 2). This is consistent with studies reviewed by Ritchie and Dunlap (1980), and with the proposition made above where spring RGP is released more rapidly from dormancy control than are the buds.

It is also of interest to compare the timing of the spring RGP peaks during the two lifting seasons- both occurred at about the same time, in early to mid-March (03/23/85 and 03/06/86). This March peak also occurred in a separate experiment which evaluated RGP in loblolly pine seedlings from the same nursery during the 1983-84 and 1984-85 lifting seasons (DeWald, 1986). The seedlings apparently develop maximum RGP at about the same time each year (± 1 week) despite differing environmental conditions. The accumulation of chilling hours was very different for the 1984-85 and the 1985-86 seasons (Figure 3). During the 1985-86 season chilling hours were accumulated early in October but few were gained during a warm November. Chilling hour accumulation in 1985-86 lagged behind that in the 1984-85 season for the rest of the fall but attained equivalent chilling hours by the end of December. The winter of 1984-85 also had colder periods than that of 1985-86 season. Despite these different environmental conditions in the two years, RGP peaked at about the same time in the spring.

CONCLUSIONS

The data presented supports past work with other species and with loblolly pine that the typical RGP trend of low in the fall- increase through the winter- peak in early spring- and decline at the point when bud break and growth occur, can be expected to be consistent over years for a given nursery. Early fall RGP peaks may not be the same type of peak as occurs in the spring. Also shown is the possibility that RGP peaks will be consistent from year to year for any given nursery. RGP development early in the lifting season may be strongly affected by chilling hour accumulation, but after a certain threshold past and present chilling hour trends may exert little influence on RGP. The possibility exists that an RGP profile can be generated for a given nursery.

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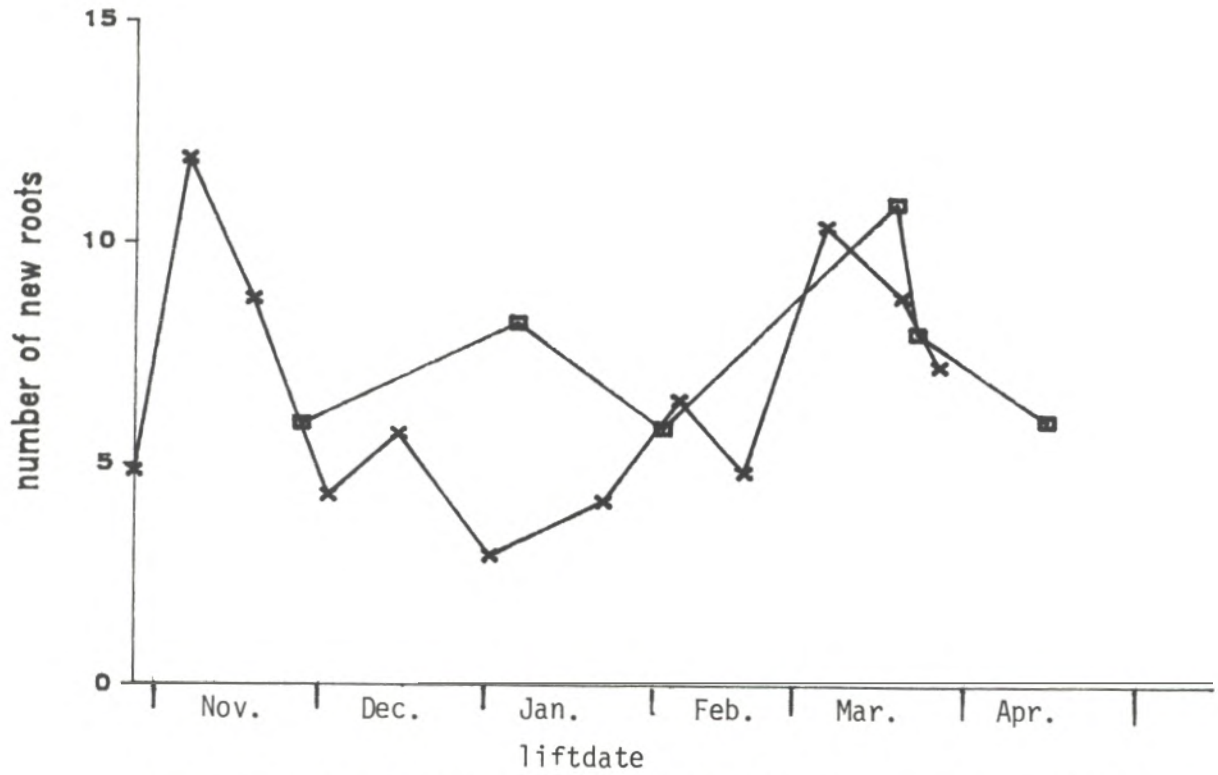


Figure 1.--Effect of liftdate on loblolly pine seedling RGP (number of new roots) for the 1984-85 lifting season (—⊟) and for the 1985-86 lifting season (—✱) at the New Kent Forestry Center.

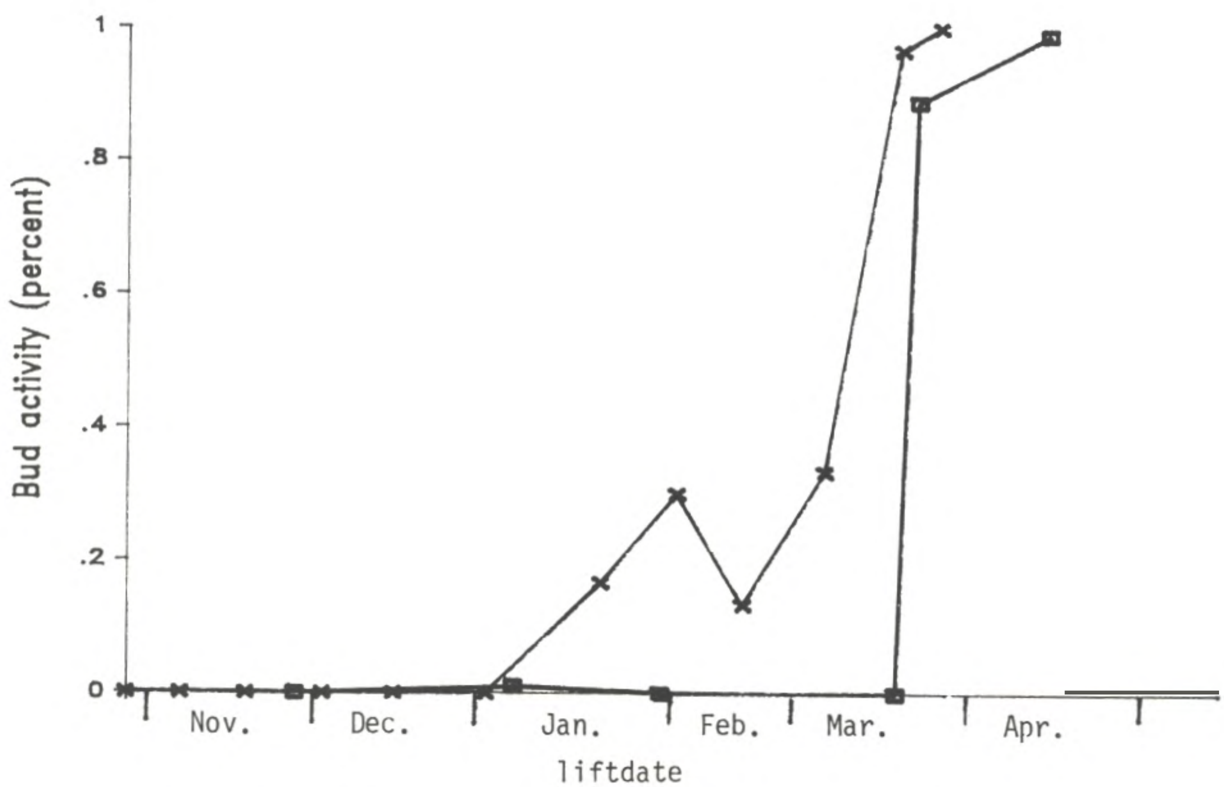
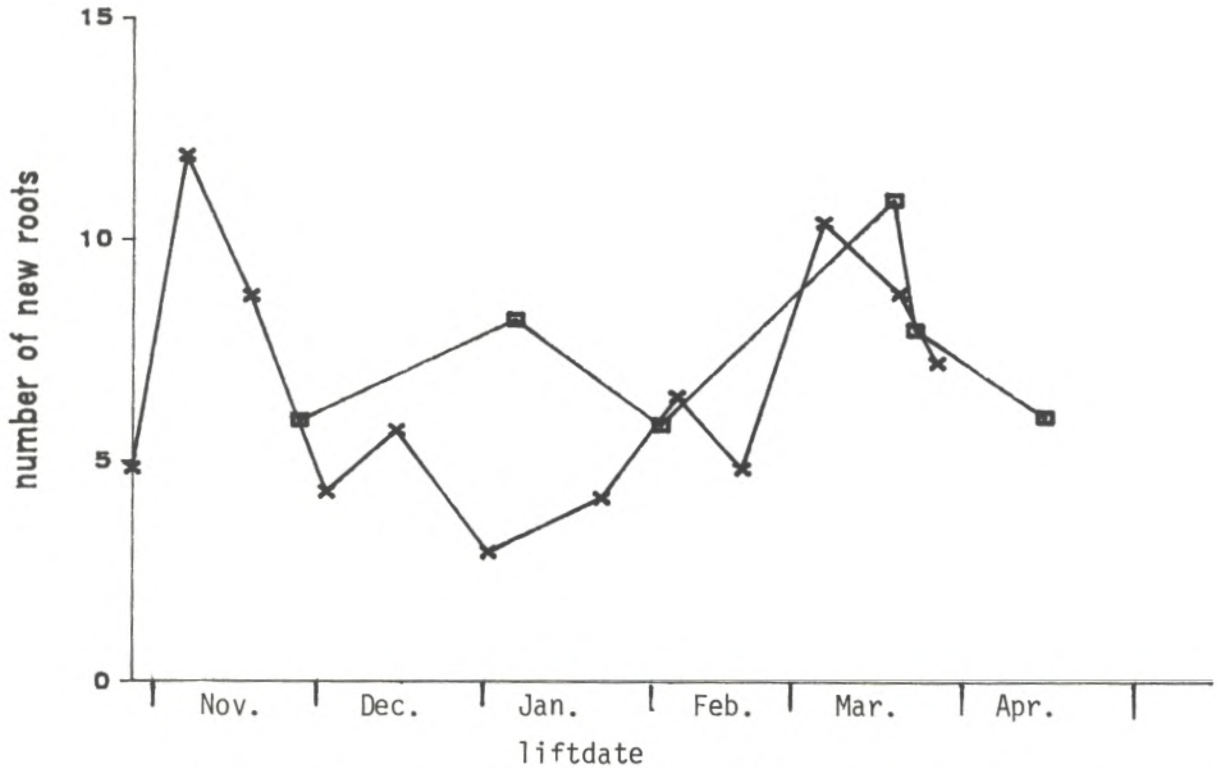


Figure 2.--Effect of liftdate on bud activity for the 1984-85 lifting season (—⊟) and for the 1985-86 lifting season (—✱). This is the percentage of a 30 seedling sample showing noticeable bud activity (either swelling or elongation) at the end of the 15 day hydroponic RGP test.



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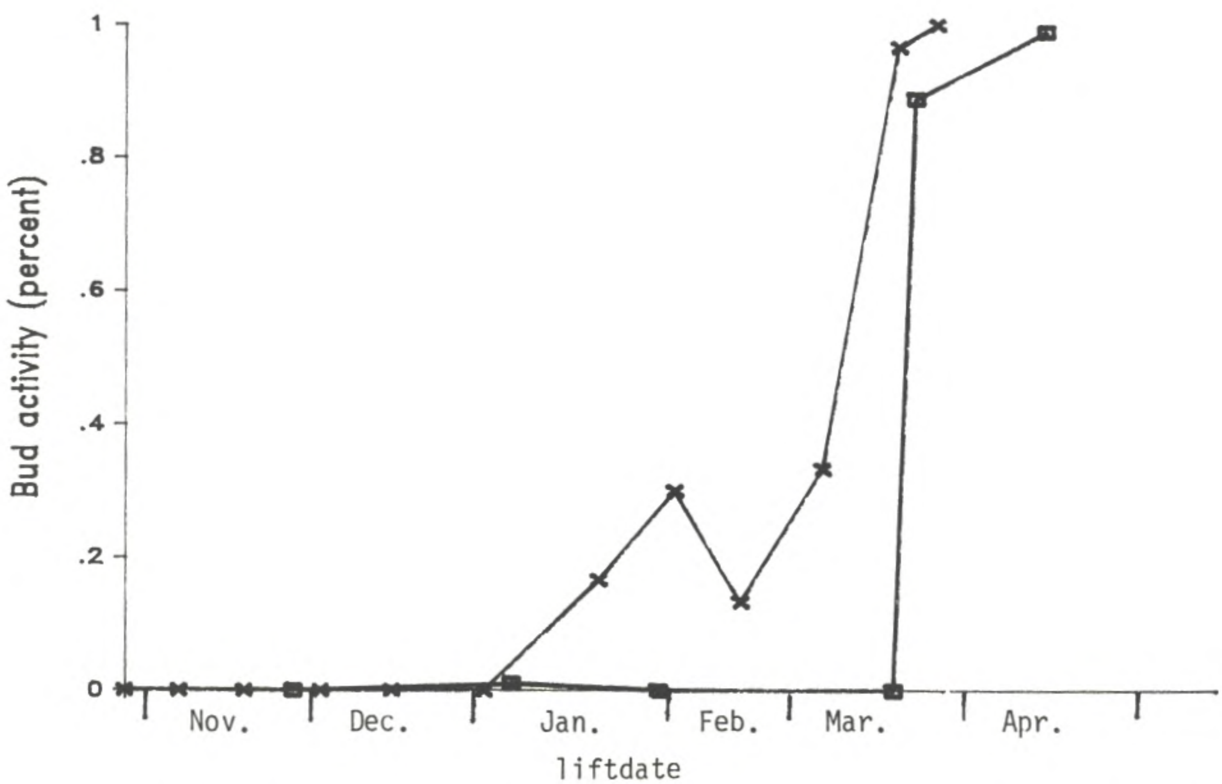

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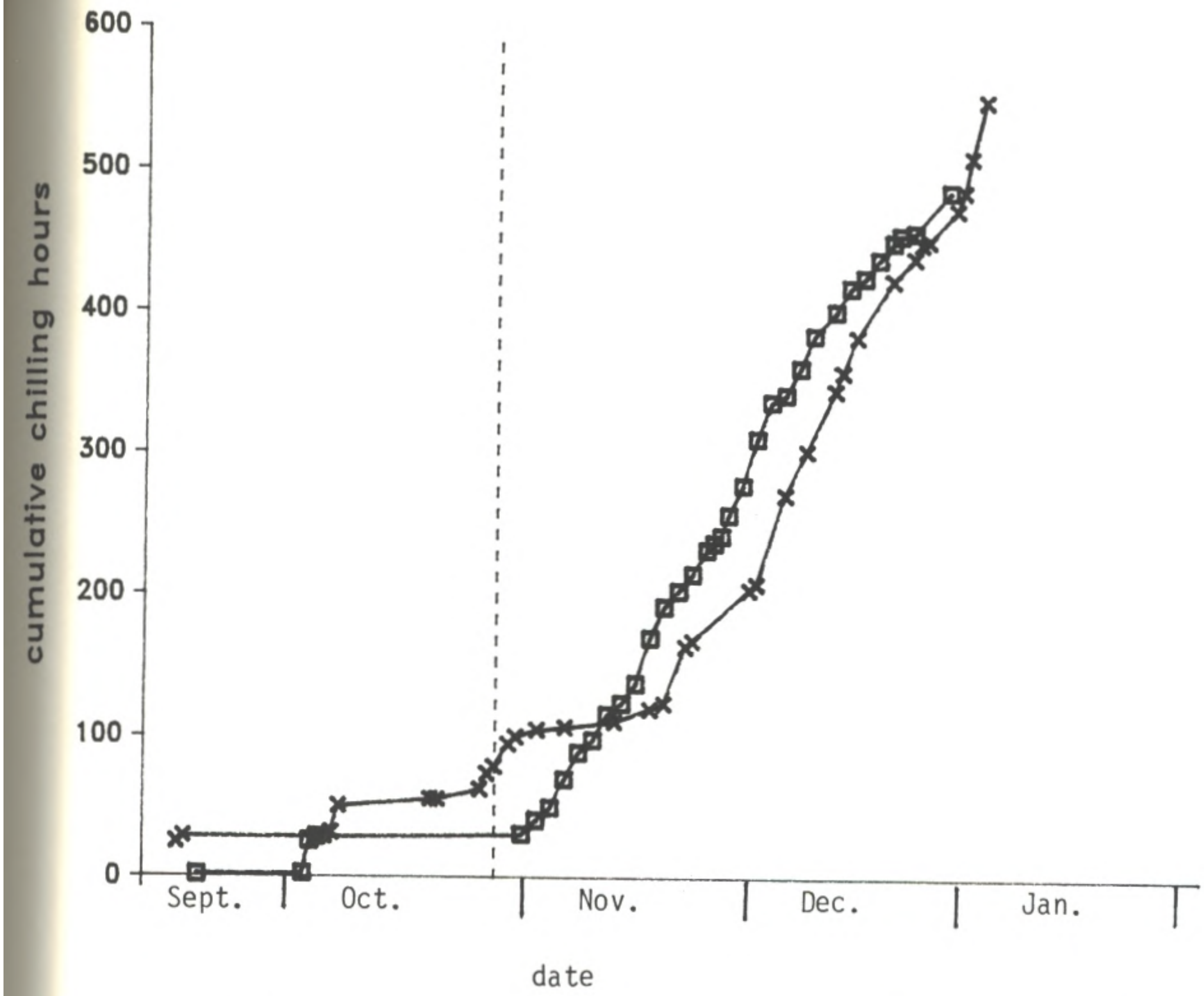

Figure 3.--Cumulative chilling hours (0 < hours < 8°C) at the New Kent Forestry Center for the 1984-85 (—□—) and the 1985-86 (—✳—) lifting seasons.