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Genetic and environmental variation in seed, cone and progeny characteristics of black spruce clones in a northern Ontario seed orchard

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GENETIC AND ENVIRONMENTAL VARIATION IN SEED, CONE AND PROGENY CHARACTERISTICS OF BLACK SPRUCE CLONES IN A NORTHERN ONTARIO SEED ORCHARD

BY

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ABSTRACT

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Genetic and environmental variance in cone and seed properties and early progeny growth of Picea mariana (Mill.) B.S.P. clones were evaluated using cones and seed from two to three ramets of 19 clones each growing in a northern Ontario grafted clonal seed orchard. A cone analysis and a germination test were conducted to estimate variation among clones and among ramets within clones. Variation in growth of 19 open-pollinated families growing under two fertilizer regimes in a greenhouse was evaluated after three, four and five months of test establishment. Mean cone volume and mean cone length were found to be 2.2 cm^3 and 24.4 mm, respectively. The mean for number of seed per cone was 71, although only 18% of these seeds were filled. Nested analyses of variance indicated that clones accounted for 23% to 39% of the total variation in cone size and seed yield per cone. Variation among ramets within clones for these characteristics accounted for 13% to 19% of total variance. The average germination percent, based on filled seed, was 68% and was completed (90%) after 11 days. Genetic variance in germination percent and germination speed acccounted for 67% and 21% of the total variance, respectively. For germination percent and germination speed, 18% and 33% of the total variation, respectively, were due to ramets within clones. In the progeny test, family heights were highly significant at all three ages. At five months family height means ranged from 30 cm to 34 cm and from 11 cm to 14 cm at the low and high fertilizer level, respectively. Ramet-within-clone effects were only significant after three and four months, when seedling heights were significantly correlated with seed weights. Family-fertilizer interactions were not significant at all three ages, although the variance component for this source of variation increased substantially towards the end of the test period.

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INTRODUCTION

A fundamental goal in forest genetics is to analyze variation in quantitative traits to determine the sources of this variation. The geneticist needs to know how much of the total (phenotypic) variance (V_P) in a trait is attributable to genetic or non-genetic sources (Falconer 1981).

Genotypic variance and environmental variance can be estimated in a test population by growing a group of randomly arranged clones in a normal set of environmental circumstances. In such tests, the phenotypic variance can be partitioned into genetic and envrionmental components (Falconer 1981). Once the genotypic variance (V_G) is estimated, the degree of genetic control over the phenotypes can be estimated through the ratio of V_G/V_P, called broad-sense heritability.

Many clonal trials of this kind have been established to investigate the genetic make-up of many plant species (Libby 1969). For this purpose, several ramets (e.g., rooted cuttings or grafts of one ortet) representing several clones are outplanted on one or more plantation sites. In these trials, the variance associated with clones is an estimate of genetic variance, and the remainder of the phenotypic variance is an estimate of environmental variance (Falconer 1981). However, instead of establishing clonal trials exclusively for experimental use, many workers have used already established clonal seed orchards to estimate genetic and environmental variances.

Clonal seed orchards are established for the purpose of seed production for operational use or progeny testing. These orchards usually contain many randomly arranged ramets of numerous clones. This arrangement, therefore, presents an opportunity to estimate genetic and environmental variances by evaluating variation due to clones and ramets within clones.

The major objectives of this study were to estimate genetic and environmental variance in cone, seed and germination properties in a population of black spruce (*Picea mariana* (Mill.) B.S.P.) clones already established in a production seed orchard. A further objective was to evaluate variation in early growth of sexual progeny of the studied clones. To meet these objectives, two or three ramets of 19 clones growing in a 17-year old grafted clonal seed orchard in northern Ontario were used as mother trees for a short-term open-pollinated progeny test and as cone and seed sources for a cone analysis and a germination test. A secondary objective was to test for a possible family-environment interaction in the progeny test by subjecting two sets of seedlings to two drastically different fertilizer regimes.

REVIEW OF LITERATURE

This review of literature describes the processes that lead to genetic and environmental variation in conifers with emphasis on clonal seed orchards. The review is composed of four parts: 1) the place of seed orchards in forest tree breeding, 2) the role of environmental preconditioning in increasing variation among and within clones, 3) the role of other factors leading to increased within-clone variation, such as rootstock effects and maternal effects on early seedling growth and, 4) general aspects of clonal variation in conifers.

CLONAL SEED ORCHARDS IN FOREST TREE BREEDING

Seed orchards are established for the production of genetically improved seed in quantity. Clonal seed orchards are composed of vegetatively reproduced (grafted or rooted) trees that are selected from natural stands or plantations for their phenotypic superiority (Wright 1976). The improvement of quantity and genetic quality of seed in seed orchards is achieved through some or all of the following means (Morgenstern et al. 1975):

1. Selection of a seed orchard location with favourable climate and soil conditions.
2. Presence of pollen barriers to minimize contamination of pollen cloud within seed orchards.
3. Minimizing of inbreeding through randomization of clones.
4. Stimulating seed yield through cultural practices such as fertilization, irrigation, thinning, removal of competition and root pruning.
5. Protection from fire, insect attack and disease.

Stern (1959) recommended the use of 20 to 30 clones per seed orchard to avoid inbreeding. However, a larger number may be needed if the flowering period is long and sufficient overlap among clones in sexual phenology is not present. The recommended spacing between clones ranges from 10' by 10' to 30' by 30' (Wright 1976).

To test the genetic quality of the parent trees in the seed orchard, the performance of their offspring is evaluated in progeny tests. Thus, the results of progeny tests can be used to eliminate undesirable mother trees from the orchard and to estimate genotypic and environmental variances needed to calculate narrow-sense heritability. Open-pollinated progeny tests using some of the clones growing in the Matawin seed orchard were established by the Ontario Ministry of Natural Resources (OMNR) in northern Ontario (Rauter 1977), but results have not been published yet.

Progeny tests are usually conducted on more than one site to obtain an estimate of family-environment interactions (Morgenstern 1979). Half-sibling (wind-pollinated) family-environment interactions have been reported by Johnstone (1973) with Scots pine (Pinus sylvestris L.) growing at three different elevations in Great Britain. Full-sibling family-environment interactions have been demonstrated by Roberds et al. (1976) and Jahromi et al. (1976). in loblolly pine (Pinus taeda L.) and slash pine (Pinus eliottii Engelm.) respectively by growing seedlings under different fertilizer regimes. Similar interactions have been reported by Bell et al. (1979) with one year old full-sibling families of Douglas fir (Pseudotsuga menziesii (Mirb.) Franco.). Significant family-fertilizer interactions were detected after 14 weeks for stem diameter, height, dry weight and shoot/root ratio. Burdon

(1971) established a clonal test with cuttings of Monterey pine (*Pinus radiata* D. Don) on four different locations and found significant genotype-environment interactions due to a change in the performance ranking of clones on a phosphorus-deficient site.

In practice, the presence of family-environment interactions could be utilized to match planting stock with the most suitable site conditions (e.g., nitrogen deficient sites, dry sites etc.) to achieve higher yields.

ENVIRONMENTAL PRECONDITIONING

Environmental preconditioning or "C-effects" can be defined as heritable morphological and/or physiological changes induced by the environment in which a genotype is growing. For example, if identical (i.e., cloned) genotypes are growing in a range of environments, the phenotypic expression of these genotypes will vary with environment. If environmental preconditioning is present, these differences will be passed on to sexual or vegetatively propagated offspring, for one or more generations.

Lerner (1958) defines "C-effects" as the effect of an environment that is common to members of particular subgroups, such as half-siblings in sexual progeny or scions from one ortet. He states that "C-effects are present when the environment of members of a family is more alike than that of a group of individuals picked at random from a given population." For example, the environment of a parent may directly influence the phenotype of the offspring; e.g., the nutritional status of a dam, which can be assumed to be partly environmentally determined, has a great influence on the body weight of its nursing offspring. The offspring's body weight will be lower than that of its contemporaries nursed by better-fed mothers (Lerner 1958).

Environmental Preconditioning Of Vegetative Propagules

The occurrence of environmentally induced heritable effects in asexually propagated material has been shown by Went (1959) with tuber production in potatoes. From previous work (Gregory 1956) it was known that potato plants grown under low night temperatures ($12^{\circ}C$ - $14^{\circ}C$) produce more and heavier potatoes. Went found that "seed" potatoes that were grown under ideal temperatures (i.e., night temperatures around $13^{\circ}C$) also produced plants that yielded more and heavier potatoes than plants from seed potatoes that were grown under warmer night temperatures. This trend held for several generations, indicating long-lasting effects of environmental preconditioning.

Significant "C-effects" associated with cloning have been demonstrated by Libby and Jund (1962) with <u>Mimulus guttatus</u> Fisch. (yellow monkey flower). They grew genetically identical cuttings (primary ramets from one ortet) in (1) a sand mixture, (2) in water as hydroponics in (3) a greenhouse and (4) on an outside bench. After three months, primary ramets from these four environments were recloned and rooted runners of these secondary ramets were placed in a uniform environment. During the three months in the non-uniform environments, primary ramets had time to respond internally to their unique environment. By evaluating the variation among primary ramets within a clone, Libby and Jund estimated C-effects. They found significant ($p<0.05$) C-effects in traits measured early after recloning such as four-week height and "days to first flower". However, for traits measured after six to sixteen weeks after cloning, such as height to first flower and six-internode length, C-effects vanished and the largest component of the variation was due to clones. Wilcox and Farmer (1968) also used two-stage cloning to test for C-effects in Populus deltoides Bart. (eastern cottonwood). They found significant ($p<0.05$) C-effects in foliation date, shoot weight, root numbers and root weight.

If C-effects are present in a clonal seed orchard, the variation due to clones will not only include differences due to genotypes but also effects due to the specific ortet environment that were transmitted to all descendants of a clone (Falconer 1981). Thus, broad-sense heritabilities estimated through clonal tests might be overestimated as the clonal (genetic) component of the total variation may include environmentally induced variation associated with the original ortets (Varnell et al. 1967, Zsuffa 1975). For example, in the study of Wilcox and Farmer heritability estimates for root number and root weight would have been overestimated by 8% and 6% respectively, had they not separated genetic effects from C-effects. However, there is some indication that C-effects are not long-lasting (Libby and Jund 1962), especially if cuttings of uniform age and size are used to derive the test population (Wilcox and Farmer 1968). Because of this possible overestimation of broad-sense heritability through the presence of C-effects, many forest geneticists (e. g., Burdon and Low 1973a,b, Burdon 1971, Shelbourne and Thulin 1974, Griffin 1982) use the term "clonal repeatability" as proposed by Falconer (1981).

Environmental Preconditioning Of Seeds

As early as 1919, when Kidd and West wrote their review on the effects of conditions during seed germination upon subsequent growth and final yield, it was recognized that the seed environment can influence the growth pattern of a resulting plant. Rowe (1964) cites several studies that demonstrated long-lasting effects of pregermination and germination treatments on the growth of several species. For example, Flemion (1934) showed that some insufficiently chilled fruit tree seeds resulted in dwarfed plants, and Knapp (1957) reported that Senecio vulgaris seeds when germinated at $10^{o}C$, $14^{o}C$, $23^{o}C$ and $30^{o}C$ and subsequently grown at $17^{o}C$ yielded shoot dry weights after 80 days of 147, 775, 1078 and 390 mg respectively.

Baskin and Baskin (1973) question the validity of many genecology studies of dormancy and germination characteristics, since population differences could be induced by the environment under which the seed matured and, therefore, may not have a genetic basis. The study by Nelson et al. (1970) showed such environment-induced variation in medusahead (Taeniatherum asperum (Simonkai) Nevski). They collected medusahead seed from 20 locations in the northwestern United States and sowed the seed in two nurseries in Washington. In the following year, when they harvested the seed from the two nurseries and sowed it in one nuresry, significant differences due to nurseries where the seed ripened were observed in seed weight, germination capacity, winter survival and date of anthesis. Koller (1962) demonstrated environmental preconditioning of "Grand Rapids" lettuce (Lactuca sativa) seed. He grew his lettuce plants in a uniform greenhouse environment (26°C/16 hours light, 20°C/8 hours darkness) until flower buds developed. The lettuce plants were then assigned to various temperature/photoperiod combinations to complete their reproductive growth phase. Substantial differences in seed yield and germination capacity were observed. Continuous light inhibited seed set, whereas high temperatures (26°C) during seed maturation increased germination capacity. Variation in progeny performance due to the environment of the pollen parent has been observed in peas (*Pisum sativa*) by Highkin (1958). He grew the designated male parent plants of two highly inbred lines under a range of temperatures and found significant differences in progeny growth rate due to these temperatures. Stearns (1960) investigated the effects of different growing temperatures during seed maturation on early growth of *Plantago arista* Michx. (bracted plantain). The parent plants were grown to maturity at 60°F, 70°F and 80°F. Seedling performance (height, vigour, leaf area) was positively correlated with increasing temperatures during seed maturation. This relationship persisted for 120 days.

Some evidence of environmental preconditioning that lasted more than one generation is given by Hill (1965) and Durrant (1958). Hill grew three highly inbred lines of *Nicotiana rustica* under the eight N-P-K fertilizer combinations. Seeds from each treatment combination were then grown under identical conditions. Height differences among the offspring of one line whose parent plants were grown under different fertilizer levels did not diminish in three subsequent generations (Hill 1967). Durrant also used the eight fertilizer treatment combinations to grow an inbred line of flax plants. The environment-induced differences in progeny weight were still apparent after four generations, but were not reflected in seed weight and germination capacity and energy.

Evidence of environmental preconditioning of conifer seeds was shown in the study by Bjornstad (1981). He used clones of Norway spruce (<u>Picea abies</u> (L.) Karst.) that were grown in their native habitat at 63^{o}N - 66^{o}N and in a more southern seed orchard (58^{o}N) in Norway. Open-pollinated seeds from the northern habitat and seeds from the seed orchard that were control-pollinated with a northern pollen mix were collected and grown in a phytotron and in a tree nursery. Significant differences in time of budset were observed between seedlings from the two locations. Budset in the seed orchard progeny was delayed by up to three weeks. In Shear and Perry's study (1982) with loblolly pine, environment-induced carry-over effects were evident in 35 day-old progeny. Mean progeny dry weights of ramets within one clone ranged from 49.6 to 58.5 mg. Verheggen and Farmer (1983) worked with three ramets each of nine clones growing in the Matawin seed orchard. They found significant differences associated with ramets within clones in germination capacity. Ramet-within-clone variation accounted for 17% of the total variation in this trait.

It is not possible to explain ramet-within-clone variation in traits that are not measured in the next generation in terms of environmental preconditioning, as there is no way of knowing whether the environmentally induced ramet-within-clone differences will be passed on to the progeny. The ramet-within-clone variation in such traits (e. g., cone length, cone volume, number of female and male strobili, seed yield) may be caused by environmental differences within the test site that alter the phenotypic expression of genetically identical plants without necessarily affecting these traits in the next generation. However, regardless of what causes ramet-within-clone variation, the total phenotypic variance can be partitioned into a genetic and environmental component (Falconer 1981).

The precise mechanisms of transmitting the effects of environmental preconditioning from generation to generation is not known yet. Darlington and Mather (1949) suggest that "dauermodifications" play an important role. Dauermodifications are environment-induced long-lasting changes in the cytoplasm which are not permanent (Grant 1975). In this sense, environmental preconditioning would be manifested through maternal effects. Jinks (1964) and Grun (1976) postulate that selection of plants that are under stress may lead to such dauermodifications. An alternative explanation of the transmission of environment-induced heritable changes is given by Hill (1967). He hypothesizes that a genetic switching mechanism may operate on the chromosomes under certain conditions under which labile genotypes respond. If this is the case, the previously cited work by Highkin (1958) could be explained. However, "the evidence at present tends to suggest that neither the chromosomes operating alone nor the cytoplasm by itself can satisfactorily explain these results .... and (the precise mechanism) must remain a matter of speculation..." (Hill 1967).

In summary, environmental preconditioning of vegetative propagules, such as scions used to establish a clonal seed orchard, can lead to C-effects, if the response of the ortets to their unique environment is passed on to the ramets. These C-effects associated with the original ortets may increase the clonal variance, causing an overestimation of broad-sense heritability. However, the studies by Libby and Jund (1962) and Wilcox and Farmer (1968) suggest that this variance associated with cloning is short-lived. The evidence of environmental preconditioning of seeds and its effects on germination and early seedling performance suggests that some of the variance in the sexual offspring of ramets within clones is caused by environmental factors whose effects were passed on. However, it is important to realize that much of the variation in the early performance of the progeny is associated with other factors such as rootstock effects on the mother tree or paternal influences and maternal effects as described below.

MATERNAL EFFECTS

Generally, maternal effects arise when the mother contributes to the phenotype of her offspring over and above that which results from genes she contributes to the zygote (Mather and Jinks 1982). According to the same authors these contributions may take one or more of the following forms:

1. Cytoplasmic inheritance
2. Maternal nutrition via the egg or via pre- and post-natal supplies of food.
3. Transmission of pathogens and antibodies through the pre-natal blood supply or by post-natal feeding.
4. Imitative behaviour.
5. Interaction between siblings either directly with one another or through the mother.

In plant genetics maternal effects through the latter three contributions do not occur and need not to be discussed here. Most characteristics are inherited via genes borne on chromosomes, but there are cases where characteristics are transmitted through cytoplasmic factors (Wright 1976). As most of the cytoplasm is contributed by the female parent, this mode of inheritance is referred to as cytoplasmic or maternal inheritance. Cytoplasmic inheritance is evident if the result of reciprocal crosses are not identical. According to Sager (1972) 34 species of angiosperms show a cytoplasmic inheritance pattern, as evident, for example, in the male sterility in corn (Zea mays) (Duvick 1965), the variegated form of Mirabilis jalapa (Correns 1909) and the leaf shape and petal size of Epilobium hirsitum (Michaelis 1954). Cytoplasmic transmissions of the genetic information are usually long-lasting and therefore, these types of maternal effects get passed on generation after generation (Lerner and Libby 1976).

In contrast, maternal effects through the mother's supply of food to the young affect only one or at most a few generations (Lerner and Libby 1976). Such nutritional maternal effects in conifers are very common and are mainly attributable to differnces in seed weight (Perry 1976). In his review on maternal effects, Perry demonstrated that 88% of the total variation in seed weight in controlled crosses with loblolly pine was associated with the female parent. This variation in seed weight likely will lead to increased levels of variation in the early performance of seedlings, as demonstrated for the relationship between seed weight and early growth by Righter (1965) and Nanson (1965). A simple way of influencing seed weight was shown by Mergen and Voigt (1960). They fertilized a seed production area of slash pine and found an increase of 55% in the seed weight, resulting in an increase in one-year-old seedling weight by 40%. This is an example where the effects of environmental preconditioning are confounded with maternal effects, as the environment-induced changes were carried over to the next generation through an increase in seed weight.

The presence of maternal effects has also been reported by Kriebel et al. (1972) with an incomplete diallel cross with Pinus strobus L. (eastern white pine). They found that maternal factors accounted for 52% of the genetic variance in total height of six year-old white pine seedlings. Greathouse (1966) evaluated the course of germination of seeds obtained from a six-parent diallel mating design (excluding selfing) with Douglas fir. Germination speed was under significant ($p<0.01$) maternal influence. Bramlet et al. (1983), working with loblolly pine in a similar study, obtained comparable results. For germination speed, measured as the time to reach 95% of the final germination, 14% of the total variation was due to maternal effects. They stated that this variation is caused by the "special environment" of the female parent, which included differences in nutrition, micro-climate and other edaphic factors.

The differences between environmental preconditionin and maternal effects are not clear cut. If changes a manifested through dauermodifications, t en environmental preconditioning is confounded with cytoplasmic inheritance, which is a maternal effe t. If environment effects cause a change in the genome, then environmental preconditioning and maternal effects are not related. However, as maternal effects are mainly nutritional (Falconer 1981) and, therefore, may last only a relatively short time, a distinction between environmental preconditioning and maternal effects on the basis of longevity of the effects may be made. With respect to progeny testing clonal seed orchard material, it is probably safe to assume that if the within-clone variation in progeny performance (i.e., differences in progeny due to ramets within a clone) is short-lived, nutritional maternal effects are the basis of this environmental variation, especially if progeny heights are correlated with seed weight in the early stages of the test. If, however, the ramet-within-clone variation in growth is long-lasting, presence of environmental preconditioning or differences in male parenthood can be expected.

OTHER FACTORS AFFECTING RAMET-WITHIN-CLONE VARIATION

To establish a grafted seed orchard, scions are usually grafted to rootstock of unknown genetic quality. In fruit trees it has long been known that rootstocks can affect yield and quality of fruit (Sax 1958). In forest trees, the effects of rootstocks on survival, height growth, fruitfulness and vegetative and reproductive phenology have been investigated (Krusche and Melchior 1977, Ahlgren 1972, Schmidtling 1973). From these studies it can be concluded that rootstocks can have a great influence on the parameters mentioned above. It is noteworthy to point out that in Krusche and Melchior's work, the rootstocks were either a cloned variety of Norway spruce dwarfs or "normal" Norway spruce seedlings. The within-clone variation in mean height was higher when the clones were grafted to normally growing seedling rootstock than when grafted to dwarfed, cloned rootstock. This effect of genetically non-uniform rootstock on height growth may also be present in other traits, thus potentially increasing ramet-within-clone variation in cone and seed properties and consequently lowering broad-sense heritability estimates (Schmidtling 1983).

Other non-genetic sources possibly increasing variation among ramets of the same clone are differences in time of establishment of ramets, differences in quality of planting of ramets and other site differences such as localized presence of root diseases and micro-climate differences.

In open-pollinated progeny, the male parent is unknown and the offspring from one mother tree is considered a half-sibling family, although some seedlings are probably full-siblings. For example, O'Reilly et al. (1982) in their study with 12 clones of black spruce growing in the Matawin seed orchard, found that just two clones would contribute over half the male gametes in a hypothetical seed crop. Thus, the genetic composition of the progeny of one ramet close to a potent pollen producer might be substantially different than the genetic composition of the offspring of a ramet of the same clone that is surrounded by average pollen producers. This in turn may lead to increased ramet-within-clone variation that is genetic in nature, especially in the absence of seed weight effects, or after seed weight effects vanished.

From the past three sections of this chapter, it is clear that there are several causes of an increase in ramet-within-clone variation in a grafted clonal seed orchard. Further, these sources of variation may often be related or confounded with each other, thus making it difficult to identify each source precisely.

CLONAL VARIATION IN CONIFERS

In this section of the review of literature, evidence is presented of clonal variation in conifer 1) phenology, 2) cone and seed properties, 3) wood characteristics and 4) growth characteristics. Finally, in the last part, the published papers on some aspects of clonal variation in the Matawin seed orchard are summarized.

Clonal variance is the part of the phenotypic variance that is associated with clones. According to Falconer (1981) the differences among clones is mainly due to their difference in genotype and can be regarded as an estimate of the genetic variance. However, certain non-genetic effects that are due to the ortet (i.e., Lerner's "C-effects") may cause an inflation in the estimate of the genetic component of the total variance.

In a Swedish trial with Norway spruce, Eriksson et al. (1973) found that 62.9% and 41.6% of the total variation in the numbers of female and male strobili respectively were associated with clones. Schmidtling (1983) reported similar results from a study of a loblolly pine seed orchard in southern Mississippi. He calculated broad-sense heritability for number of female flowers per ramet to be 0.50 and 0.63 for 1976 and 1977 respectively. Further, he determined the total number of seeds per cone of ten ramets each of 18 clones for three consecutive years. In 1976, the clonal means for number of sound seed per cone ranged from 0 to 53; broad-sense heritability was 0.25. Heritabilities for this trait based on 1977 and 1978 data were 0.30 and 0.31, respectively. Clonal means in cones per ramet ranged from 0.1 to 50.8 in 1976 and the heritability estimate was 0.45. This value is in close agreement with the heritability of mean annual cone production for slash pine of 0.50 (Varnell et al. 1967). In another study with loblolly pine, Shear and Perry (1982) found substantial variation among clones in seed weight and seed quality. Mean seed weights for clones ranged from 25.5 to 32.7 mg; mean percent of unsound seed ranged from 5.2% to 22.5%.

In a series of tests with Monterey pine (<u>Pinus radiata</u> D. Don) in New Zealand, Burdon and Low (1973a,b) evaluated the effects of four different sites on clonal repeatability in some cone and seed properties. The repeatability values for the four sites for cone length and cone volume ranged from 0.56 to 0.85 and from 0.48 to 0.66, respectively (Burdon and Low 1973a). Repeatability estimates for number of filled seed per cone ranged from 0.00 to 0.33, and the repeatability for percent filled seed ranged from 0.04 to 0.23 (Burdon and Low 1973b).

Griffin (1982), working with 30 clones of Monterey pine in a seed orchard in Australia, calculated repeatability for number of seed per cone, 100-seed weight and cone weight (before extracting) to be 0.40, 0.54 and 0.53 respectively. In his study, these values indicate a clonal component of the total variance of 40%, 54% and 53% for the traits mentioned above.

Clonal variation in several growth parameters has been reported as well. For example, Zsuffa (1975) evaluated some growth and branching characteristics for Pinus griffithii x Pinus strobus clones. He obtained broad-sense heritability estimates for tree height and diameter at breast height of 0.62 and 0.45, respectively. For branch length and branch angle, heritability was 0.76 and 0.71, respectively. Burdon (1971) found high repeatability values on different sites (0.50-0.75) for total height, stem straightness and frequency of branch clusters in Monterey pine. In the same study, he also reported high clone-site interactions for stem straightness and branching characteristics. More moderate repeatability estimates for growth and branching habits were obtained by Shelbourne and Thulin (1974). They used rooted cuttings of 216 Monterey pines and evaluated crown diameter and height at six years. The repeatability estimates for height and crown diameter were 0.40 and 0.39 respectively. For number of branch clusters and branch angle, the repeatability was 0.41 and 0.24.

Differences in phenology among clones have also been reported. Eriksson et al. (1973), working with Norway spruce, found significant differences among clones in onset of pollen dispersal, duration of pollen dispersal and duration of the receptive period of female flowers. Vegetative growth patterns are also reported to be under strong genetic control (Nienstadt 1974, Warral 1975).

In his review of earlier work, Zobel (1961) concluded that the genetic control over many wood properties is moderate to high. Broad-sense heritability estimates of some southern pines for specific gravity ranged from 0.50 to 0.84 (Einspahr et al. 1964, Van Buijtenen 1962). In Monterey pine heritability for specific gravity was estimated to be 0.74 (Dadswell et al. 1961), and in Norway spruce it ranged from 0.51 to 0.70 (Warral 1975). Similar estimates for fibre length and fibre strength have been reported in some of the studies cited above. Substantially higher heritability estimates (0.89-0.99) have been found for some gum characteristics in slash pine (Squillace 1971, Peters 1971).

In the Matawin seed orchard, where this study was conducted, studies of clonal variation in black spruce and white spruce (<u>Picea glauca</u> (Moench.) Voss.) have been carried out. O'Reilly and Parker (1982) found highly significant ($p<0.01$) clonal differences in degree-day requirement for bud break in both species. In black spruce, the early-flushing clones had significantly greater leader growth than late-flushing ones. In another study in the same black spruce orchard, highly significant clonal differences were found in the number of male and female strobili per ramet, ramet heights and number of ovuliferous scales per cone (O'Reilly et al. 1982). Verheggen and Farmer (1983) worked with three ramets each of nine black spruce clones growing in this orchard. They reported significant ($p<0.05$) clonal differences in germination capacity, percent filled seed content, cone volume and number of seed per cone. Between 20% and 26% of the total variation for the characteristics was associated with clones. Some of the pertinent observations of black spruce clones growing in the Matawin seed orchard are summarized in Table 1.

The evidence of clonal variation in conifers is well documented for several characteristics. Of particular interest to this study are the studies conducted on cone and seed properties, which seem to be under moderate genetic control as evident from the heritablity estimates generally ranging from 0.20 to 0.60. The studies conducted in the Matawin seed orchard on phenology and on some cone and seed properties have already revealed the presence of genetic differences among clones there. Thus, variation due to clones in the characteristics evaluated in this study can be expected.

Table 1. Clone means and ranges for several cone and seed traits obtained from black spruce (Picea mariana (Mill.) B.S.P.) clones growing in the Matawin seed orchard.

Traits	Clone Mean Ranges	Grand Mean	Clonal Component of Variation (%)
No. ovuliferous scales/cone*	27.9 - 45.9	38.5	N/A
Cone Volume** (cm^3)	1.4 - 2.5	2.0	20
No. of Seed** per Cone	14 - 49	33	26
Filled Seed** per Cone (%)	23 - 59	46	20
Germination** Capacity (%)	86 - 100	94	21

* taken from O'Reilly et al. (1982)
** taken from Verheggen and Farmer (1983)

MATERIALS AND METHODS

In this study, data from a cone analysis, germination test and progeny test were used to estimate variation among clones and among ramets within clones growing in a northern Ontario black spruce seed orchard. Following is a description of this orchard and cone collection. Each test (cone analysis, germination test, progeny test) is then described separately with the applied statistical procedures outlined in the section on data analysis.

MATAWIN SEED ORCHARD

The Matawin seed orchard, established by the Ontario Ministry of Natural Resources, is located about 60 km to the west of Thunder Bay, Ontario in the Fort William Crown Management Unit. It is situated in Hills' (1960) Site Region 4 W at a latitude of $48^{\circ}23'$ N and a longitude of $90^{\circ}03'$ W and contains black and white spruce clones that originated from ortets growing between latitudes 48° and 50° N and longitudes 88° and 91° W. All scions were collected from tops of mature ortets (> 30 years) and grafted to white spruce rootstock.

The total area of the seed orchard is 10 ha, and it is surrounded by a mature, even-aged <u>Pinus</u> <u>banksiana</u> Lamb. (jack pine) stand functioning as a pollen barrier. The orchard is divided into two units, one containing 18 blocks of white spruce and the other containing 18 blocks of black spruce (Figure 1). Each block has an area of approximately 0.2 ha and contains 12 ramets for each of 12 clones. The spacing is 3.6 m by 3.6 m (12' by 12'). The arrangement of the ramets within the blocks is random with the condition that ramets of the same clone could not be adjacent. The first blocks were established in 1966, the last ones in 1972. A total of 61 black spruce clones and 39 white spruce clones were outplanted. In the younger blocks, mortality has been high due to recurring frost damage, root diseases and/or poor planting. The seed orchard is not well maintained, and efforts to increase seed yields are currently not being undertaken. Judging by informal evaluation, the cone crop in 1983 was below average in the black spruce blocks and poor in the white spruce blocks.

COLLECTION OF MATERIALS

On September 24, 1983 three cone-bearing ramets each of 19 clones were selected from six black spruce blocks (Figure 1, Appendix A). The selection of the ramets was random with respect to the variables measured in this study. However, the selected ramets had to have at least 30 cones in the 1983 cone crop.

Between 30 and 50 randomly picked cones of the current crop were collected from each selected ramet outlined in Appendix A. At this stage, all cones were still closed. Cones were kept separately by ramets in sealed glass jars. The jars were placed in a cold storage room until January of 1984 at an average temperature of 4 ^{o}C.

As it was essential to have all ramets properly identified, Dr. Peggy Knowles (Assistant Professor Biology/ Forestry Lakehead University) used an electrophoretic isozyme analysis on foliar tissue to genotype all selected ramets. Her interpretations of the results revealed that one ramet each in Clone 284 (R4-T1-67A) and 492 (R12-T4-67A) have been improperly tagged. The results of this analysis are outlined in Appendix

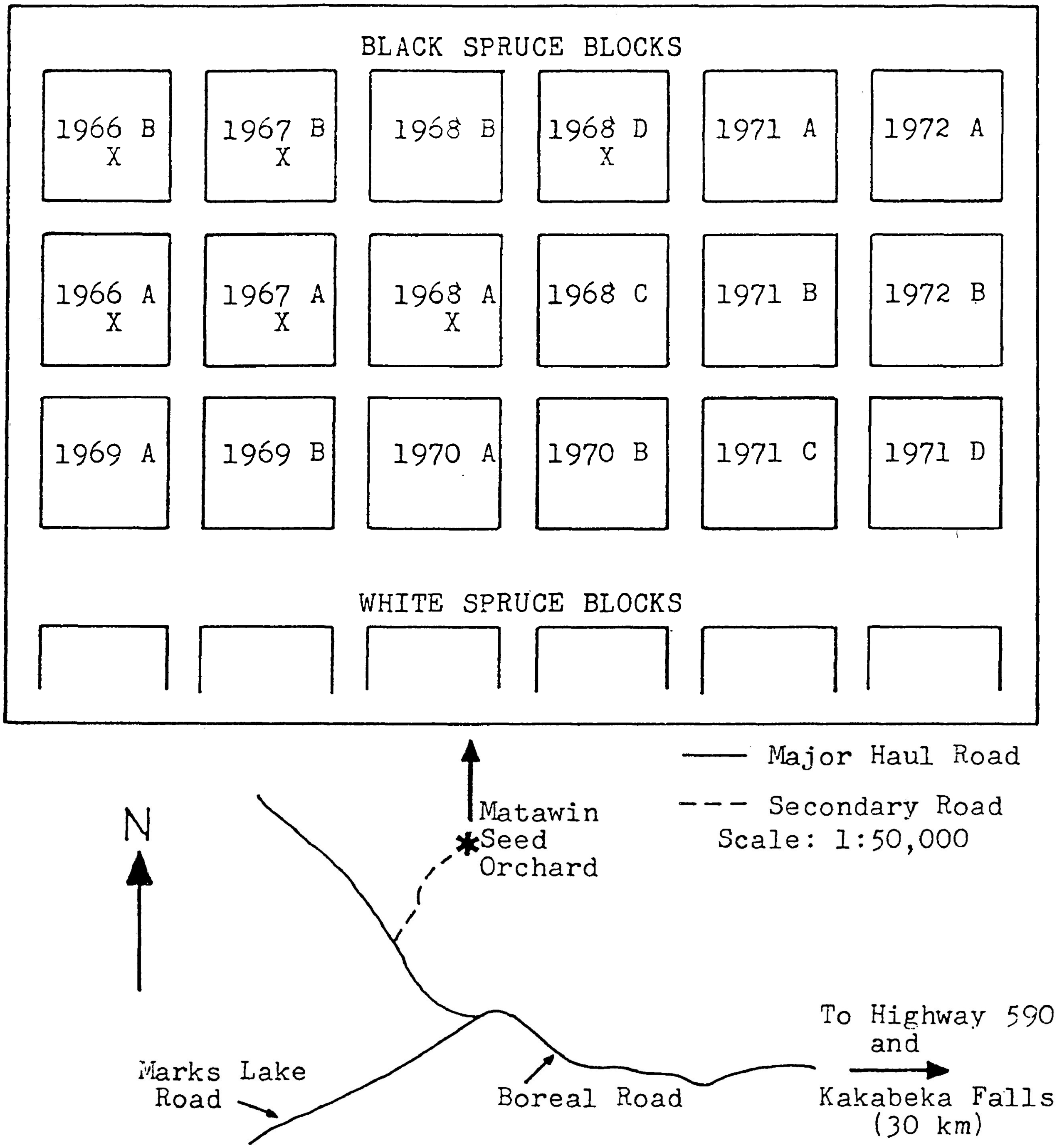

Figure 1. Location of Matawin Seed Orchard (✱) and lay-out of black spruce blocks. Ramets from marked blocks (X) were used in this study (lay-out not to scale).

B. Unfortunately, the isozyme analysis was conducted in the spring of 1984, at a time when most tests of this study were already in progress. Consequently, the two mislabelled ramets could not be replaced, but they were excluded from the analysis.

TEST 1: CONE ANALYSIS

Originally, the cone analysis procedure was developed by Bramlett et al. (1977) to evaluate seed production efficiency in southern pine seed orchards. Under this procedure individual cones are assessed with respect to cone and seed characteristics, such as extraction efficiency, total seed yield per cone, and percent of filled and sound seed per cone. In this study, cone analysis data were used to analyze clonal and environmental variation in cone and seed properties of black spruce clones growing in the Matawin seed orchard.

In January of 1984, ten cones of each ramet were selected at random from cones collected as described in the previous section. At this stage, the cones were still closed. The volume and length of each cone were measured. Cone volume was measured to the nearest 0.1 cm^3 by the water displacement method (Panshin and De Zeuw 1980). Cone length was measured to the nearest 0.1 mm using calipers.

Cones were prepared for seed extraction as outlined by Safford (1974). This procedure was as follows:

1. Individual cones were placed in small glass jars.
2. Cones were soaked in cold water for three to four hours.
3. The water was then drained and the cones were airdried in their jars for 20 hours.
4. Cones were placed in a cold oven and the temperature was

increased gradually to 55°C over a period of three to four hours.

5. Cones were left in the oven at 55°C for five to 11 hours.
6. Cones were placed at room temperature for several hours to cool before extracting the seed.

Seeds were extracted by tumbling each cone in a small container for 30 seconds. Extracted seeds of each cone were counted and put into small paper envelopes. The envelopes were placed into sealed glass jars and stored at 4°C. This extraction procedure (including steps 1 to 6) was repeated three times as recommended by Safford (1974). Seeds from the second and third extraction were counted, recorded and added to the seeds from the first extraction. To determine the total number of seeds per cone (in addition to the seeds from three extractions), all cones were dissected and the remaining seeds counted, recorded and added to the respective paper envelopes.

Seeds were dewinged and placed in a 95% ethanol solution. Empty seeds floated and were discarded. The number of filled seed per cone were counted. The filled seed from each ramet were then combined and used in the germination test described below.

TEST 2: GERMINATION

The filled seed of each ramet obtained from cone analysis test were divided into three replicate seed lots. The number of seeds per replicate ranged from 15 to 50 due to variation in the number of filled seed per ramet (see Appendix C for details). Seeds in each replicate were placed on two layers of square Whatman No. 2 filter paper in 9 cm by 9 cm plastic petri-dishes. Each petri-dish was randomly assigned to one of six plastic flats, holding between 27 and 30 petri-dishes each. Filter paper and seeds were thoroughly soaked with distilled water before the plastic flats were put in polyethylene bags which were then sealed. All flats were stored at 4°C for 14 days. After this stratification period, the flats (still in their polyethylene bags) were placed in one incubator which was programmed for 16 hours with light at 20°C and 8 hours of darkness at 10°C. The seeds were checked daily for 21 days and the number of germinants recorded and removed from the petri-dishes. A seed was judged to have germinated if the radicle was longer than 2 mm. After the termination of the germination test, ungerminated seeds were dissected and classified into the following groups: 1) filled and sound, 2) empty, and 3) filled but decayed.

TEST 3: PROGENY TEST

The purpose of the progeny test was to evaluate clone and ramet variance in early seedling growth. Further, family-environment interactions were evaluated.

In early January 1984, seeds from cones that were not used in the cone analysis (Test 1) were extracted several times as outlined for Test 1. The seeds of each ramet were bulked, dewinged and culled of empty seed by ethanol floatation. The filled seed of each ramet were randomly divided into seed lots containing ten seeds each. Ten or fewer seed lots per ramet (Appendix E) were used as some ramets yielded less than 100 filled seeds. All seed lots of each ramet were weighed with an analytical balance to determine the mean seed weight for each ramet. All seed lots of each ramet were then bulked and stratified in petri-dishes at 4°C for 14 days as outlined for Test 2.

On February 14, 1984, the progeny test was started in a greenhouse. The seedlings were grown under a photoperiod of 16 hours at around 25°C and 15°C during the dark. The photoperiod was extended during the winter and spring with sodium lights.

As one of the aims of this test was to evaluate family-environment interactions, the seedlings were grown under two drastically different fertilizer regimes. For this reason, the test was conducted using a split-plot design. Four blocks were subdivided into two main plots each. The main plots received one of the two fertilizer treatments: 25 ppm or 200 ppm 20-20-20 N-P-K fertilizer (Soluble Fertilizer Concentrate, Plant Products, Bramalea, Ont.). A mixture of peat and vermiculite at a ratio of 1:1 by volume was used as a growing medium.

In the main plots, each ramet was represented by four seedlings in one Tinus container book. Tinus books are a type of Spencer-Lemaire container with four cells per book each holding 500 cm^3 of soil per cell. All books (i.e., individual ramet plots) were randomly placed in the main plots. Two randomly selected seeds from the stratified seed lots were planted in each cell. Thirty-five days after seeding, the cells were thinned to one seedling. To avoid personal bias, the seedling closest to the centre of the cell was left standing. Empty cells were planted with a seedling that had been thinned from another cell of the same ramet. The fertilizer treatment was started three weeks after thinning according to the schedule outlined in Appendix D. Height measurements of all seedlings were taken on May 17, June 19, and July 16, 1984 about three, four and five months respectively after establishment of the test.

DATA ANALYSIS

Collection of cones from two improperly labelled ramets resulted in the discarding of two ramets of two clones (see Collection of Materials). This resulted in samples of unequal size in all three tests. Consequently, 17 clones were represented by three ramets, and two clones had only two ramets. The coefficient associated with the variance component associated with ramets was calculated according to the equation outlined by Snedecor and Cochran (1967, p. 289). Coefficients of variance components in the seed weight test (part of Test 3) had to be calculated as outlined by Sokal and Rohlf (1981, p. 294) since unequal ramet numbers, coupled with unequal seed lot numbers (replicates), had to be used. The calculations of all variance component coefficients are shown in Appendix E.

Cone Analysis

Nested analyses of variance were used to test differences in cone volume, cone length, total number of seed per cone and percent filled seed per cone. The last variable was transformed using the inverse sine transformation, as the percentages covered a wide range of values (Steel and Torrie 1980, p. 236). The null hypothesis for each test was that there is no difference among and within clones for the measured variables. The linear model of this design is as follows:

$$Y_{ijk} = u + C_i + R_{(i)j} + e_{(ij)k}$$

where $i = 1,2,3 \ldots 19$

$j = 1,2,3$ or $j = 1,2$

$k = 1,2,3 \ldots 10$

Y_{ijk} = the response variable, ie. the volume or length or number of seed or the percent of filled seed of cone k of ramet j of clone i;

u = the population mean;

C_i = the effect of clone i (a random effect as clones were selected at random);

$R_{(i)j}$ = the effect of ramet j of clone i (a random effect);

$e_{(ij)k}$ = the random error due to cone k of ramet j of clone i;

The analysis of variance table for this design is presented in Table 2.

Table 2. Analysis of variance table associated with the cone analysis.

Source	df	EMS
Clones	18	$s_e^2+10s_R^2+28.9s_C^2$
Ramets/Clones	36	$s_e^2+10s_R^2$
Cones/Ramets	495	s_e^2
Total	549	

Variance components associated with clones and ramets within clones were calculated to estimate broad-sense heritability for each cone and seed trait.

Germination Test

Nested analyses of variance were used to test differences in germination percent and germination speed associated with clones and ramets within clones. The null hypothesis was, that no differences among and within clones are present in the two germination characteristics.

Final germination percents were based on both 1) all filled seed that were ungerminated at the end of the test and 2) only sound seed, that were ungerminated at the end of the test. All germination percents were transformed with the inverse sine transformation and subjected to an analysis of variance. The linear model for this design is follows:

$$Y_{ijk} = u + C_i + R_{(i)j} + e_{(ij)k}$$

where $i = 1,2,3 \ldots 19$

$j = 1,2,3$ or $j = 1,2$

$k = 1,2,3$

Y_{ijk} = the response variable, i.e., the germination percent or germination energy of replicate k of ramet j of clone i;

C_i = the effect of clone i (a random effect);

$R_{(i)j}$ = the effect of ramet j of clone i (a random effect);

$e_{(ij)k}$ = the effect of replicate k of ramet j of clone i;

The analysis of variance table resulting from this design is outlined in Table 3.

Table 3. Analysis of variance table associated with germination test.

Source	df	EMS
Clones	18	$s_e^2+3s_R^2+8.67s_C^2$
Ramets/Clones	36	$s_e^2+3s_R^2$
Replicates/Ramets	110	s_e^2
Total	164	

Germination energy was analyzed by evaluating the number of days to reach 90% of the final germination in each replicate. The values were determined from germination curves. The linear model and the analysis of variance table are the same as for germination percent. Variance components to estimate broad-sense heritability were calculated for both germination parameters.

Broad-sense heritability (h^2) estimates for cone, seed and germination characteristics were calculated according to the following formula:

$$h^2 = s_C^2/(s_C^2+s_R^2+s_e^2)$$

Progeny Test

A nested analysis of variance was performed on the seed weight data to test the null hypothesis of no difference in seed weight among clones and among ramets within clones. The linear model for the design is as follows:

$$Y_{ijk} = u + C_i + R_{(i)j} + e_{(ij)k}$$

where $i = 1,2,3 \ldots 19$

$j = 1,2,3$ or $j = 1,2$

$k = 1,2,3 \ldots a$

Y_{ijk} = the weight of replicate k of ramet j of clone i

u = overall mean

C_i = the effect of clone i (a random effect);

$R_{(i)j}$ = the effect of ramet j of clone i;

$e_{(ij)k}$ = the random error due to replicate k of ramet j of clone i;

The resulting analysis of variance table is presented in Table 4.

Table 4. Analysis of variance table associated with seed weight test.

Source	df	EMS
Clones	18	$s_e^2+9.54s_R^2+27.45s_C^2$
Ramets/Clones	36	$s_e^2+9.46s_R^2$
Replicates/Ramets	467	s_e^2
Total	521	

Separate analyses of variance were carried out for seedling height measurements made three, four and five months after test establishment. The null hypothesis for each test was that there is no difference in seedling heights regardless of blocks, fertilizer level, clones and ramets within clones. The experimental design was of a split plot type, with the split plots receiving the different levels of fertilizer. The linear model is as follows:

$$Y_{ijklmn} = u + B_i + d_{(i)} + F_j + BF_{ij} + w_{(ij)} + C_k + BC_{ik} + FC_{jk} + BFC_{ijk} + R_{(k)l} + BR_{(k)li} + FR_{(k)lj} + BFR_{(k)lij} + e_{(ijkl)m} + s_{(ijklm)n}$$

where $i = 1,2,3,4$

$j = 1,2$

$k = 1,2,3 \ldots 19$

$l = 1,2,3$ or $l = 1,2$

$m = 1$

$n = 1,2,3,4$

Y_{ijklmn} = height of individual seedling;

u = overall mean;

B_i = effect of block i (a fixed effect);

$d_{(i)}$ = the restriction error associated with the randomization of the fertilizer treatment in the i-th block. For a complete discussion of restriction errors, see Anderson and McLean (1974);

F_j = the effect of fertilizer level j, (a fixed effect);

$w_{(ji)}$ = the restriction error associated with the randomization of the clones within the fertilizer - block combination;

C_k = the effect of clone k, (a random effect);

$R_{(k)l}$ = the effect of ramet l of clone k, (a random effect);

BF_{ij}, BC_{ik}, FC_{jk}, BFC_{ijk}, $BR_{(k)li}$, $FR_{(k)lj}$, $BFR_{(k)lij}$ = the effects of the indicated interactions;

$e_{(ijkl)m}$ = the random error due to the m-th plot in the ijkl-th treatment combination (experimental error);

$s_{(ijklm)n}$ = the random error due to the n-th seedling in plot m of the ijkl-th treatment combination (sampling error);

The analysis of variance table for this design is outlined in Table 5.

Table 5. The analysis of variance table associated with the progeny test.

Source	df	EMS
B_i	3	$s_s^2 + 4s_e^2 + 8s_{BR}^2 + 23.1s_{BC}^2 + 439.3s_d^2 + 439.3\phi_B$
$d_{(i)}$	0	$s_s^2 + 4s_e^2 + 8s_{BR}^2 + 24s_{BC}^2 + 439.3s_d^2$
F_j	1	$s_s^2 + 4s_e^2 + 16s_{FR}^2 + 46.2s_{FC}^2 + 304\phi_F$
BF_{ij}	3	$s_s^2 + 4s_e^2 + 4s_{BFR}^2 + 11.6s_{BFC}^2 + 219.6s_w^2 + 219.6\phi_{BF}$
$w_{(ij)}$	0	$s_s^2 + 4s_e^2 + 4s_{BFR}^2 + 11.6s_{BFC}^2 + 219.6s_w^2$
C_k	18	$s_s^2 + 4s_e^2 + 32s_R^2 + 92.5s_C^2$
BC_{ik}	54	$s_s^2 + 4s_e^2 + 8s_{BR}^2 + 23.1s_{BC}^2$
FC_{jk}	18	$s_s^2 + 4s_e^2 + 16s_{FR}^2 + 16s_{FC}^2$
BFC_{ijk}	54	$s_s^2 + 4s_e^2 + 4s_{BFR}^2 + 11.6s_{BFC}^2$
$R_{(k)l}$	36	$s_s^2 + 4s_e^2 + 32s_R^2$
$BR_{i(k)l}$	108	$s_s^2 + 4s_e^2 + 8s_{BR}^2$
$FR_{j(k)l}$	36	$s_s^2 + 4s_e^2 + 16s_{FR}^2$
$BFR_{ij(k)l}$	108	$s_s^2 + 4s_e^2 + 4s_{BFR}^2$
$e_{(ijkl)m}$	0	$s_s^2 + 4s_e^2$
$s_{(ijklm)n}$	1320	s_s^2
Total	1759	

As there was no estimate of experimental error (0 df), six randomly selected ramets in each main plot were replicated once when the progeny test was established. For this purpose, one Tinus container book (four seedlings) per selected ramet was placed randomly in the main plots. From these partial replications, an estimate of experimental error was obtained for each analysis of variance (Anderson and McLean 1974). Table 6 outlines the analysis of variance used to estimate experimental error.

Table 6. Outline of analysis of variance used to estimate experimental error.

Source	df	EMS
Ramets	47	$s_S^2 + 4s_e^2 + 8s_R^2$
Experimental Error	48	$s_S^2 + 4s_e^2$
Sampling Error	288	s_S^2
Total	483	

The estimated error was used to test the approriate interactions for the purpose of pooling. This preliminary testing was done at the 75% level of confidence (Winer 1971, p. 378 ff.). The error estimate from the side test was not used in the main test as recommended by Anderson and McLean (1974).

Linear correlation analyses were carried out with ramet mean seed weight as the independent variable and the mean progeny performance of each ramet as the dependent variable. Separate analyses were conducted for high and low fertilizer levels and for each of the three height measurements. All statistical procedures were carried out with SPSS (Stat stical Package for the Social Sciences) on a VAX 11/780 computer at Lakehead University.

RESULTS

CONE ANALYSIS

The results of the cone analysis are shown in Table 7 and Table 8. Significant ($p<0.01$) differences due to clones and to ramets within clones were observed for all variables measured in this test (Table 9).

Mean cone volume was found to be 2.2 cm^3 and ranged from 1.3 cm^3 for Clone 493 to 3.5 cm^3 for Clone 492. The largest within-clone range was observed for Clone 291 (1.9 cm^3 to 3.6 cm^3). Variation in cone length showed a pattern similar to that of cone volume. Clone 492 had the longest cones on the average (30.6 mm); cones of Clone 493 were shortest (18.9 mm). Clone 291 again showed the widest range in ramet means for this trait. The proportions of the total variance associated with clones and ramets within clones were also of similar magnitude for the two cone characteristics. The clonal component of the total variance in cone volume and cone length were 37.1% and 39.4%, respectively (Table 9). The ramet-within-clone proportion of the total variance was 19.4% and 18.0% for cone volume and cone length, respectively (Table 9).

The average number of seed per cone was 71.2 (Table 8); however, only 18.2% of these seeds were filled. Clone 492 yielded the most seed per cone (102.2), and Clone 493 yielded the lowest number of seed per cone (48.7). For the total sample, individual ramet means ranged from 43.1 seed per cone to 109.0 seed per cone (Table 8). Thirty-one percent of the total variation of the number of seed per cone was due to clones; the ramet-within-clone variation accounted for 18.2%

(Table 9).

Table 7. Clone means and ranges in ramet means for cone volume and cone length for nineteen black spruce clones.

Clone No.	Cone Volume (cm^3)		Cone Length (mm)	
	Clone Mean	Range in Ramet Means	Clone Mean	Range Ramet Means
283	2.0	1.6-2.4	24.3	23.2-26.2
284	2.3	1.9-2.7	24.7	22.7-26.7
288	1.3	1.0-1.6	21.8	19.0-23.1
290	1.8	1.7-2.0	22.3	21.7-23.3
291	2.8	1.9-3.6	27.3	23.5-31.2
303	2.2	1.8-2.5	25.3	23.5-26.7
304	2.6	2.3-3.1	25.4	24.8-26.2
354	1.6	1.5-1.7	22.3	22.1-22.5
355	1.6	1.5-1.8	23.4	22.8-24.0
367	2.3	2.1-2.6	27.1	26.4-28.4
369	2.5	2.4-2.6	26.2	26.0-26.4
370	2.4	2.2-2.6	26.0	25.1-27.1
383	2.9	2.1-3.4	25.1	22.6-26.8
385	2.3	2.2-2.5	25.4	24.9-26.4
387	2.1	2.0-2.2	23.1	22.8-23.5
393	1.6	1.3-2.0	21.6	20.1-24.2
491	2.1	1.6-2.4	22.7	19.6-24.6
492	3.5	3.1-4.0	30.6	28.8-32.3
493	1.3	1.2-1.4	18.9	17.8-19.8
Mean	2.2		24.4	
h^2	.37		.39	

The percent of filled seed, calculated as the proportion of sinking seed in the floating test, was low. Clone means ranged from 8.5 to 27.2, and individual ramet means ranged from 7.5% to 32.8% (Table 8). The clonal component of the total variance in the two seed properties was smaller than in the cone properties. For the number of seeds per cone it was 31.2%, for the percent filled seed it was 23.1%. The ramet effects for those two traits accounted for 18.2% and 12.6% of the total variance respectively (Table 9).

The broad-sense heritability estimates (h^2) for cone volume, cone length, total number of seed per cone and percent filled seed per cone were .37, .39, .31 and .23, respectively (Tables 7 to 9).

Table 8. Clone means and ranges in ramet means for total number of seeds per cone and percent filled seed per cone for nineteen black spruce clones.

Clone No.	Number of seed per cone		Percent of seed filled	
	Clone Mean	Range in Ramet Means	Clone Mean	Range in Ramet Means
283	62.1	57.4-65.2	14.0	12.3-16.3
284	79.6	77.1-82.1	24.4	16.0-32.8
288	61.5	58.1-64.9	19.3	11.4-28.2
290	77.0	73.1-81.1	10.9	8.4-13.6
291	84.2	81.5-87.1	12.7	8.3-15.3
303	87.6	76.4-94.3	8.5	7.5-9.6
304	65.4	55.1-70.7	26.4	23.7-28.2
354	59.2	54.1-61.7	14.4	12.4-16.8
355	70.0	64.1-74.9	14.6	13.9-15.6
367	81.7	76.9-86.0	16.0	11.6-21.8
369	90.1	87.1-93.7	10.1	8.4-12.5
370	64.5	58.6-68.4	19.1	11.8-27.8
383	63.2	49.7-71.4	23.7	17.6-31.5
385	73.6	71.7-75.1	22.7	18.8-26.9
387	69.9	65.5-74.0	27.2	20.4-31.3
393	64.9	57.3-74.1	11.8	11.2-12.9
491	53.3	40.0-60.2	27.2	18.9-31.5
492	100.2	91.5-109.0	26.1	25.2-27.0
493	48.7	43.1-51.8	16.1	9.3-23.4
Mean	71.2		18.2	
h^2	.31		.23	

Table 9. Analyses of variance and estimated components of variance for cone and seed characteristics for nineteen black spruce clones.

Response Variable and Source of Variation	df	Mean Square	Estimated Component of Variance	Proportion of total Variation
Cone Volume				
Clones	18	8.19**	.23	37.1%
Ramets	36	1.42**	.12	19.4%
Error	495	.27	.27	43.5%
Cone Length				
Clones	18	188.69**	5.46	39.4%
Ramets	36	30.81**	2.49	18.0%
Error	495	5.91	5.91	42.6%
Number of Seed/Cone				
Clones	18	3960.22**	108.83	31.2%
Ramets	36	812.74**	63.64	18.2%
Error	495	176.33	176.33	50.6%
Percent of Seed filled				
Clones	18	663.93**	17.88	23.1%
Ramets	36	146.76**	9.71	12.6%
Error	495	49.65	49.65	64.3%

** significant at the 99% level of confidence.

The raw data for the cone analysis are listed in Appendix G.

GERMINATION TEST

The separation of filled seed from empty seed through alcohol floatation was effective. The cutting test at the end of the germination trial revealed that out of 1353 ungerminated seeds, 67 (or less than 5%) were empty (Appendix C).

Germination percent, based on all filled seed, was generally low. The overall mean for the whole test was 67.8%. Clonal means ranged from 27.6% (Clone 304) to 88.1% (Clone 303). Germination percent of individual ramets ranged from 3.4% (Ramet 3 of Clone 304) to 94.4% (Ramet 1 of Clone 393) (Table 11). Wide within-clone variation was observed in many clones, with Clone 304 having the largest within-clone range (3.4% to 52.7%). Clone and ramet effects were highly significant, accounting for 66.8% and 18.2% of the total variation, respectively (Table 10). When germination percents were based on sound seed only, the overall mean was 90.3% (Appendix C). An additional analysis of variance of germination percent based on sound seed only revealed that 29.3% and 20.7% of the total variation were associated with clones and ramets within clones, respectively (Table 10). These estimates are both lower than those obtained for germination percent based on all filled seed.

Germination speed was evaluated by analyzing the number of days to reach 90% of the final germination in each replicate. On the average, 90% of all germinable seeds germinated after 11 days (Table 11). Clone 367 germinated most rapidly (7.9 days to reach 90%), and Clone 491 germinated slowest, reaching 90% of the final germination after 15.3 days. Maximum ramet-within-clone variation was again observed in Clone 304, with ramet means ranging from 6.9 days to 15.7 days to reach 90% of final germination. Differences due to clones in germination speed were significant ($p<.05$), accounting for 20.7% of the total variation. Differences due to ramets within clones were highly significant, accounting for 33.2% of the phenotypic variation (Table 10).

Broad-sense heritabilities for germination percent and germination energy were .67 and .21, respectively (Table 11).

Table 10. Analyses of variance and estimated components of variance for germination percent and germination speed of seed from nineteen black spruce clones.

Response Variable and Source of Variation	df	Mean Square	Variance Component	Proportion of total Variation
Germination Percent (filled seed only)				
Clones	18	1627.43**	167.58	66.8%
Ramets/Clones	36	174.47**	45.58	18.2%
Replicates/Ramets	110	37.74	37.74	15.0%
Germination Percent (sound seed only)				
Clones	18	713.60**	57.13	29.3%
Ramets/Clones	36	218.29**	40.32	20.7%
Replicates/Ramets	110	97.34	97.34	50.0%
Germination Energy				
Clones	18	41.90*	2.67	20.7%
Ramets/Clones	36	18.78**	4.28	33.2%
Replicates/Ramets	110	5.93	5.93	46.1%

* significant at the 95% level of confidence
** significant at the 99% level of confidence

The germination test data, including the results of the cutting test, are outlined in Appendix C.

PROGENY TEST

The mean seed weight for all clones was 11.8 mg per ten seeds. Clone 291 produced the heaviest seeds with 15 mg per ten seeds, and the lightest seeds were harvested from Clone 355 with 9.4 mg per ten seeds (Table 12). Clone and ramet-within-clone effects were highly significant, accounting for 74.6% and 17.9% of the total variance, respectively (Table 13).

Table 11. Clone means and ranges in ramet means of germination percent and germination speed of seed from nineteen black spruce clones.

Clone No.	Germination Percent[a]		Germination Energy[b]	
	Clone Mean	Range in Ramet Means	Clone Mean	Range in Ramet Means
283	59.2	50.6-67.5	9.5	8.2-11.9
284	71.4	64.7-78.0	12.4	11.9-12.8
288	79.8	74.0-86.4	10.0	8.8-10.8
290	78.8	70.9-94.0	9.9	8.8-11.0
291	60.0	49.1-72.1	10.4	9.4-11.0
303	88.1	79.9-93.0	10.6	6.9-15.7
304	27.6	3.4-52.7	12.1	8.9-17.2
354	37.2	28.0-51.1	14.6	9.8-17.3
355	44.7	43.3-46.4	13.6	10.9-17.4
367	42.2	32.7-49.5	7.9	7.0- 8.9
369	47.1	36.2-54.7	14.8	10.7-17.5
370	86.6	83.3-92.0	9.1	7.6-11.4
383	79.3	70.7-85.9	9.3	8.4-10.3
385	89.8	83.5-93.3	10.4	9.8-11.6
387	82.7	76.7-91.3	11.1	10.7-11.7
393	86.7	76.1-94.4	9.2	8.6- 9.7
491	55.7	46.0-61.7	15.3	12.3-18.8
492	85.7	80.7-90.7	8.5	7.5- 9.5
493	84.6	78.7-88.9	10.4	9.3-12.0
Mean	67.8		11.0	
h^2	.61		.21	

[a] based on filled seed only
[b] days to reach 90% of final germination

Table 12. Mean weight of seeds from ramets of nineteen grafted black spruce clones.

Clone No.	Mean Weight of Ten Seeds (mg)			
	Clone Mean	Ramet 1	Ramet 2	Ramet 3
283	10.7	9.7	11.5	10.8
284	10.0	9.8	10.2	N/A
288	10.6	9.2	12.7	9.9
290	9.7	10.0	9.6	9.4
291	15.3	15.7	17.1	13.2
303	10.3	10.1	10.0	10.7
304	10.6	10.1	10.6	11.1
354	11.4	11.2	11.7	11.4
355	9.4	8.7	9.8	9.7
367	12.5	12.6	12.5	12.3
369	11.3	11.5	11.7	12.6
370	13.9	13.9	14.0	13.7
383	13.1	13.3	12.6	13.3
385	13.2	12.0	13.8	13.7
387	12.9	12.9	12.7	13.1
393	11.3	11.6	11.7	10.5
491	11.8	12.3	11.4	11.7
492	14.6	14.9	14.4	N/A
493	11.2	11.1	11.4	11.1
Mean	11.8			
h^2	.75			

Table 13. Analysis of variance and estimated components of variance for seed weight of nineteen black spruce clones.

Source of Variation	df	Mean Square	Estimated Variance Component	Proportion of total Variation
Clones	18	74.69**	2.50	74.6%
Ramets	36	5.90**	.60	17.9%
Error	467	.25	.25	7.5%
Total	521			

** significant at the 99% level of confidence

The clonal means of progeny heights at the three measured ages are summarized in Table 14. After three months under the high fertilizer level, the family mean heights ranged from 8.5 cm to 10.5 cm. After four and five months, family means ranged from 17.8 cm to 20.9 cm and from 29.6 cm to 33.9 cm, respectively. The height difference between the smallest and largest family after five months was 12%.

At the low fertilizer level after three and four months, family means ranged from 7.5 cm to 8.8 cm and from 10.9 cm to 12.5 cm, respectively. After five months, family mean heights ranged from 11.2 cm to 13.8 cm, a difference of 19%.

Generally, progeny from clones yielding heavy seeds performed better after three months, (e.g., Clone 291, 367 and 492), but this effect on early growth disappeared after five months (Table 15). At three months, 26% and 41% of the total variation at the low and high fertilizer level, respectively, was associated with differences in seed weight. After five months of test establishment these values decreased to 3% and 1% in the low and high fertilizer regime, respectively (Table 15).

Family variance in progeny height was significant ($p<0.01$) at all three measurement dates (Table 16), but ramet effects were significant ($p<0.01$) only after three and four months of test establishment. Fertilizer effects continually increased in importance. The fertilizer-family interaction was not significant on any of the three measurement dates, although the relative importance of the term increased with time (Table 17).

Table 14. Mean heights of black spruce progeny growing under two levels of fertilizer.

	Mean Seedling Height (cm)					
	3 Months		4 Months		5 Months	
	Fertilizer		Fertilizer		Fertilizer	
Clone No.	Low	High	Low	High	Low	High
283	8.1	8.9	12.3	19.6	13.8	32.6
284	8.4	9.2	12.4	19.6	13.0	30.8
288	7.8	9.1	11.7	19.5	12.8	31.7
290	7.8	8.8	11.7	18.9	12.2	31.6
291	8.8	10.5	12.5	20.9	13.1	33.4
303	8.2	9.0	12.3	20.1	13.4	33.3
304	7.5	8.5	11.0	17.8	12.0	30.3
354	8.1	9.4	12.1	20.3	13.0	33.9
355	7.8	9.0	11.4	19.6	11.8	32.8
367	8.8	9.8	11.7	20.6	11.9	31.6
369	7.5	8.7	10.9	18.9	11.7	31.2
370	7.9	9.5	11.6	19.7	13.2	33.1
383	8.3	9.3	11.6	19.5	11.9	31.8
385	8.4	9.4	12.1	20.5	12.4	33.6
387	8.2	9.1	11.0	18.2	11.2	29.6
393	7.8	8.9	11.8	18.3	12.3	30.4
491	8.3	9.3	12.4	19.2	13.7	31.6
492	8.7	9.5	12.5	19.4	13.3	32.9
493	7.5	8.8	11.2	19.7	11.9	32.5

Table 15. Linear correlation for seed weight of individual black spruce ramets and progeny heights at three ages.

Progeny Age	Fertilizer Level	Correlation Coefficient (r)	Coefficient of Determination (r^2)
3 Month	Low	.51	.26
	High	.64	.41
4 Month	Low	.26	.07
	High	.27	.07
5 Month	Low	.18	.03
	High	.09	.01

Table 16. Analyses of variance for heights of progeny from three ramets of nineteen black spruce clones.

Source of Variation	Seedling Age: 3 Months df	3 Months MS	4 Months df	4 Months MS	5 Months df	5 Months MS
Block (B)	3	5.1	3	93.5	3	312.6
d	0	none	0	none	0	none
Fertilizer (F)	1	545.2*	1	26136.7**	1	165665**
F x B	3	36.0	3	278.1	3	544.5
w	0	none	0	none	0	none
Clone (C)	18	16.4**	18	33.3**	18	67.9**
B x C	54	1.9	54	8.8	54	20.0
F x C	18	1.5	18	10.7	18	26.9
B x F X C	54	.7	54	6.1	54	19.3
Ramet (R)	36	3.6**	36	11.4**	36	22.4
B x R	108	1.5		N/A[2]		N/A[2]
F x R		N/A[1]		N/A[2]		N/A[2]
B x F x R	108	1.6		N/A[2]		N/A[2]
Exp. Error	36[1]	1.1	252[2]	7.0	252[2]	19.2
Samp. Error	1320	1.2	1318[3]	4.8	1308[3]	16.4
"Within Duplicate Error"	(48)	1.1	(48)	7.4	(48)	53.5
Total	1759		1757		1747	

[1] FxR interaction used as experimental error (see Methods)

[2] FxR, BxR, BxFxR pooled to obtain estimate for exp. error

[3] loss of degree of freedom due to mortality of seedlings

Table 17. Summary of pertinent variance components obtained from three analyses of variance for height shown in Table 16.

Source of Variation	Variance Components		
	3 Months	4 Months	5 Months
Family	.14	.24	.49
Family x Fertilizer	.01	.08	.47
Ramet	.08	.14	.10
Ramet x Fertilizer	0	0	0

The raw data for the progeny test are summarized in Appendix H.

DISCUSSION

The results of this study demonstrate that between 23% and 39% of the total variation in seed and cone properties are associated with clones. The ramet-within-clone component in these traits ranged from 13% to 19% of the phenotypic variance. Germination percent, based on filled seed, was under substantially greater genetic control as 67% of the total variance was associated with clones. For germination speed 21% of the total variance was due to clones. The ramet effects in both germination parameters were highly significant, accounting for 18% and 33% of the total variance in germination percent and germination speed, respectively. In the progeny test, highly significant family differences in progeny heights were observed at all three ages. The ramet effects were highly significant at the beginning of the test, but did not have a lasting influence on progeny performance. Family-fertilizer interactions were not detected, although the variance component for this source of variation increased substantially towards the end of the test period.

It is probably safe to assume that the variance associated with clones in the individual tests of this study is an estimate of the genotypic variance, as "C-effects" associated with the original ortets probably have vanished.

The genetic control over the measured cone and seed properties is moderate and may vary from year to year. In a similar study using some of the same clones, Verheggen and Farmer's (1983) clonal components of the total variation were all smaller and ranged from 20% to 26%. One explanation for these differences may be the fact that they used a much smaller sample size. Another reason for the differences in the two studies could be the natural yearly fluctuations in reproductive features, such as those already observed by Schmidtling (1983) in loblolly pine. Generally, it is evident that the degree of genetic determination in cone and seed characteristics in this population of black spruce clones is lower than in loblolly pine and Monterey pine (Schmidtling 1983, Burdon and Low 1973a, Griffin 1982).

Another estimation of a genetic variance in a cone characteristic was obtained by Kahlil (1975) in a provenance study of black spruce in Newfoundland. He showed that 46% of the total variation in cone length was associated with "trees within provenance". His trees within provenance are probably comparable to clones used in this study, where genetic variance was 39% of the total variation in cone length. Other genetic variance estimates for cone and seed properties of black spruce have not been published. However, some results of my cone analysis can be compared with data from other studies. For example, the average number of seed per cone in this study (71) is in close agreement with O'Reilly et al.'s (1982) estimate of 38.5 ovuliferous scales per cone, potentially resulting in 77 seeds per cone on the average. McPherson et al. (1982) found that the mean number of filled seed per cone from a grafted clonal black spruce seed orchard was 11, a figure slightly lower than the 13 observed in this study.

The ramet-within-clone variation, highly significant in all four tests of the cone analysis, is probably caused by a combination of micro-site differnces in the orchard and variable rootstock effects. Differences in the pollen cloud unlikely would affect traits such as cone volume or cone length, although the number of seeds and the percent filled seed could be influenced by the abundance and source of pollen during the receptive period of the female strobili.

The relatively low germination percent compared to other published reports needs to be explained. Germination tests are usually conducted with seedlots containing both filled and unfilled seed. At the end of these tests, ungerminated seeds are classified as 1) filled and sound, 2) filled but decayed and 3) empty. Total germination is then calculated based on all filled sound seed. Thus, germination percent is usually fairly high in black spruce (around 95%) (McPherson et al. 1982, Farmer et al. 1983, Verheggen and Farmer 1983). In this germination trial, germination percents were calculated in two ways: 1) Based on all filled seeds (including the decayed) and 2) based on sound seed only. The results of the two evaluation methods vary greatly, being 68% and 90% for the first and second method respectively (Table 6, Appendix C). It is important to point out, that out of 100 filled seed one would not get 90 germinants, but a number that is substantially lower, as some (low-vigour) seeds will decay during the test.

A substantial difference in the genetic component of the total variation is evident for the two evaluations. When the calculated germination percent was based on all filled seeds, 67% of the total variance was associated with clones. In contrast, when the germination percent was based on sound seed only, 29% of the total variation were due to clones. Therefore, clonal variation in germination percent based on all filled seed, includes clonal differences in the ability of sound seed to germinate completely within three weeks and clonal variation in the portion of filled but unsound seed. Clonal differences in the number of decayed seed may also be related to clonal variation in germination speed and genotype differences in the number of recessive lethal genes, whose effects are apparent after self-pollination.

Further indications of clonal variation in germination vigour are the significant differences among clones in germination speed. Schell (1960) and Barnett (1972) found that germination speed is mainly a function of seed coat thickness, a maternal characteristic. Thus, the wide ramet-within-clone variation in germination speed is probably due to maternal effects, although genetic differences due to variance in pollen parents cannot be excluded.

The fact that germination percent is under higher genetic control than germination speed in black spruce has been reported by Morgenstern (1969). He showed that the "family within subpopulation" component accounted for 51% and 28% of the total variation in germination percent and germination speed, respectively.

In summary, clonal differences in germination percent and germination speed may be the result of genetic variation in pre-germination requirement to break dormancy and variation in the respond to germination conditions. The highly significant ramet-within-clone effects in both germination properties suggest that environmental factors play an important role in influencing the germination pattern of seeds. However, differnces in male parenthood may also increase clone and ramet effects in germination characteristics.

The results of the progeny test indicate that much of the height differences among the progeny of genetically identical mother trees are probably caused by differences in seed weight. When the mean seedling performance was significantly correlated with mean seed weight (after three and four months), highly significant ramet effects were observed.

After five months, seed weight influences and ramet effects disappeared. This lack of correlation between seedling height at five months and seed weight indicates that within-clone variation in this case may have been caused by nutritional maternal effects, which lasted only a short time. Family differences were highly significant in all three tests, although after five months mean family heights in the high and low fertilizer regime ranged only from 30 cm to 34 cm and from 11 cm to 14 cm, respectively. It is possible that family differences will increase in importance when forces that are under strong genetic control, such as growth cessation and flushing time, start to operate on height growth. If one looks at the family differences in the low and high fertilizer regime separately, such a possible increase in family variation is evident. In the low fertilizer blocks, some seedlings of some families stopped growing and set a terminal bud before the five-month data were collected. The height differences between the smallest and largest families were 19%, whereas in the high fertilizer blocks, where all seedlings were actively growing, the difference between seedlings of the smallest and largest family were only 12%. It is also possible, that fertilizer-family interaction will become more important as the end of the growing season approaches. The variance component of this interaction increased substantially in the five-month test (Table 17), but was still not statistically significant (Table 16).

It is noteworthy to point out the implications of the combined results of the cone analysis and germination test. First, out of the average of 71 seed per cone, only 8.8 germinants were observed on the average, a number rather low for seed that was collected in an area especially set up for the production of quality seed. In a tree nursery, the number of germinants probably would have been even lower due to more unfavourable conditions during the germination process. Secondly, if the seed of this orchard were bulked and used on an operational basis for forest regeneration, some mother trees would contribute very few seedlings to the crop. This potential reduction of the genetic base is a combination of wide clonal variation in percent filled seed, germination percent, germination speed and culling practices in the nursery. If O'Reilly et al.'s (1982) hypothesis that only two out of twelve clones contribute over 50% of the male gametes is correct, the problem of a reduction of the genetic base is even more serious. One way to prevent this reduction is to rogue the orchard of clones with low germination percent and low filled seed content and to replace them with clones that have seed with more desirable germination properties. Griffin (1972) even suggested eliminating clones that produce small seeds, since their seedlings remain small and will be culled in the nursery. Seed weight seems to be under high enough genetic control (broad-sense heritability, .75) in black spruce to make selection for this trait effective.

Yearly fluctuations in numbers of male and female strobili per ramet, conelet survival and seed yield per cone have been observed in other conifers (e.g., Eriksson et al. 1973, Schmidtling 1983). Therefore, the results of this study may not be representative for other years. Also, as ortets growing only in northern Ontario were used to establish the Matawin seed orchard and as the genotypes used in this study are only growing in a single orchard, these results may not apply to the black spruce population as a whole.

To better identify the precise nature of the wide within-clone variation observed throughout this study, diallel crosses should be conducted to separate the true environmental effects from possible variance in male parenthood.

CONCLUSION

In summary, it can be concluded that:

1. Wide clonal differences in cone volume, number of seed per cone and percent of filled seed are under moderate genetic control.
2. Ramets within clones accounted for 13 to 19 percent of the phenotypic variance in cone and seed properties.
3. Germination percent (based on all filled seed) and germination energy varied widely among clones.
4. Ramet effects accounted for significant variance in these germination characteristics.
5. Family variance in seedling height increased during the five-month period after test establishment.
6. Variance due to ramets within families decreased to a non-significant level during the five-month period after test establishment.

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APPENDICES

APPENDIX A

LIST OF PICEA MARIANA RAMETS USED IN THIS STUDY

Clone	Ramet Location[1]	Block	Ortet Origin
283	R1 - T1	1967 A	Kimberly-Clark Camp 35
283	R7 - T2	1967 A	Geraldton District
283	R11- T4	1967 A	
284	R4 - T6	1967 A	Kimberly-Clark Camp 35
284	R8 - T2	1976 A	Geraldton District
288	R5 - T12	1966 B	Black Sturgeon Lake
288	R7 - T9	1966 A	Thunder Bay District
288	R10- T7	1966 B	
290	R4 - T1	1966 A	Black Sturgeon Lake
290	R4 - T6	1966 A	Thunder Bay District
290	R11- T7	1966 A	
291	R9 - T6	1967 B	Black Sturgeon Lake
291	R10- T3	1968 D	Thunder Bay District
291	R11- T1	1967 A	
303	R10- T12	1966 B	Abitibi-Price
303	R11- T5	1966 B	Freehold Block 3
303	R12- T5	1967 B	Thunder Bay District
304	R4 - T2	1966 B	Abitibi-Price
304	R12- T1	1966 B	Freehold Block 3
304	R12- T6	1966 B	Thunder Bay District
354	R2 - T8	1968 A	Kimberly-Clark Camp 57
354	R7 - T7	1968 D	Geraldton District
354	R12- T6	1968 D	
355	R2 - T9	1968 A	Kimberly-Clark Camp 57
355	R3 - T11	1968 A	Geraldton District
355	R7 - T7	1968 A	
367	R1 - T8	1968 A	Kimberly-Clark
367	R4 - T9	1968 A	McKay Road Area
367	R6 - T8	1968 A	Geraldton District
369	R6 - T11	1966 B	St. Lawrence Corp. Co.
369	R10- T4	1966 B	Camp 95 Area
369	R11- T1	1966 B	Geraldton District
370	R5 - T1	1966 B	St. Lawrence Corp. Co.
370	R12- T5	1966 B	Camp 95 Area
370	R12- T8	1966 B	Geraldton District

Clone	Ramet Location	Block	Ortet Origin
383	R4 - T3	1966 A	Kimberly-Clark
383	R9 - T3	1966 A	Club Lake Road Area
383	R9 - T7	1966 A	Geraldton District
385	R2 - T2	1966 B	Kimberly-Clark
385	R8 - T5	1966 B	Club Lake Road Area
385	R11- T2	1966 B	Geraldton District
387	R7 - T6	1966 A	Kimberly-Clark
387	R8 - T3	1966 A	Club Lake Road Area
387	R9 - T1	1966 A	Geraldton District
393	R6 - T10	1966 A	Kimberly-Clark Camp 35
393	R10- T6	1966 A	Geraldton District
393	R11- T6	1966 A	
491	R6 - T10	1967 B	Leonard Lake Area
491	R7 - T12	1967 A	Geraldton District
491	R10- T6	1967 A	
492	R7 - T6	1967 A	Leonard Lake Area
492	R12- T7	1967 A	Geraldton District
493	R3 - T9	1967 B	Beardmore Area
493	R5 - T5	1967 A	Nipigon District
493	R11- T6	1967 A	

[1]"R" represents row in block, "T" represents the tree number within row

APPENDIX B

In the table below, the genotypes at five enzyme loci are listed for the ramets used in this study. Identical numbers, (e.g., 11,22) indicate a homozygote at that locus, as alleles are expressed in bands moving at same speed during electrophoresis. Variable numbers, (e.g., 13,23), indicate heterozygote with the two alleles being expressed as bands travelling at different speeds. Ramets within clones must have the same genotypes at all loci analyzed to be considered genetically identical.

SUMMARY OF RESULTS OF ISOENZYME ANALYSIS CONDUCTED TO VERIFY PROPER IDENTIFICATION OF RAMETS USED IN THIS STUDY

	Enzyme Systems Analyzed[1]				
Ramet Number	PGI	PGM	SKDH	AAT	G2D
283-R1-T1	12		12	11	23
-R7-T2	12		12	11	23
-R11-T4	12		12	11	23
284-R4-T1 *	11	12	11	11	33
-R4-T6	12		22	11	33
-R8-T2	12		22	11	33
288-R5-T12	12	11	12	11	33
-R7-T9	12	11	12	11	33
-R10-T7	12	11	12	11	33
290-R4-T1	11	33		11	33
-R4-T6	11	33		11	33
-R11-T7	11	33	12	11	33
291-R9-T6	12	13	12	11	33
-R10-T3	12	13	12	11	33
-R11-T1	12	13	12	11	33
303-R10-T12	11		22	11	33
-R11-T5	11	22	22	11	33
-R12-T5	11		22	11	33
304-R4-T2	11		22	12	33
-R12-T1	11		22	12	33
-R12-T6	11		22	12	33
354-R2-T8	11	23	12	11	33
-R7-T7	11	23	12	11	
-R12-T6	11		12	11	33

Ramet Number	PGI	PGM	SKDH	AAT	G2D
355-R2-T9	11		22	11	22
-R3-T11	11		22	11	22
-R7-T7	11		22	11	22
367-R1-T8	11		22	11	13
-R4-T9	11		22	11	13
-R6-T8	11		22	11	13
369-R6-T11	11		12	11	33
-R10-T4	11		12	11	33
-R12-T8	11		12	11	33
370-R5-T1	01	23	12	11	33
-R12-T5	01		12	11	33
-R12-T8	01	23	12	11	33
383-R4-T3	01	13	22	11	33
-R9-T3	01	13	22	11	33
-R9-T7	01	13	22	11	33
385-R2-T2	11	11		11	33
-R8-T5	11	11	11	11	33
-R11-T2	11	11	11	11	33
387-R7-T6	11	11	11	11	33
-R8-T3	11	11	11	11	33
-R9-T1	11	11	11	11	33
393-R6-T9	11	11		11	33
-R10-T8	11	11		11	33
-R11-T6	11	11		11	33
491-R6-T10	12	13	22	11	33
-R7-T12	12	13	22	11	33
-R10-T6	12	13	22	11	33
492-R7-T6	11	22	11	12	33
-R12-T4 *	11	12	12	11	33
-R12-T7	11	22	11	12	33
493-R3-T9	11	11	12	01	33
-R5-T5	11	11	12	01	
-R11-T6	11	11	12	01	33

[1]PGI=Phosphoglucose Isomerase, PGM=Phosphoglucomutase, SKDH=Shikimic Acid Dehydrogenase, AAT=Aspartate Aminotransferase, G2D=Glycerate-2-Dehydrogenase

* Ramets that were excluded from this study, as some of their genotypes did not correspond to genotypes of other two ramets of the same clone.

APPENDIX C

GERMINATION TEST DATA

Ramet #	Replicate	# Seed in Sample	# Seed Germin-ated	# Seed Cut	# Sound Seed	# Decay-ed Seed	# Empty Seed	Germination % based on all filled Seed	Germination % based on sound Seed only	Days to r 90% of fi Germinati
283-1	1	25	10	10	0	9	1	42.6	100	7
	2	25	11	10	0	10	0	44	100	6.8
	3	25	15	10	3	5	2	65.2	83.3	11.8
283-2	1	30	18	10	0	9	1	62.5	100	9.6
	2	30	24	6	2	4	0	80	92.3	12.8
	3	30	18	10	0	10	0	60	100	13.2
283-3	1	25	16	9	0	9	0	64	100	8.5
	2	25	15	10	1	8	1	62.5	93.8	6.5
	3	25	13	10	0	10	0	52	100	9.7
284-1	1	45	28	10	1	9	0	62.2	94.2	14.2
	2	45	34	6	0	6	0	75.6	100	9.2
	3	40	19	10	2	5	3	56.4	81.9	12.2
284-2	1	50	41	9	5	4	0	82	89.1	13.3
	2	50	36	10	2	8	0	72	92.8	12.2
	3	50	40	10	8	2	0	80	83.3	13
288-1	1	20	15	5	0	5	0	75	100	8.5
	2	20	16	4	0	4	0	80	100	9.4
	3	20	14	6	1	2	3	82.4	93.3	8.6
288-2	1	50	42	8	3	5	0	84	93.3	10.3
	2	50	35	10	0	10	0	70	100	10.5
	3	50	34	10	2	8	0	68	91.4	11.6
288-3	1	40	32	8	2	6	0	80	91.4	10.8
	2	40	34	6	0	6	0	85	100	8.6
	3	35	32	3	1	1	1	94.1	97	11.8
290-1	1	20	20	0	0	0	0	100	100	9
	2	20	18	3	0	1	2	94.4	100	9.7
	3	20	16	6	1	2	3	87.5	94.1	7.6
290-2	1	25	20	5	4	1	0	80	83.3	11
	2	25	14	10	0	3	7	80.9	100	8.7
	3	25	12	10	1	7	2	53.6	90.2	10.1
290-3	1	25	19	6	0	4	2	82.6	100	10.1
	2	25	16	9	0	7	2	69.6	100	12.4
	3	25	12	10	0	6	4	60.6	100	10.4
291-1	1	35	18	10	1	9	0	51.4	91.4	9.2
	2	30	16	10	0	10	0	53.3	100	8.5
	3	30	12	10	0	9	1	42.6	100	15.1
291-2	1	40	21	10	3	7	0	52.5	78.7	10.9
	2	40	20	10	0	9	1	52.6	100	10.7
	3	35	25	10	0	10	0	71.4	100	6.5
291-3	1	20	13	7	0	6	1	68.4	100	5.9
	2	20	14	6	2	4	0	70	87.5	15.6
	3	20	14	6	1	3	2	77.8	93.3	11.6

Ramet #	Replicate	# Seed in Sample	# Seed Germin-ated	# Seed Cut	# Sound Seed	# Decay-ed Seed	# Empty Seed	Germination % based on all filled Seed	Germination % based on sound Seed only	Days to r 90% of fi Germinati
303-1	1	19	16	3	0	2	1	88.9	100	18.2
	2	20	20	0	0	0	0	100	100	15.7
	3	20	18	2	0	2	0	90	100	13.2
303-2	1	20	18	2	0	2	0	90	100	10.2
	2	20	20	0	0	0	0	100	100	9
	3	20	16	4	0	3	1	84.2	100	8.4
303-3	1	29	26	3	0	3	0	89.7	100	7.4
	2	30	24	6	1	5	0	80	96	6.5
	3	30	21	9	0	9	0	70	100	6.7
304-1	1	50	23	25	0	22	3	49.2	100	7.4
	2	50	25	25	0	22	3	53.2	100	10.5
	3	40	17	25	4	16	5	55.6	82.2	8.8
304-2	1	50	11	25	0	25	0	22	100	10
	2	50	16	25	3	21	1	32.9	79.7	11.4
	3	50	12	25	3	21	1	24.8	72.5	8.9
304-3	1	50	3	25	2	22	1	6.2	44.4	15.7
	2	50	0	25	2	22	1	0	0	17.2
	3	50	2	25	1	24	0	4	51	18.8
354-1	1	30	20	10	0	10	0	66.7	100	9
	2	30	15	10	3	7	0	50	76.9	9.5
	3	30	11	10	1	9	0	36.7	85.3	10.9
354-2	1	25	10	10	1	9	0	40	87	15
	2	25	7	10	2	8	0	28	66	15.3
	3	25	4	10	2	8	0	16	48.8	18.6
354-3	1	20	6	10	2	8	0	30	68.2	19.4
	2	20	7	10	1	8	1	37.4	84.3	14.4
	3	20	6	10	3	7	0	30	58.8	19.4
355-1	1	30	12	10	1	9	0	40	87	17.8
	2	30	13	10	2	8	0	43.3	74.7	19.7
	3	30	14	10	1	9	0	46.7	89.7	14.8
355-2	1	30	16	10	1	9	0	53.3	92	14.2
	2	30	10	10	3	7	0	33.3	62.5	8
	3	30	14	10	1	9	0	46.7	89.7	10.6
355-3	1	30	17	10	1	8	1	59.2	92.9	13.5
	2	30	10	10	1	9	0	33.3	83.3	11
	3	30	14	10	0	10	0	46.7	100	12.6
367-1	1	50	16	10	1	9	0	32	82.5	5
	2	50	14	10	0	10	0	28	100	16.6
	3	50	19	10	0	10	0	38	100	5.1
367-2	1	30	14	10	3	7	0	46.7	74.5	5.9
	2	30	10	10	1	9	0	33.3	83.3	4
	3	25	12	10	0	8	2	53.6	100	11.1
367-3	1	35	19	10	1	9	0	54.3	92.2	7.1
	2	35	17	10	4	6	0	48.6	70.2	9.3
	3	35	16	10	3	7	0	45.7	73.7	7.2
369-1	1	35	19	10	3	7	0	54.3	79.8	18.4
	2	35	17	10	3	7	0	48.6	75.9	16.1
	3	35	17	10	2	8	0	48.6	82.5	17.9
369-2	1	25	6	10	1	9	0	24	75.9	20.4
	2	25	8	10	2	8	0	32	70.2	17.2
	3	20	10	10	2	7	1	52.6	83.3	11

Ramet #	Replicate	# Seed in Sample	# Seed Germinated	# Seed Cut	# Sound Seed	# Decayed Seed	Empty Seed	Germination % based on all filled seed	Germination % based on sound seed only	Days to r 90% of fi Germinati
369-3	1	25	17	8	3	5	0	68	85	8.3
	2	25	11	10	2	8	0	44	79.7	7
	3	25	13	10	1	9	0	52	91.5	16.7
370-1	1	35	28	7	0	6	1	82.4	100	7.7
	2	35	32	3	1	2	0	91.4	97	8.8
	3	35	28	7	3	4	0	80	90.3	8.2
370-2	1	50	48	2	0	1	1	98	100	7.6
	2	50	43	7	4	3	0	86	91.5	8.4
	3	50	46	4	0	4	0	92	100	6.8
370-3	1	20	17	3	2	1	0	85	89.5	17.6
	2	20	16	4	0	4	0	80	100	8.4
	3	20	17	3	0	3	0	85	100	8.3
383-1	1	50	34	10	0	10	0	68	100	8.9
	2	50	37	10	0	10	0	74	100	8.8
	3	50	35	10	1	9	0	70	95.9	7.5
383-2	1	25	21	4	0	4	0	84	100	6.7
	2	25	20	5	1	4	0	80	95.2	9
	3	25	20	5	0	5	0	80	100	12
383-3	1	45	37	8	1	7	0	82.2	97.4	9.3
	2	45	39	6	3	3	0	87.7	92.9	9.5
	3	45	40	5	2	3	0	88.9	97.5	12
385-1	1	45	39	6	1	5	0	86.7	97.4	8.7
	2	45	38	7	1	6	0	84.4	97.2	10.1
	3	45	35	10	1	8	1	79.5	100	10.5
385-2	1	50	49	1	0	1	0	98	97.8	10.1
	2	50	45	5	1	4	0	90	95.7	10.6
	3	50	45	5	2	3	0	90	91.7	8.8
385-3	1	50	44	6	4	2	0	88	98	8.8
	2	50	48	2	1	1	0	96	100	9.8
	3	50	48	6	0	6	0	96	100	16.2
387-1	1	50	39	10	0	10	0	78	81.9	12.1
	2	50	38	10	7	3	0	76	88.8	10.3
	3	50	38	10	4	6	0	76	61.7	10.2
387-2	1	40	31	9	3	6	0	77.5	63.4	9.5
	2	40	32	8	1	7	0	80	65.3	11.8
	3	40	33	7	2	5	0	82.5	71.6	13.8
387-3	1	50	45	5	1	4	0	90	71.6	9.2
	2	50	45	5	1	4	0	90	75.8	8.7
	3	50	47	3	1	2	0	94	90	14.3
393-1	1	30	30	0	0	0	0	100	75	8
	2	30	28	2	0	2	0	93.3	71.6	7.7
	3	30	27	3	1	2	0	90	75.6	10.1
393-2	1	16	15	1	0	1	0	93.8	67.2	10.8
	2	20	17	3	0	3	0	85	71.6	9.3
	3	20	18	2	0	2	0	90	67.2	7.7
393-3	1	20	17	3	1	2	0	85	65.9	12.3
	2	19	15	4	3	0	1	83.3	50.8	7.9
	3	20	12	8	1	7	0	60	43.9	8.8

Ramet #	Replicate	# Seed in Sample	# Seed Germinated	# Seed cut	# Sound Seed	# Decayed Seed	# Empty Seed	Germination % based on all filled Seed	Germination % based on sound Seed only	Days to 90% of Germina
491-1	1	50	24	10	5	5	0	48	51.9	10.3
	2	50	31	10	1	9	0	62	55.6	12.4
	3	50	34	10	3	7	0	68	42.1	14.2
491-2	1	20	9	10	3	7	0	45	53.7	15.1
	2	20	13	7	4	3	0	65	60	14.8
	3	20	15	5	3	2	0	75	45	14.5
491-3	1	50	25	10	5	5	0	50	43.9	18.8
	2	50	24	10	7	3	0	48	39.2	18.5
	3	50	20	10	8	2	0	40	68	19
492-1	1	50	43	7	3	4	0	86	60.7	10.7
	2	50	38	10	3	7	0	76	63.4	9.7
	3	50	40	10	0	10	0	80	73.6	8
492-2	1	50	46	4	1	3	0	92	69.7	6.8
	2	50	44	6	3	3	0	88	73.6	9.8
	3	50	46	4	0	4	0	92	60.7	6
493-1	1	25	19	6	3	3	0	76	66.4	13.1
	2	25	21	4	1	3	0	84	60.7	12.9
	3	25	19	6	3	3	0	76	70.3	10.1
493-2	1	35	31	4	1	3	0	88.6	59	9.5
	2	35	25	10	3	6	1	73.5	80.2	8.8
	3	35	34	1	1	0	0	97.1	63.4	10.9
493-3	1	15	12	3	0	3	0	80	75	10.8
	2	15	14	1	0	1	0	93.3	75	9.6
	3	15	14	1	1	0	0	93.3	93.3	7.6
	TOTALS	5678	3758	1353			66			
	MEANS							67.8	90.3	11

APPENDIX D

FERTILIZER SCHEDULE FOR PROGENY TEST

	Fertilizer Concentration (ppm of 20-20-20 NPK)	
	Low Fertilizer	High Fertilizer
Date	Blocks	Blocks
March 23	25	25
March 27	25	100
March 30	25	200
April 14	25	200
April 23	25	200
May 1	25	200
May 6	0	200
May 11	25	200
May 15	0	200
May 18	25	200
May 25	0	200
May 30	25	200
June 2	0	200
June 9	25	200
June 16	0	200
June 24	25	200
July 1	25	200

APPENDIX E

SAMPLE CALCULATIONS OF COEFFICIENTS OF VARIANCE COMPONENTS

Calculation of coefficients of variance components for samples of unequal size according to Snedecor and Cochran (1967 p. 289).

$$n_o = (N - \sum n_i^2 / N) / a-1$$

where n_o = calculated variance component coefficient

a = number of classes (clones) = 19

n_i = size of sample in class i = 2 or 3 ramets per clone

$N = \sum n_i = 55$

$$n_o = ((17*3+2*2)-(17*3^2+2*2^2)/55)/18 = 2.89$$

Calculation of coefficients of variance components for seed weight test according to Sokal and Rohlf (1981 p. 294).

Number of seed lots per ramet in seed weight test.

Clone No.	Ramet 1	Ramet 2	Ramet 3
283	10	10	10
284	7	10	N/A
288	10	10	8
290	8	8	9
291	10	9	8
303	8	9	8
304	10	10	10
354	10	10	10
355	10	8	10
367	10	10	10
369	7	9	10
370	10	10	10
383	10	10	10
385	10	10	10
387	10	10	10
393	10	10	10
491	10	5	10
492	10	10	N/A
493	10	10	9

$MS_{clones} = 74.69 = s_e^2 + n'_o s_R^2 + (nb)_o s_C^2$

$MS_{ramets} = 5.90 = s_e^2 + n_o s_R^2$

$MS_{error} = .25 = s_e^2$

Calculations:

Quantity 1 = sum of seed lots per ramet
= 10+10+10+...+10+10+9 = 522

Quantity 2 = sum of squares of seed lots per ramet
= 100+100+100+...+100+100+81 = 5012

Quantity 3 = sum of squares of seed lots per clone
$= 30^2+17^2+28^2+...+25^2+20^2+29^2 = 14578$

Quantity 4 = sum of squares of seed lots per ramet divided by number of seed lots per clone
$=(10^2+10^2+10^2)/30+(7^2+10^2)/17+...+(10^2+10^2+9^2)/29$
= 181.31

$n'_o = (181.31-(5012/522)/18 = 9.54$

$n_o = (522-181.31)/36 = 9.46$

$(nb)_o = (522-(14578/522))/18 = 27.45$

Calculation of variance components:

$s_e^2 = .25$

$s_R^2 = (MS_R - MS_{error})/n_o = (5.90-.25)/9.46 = .60$

$s_C^2 = (MS_C - MS_{error} - 9.54 s_R^2)/(nb)_o$
$= (74.69-.25-9.54*.60)/27.45 = 2.50$

APPENDIX F

SEEDLING HEIGHTS AND ANALYSES OF VARIANCE OF PARTIAL REPLICATIONS USED TO ESTIMATE EXPERIMENTAL ERROR IN PROGENY TEST

Blck.	Fert.	Ramet No.	Seedling Heights (cm)														
			Three Months				Mean	Four Months				Mean	Five Months				Mean
1	high	393R11T6	8.6	8.7	7.2	7.7	8.05	14.6	14.3	18.4	16.3	15.9	28.1	24.5	31.2	22.5	26.6
		493R11T6	8.4	8.4	7.2	7.7	7.93	14.7	14.6	17	15.6	15.5	27.2	28.3	29.5	29.5	28.6
		493R3T9	9.6	6.9	8.8	9.2	8.63	19.8	16.6	15.5	20.6	18.1	33.7	31.2	27.8	36.5	32.3
		355R3T11	8.9	8.6	10.1	7.5	8.78	17.1	19.3	18.4	20	18.7	30.3	32.4	34.1	23.6	30.1
		492R7T6	10	11.3	11.7	11.7	11.2	22	20	25.2	19.5	21.7	29.9	30.6	31.7	29.8	30.5
		393R10T8	8.7	8.8	7.8	9.8	8.78	19.4	18.1	19.3	18	18.7	34.7	33.1	34	30.9	33.2
	low	385R2T2	11.1	8.5	8.2	8	8.95	14.2	10.3	12.4	10.5	11.9	14.5	10.4	12.9	10.4	12.1
		288R10T7	6.1	7.5	7.1	9.4	7.53	10.3	10.6	10.6	14	11.4	13.4	11	10.8	14.6	12.5
		492R12T7	6.2	10.5	8.6	10.5	8.95	9.7	12.7	12.5	14.6	12.4	10.1	13	13.1	14.7	12.7
		387R9T1	8.4	8.8	9	7.7	8.48	12	11	11	10	11	12.3	10.7	11.1	10.3	11.1
		491R6T10	8.4	8.5	9.2	9.3	8.85	12.2	12.8	13.2	13.2	12.9	14.4	14.7	14.6	15.6	14.8
		291R9T6	7.6	9	8.5	9.7	8.7	13.4	12.7	11	13.7	12.7	17.3	12.8	11.3	13.8	13.8
2	high	304R12T1	7.6	9.2	8.6	8.5	8.48	18.7	18.7	19.1	16.6	18.3	29.2	28.4	31.1	30.3	29.8
		303R11T5	8.1	8.6	8.3	11.5	9.13	25.8	18.4	20.3	19.4	21.0	30.2	35.4	30.7	42	34.6
		367R6T8	10	9.1	10.7	9.8	9.9	22.2	22.3	19.6	20.2	21.1	37.5	37.7	26.8	34.9	34.2
		290R4T1	10.2	8.2	10.4	5.4	8.55	23.6	19.5	21.4	8.3	18.2	38.8	31.4	34.7	8.6	28.4
		370R12T8	8.2	11	8.6	9.5	9.33	15.6	21.4	18.6	19.2	18.7	24.6	37.8	33.2	32.3	32.0
		387R9T1	10.4	9.4	9.7	10.4	9.98	21.2	18.7	18.5	19.1	19.4	34.1	29.6	32	19.6	28.8
	low	354R7T7	8.9	8.1	9	8.6	8.65	13.2	11.6	12	12.5	12.3	14.2	11.5	14.6	12.5	13.2
		354R2T8	9	6.5	6.7	8.1	7.58	11	9	7.8	11.6	9.85	11.5	9.3	8.1	11.6	10.1
		355R7T7	9.1	8.1	7.4	7.5	8.03	13.1	12.1	10.8	10.2	11.6	13.5	12.6	10.9	10.6	11.9
		492R12T4	5.6	6.7	8.1	9.1	7.38	9.8	9.5	12	11.6	10.7	10.4	9.9	12.3	12.2	11.2
		284R4T1	8.1	7	5	9.4	7.38	11.5	9.5	6.7	11.7	9.85	12	9.7	7	12	10.2
		387R8T3	8.2	6.7	7.2	8	7.53	11	8.6	10.1	11.1	10.2	11	8.6	10.5	11.1	10.3
3	high	369R11T1	9.7	8.9	8.9	9.2	9.18	21.8	19.7	21	22	21.1	38.3	33.7	23.7	36.6	33.1
		290R11T7	8.9	8.2	7.9	10.4	8.85	19.3	19.2	17.7	18.4	18.7	38	33	31.8	31.1	33.5
		370R12T5	10	10.3	9.1	9.1	9.63	22	22.5	18.5	20.2	20.8	37.7	39.7	33.1	37.2	36.9
		303R10T12	10.6	7	10.5	10.7	9.7	25.4	18.3	24.1	23.7	22.9	40.1	30.2	39	35.5	36.2
		291R11T1	13.1	10.8	9.4	12.7	11.5	26.7	22	22	26.9	24.4	44.3	33.2	36.4	45.3	39.8
		354R12T6	10.5	10.2	10	10.1	10.2	22.7	20.3	22.3	23.2	22.1	35.6	35.2	40.4	41	38.1
	low	290R4T6	7	7.2	6.1	7.6	6.98	11.2	9.6	8.3	11.9	10.3	14.3	9.9	8.8	12.6	11.4
		367R4T9	6.6	8	9.2	7.2	7.75	11.8	11	10.5	8.8	10.5	12	11.1	10.4	9	10.6
		387R7T6	6.6	8.2	7.3	9.7	7.95	8.5	10.3	9	13.6	10.4	9	10.4	9.2	13.7	10.6
		385R11T2	8	6	7.4	8.1	7.38	11.4	9.3	10.5	12.1	10.8	11.2	10.1	10.7	12.2	11.1
		491R10T6	7	7.1	7	8.1	7.3	10	12.2	11.1	11.5	11.2	10.6	16.6	11.8	12.1	12.8
		370R5T1	7.5	8.5	8.6	8.1	8.18	14.1	11.5	11.7	10.2	11.9	14.7	14.6	11.9	10.8	13
4	high	355R2T9	9.1	7.5	6	9.6	8.05	20.1	14.1	10.6	21.6	16.6	36.1	26.1	11.4	37.2	27.7
		383R9T3	7.8	8.5	7.9	8.3	8.13	17.1	19.1	19	17.8	18.3	30.4	31.1	35.2	32.6	32.3
		304R12T6	6.5	8.5	8.5	8.1	7.9	12.9	17.7	17.6	16.7	16.2	24	34.1	31.2	27.4	29.2
		493R5T5	10.1	7.9	8.6	8.5	8.78	23	18.2	19	17.6	19.5	34	30.7	30.4	30.3	31.4
		284R4T6	8	10.1	7.4	9.6	8.78	16.6	20.5	15.3	19.6	18	30.4	36.4	16	33.7	29.1
		283R7T2	9.3	8.5	8.8	9.6	9.05	20.2	18.7	18.4	18.8	19.0	33.6	32.8	29.1	33.9	32.4
	low	369R10T4	6.6	6.3	7.1	8	7	10.5	10.2	10.2	11	10.5	10.7	10.5	14.9	11.7	12.0
		283R1T1	8.3	6.7	8.8	7.1	7.73	12.6	11	10.5	11.1	11.3	13.7	11.4	11	11.5	11.9
		383R4T3	7.5	7.5	9.3	8.8	8.28	13.1	12	10.1	9.5	11.2	13	12.1	10.4	9.9	11.4
		288R5T12	9.9	8.7	8.2	7.8	8.65	13.3	14.1	12.7	11.5	12.9	13.5	14.7	12.9	12.1	13.3
		383R9T7	6.7	9.4	6.1	8.8	7.75	9.6	13	8.6	11.2	10.6	10.3	13	8.3	11.4	10.8
		304R4T2	8.5	7.1	7.5	6.9	7.5	12.8	11.6	11.8	10.6	11.7	16.9	12.1	12.3	12.1	13.4

Analyses of variance used to obtain estimates of experimental error from partial replications in progeny test.

Source of Variation	df	Mean Squares of Seedling Heights at:		
		3 Months	4 Months	5 Months
Ramets	47	6.18	150.74	879.06
Exp. Error[1]	48	1.14	7.36	53.51
Samp. Error	288	1.17	4.42	44.05
Total	483			

[1] mean square of this source used to estimate experimental error in analyses of variance of progeny test (Table 16).

APPENDIX G

CONE ANALYSIS RAW DATA

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
283-R1-T1									
1	2.20	25.50	1	3	21	45	70	14	20.00
2	1.80	24.50	0	2	24	41	67	8	11.94
3	1.70	23.20	0	9	14	39	62	8	12.90
4	1.40	22.30	0	3	4	59	66	6	9.09
5	1.50	23.50	0	7	9	42	58	11	18.97
6	2.00	25.00	0	1	19	49	69	3	4.35
7	1.30	21.30	0	5	12	41	58	4	6.90
8	1.70	23.70	0	11	10	44	65	11	16.92
9	1.40	24.20	0	3	15	49	67	9	13.43
10	0.90	18.80	0	2	13	40	55	10	18.18
MEAN	1.59	23.20	0.10	4.60	14.10	44.90	63.70	8.40	13.27
283-R7-T2									
1	2.10	26.10	3	9	15	41	68	12	17.65
2	2.00	23.40	0	7	21	35	63	12	19.05
3	2.70	28.20	0	0	20	49	69	10	14.49
4	1.50	18.20	0	2	12	32	46	6	13.04
5	1.80	24.30	0	6	14	38	58	13	22.41
6	1.60	21.40	0	8	11	26	45	13	28.89
7	2.40	26.40	1	10	15	44	70	9	12.86
8	1.70	23.70	0	2	8	44	54	6	11.11
9	1.70	21.30	0	8	12	34	54	7	12.96
10	1.60	22.50	0	6	14	27	47	5	10.64
MEAN	1.91	23.55	0.40	5.80	14.20	37.00	57.40	9.30	16.31
283-R11-T4									
1	2.40	26.10	0	2	19	43	64	10	15.63
2	3.30	29.30	0	3	16	51	70	9	12.86
3	1.90	23.20	0	4	14	33	51	4	7.84
4	2.90	27.80	0	6	9	62	77	9	11.69
5	1.40	24.00	0	3	10	38	51	6	11.76
6	2.30	24.50	0	5	8	58	71	5	7.04
7	2.50	27.10	0	4	11	54	69	9	13.04
8	2.70	27.50	0	5	13	54	72	11	15.28
9	1.80	24.10	0	4	7	47	58	11	18.97
10	2.80	28.50	0	3	16	50	69	6	8.70
MEAN	2.40	26.21	0.00	3.90	12.30	49.00	65.20	8.00	12.28

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
284-R4-T6									
1	1.60	21.50	2	8	9	43	62	17	27.42
2	2.70	26.80	23	0	27	33	83	23	27.71
3	1.90	22.20	4	1	13	64	82	6	7.32
4	2.30	23.20	11	1	11	61	84	16	19.05
5	1.50	21.30	1	5	8	63	77	5	6.49
6	2.10	24.50	24	0	10	43	77	20	25.97
7	2.00	23.40	3	0	13	60	76	4	5.26
8	1.10	19.00	1	2	18	54	75	10	13.33
9	1.80	23.20	12	1	10	58	81	9	11.11
10	1.60	21.90	4	10	12	48	74	12	16.22
MEAN	1.86	22.70	8.50	2.80	13.10	52.70	77.10	12.20	15.99
284-R8-T2									
1	2.80	27.50	13	0	23	50	86	12	13.95
2	3.20	27.80	13	0	31	51	95	36	37.89
3	2.60	26.00	8	1	34	34	77	26	33.77
4	2.90	28.20	0	0	37	53	90	23	25.56
5	2.60	26.00	5	0	26	42	73	27	36.99
6	3.10	28.00	2	0	35	56	93	34	36.56
7	2.50	25.20	9	0	20	45	74	25	33.78
8	2.50	26.50	10	4	17	47	78	25	32.05
9	2.70	26.50	17	0	23	41	81	27	33.33
10	2.30	25.50	8	0	18	48	74	33	44.59
MEAN	2.72	26.72	8.50	0.50	26.40	46.70	82.10	26.80	32.85

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
288-R5-T12									
1	0.90	17.00	3	16	4	33	56	2	3.57
2	1.30	20.40	27	11	8	21	67	9	13.43
3	1.30	20.50	7	7	18	30	62	11	17.74
4	0.70	17.30	7	14	3	22	46	4	8.70
5	1.10	18.50	8	6	11	39	64	5	7.81
6	1.10	19.00	7	9	5	42	63	5	7.94
7	1.10	19.60	5	18	15	22	60	7	11.67
8	1.00	19.60	4	1	2	46	53	15	28.30
9	0.90	18.40	0	8	14	29	51	3	5.88
10	1.10	20.00	20	5	6	28	59	5	8.47
MEAN	1.05	19.03	8.80	9.50	8.60	31.20	58.10	6.60	11.35
288-R7-T9									
1	1.80	24.60	1	9	11	37	58	22	37.93
2	2.00	24.50	0	10	22	36	68	31	45.59
3	1.60	23.00	15	7	16	28	66	11	16.67
4	2.00	24.60	0	4	14	52	70	23	32.86
5	1.40	21.90	18	15	14	10	57	10	17.54
6	1.60	24.10	1	10	24	25	60	24	40.00
7	1.00	18.20	19	5	2	28	54	3	5.56
8	1.70	23.50	0	19	0	44	63	23	36.51
9	1.60	24.90	0	1	1	51	53	14	26.42
10	1.30	21.70	15	13	5	32	65	15	23.08
MEAN	1.60	23.09	6.90	9.30	10.90	34.30	61.40	17.60	28.21
288-R10-T7									
1	1.90	24.60	16	22	7	33	78	23	29.49
2	1.30	20.60	9	19	18	17	63	10	15.87
3	1.30	21.80	15	7	6	31	59	17	28.81
4	1.30	21.20	12	8	13	31	64	11	17.19
5	1.50	21.40	13	13	12	32	70	16	22.86
6	1.40	21.00	3	16	9	40	68	12	17.65
7	1.00	19.00	6	10	12	29	57	7	12.28
8	1.30	20.70	5	14	14	36	69	6	8.70
9	1.00	19.10	4	13	5	36	58	5	8.62
10	1.20	20.40	4	14	15	30	63	13	20.63
MEAN	1.32	20.98	8.70	13.60	11.10	31.50	64.90	12.00	18.21

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
290-R4-T1									
1	2.10	22.30	4	17	8	52	81	1	1.23
2	2.30	25.50	0	0	25	57	82	7	8.54
3	2.10	24.10	7	1	24	45	77	6	7.79
4	2.40	25.40	5	14	15	64	98	11	11.22
5	1.80	22.40	4	1	3	54	62	4	6.45
6	2.40	25.70	4	3	1	76	84	1	1.19
7	1.90	23.50	5	3	11	54	73	11	15.07
8	1.90	22.50	7	1	7	55	70	12	17.14
9	1.80	21.20	4	12	0	53	69	6	8.70
10	1.70	20.50	4	11	11	46	72	5	6.94
MEAN	2.04	23.31	4.40	6.30	10.50	55.60	76.80	6.40	8.43
290-R4-T6									
1	1.50	20.20	0	0	9	67	76	5	6.58
2	2.10	23.20	4	0	2	76	82	5	6.10
3	1.90	23.10	10	5	6	54	75	22	29.33
4	1.70	22.30	0	2	13	54	69	10	14.49
5	0.80	18.40	0	0	0	47	47	12	25.53
6	1.60	20.70	0	6	1	65	72	8	11.11
7	1.90	22.70	4	6	0	74	84	7	8.33
8	1.80	22.30	1	0	0	76	77	7	9.09
9	2.00	22.70	1	1	0	80	82	9	10.98
10	1.60	21.50	9	3	1	54	67	10	14.93
MEAN	1.69	21.71	2.90	2.30	3.20	64.70	73.10	9.50	13.65
290-R11-T7									
1	2.00	23.10	4	0	6	79	89	1	1.12
2	1.50	20.30	6	13	2	52	73	6	8.22
3	2.20	24.00	3	1	20	66	90	19	21.11
4	1.90	23.00	3	6	0	69	78	12	15.38
5	1.90	22.00	9	10	3	68	90	4	4.44
6	1.90	22.10	4	14	2	69	89	20	22.47
7	2.20	25.00	0	13	0	72	85	15	17.65
8	1.30	19.90	6	21	11	29	67	5	7.46
9	1.60	20.00	0	6	3	67	76	3	3.95
10	1.50	20.40	3	10	2	59	74	4	5.41
MEAN	1.80	21.98	3.80	9.40	4.90	63.00	81.10	8.90	10.72

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
291-R9-T6									
1	3.60	28.20	37	8	1	45	91	23	25.27
2	3.70	31.40	22	15	1	60	98	16	16.33
3	1.90	24.00	17	5	0	43	65	7	10.77
4	2.10	24.60	12	8	1	56	77	10	12.99
5	2.00	24.50	14	5	13	38	70	0	0.00
6	3.00	28.20	19	11	0	44	74	22	29.73
7	3.90	29.80	20	8	1	61	90	15	16.67
8	2.80	25.50	12	8	0	58	78	9	11.54
9	2.90	28.10	26	6	0	49	81	13	16.05
10	2.70	27.80	12	12	0	67	91	7	7.69
MEAN	2.86	27.21	19.10	8.60	1.70	52.10	81.50	12.20	14.70
291-R10-T3									
1	3.60	31.40	25	19	0	51	95	5	5.26
2	3.80	30.40	33	11	1	46	91	13	14.29
3	3.10	29.80	23	5	0	58	86	20	23.26
4	2.20	26.00	25	10	1	24	60	11	18.33
5	4.50	34.10	34	27	1	33	95	23	24.21
6	3.20	29.00	35	11	0	41	87	7	8.05
7	4.00	34.30	17	7	1	63	88	23	26.14
8	3.50	31.90	21	7	0	50	78	17	21.79
9	3.80	32.80	19	16	0	65	100	7	7.00
10	3.90	32.30	14	20	0	57	91	4	4.40
MEAN	3.56	31.20	24.60	13.30	0.40	48.80	87.10	13.00	15.27
291-R11-T1									
1	1.50	21.40	8	11	10	51	80	4	5.00
2	1.30	19.80	6	4	5	49	64	2	3.13
3	1.80	22.70	14	5	3	64	86	1	1.16
4	1.90	23.20	20	10	1	49	80	6	7.50
5	2.30	24.50	17	6	3	75	101	4	3.96
6	2.20	26.90	21	13	9	46	89	15	16.85
7	2.10	24.50	14	5	12	61	92	11	11.96
8	2.50	26.40	22	8	13	46	89	17	19.10
9	2.10	24.00	15	14	1	51	81	6	7.41
10	1.60	21.50	22	5	4	46	77	5	6.49
MEAN	1.93	23.49	15.90	8.10	6.10	53.80	83.90	7.10	8.26

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
303-R10-T12									
1	1.90	23.30	39	19	7	16	81	4	4.94
2	2.00	23.70	49	21	3	10	83	11	13.25
3	1.70	22.30	38	14	6	15	73	7	9.59
4	1.90	23.70	35	14	12	15	76	6	7.89
5	1.80	23.70	52	14	1	11	78	4	5.13
6	1.70	22.50	49	13	3	11	76	2	2.63
7	2.10	24.80	42	20	7	16	85	10	11.76
8	1.70	23.30	39	15	5	15	74	9	12.16
9	2.00	25.00	41	20	2	14	77	5	6.49
10	1.50	23.00	45	6	3	7	61	6	9.84
MEAN	1.83	23.53	42.90	15.60	4.90	13.00	76.40	6.40	8.37
303-R11-T5									
1	2.30	27.00	65	6	3	13	87	7	8.05
2	2.30	25.70	51	19	6	23	99	6	6.06
3	2.50	27.00	64	12	3	20	99	11	11.11
4	1.70	24.30	44	15	7	13	79	5	6.33
5	2.40	26.80	45	18	6	30	99	4	4.04
6	2.10	24.80	30	35	5	23	93	9	9.68
7	2.60	27.20	39	28	13	18	98	18	18.37
8	2.40	26.60	55	21	8	17	101	7	6.93
9	2.00	25.00	50	17	1	24	92	3	3.26
10	1.50	22.30	37	12	7	17	73	1	1.37
MEAN	2.18	25.67	48.00	18.30	5.90	19.80	92.00	7.10	7.52
303-R12-T5									
1	1.40	22.00	0	1	0	48	49	0	0.00
2	2.20	25.70	45	10	2	42	99	8	8.08
3	2.70	27.80	55	17	13	19	104	11	10.58
4	2.20	25.20	38	12	3	26	79	7	8.86
5	2.70	28.00	40	22	2	43	107	5	4.67
6	3.30	29.60	39	37	5	34	115	11	9.57
7	3.00	29.30	41	30	6	28	105	13	12.38
8	3.10	28.50	43	25	7	32	107	13	12.15
9	2.30	25.60	16	19	3	58	96	14	14.58
10	2.20	25.30	13	17	4	48	82	12	14.63
MEAN	2.51	26.70	33.00	19.00	4.50	37.80	94.30	9.40	9.55

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
304-R4-T2									
1	2.50	25.60	14	0	7	36	57	12	21.05
2	2.60	26.60	13	0	13	36	62	15	24.19
3	2.50	25.90	0	0	6	43	49	19	38.78
4	2.10	24.10	20	11	6	23	60	11	18.33
5	2.70	26.00	5	0	14	44	63	27	42.86
6	2.40	25.70	10	4	11	29	54	10	18.52
7	2.10	23.30	13	0	10	22	45	7	15.56
8	2.50	23.40	4	0	7	46	57	16	28.07
9	1.90	23.00	17	0	6	23	46	21	45.65
10	2.10	24.50	7	0	7	44	58	17	29.31
MEAN	2.34	24.81	10.30	1.50	8.70	34.60	55.10	15.50	28.23
304-R12-T1									
1	2.20	25.10	5	15	3	43	66	13	19.70
2	3.40	28.30	0	0	1	75	76	28	36.84
3	2.20	23.70	1	0	10	56	67	15	22.39
4	1.90	22.20	14	0	8	35	57	10	17.54
5	3.10	27.20	11	2	2	75	90	12	13.33
6	3.50	28.00	1	0	17	74	92	23	25.00
7	1.90	23.80	9	0	2	50	61	15	24.59
8	2.50	25.70	0	0	9	58	67	19	28.36
9	2.20	24.90	0	0	30	38	68	20	29.41
10	2.20	24.70	3	0	0	58	61	12	19.67
MEAN	2.51	25.36	4.40	1.70	8.20	56.20	70.50	16.70	23.68
304-R12-T6									
1	2.40	23.40	3	0	9	41	53	25	47.17
2	3.80	29.30	0	0	8	60	68	26	38.24
3	3.00	26.70	0	0	6	67	73	13	17.81
4	2.60	24.30	13	0	3	43	59	18	30.51
5	3.30	26.20	1	0	11	63	75	8	10.67
6	4.20	29.30	1	0	22	82	105	28	26.67
7	2.70	25.50	3	0	2	66	71	10	1[illegible].08
8	3.00	25.50	1	0	4	62	67	25	37.31
9	2.30	23.50	3	0	8	49	60	15	25.00
10	3.30	27.80	0	0	17	59	76	19	25.00
MEAN	3.[illegible]	26.15	2.50	0.00	9.00	59.20	70.70	18.70	27.25

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
354-R2-T8									
1	1.70	24.90	17	7	10	35	69	13	18.84
2	1.50	22.20	13	6	9	32	60	11	18.33
3	1.40	23.20	16	12	8	28	64	9	14.06
4	2.00	24.20	19	4	19	28	70	15	21.43
5	1.70	24.50	31	11	7	15	64	15	23.44
6	1.40	22.00	23	4	5	20	52	11	21.15
7	1.60	24.80	22	2	8	40	72	2	2.78
8	1.50	20.50	35	5	3	18	61	14	22.95
9	1.00	18.50	14	0	6	33	53	0	0.00
10	1.10	20.00	33	6	1	12	52	13	25.00
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MEAN	1.49	22.48	22.30	5.70	7.60	26.10	61.70	10.30	16.80
354-R7-T7									
1	1.90	22.30	11	4	19	30	64	6	9.38
2	1.40	21.20	13	5	13	38	69	6	8.70
3	1.40	23.30	32	3	7	15	57	15	26.32
4	1.80	23.50	23	6	5	31	65	8	12.31
5	2.30	23.80	26	3	12	30	71	8	11.27
6	1.80	23.70	16	4	16	30	66	7	10.61
7	1.60	20.40	31	1	4	21	57	5	8.77
8	1.70	21.00	11	7	12	31	61	19	31.15
9	1.70	23.00	9	6	8	38	61	7	11.48
10	1.00	18.70	13	7	3	23	46	4	8.70
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MEAN	1.66	22.09	18.50	4.60	9.90	28.70	61.70	8.50	13.87
354-R12-T6									
1	1.70	22.40	21	7	9	9	46	8	17.39
2	2.10	25.30	20	8	13	17	58	6	10.34
3	1.70	22.60	13	15	15	12	55	5	9.09
4	2.50	22.50	22	20	10	17	69	9	13.04
5	1.60	21.90	23	11	7	12	53	6	11.32
6	1.60	21.20	22	1	10	13	46	1	2.17
7	2.00	24.20	21	6	6	23	56	6	10.71
8	1.50	21.10	13	3	6	25	47	10	21.28
9	1.20	19.50	19	3	7	19	48	6	12.50
10	1.40	22.00	22	3	12	26	63	10	15.87
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MEAN	1.73	22.27	19.60	7.70	9.50	17.30	54.10	6.70	12.37

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
355-R2-T2									
1	1.60	22.10	12	13	2	44	71	9	12.68
2	1.90	24.50	4	1	12	64	81	8	9.88
3	2.60	27.40	37	0	9	37	83	16	19.28
4	2.30	26.50	12	0	16	67	95	11	11.58
5	1.80	23.80	3	3	17	53	76	9	11.84
6	1.50	23.00	5	10	5	44	64	14	21.88
7	1.40	21.30	4	6	16	43	69	4	5.80
8	1.70	23.30	3	0	11	55	69	6	8.70
9	1.90	25.10	6	1	19	56	82	15	18.29
10	1.40	22.60	8	2	11	38	59	11	18.64
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MEAN	1.81	23.96	9.40	3.60	11.80	50.10	74.90	10.30	13.86
355-R3-T11									
1	2.00	26.50	5	0	14	65	84	12	14.29
2	1.40	23.20	7	4	16	43	70	7	10.00
3	1.40	20.30	8	9	9	43	69	8	11.59
4	1.50	24.10	1	4	4	48	57	13	22.81
5	1.50	22.80	13	8	7	46	74	8	10.81
6	1.60	22.80	13	8	14	35	70	12	17.14
7	1.50	23.30	8	15	8	42	73	7	9.59
8	1.60	23.70	8	0	23	43	74	13	17.57
9	1.50	23.10	11	0	12	38	61	13	21.31
10	1.70	25.00	11	8	11	48	78	16	20.51
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MEAN	1.57	23.48	8.50	5.60	11.80	45.10	71.00	10.90	15.56
355-R7-T7									
1	1.20	21.10	8	4	12	37	61	7	11.48
2	1.70	26.20	8	0	21	36	65	8	12.31
3	1.20	18.10	1	6	8	30	45	6	13.33
4	1.30	23.00	4	2	16	33	55	11	20.00
5	2.00	25.60	17	0	13	59	89	21	23.60
6	1.80	24.60	5	13	12	51	81	8	9.88
7	1.50	22.80	15	2	13	34	64	14	21.88
8	1.60	24.10	17	12	13	24	66	10	15.15
9	1.60	23.20	10	9	6	36	61	9	14.75
10	1.10	19.50	4	6	6	38	54	1	1.85
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MEAN	1.50	22.82	8.90	5.40	12.00	37.80	64.10	9.50	14.42

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
367-R1-T8									
1	3.40	32.50	24	1	34	49	108	29	26.85
2	2.20	25.30	7	16	12	49	84	26	30.95
3	3.20	30.80	18	3	24	46	91	22	24.18
4	2.50	27.30	10	1	32	27	70	14	20.00
5	1.90	25.50	22	9	24	25	80	8	10.00
6	2.50	27.30	31	6	25	24	86	14	16.28
7	2.10	26.10	6	2	34	38	80	24	30.00
8	3.10	31.20	11	1	50	38	100	27	27.00
9	2.50	29.50	14	6	30	27	77	16	20.78
10	2.50	28.40	10	0	30	44	84	10	11.90
MEAN	2.59	28.39	15.30	4.50	29.50	36.70	86.00	19.00	21.79
367-R4-T9									
1	2.30	27.30	17	19	11	34	81	5	6.17
2	2.10	27.10	19	10	27	32	88	6	6.82
3	2.00	25.50	10	5	30	39	84	14	16.67
4	2.40	27.60	13	15	30	31	89	9	10.11
5	2.10	28.00	16	22	20	28	86	7	8.14
6	1.50	22.20	11	7	5	45	68	10	14.71
7	2.20	27.50	30	0	21	28	79	11	13.92
8	1.90	25.70	14	0	32	35	81	9	11.11
9	2.10	25.90	11	11	22	35	79	6	7.59
10	2.30	27.60	19	18	20	29	86	18	20.93
MEAN	2.09	26.44	16.00	10.70	21.80	33.60	82.10	9.50	11.62
367-R6-T8									
1	1.90	24.00	18	14	14	22	68	6	8.82
2	1.60	23.70	17	12	18	16	63	9	14.29
3	1.80	25.30	21	9	13	25	68	13	19.12
4	2.90	30.40	24	11	32	25	92	9	9.78
5	3.10	29.60	29	10	22	42	103	20	19.42
6	2.30	28.00	35	6	17	21	79	22	27.85
7	2.10	25.80	30	2	20	25	77	12	15.58
8	1.80	23.70	6	3	17	48	74	5	6.76
9	2.50	28.40	22	3	27	38	90	17	18.89
10	1.90	25.40	1	2	7	45	55	3	5.45
MEAN	2.19	26.43	20.30	7.20	18.70	30.70	76.90	11.60	14.60

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR:				TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
			EXTR.1	EXTR.2	EXTR.3	DISSECTION			
369-R6-T11									
1	2.40	25.20	10	7	15	65	97	8	8.25
2	3.20	29.40	11	3	20	75	109	19	17.43
3	2.30	25.00	13	9	18	60	100	8	8.00
4	1.70	23.00	11	14	8	49	82	5	6.10
5	2.40	25.90	9	5	20	58	92	9	9.78
6	2.60	26.10	17	0	21	52	90	10	11.11
7	3.30	29.30	23	0	15	74	112	17	15.18
8	2.00	23.70	14	0	17	45	76	9	11.84
9	2.20	25.30	1	0	8	78	87	11	12.64
10	2.70	27.30	15	6	18	53	92	23	25.00
MEAN	2.48	26.02	12.40	4.40	16.00	60.90	93.70	11.90	12.53
369-R10-T4									
1	1.60	23.00	11	6	10	49	76	1	1.32
2	2.80	27.50	24	1	20	42	87	9	10.34
3	2.00	25.00	7	2	24	62	95	5	5.26
4	2.50	26.80	7	0	25	61	93	2	2.15
5	2.20	25.20	17	0	19	38	74	9	12.16
6	2.30	26.80	11	6	28	43	88	6	6.82
7	2.00	24.60	7	7	23	42	79	2	2.53
8	3.10	27.20	14	2	21	58	95	21	22.11
9	2.70	27.80	7	1	16	77	101	3	2.97
10	2.60	27.80	16	1	21	45	83	15	18.07
MEAN	2.38	26.37	12.10	2.60	20.70	51.70	87.10	7.30	8.37
369-R11-T4									
1	2.10	24.30	18	0	15	43	76	6	7.89
2	3.10	28.20	30	0	15	62	107	18	16.82
3	1.90	22.60	8	0	8	52	68	2	2.94
4	2.40	25.70	11	0	11	59	81	12	14.81
5	3.00	28.00	30	5	17	52	104	11	10.58
6	3.00	28.60	20	0	9	68	97	16	16.49
7	2.80	27.80	26	0	24	44	94	6	6.38
8	2.90	27.30	19	1	24	58	102	4	3.92
9	2.50	26.60	21	3	18	55	97	8	8.25
10	1.80	23.50	6	5	10	49	70	4	5.71
MEAN	2.55	26.26	18.90	1.40	15.10	54.20	89.60	8.70	9.38

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
370-R5-T1									
1	2.50	26.70	14	17	13	21	65	15	23.08
2	1.90	23.20	14	10	10	13	47	9	19.15
3	2.70	27.10	14	25	7	23	69	10	14.49
4	1.70	22.60	10	9	6	26	51	11	21.57
5	2.30	26.50	17	22	3	27	69	11	15.94
6	3.00	27.50	16	17	0	39	72	24	33.33
7	3.30	30.70	29	20	6	33	88	26	29.55
8	1.10	19.50	0	0	0	9	9	0	0.00
9	2.80	27.90	9	21	12	27	69	3	4.35
10	2.20	26.00	0	17	6	24	47	7	14.89
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MEAN	2.35	25.77	12.30	15.80	6.30	24.20	58.60	11.60	17.63
370-R12-T5									
1	2.70	28.60	38	20	10	11	79	15	18.99
2	2.20	25.00	26	21	5	9	61	15	24.59
3	3.20	29.40	17	24	2	28	71	26	36.62
4	1.00	18.90	0	1	0	18	19	5	26.32
5	2.00	23.70	25	16	8	16	65	16	24.62
6	1.90	25.10	22	13	13	18	66	10	15.15
7	2.60	28.20	31	17	9	5	62	19	30.65
8	3.00	30.00	35	22	9	6	72	26	36.11
9	4.40	33.70	35	24	4	34	97	30	30.93
10	2.80	28.00	35	14	14	11	74	25	33.78
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MEAN	2.58	27.06	26.40	17.20	7.40	15.60	66.60	18.70	27.77
370-R12-T8									
1	2.40	26.70	11	13	12	29	65	14	21.54
2	2.80	28.70	24	25	1	31	81	14	17.28
3	1.30	20.60	0	0	1	21	22	1	4.55
4	1.90	24.20	20	18	7	25	70	10	14.29
5	1.80	23.20	14	12	9	20	55	8	14.55
6	3.10	29.40	25	21	6	33	85	7	8.24
7	2.40	27.00	20	29	3	27	79	13	16.46
8	2.00	24.30	16	17	14	18	65	7	10.77
9	1.90	22.30	12	19	7	19	57	4	7.02
10	2.00	24.40	21	24	49	11	105	4	3.81
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MEAN	2.16	25.08	16.30	17.80	10.90	23.40	68.40	8.20	11.85

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
383-R4-T3									
1	3.10	25.70	4	10	2	46	62	20	32.26
2	3.40	24.60	7	7	1	58	73	34	46.58
3	2.90	25.70	20	16	0	29	65	29	44.62
4	3.70	27.50	6	6	2	62	76	16	21.05
5	3.10	23.70	5	7	1	45	58	18	31.03
6	3.10	26.00	4	11	8	44	67	19	28.36
7	3.50	27.00	7	11	0	62	80	13	16.25
8	3.50	26.30	3	8	4	53	68	24	35.29
9	3.70	27.00	5	8	1	45	59	15	25.42
10	4.20	29.30	11	10	7	49	77	26	33.77
MEAN	3.42	26.28	7.20	9.40	2.60	49.30	68.50	21.40	31.46
383-R9-T3									
1	1.20	17.00	0	1	0	11	12	1	8.33
2	2.30	23.00	1	3	1	29	34	10	29.41
3	2.30	24.20	8	0	9	34	51	14	27.45
4	2.00	22.30	7	0	8	34	49	9	18.37
5	2.60	23.30	10	0	7	48	65	10	15.38
6	2.40	23.70	7	0	8	43	58	6	10.34
7	1.60	19.40	7	0	12	24	43	9	20.93
8	2.80	24.60	6	4	4	60	74	15	20.27
9	2.00	23.00	16	0	6	37	59	13	22.03
10	2.00	22.20	7	1	5	39	52	2	3.85
MEAN	2.12	22.27	6.90	0.90	6.00	35.90	49.70	8.90	17.64
383-R9-T7									
1	3.00	27.10	11	8	3	43	65	32	49.23
2	3.20	27.80	16	9	4	51	80	11	13.75
3	3.10	27.00	4	5	4	56	69	12	17.39
4	2.70	26.30	15	10	6	38	69	17	24.64
5	3.00	26.00	5	7	2	60	74	8	10.81
6	2.40	24.40	12	5	5	28	50	10	20.00
7	2.30	22.70	5	10	7	35	57	14	24.56
8	4.50	30.30	8	15	5	62	90	25	27.78
9	3.50	28.40	12	10	2	57	81	8	9.88
10	3.30	27.60	13	5	3	58	79	18	22.78
MEAN	3.10	26.76	10.10	8.40	4.10	48.80	71.40	15.50	22.08

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
385-R2-T2									
1	1.80	22.70	18	13	4	20	55	10	18.18
2	3.20	29.60	35	10	6	47	98	17	17.35
3	2.20	25.40	24	5	4	46	79	10	12.66
4	2.50	26.00	20	11	7	51	89	19	21.35
5	2.00	24.40	36	4	7	29	76	14	18.42
6	1.90	23.40	27	5	8	29	69	15	21.74
7	3.00	27.70	25	12	0	49	86	26	30.23
8	1.20	21.00	0	1	3	31	35	6	17.14
9	2.90	27.30	27	9	2	56	94	9	9.57
10	1.70	23.10	15	14	10	31	70	15	21.43
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MEAN	2.24	25.06	22.70	8.40	5.10	38.90	75.10	14.10	18.81
385-R8-T5									
1	2.70	26.90	33	20	4	31	88	23	26.14
2	2.40	25.00	25	9	5	44	83	17	20.48
3	2.30	26.30	28	19	9	31	87	17	19.54
4	2.40	26.40	28	10	6	27	71	27	38.03
5	1.20	18.50	0	1	0	25	26	2	7.69
6	1.90	24.00	12	8	7	41	68	20	29.41
7	1.90	24.00	23	10	7	28	68	18	26.47
8	2.30	24.70	26	12	1	31	70	27	38.57
9	2.40	25.90	36	9	5	28	78	28	35.90
10	2.70	27.00	33	10	9	26	78	21	26.92
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MEAN	2.22	24.87	24.40	10.80	5.30	31.20	71.70	20.00	26.92
385-R11-T2									
1	2.10	24.20	24	12	3	27	66	21	31.82
2	2.80	28.20	28	6	10	37	81	24	29.63
3	1.80	24.10	15	8	7	28	58	16	27.59
4	2.60	28.00	26	4	8	43	81	14	17.28
5	2.40	26.00	25	9	8	39	81	19	23.46
6	2.80	28.40	34	9	8	32	83	17	20.48
7	2.80	27.60	26	7	7	39	79	21	26.58
8	1.70	22.30	0	2	0	40	42	0	0.00
9	1.90	24.80	32	9	7	31	79	15	18.99
10	3.80	30.30	38	9	2	40	89	24	26.97
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MEAN	2.47	26.39	24.80	7.50	6.00	35.60	73.90	17.10	22.28

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
387-R7-T6									
1	2.50	24.10	8	0	14	53	75	38	50.67
2	2.40	24.40	7	0	3	58	68	26	38.24
3	2.10	23.30	10	0	28	39	77	15	19.48
4	2.00	22.70	6	0	17	43	66	20	30.30
5	2.60	25.50	6	0	6	71	83	29	34.94
6	2.70	26.30	7	0	10	61	78	31	39.74
7	2.30	24.80	12	1	25	44	82	25	30.49
8	2.00	22.40	2	0	16	58	76	10	13.16
9	2.30	24.00	6	0	1	71	78	24	30.77
10	1.10	17.60	0	1	0	17	18	2	11.11
MEAN	2.20	23.51	6.40	0.20	12.00	51.50	70.10	22.00	29.89
387-R8-T3									
1	2.30	24.30	5	1	8	69	83	36	43.37
2	2.20	24.20	14	0	12	53	79	26	32.91
3	2.30	23.50	6	0	14	55	75	44	58.67
4	1.80	21.60	4	0	4	62	70	35	50.00
5	2.60	25.70	9	0	7	75	91	1	1.10
6	0.50	14.20	0	0	4	22	26	1	3.85
7	3.00	27.20	13	2	18	59	92	33	35.87
8	1.80	23.50	9	0	1	59	69	14	20.29
9	2.10	23.10	4	0	13	63	80	25	31.25
10	2.10	23.70	6	0	4	65	75	27	36.00
MEAN	2.07	23.10	7.00	0.30	8.50	58.20	74.00	24.20	31.33
387-R9-T1									
1	2.90	26.40	7	1	23	58	89	17	19.10
2	3.00	26.60	6	0	4	73	83	18	21.69
3	0.90	16.40	0	0	0	87	87	10	11.49
4	2.60	26.50	10	0	8	54	72	25	34.72
5	1.70	21.00	5	7	17	35	64	10	15.63
6	1.10	18.50	0	1	3	23	27	5	18.52
7	1.20	19.00	0	1	2	12	15	1	6.67
8	2.70	26.30	11	0	4	66	81	22	27.16
9	2.40	24.60	13	0	16	42	71	22	30.99
10	1.90	22.70	3	16	6	41	66	12	18.18
MEAN	2.04	22.80	5.50	2.60	8.30	49.10	65.50	14.20	20.41

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
393-R6-T9									
1	2.40	25.50	14	33	19	30	96	18	18.75
2	1.40	20.70	0	0	6	42	48	3	6.25
3	2.60	28.20	29	15	2	39	85	15	17.65
4	1.70	23.00	6	9	14	44	73	4	5.48
5	1.90	23.40	19	17	17	27	80	13	16.25
6	2.70	28.20	17	22	7	48	94	18	19.15
7	1.60	22.40	0	0	0	56	56	5	8.93
8	1.70	21.80	13	8	11	42	74	10	13.51
9	1.90	24.50	17	7	2	47	73	12	16.44
10	2.00	24.50	3	10	13	36	62	4	6.45
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MEAN	1.99	24.22	11.80	12.10	9.10	41.10	74.10	10.20	12.89
393-R10-T8									
1	1.00	17.00	2	5	7	49	63	3	4.76
2	4.20	29.00	26	12	4	42	84	26	30.95
3	0.90	17.10	5	15	6	29	55	2	3.64
4	1.10	18.40	4	13	11	29	57	2	3.51
5	1.10	19.00	4	11	10	36	61	2	3.28
6	1.30	21.00	8	6	11	32	57	7	12.28
7	1.60	22.30	9	16	8	44	77	5	6.49
8	1.80	21.00	0	0	0	25	25	10	40.00
9	1.10	17.50	5	4	12	30	51	0	0.00
10	1.10	18.80	4	8	6	25	43	4	9.30
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MEAN	1.52	20.11	6.70	9.00	7.50	34.10	57.30	6.10	11.42
393-R11-T6									
1	1.50	22.50	16	13	11	38	78	7	8.97
2	1.30	20.50	15	13	12	35	75	10	13.33
3	1.00	18.80	0	0	0	26	26	6	23.08
4	1.60	22.50	11	16	16	34	77	9	11.69
5	1.60	24.00	11	22	16	27	76	11	14.47
6	1.40	20.70	5	8	19	37	69	6	8.70
7	0.90	17.50	0	0	1	41	42	4	9.52
8	1.40	21.50	15	20	10	29	74	10	13.51
9	1.20	20.50	0	8	15	40	63	4	6.35
10	0.80	17.30	1	3	17	31	52	1	1.92
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MEAN	1.27	20.58	7.40	10.30	11.70	33.80	63.20	6.80	11.16

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
491-R6-T10									
1	1.90	23.10	4	7	4	38	53	21	39.62
2	2.30	25.30	9	6	3	36	54	25	46.30
3	2.40	25.10	6	5	3	40	54	21	38.89
4	2.10	22.70	5	12	3	37	57	9	15.79
5	2.30	24.30	18	4	3	37	62	25	40.32
6	2.00	22.70	8	5	1	41	55	11	20.00
7	2.20	23.80	18	8	4	34	64	24	37.50
8	2.30	25.10	12	6	9	35	62	16	25.81
9	2.90	25.60	9	16	7	40	72	6	8.33
10	3.10	28.00	19	10	5	30	64	27	42.19
MEAN	2.35	24.57	10.80	7.90	4.20	36.80	59.70	18.50	31.47
491-R7-T12									
1	1.50	19.90	0	3	3	44	50	3	6.00
2	2.10	22.00	6	3	2	29	40	14	35.00
3	1.00	16.20	0	0	0	10	10	3	30.00
4	1.00	16.20	0	0	2	26	28	4	14.29
5	1.60	19.50	2	10	3	37	52	9	17.31
6	1.20	19.00	0	3	1	29	33	4	12.12
7	1.90	21.30	5	5	4	37	51	8	15.69
8	1.92	21.30	0	4	4	37	45	11	24.44
9	1.50	19.30	1	2	3	28	34	5	14.71
10	2.00	21.70	2	9	5	41	57	11	19.30
MEAN	1.57	19.64	1.60	3.90	2.70	31.80	40.00	7.20	18.88
491-R10-T6									
1	2.50	24.80	3	5	2	47	57	35	61.40
2	2.50	25.10	4	8	2	51	65	24	36.92
3	3.00	26.80	5	4	6	58	73	24	32.88
4	2.30	23.40	5	13	2	39	59	14	23.73
5	1.70	20.60	3	4	6	28	41	10	24.39
6	2.50	24.30	6	2	2	66	76	20	26.32
7	2.10	23.10	3	12	0	43	58	15	25.86
8	2.80	25.10	2	7	3	48	60	21	35.00
9	2.70	26.30	7	8	4	39	58	24	41.38
10	1.50	20.00	0	1	7	47	55	3	5.45
MEAN	2.36	23.95	3.80	6.40	3.40	46.60	60.20	19.00	31.33

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
492-R7-T6									
1	3.10	28.40	7	22	13	58	100	15	15.00
2	4.60	33.50	1	11	2	96	110	33	30.00
3	4.70	34.00	10	17	22	69	118	38	32.20
4	3.80	32.30	7	29	11	61	108	34	31.48
5	4.10	33.20	6	19	16	66	107	30	28.04
6	5.10	35.50	14	36	14	65	129	35	27.13
7	2.90	28.40	0	2	3	84	89	2	2.25
8	4.30	33.50	22	23	1	69	115	50	43.48
9	4.00	31.60	24	16	9	66	115	29	25.22
10	3.20	32.80	10	24	0	65	99	17	17.17
MEAN	3.98	32.32	10.10	19.90	9.10	69.90	109.00	28.30	25.20
492-R12-T7									
1	1.90	25.10	0	0	0	85	85	0	0.00
2	4.90	35.40	19	32	3	89	143	44	30.77
3	1.80	24.20	4	23	6	35	68	11	16.18
4	1.10	20.20	0	0	0	19	19	5	26.32
5	1.50	22.50	0	0	0	49	49	13	26.53
6	4.00	31.30	10	38	9	58	115	29	25.22
7	4.20	33.30	16	28	14	62	120	35	29.17
8	4.30	33.50	16	34	8	64	122	52	42.62
9	2.30	27.10	12	20	11	33	76	23	30.26
10	4.70	35.70	24	31	8	55	118	51	43.22
MEAN	3.07	28.83	10.10	20.60	5.90	54.90	91.50	26.30	27.03

RAMET NUMBER	CONE VOL. (CCM)	CONE LENGTH (MM)	NUMBER OF SEED OBTAINED FOR: EXTR.1	EXTR.2	EXTR.3	DISSECTION	TOTAL NO. SEED	# SEED FILLED	% FILLED SEED
493-R3-T9									
1	1.20	18.20	0	4	9	29	42	9	21.43
2	1.20	18.30	0	0	0	14	14	0	0.00
3	0.80	16.10	0	0	0	11	11	2	18.18
4	1.90	23.20	11	8	0	43	62	8	12.90
5	2.00	21.90	15	4	0	47	66	16	24.24
6	1.30	20.00	3	10	6	27	46	3	6.52
7	1.80	22.80	9	7	0	44	60	7	11.67
8	2.00	22.90	10	3	2	54	69	19	27.54
9	1.00	17.80	0	0	0	15	15	1	6.67
10	1.10	17.20	3	8	2	33	46	13	28.26
MEAN	1.43	19.84	5.10	4.40	1.90	31.70	43.10	7.80	15.74
493-R5-T5									
1	1.40	20.40	5	10	3	37	55	13	23.64
2	1.20	18.30	1	3	6	40	50	6	12.00
3	1.30	18.40	3	8	4	38	53	9	16.98
4	1.60	21.60	8	9	2	38	57	15	26.32
5	1.10	17.80	0	6	4	36	46	6	13.04
6	1.40	19.50	3	12	0	37	52	14	26.92
7	1.30	19.60	2	6	4	39	51	17	33.33
8	1.10	17.90	0	14	1	30	45	8	17.78
9	1.40	20.30	10	3	0	39	52	18	34.62
10	1.30	17.90	10	9	1	32	52	15	28.85
MEAN	1.31	19.17	4.20	8.00	2.50	36.60	51.30	12.10	23.35
493-R11-T6									
1	1.00	16.40	0	4	13	33	50	3	6.00
2	1.10	17.20	0	2	1	40	43	3	6.98
3	1.00	17.40	0	8	8	30	46	2	4.35
4	1.40	20.00	0	6	4	46	56	5	8.93
5	0.90	18.00	0	1	9	39	49	4	8.16
6	1.30	19.10	0	6	5	42	53	3	5.66
7	1.10	8.00	0	9	4	30	43	3	6.98
8	1.20	19.10	6	9	9	31	55	10	18.18
9	1.10	19.10	1	7	2	40	50	9	18.00
10	1.90	23.90	4	11	10	48	73	7	9.59
MEAN	1.20	17.82	1.10	6.30	6.50	37.90	51.80	4.90	9.28

APPENDIX H

PROGENY TEST RAW DATA

Ramet No.	Blck.	Fert.	Seedling Heights (cm) Three Months				Mean	Four Months				Mean	Five Months				Mean
283R1T1	1	high	6.2	9.3	9.2	7.5	8.05	18	19.3	22	13.6	18.2	28.2	32.6	35.3	27.6	30.9
		low	8.9	8.2	7.6	7.7	8.1	14.5	13	11.5	12.4	12.9	17.3	13.2	12.7	13.5	14.2
	2	high	4.8	7.6	8.4	9.1	7.48	17.9	16	19	19.5	18.1	30.6	29.2	31.7	33	31.1
		low	8.5	6.8	5.9	8.1	7.33	12.3	11.4	10.2	11.6	11.4	12.4	10.5	12	13.1	12
	3	high	10.3	7.6	9.5	9.2	9.15	23.2	17.6	22	21	21.0	36.2	30.6	36	35.2	34.5
		low	6.4	8.5	7.4	7.6	7.48	9.6	11.5	10.5	10.6	10.6	11.1	12	11.4	13.1	11.9
	4	high	9.6	7.7	11.1	8	9.1	21.2	16.3	23.2	15.3	19	35.4	31	38.5	15.6	30.1
		low	6.4	8	9	2	7.9	10.7	13.3	14.2	12.7	12.7	15.2	19.5	17.2	13.2	16.3
283R7T2	1	high	10.1	9.2	7.6	9	8.98	18.8	15.6	20.1	20.6	18.8	31	26.1	32.9	32.8	30.7
		low	9.6	9.4	8.4	7.4	8.7	15	14.2	13.1	11.8	13.5	17.1	14.7	16.7	13.6	15.5
	2	high	8.7	9.3	10.9	9	9.48	18.6	23.1	22	21.7	21.4	30.3	36.8	38	34.6	34.9
		low	8.2	8.6	9.3	7.6	8.43	11.1	11.8	14.5	11	12.1	11.6	12.4	15.3	11.4	12.7
	3	high	8.5	9.2	9.4	10.5	9.4	22.3	20.3	18.5	22.9	21	36	37.6	32.4	38.7	36.2
		low	7.9	8	10.8	9.3	9	12.8	11.6	15.2	12.5	13.0	13.8	12.6	16.9	12.4	13.9
	4	high	9.3	8.8	11	9.5	9.5	20.7	17	15.7	18.2	17.9	34.3	28.7	29	29.2	30.3
		low	7.5	8	8.1	6.6	7.55	12	12.3	13	10.5	12.0	12.6	16.4	18	11.3	14.6
283R11T4	1	high	7.7	8.4	9	10.3	8.85	21.7	18.3	17.8	19.1	19.2	33.6	29	28.9	27.2	29.7
		low	9.2	9.5	9	9.2	9.23	14.1	13.7	15.1	13.1	14	14.6	15.2	18.7	13.5	15.5
	2	high	8.6	7	7.7	9.6	8.23	19.6	18.2	18.7	22.4	19.7	39.7	32	31.6	23	31.6
		low	6.6	7.1	7.3	6.5	6.88	11.3	10.6	11.6	9.5	10.8	16.5	11	12.3	10.4	12.6
	3	high	9.6	9.5	8.4	8.6	9.03	22	22.3	19.1	20.2	20.9	35.6	36.3	35	36.7	35.9
		low	8	8	7.3	9.1	8.1	13.5	10	11.8	13.5	12.2	14.4	12.1	10.2	13.2	12.5
	4	high	9.1	8	8.7	10.7	9.13	20.1	18.5	20.2	21.3	20.0	34.3	33.7	37.5	34.6	35.0
		low	9	6.9	8.2	8.7	8.2	13.1	11.2	12.4	13.5	12.6	13.6	14.7	13.2	15	14.1
284R4T6	1	high	9.6	9.5	8.6	12.6	10.1	25.3	1 .5	19.8	22.5	21.8	36.1	32.3	32.3	32.6	33.3
		low	9.9	10.7	9.2	8.6	9.6	15.6	14.5	14.7	13	14.5	16.7	14.5	14.8	13.5	14.9
	2	high	8.1	7.5	9.2	8.1	8.23	18.1	20.3	15.4	16	17.5	27.6	17.4	36.5	33.7	28.8
		low	7	8.9	8	7.7	7.9	11.6	12	13.4	11.7	12.2	11.9	13.5	12	12.7	12.5
	3	high	7.2	9.7	7.7	8.2	8.2	16.8	22.5	17	18.3	18.7	29.4	37.7	21	32.4	30.1
		low	7.6	8.1	6.3	8.1	7.53	11.4	10.6	9.6	11.8	10.9	15	11.1	10.3	11.7	12.0
	4	high	8.4	8.7	9.3	8.7	8.78	19.4	18.2	19.1	17.2	18.5	33.3	32.1	22.2	21.6	27.3
		low	8.6	8.7	6.4	7.6	7.83	14.3	12.6	8	11.6	11.6	17.5	12.8	8	13.2	12.9
284R8T2	1	high	8.8	11	8.2	8.6	9.15	19.1	14.7	22.1	17	18.2	30.2	17.1	39.4	30.1	29.2
		low	8.3	9.2	9.5	9.1	9.03	11.3	11.9	14.7	12.8	12.7	11.6	11.8	15	13.6	13
	2	high	9	9	9.7	12.2	9.98	19.7	18.1	19.8	25.4	20.8	30.6	26.1	32.6	43	33.1
		low	7.9	7.4	8.6	7.8	7.93	11.9	11.6	11.9	13.6	12.3	14.3	12.2	11.7	12.3	12.6
	3	high	10.5	9.9	9.8	11.4	10.4	25.2	22.6	20	21.4	22.3	41	38.1	22.5	38.3	35.0
		low	7.1	8.9	9.9	6.4	8.08	10.5	12.6	14	10.6	11.9	11.2	14.3	13.1	11.1	12.4
	4	high	10.4	7.6	8.5	7.7	8.55	22.4	19.8	17.5	16.6	19.1	37.6	32.5	18.6	30.2	29.7
		low	10.9	9.[illegible]	8.3	7.7	9.13	15.9	14.1	12.4	11.9	13.6	15.2	14.8	12.9	12.4	13.8

Ramet No.	Blck.	Fert.	Three Months				Mean	Four Months				Mean	Five Months				Mean
			Seedling Heights (cm)														
288R5T12	1	high	6.9	8.2	9.7	8	8.2	16.6	20.6	17.5	13.2	17.0	29.7	34.9	29.5	21.2	28.8
		low	8.8	8.3	6.6	8.1	7.95	14.3	10.4	10.4	11.7	11.7	14.7	10.4	13.4	12.4	12.7
	2	high	8.7	9.4	8.3	9.3	8.93	19.5	21	19.7	20.6	20.2	24	35.5	32.6	33.2	31.3
		low	6.1	6.6	7	7.2	6.73	8	8.8	8.6	10.7	9.03	8.1	9	9.1	11.4	9.4
	3	high	10.1	6.2	8.6	7.6	8.13	22.2	14.6	20.3	19.5	19.2	38.2	17.1	36.1	35.4	31.7
		low	6.5	7.5	6.7	8.7	7.35	12.9	11.5	10.7	10.5	11.4	13.1	15.7	11.1	12.3	13.1
	4	high	6.5	7.6	9	9	8.03	14.1	16.3	16.6	15.4	15.6	27.5	28.8	31.6	29.2	29.3
		low	7.7	8.5	6.5	7.1	7.45	10.5	12.3	8.6	10.2	10.4	11.1	15.8	10.1	10.5	11.9
288R7T9	1	high	9	5.6	10.6	10.1	8.83	20.7	20.9	10.5	19.4	17.9	34	33.2	11.5	32.3	27.8
		low	7.6	5.3	8.2	9.2	7.58	11.3	8.3	11.8	12.6	11	11.5	8.6	12.2	12.8	11.3
	2	high	10	8.7	12.5	9.5	10.2	21.8	23.8	19.5	22.3	21.9	38.5	37	33.9	35.7	36.3
		low	9.5	8.2	8.2	8.8	8.68	16.1	13	12.5	15.2	14.2	15.7	12.7	14.2	21.1	15.9
	3	high	9.4	11.5	11.2	10.1	10.6	19.6	23.1	24.2	21.4	22.1	31.5	36.8	39.2	36.6	36.0
		low	7.8	8.6	10.1	9.5	9	11.8	13.2	13.9	12.4	12.8	11.8	13.6	14.1	12.4	13.0
	4	high	12.7	9.4	12.7	10.7	11.4	27	18.6	27	20.3	23.2	38.6	22.8	41.5	30.3	33.3
		low	10.2	8.4	9.2	9	9.2	13.2	16.6	12.4	14.4	14.2	14.8	12.7	21	15.3	16.0
288R10T7	1	high	9	9	7.4	7.6	8.25	15.8	16.7	14.3	19.4	16.6	16.4	29	27.6	30.1	25.8
		low	7.5	7.2	8	6	7.18	10.6	10.7	10.7	8.8	10.2	10.8	11	11.1	9.3	10.6
	2	high	7.9	8.8	9.5	9	8.8	20.8	22.5	19.5	17.5	20.1	35.3	37	33.6	28.1	33.5
		low	8	6.6	7.5	8.2	7.58	14.2	10.8	13	13	12.8	14.7	11.1	18	13.5	14.3
	3	high	9.7	9.6	9.7	9.7	9.68	22.1	24.1	20	21.3	21.9	36.9	39.1	34.3	32.7	35.8
		low	7.1	8	6.4	7.8	7.33	12.2	11.5	10.1	11.2	11.3	13.3	12.7	13	11.7	12.7
	4	high	6.6	8.1	9	10	8.43	15.4	20.8	21.2	18.7	19.0	26.8	37.9	37.2	21.5	30.9
		low	8.4	7.8	5.1	7.2	7.13	13.4	12.3	7.7	11.8	11.3	18.5	14.9	8.6	12	13.5
290R4T1	1	high	10.4	8.3	10.7	10.1	9.88	23.6	21.9	18.2	21.9	21.4	34.7	31.2	32	31.3	32.3
		low	8.8	8.3	6.8	7.6	7.88	13	11.7	9.6	11.8	11.5	13.6	11.4	9.8	12.2	11.8
	2	high	9.3	8.8	10	8.8	9.23	20.9	19.5	21.3	18.1	20.0	30.6	35.4	35.5	35.3	34.2
		low	9.5	8.5	7.3	6.8	8.03	9	10.7	10.2	12.5	10.6	12.8	10.2	10.6	9	10.7
	3	high	9	8.3	10.1	9.6	9.25	18.4	19.5	23.7	21.2	20.7	33.7	33.1	39.6		35.5
		low	6.4	7.6	6.2	8.3	7.13	12.5	9.6	12.1	9.2	10.9	13.1	12.6	14.7	9.2	12.4
	4	high	9.2	9.3	8	6.7	8.3	21.3	20	15.7	12.9	17.5	38.8	33.1	27.2	22.1	30.3
		low	8.3	7.1	7	9.3	7.93	12	11.6	9.7	12.9	11.6	13.4	17.5	10.2	13.8	13.7
290R4T6	1	high	7.7	7.5	8.3	7.2	7.68	15.4	16.6	16.5	19	16.9	26	28.2	29.5	34.1	29.5
		low	8	9	9.1	8.6	8.68	15.2	11.6	14.3	14.1	13.8	11.2	11.1	14.4	14.6	12.8
	2	high	8.1	7.5	8.6	9.3	8.38	18.1	16.7	17.7	18.5	17.8	30.5	30.4	29.4	32.6	30.7
		low	6.9	6.2	8.2	6.4	6.93	9.7	8.6	11.8	9.9	10	10.2	9	12.1	10	10.3
	3	high	8.4	9.2	9.5	11.1	9.55	19.4	21.8	20.7	23.5	21.4	33.3	36.2	34.4	36.5	35.1
		low	6.3	6.1	7.5	9.1	7.25	11.3	9.6	11.7	12.5	11.3	13.4	10.6	12.4	13.7	12.5
	4	high	7.9	7.7	8.4	8.6	8.15	16.2	16.2	17.6	19	17.3	27.3	30.4	30.4	31.5	29.9
		low	9	5.9	9.2	7.4	7.88	12.8	9.7	15	11.2	12.2	12.8	10	15.4	11.3	12.4
290R11T7	1	high	8.2	9.1	8.4	8.6	8.58	17.4	17.7	18.5	14.7	17.1	32.2	31.2	34.1	17.3	28.7
		low	8.6	8.3	7.2	10.2	8.58	13.5	13.4	11.1	11.4	12.4	13.5	13.5	11.4	11.5	12.5
	2	high	6	7.1	10.5	9.7	8.33	10.8	15.6	23.3	23.1	18.2	20.2	27	37.4	38.3	30.7
		low	8	7.2	9.4	7.7	8.08	14.1	12.5	11.6	13.1	12.8	18.8	12.6	11.6	13.4	14.1
	3	high	9.3	8.6	11.4	10.9	10.1	20.3	19.4	23.8	23	21.6	33.6	33.6	40.1	29.5	34.2
		low	7.9	7.3	8.4	8.6	8.05	12.7	13	10.8	13.1	12.4	12.2	13.1	10.9	13.2	12.4
	4	high	10.1	8	8.4	7.9	8.6	21.7	14.7	18.6	14.6	17.4	33.7	27.3	30.5	25	29.6
		low	7.3	9.1	7.3	6.8	7.63	10.7	13.2	11.3	9.2	11.1	11.7	13.3	11.4	9.6	11.5

Ramet No.	Blck.	Fert.	Three Months				Mean	Four Months				Mean	Five Months				Mean
			Seedling Heights (cm)														
291R9T6	1	high	10.2	11.2	12.1	8.6	10.5	13	24.2	19.7	22.4	19.8	21.6	42.5	32.9	34.8	33.0
		low	7.2	8.3	8.6	11	8.78	11.4	11.6	10.8	14.3	12.0	14.7	12	11	14.4	13.0
	2	high	7.9	11	8.5	11.2	9.65	15.6	22.9	18.2	23.6	20.1	26.8	37.4	32	33.8	32.5
		low	9.7	8.8	9.2	8.5	9.05	14.6	12.3	13	12.6	13.1	14.8	12.4	13	13.3	13.4
	3	high	10	11.6	12.7	11.2	11.4	23	26.7	25.6	24.3	24.9	39.5	44.8	26.2	35.3	36.5
		low	8.6	9.1	8.1	8.2	8.5	10.7	11.4	9.3	10.3	10.4	11.4	11.6	9.2	10.9	10.8
	4	high	10.5	8.8	9.1	8.9	9.33	21.4	17.7	17.3	15.9	18.1	36	29.2	29.9	24.3	29.9
		low	8.7	7.5	8.5	8.3	8.25	12.2	11.1	11.2	12.7	11.8	12	11.7	11.4	13.2	12.1
291R10T3	1	high	10.7	11.3	9.1	10.3	10.4	18.1	18.8	21.6	19.7	19.6	27.2	33.5	33.7	30.7	31.3
		low	8	9	9.6	9.2	8.95	12.6	11.6	11.5	10.4	11.5	12.8	11.7	11.4	10.6	11.6
	2	high	10.7	13.9	10.6	12.1	11.8	25.1	22.4	26.1	21.5	23.8	37.7	34.3	28	27.6	31.9
		low	9	11.5	7.6	10.2	9.58	15.1	12.2	14	13	13.6	16	12.5	14	13.1	13.9
	3	high	12.1	12	11.2	11.3	11.7	21.7	23.6	23.2	23.1	22.9	32.2	38.4	40.3	37.2	37.0
		low	9.5	8.6	10.2	11.1	9.85	13	10.5	14.7	16.7	13.7	13.2	10.5	15.2	17.2	14.0
	4	high	11.1	8	11.1	10.2	10.1	20.6	14.5	18.5	17.3	17.7	33.1	27.8	23	25.7	27.4
		low	9.3	8.4	7.7	10.7	9.03	15.1	12	12.2	15.3	13.7	20.6	12.2	12.4	15.4	15.2
291R11T1	1	high	8.7	10.2	10.2	10.6	9.93	20.3	21.1	19.8	17.4	19.7	31.3	34.7	33.4	39.8	34.8
		low	7.5	11.1	10.1	8.6	9.33	10	14.2	13.2	12.1	12.4	10.2	14.3	13.5	11.6	12.4
	2	high	9.1	11.8	10.1	10.3	10.3	18.1	25	22.2		21.8	30.6	36.4	36.9		34.6
		low	6.2	9	9.7	8.1	8.25	14.6	14.2	15.6	12.1	14.1	12.2	19.5	14.1	16	15.5
	3	high	9.7	9.3	10	11.9	10.2	21.2	20.9	22.2	26.6	22.7	31.5	37.3	39	43.6	37.9
		low	6.6	7.3	6.1	9.2	7.3	11.7	9.4	9.9	9.1	10.0	12.4	11.1	10	9.2	10.7
	4	high	8.9	11.7	10.2	11	10.5	18.7	20.8	21.4	21.2	20.5	36.1	36.6	38.8	34.1	36.4
		low	9.1	7.5	8.7	8.6	8.48	13.5	12.6	12.8	14.1	13.3	13.6	16.6	12.8	15.1	14.5
303R10T12	1	high	9	8.3	9.3	7.4	8.5	16.7	22.9	19.1	19.2	19.5	29.1	38	33.1	30.4	32.7
		low	8.1	8.6	9.3	10.2	9.05	13.8	11.8	14.2	13.9	13.4	14.6	11.5	14.7	14.1	13.7
	2	high	7.8	8	7.6	8.3	7.93	19.4	19.6	18.7	18.3	19	32.9	31.3	32.4	33.3	32.5
		low	7.5	6.6	8.5	7	7.4	12.2	10.7	11.6	12	11.6	12.6	11.4	11.7	15.3	12.8
	3	high	7.6	7.1	8.6	8.7	8	22	22.2	23.4	18.2	21.5	26.4	35.5	31.6	32	31.4
		low	7.7	6.7	7	9.5	7.73	14.4	11.2	11.5	12.3	12.4	15.8	15	13.1	12.5	14.1
	4	high	10.3	7.2	9.3	8.7	8.88	24.1	18.6	20.7	19.7	20.8	43.4	33.5	35.6	25.4	34.5
		low	10.1	7	9.6	5.6	8.08	10.7	14	11.5	12.7	12.2	12.7	14.3	16.5	13.1	14.2
303R11T5	1	high	9.7	9.6	10.5	8.5	9.58	20.1	21.3	20.7	20.3	20.6	34.6	34.3	34.8	32.4	34.0
		low	9.3	9.1	10.7	9.2	9.58	12.7	12	14.1	12.5	12.8	13.7	12.5	14.1	12.5	13.2
	2	high	7.2	6.6	7.7	7.8	7.33	18	16	12.3	14.1	15.1	25	20	30	33.7	27.2
		low	7.9	7	6.5	8.7	7.53	11.9	8.6	8.1	10.6	9.8	12.1	8.6	8.1	10.8	9.9
	3	high	11.2	11.9	7.6	8.9	9.9	24.7	25.4	18.2	21.1	22.4	38.4	40.2	32.3	37	37.0
		low	8.7	7.3	6.7	7.1	7.45	14.6	12.2	8.7	11.7	11.8	19.6	13	10	12.2	13.7
	4	high	10.1	10.1	8.9	10.7	9.95	22.1	24	20.1	24.6	22.7	36.7	43.5	35.3	43.6	39.8
		low	8	7.1	9.1	9.6	8.45	11	10.6	13.5	14.2	12.3	11.2	11	14.1	15.1	12.9
303R12T5	1	high	9	8.4	8.7	8.7	8.7	17.2	20.1	17.4	14.2	17.2	31.6	34.6	28.5	15.5	27.6
		low	9	9.4	9.3	9	9.18	11.6	13.5	13.2	14.1	13.1	12	13.6	13.3	14.5	13.4
	2	high	12.5	9.6	8.4	9.1	9.9	20.2	20.5	17.5	19.5	19.4	33.6	32.2	35	36.2	34.3
		low	8.6	8.4	8.3	6.9	8.05	13	13.1	13.8	14.7	13.7	15.6	15.7	16.1	16.8	16.1
	3	high	12.2	9.7	9.1	8.7	9.93	24.3	21.9	20.1	20.2	21.6	25.3	38.6	34	24.4	30.6
		low	6	8.5	5.8	7.5	6.95	10.6	13.4	7.3	11.7	10.8	11.6	13.4	7.3	12.5	11.2
	4	high	10.2	9.6	9.3	8.6	9.43	23.4	20.2	22.1	19.6	21.3	41.5	36	40.6	35.3	38.4
		low	7.2	5.6	7.2	6.8	6.7	15.3	11.8	12.7	12.6	13.1	22.3	12	13.6	13.8	15.4

Ramet No.	Blck.	Fert.	Seedling Heights (cm) Three Months				Mean	Four Months				Mean	Five Months				Mean
304R4T2	1	high	4	8.6	9.7	8.7	7.75	7	21.5	21.5	17.4	16.9	12	37.2	34.5	27.7	27.9
		low	7.1	7.5	8	8.6	7.8	9.6	12	10.3	11.3	10.8	11.7	12.8	10.5	11.6	11.7
	2	high	9.5	8.6	11	8.3	9.35	20.3	17	24.2	16.5	19.5	35.5	28.6	39	25.9	32.3
		low	8.4	7.5	6.2	7.3	7.35	9.7	8.4	10.9	10.4	9.85	10	8.4	11.1	10.6	10.0
	3	high	10.2	8.7	7.7	9.2	8.95	23	20.4	15.6	20.9	20.0	35.6	33.7	28	37	33.6
		low	7.2	6.5	8.5	6.7	7.23	12	10.7	13.5	10.1	11.6	16.5	10.9	19.1	11.6	14.5
	4	high	9.6	9.5	8.7	7	8.7	18.6	19.2	17	13.6	17.1	33.1	35	29.8	24.6	30.6
		low	8	4.1	8.3	6.7	6.78	11.3	6	11.7	9.5	9.63	12	9.1	11.7	9.6	10.6
304R12T1	1	high	8.9	9	8.3	7.2	8.35	15.4	16.2	20	17.5	17.3	25.5	27	35.1	30.3	29.5
		low	9	7.6	8.5	9.2	8.58	12.6	11.3	13.1	13.8	12.7	14.5	11.8	13.2	15.8	13.8
	2	high	8.3	8.3	8.7	8.3	8.4	18.3	18.8	17.5	16.1	17.7	24.5	33.6	30.5	29.7	29.6
		low	7.4	6.6	7	7.6	7.15	9.7	9	8.6	10	9.33	10.5	9.1	9	10	9.65
	3	high	8.6	5.8	8.1	8.7	7.8	20.2	13.4	17.6	16.4	16.9	33.6	19.2	32.1	30.3	28.8
		low	7.6	7.7	6.1	7	7.1	13.1	13.3	9.3	11.9	11.9	19.6	13	10	12.2	13.7
	4	high	7.5	7.7	5.8	6.8	6.95	15	14.9	11	13	13.5	27.9	20.8	23.6	23.8	24.0
		low	7.8	4.5	8.5	7.1	6.98	12.6	7.8	13.4	12.6	11.6	13.2	9	14.3	16.7	13.3
304R12T6	1	high	10.4	8.7	7.6	8	8.68	17.3	17.6	17.5	21.2	18.4	29.3	29.8	27.5	30.2	29.2
		low	8.6	7.6	8.4	9.1	8.43	13	12.4	10.3	13.7	12.4	13.5	12.7	10.5	14.3	12.8
	2	high	8.7	7.2	9.1	7.7	8.18	19.3	16	15.4	19.1	17.5	33	28.5	27	33.4	30.5
		low	9.3	6.5	7.2	8.7	7.93	12.8	10.1	11.4	12	11.6	12.9	10.5	10.4	12.6	11.6
	3	high	8.3	10.3	9.7	8.8	9.28	18	22.4	20.6	19.9	20.2	30.6	37.1	37	36.7	35.4
		low	9	7.4	6.7	7.7	7.7	13.5	11.4	8.5	12.3	11.4	14	12.4	8.6	12.6	11.9
	4	high	8.5	10.2	9	9.3	9.25	18	19.3	18.2	19.1	18.7	31.7	33.6	31.5	31.1	32.0
		low	7.2	5.6	7.2	6.8	6.7	11	7.3	11	10.2	9.88	11.2	7.6	11.2	10.7	10.2
354R2T8	1	high	9.1	8.1	8.3	8.6	8.53	19.7	17.7	19.1	18.6	18.8	31.4	31.6	30.1	28.9	30.5
		low	7.4	10.1	8.3	10.2	9	11.1	13.2	14.2	15.1	13.4	11.2	13.6	17.6	15.5	14.5
	2	high	11.7	9.2	10.9	10	10.5	21	19.8	23.5	21.1	21.4	32.5	33.1	37.8	34.5	34.5
		low	7.6	7.4	9.4	8.5	8.23	12.1	15.3	10.6	10.8	12.2	12.5	15.6	10.7	11	12.5
	3	high	7.4	10.1	9.2	9.6	9.08	18.2	24.3	19.8	21.7	21	32.5	39.9	33.9	36.2	35.6
		low	8.3	9.1	7.3	7.5	8.05	13.3	12.2	12.4	9.9	12.0	17.8	12.4	13.5	9.8	13.4
	4	high	10.6	11.1	7.2	10.2	9.78	23.1	24.7	17.7	22.7	22.1	24.2	40.5	32.2	42	34.7
		low	7.5	8.3	8.2	9.1	8.28	12.6	11.9	12	12.2	12.2	13.1	12.5	12.4	12.3	12.6
354R7T7	1	high	9.7	9.1	6.8	10.5	9.03	23.1	14.5	18.5	23.5	19.9	33.7	27.5	34	38.5	33.4
		low	7.9	9	7.6	8.5	8.25	13.4	12.5	10.5	13.1	12.4	15.9	12.9	11.2	15.7	13.9
	2	high	10.9	8.7	9	9.6	9.55	23.5	20.5	19.9	19.3	20.8	30.5	34.2	34.9	36.1	33.9
		low	7.8	8.2	8.1	10	8.53	12.5	12.8	14.5	12.4	13.1	18	14.5	15.1	13.4	15.3
	3	high	9.3	10.6	7.4	9.3	9.15	19.2	23.4	11.7	21.5	19.0	34.5	34.2	38.6		35.8
		low	3.3	7.3	6.3	8.6	6.38	5	10.3	9.6	12.6	9.38	5.4	10.5	13	12.9	10.5
	4	high	8.3	9	9.5	7.8	8.65	17.1	16.7	20.1	15.3	17.3	31.7	26.1	29.3	19	26.5
		low	9.6	7.7	7.1	8.1	8.13	13.1	10.3	11.4	12.3	11.8	13.6	10.6	13.9	12.8	12.7
354R12T6	1	high	10.7	11.2	10.2	10.1	10.6	20.9	22.1	21.4	20	21.1	33.6	35.1	33.5	31.1	33.3
		low	8.3	8.5	9	8.9	8.68	13.2	14.3	13.1	14.8	13.9	14	14.8	13.1	15.1	14.3
	2	high	8.7	8	10.2	9	8.98	20.5	18.2	21.2	20.4	20.1	35.7	35.3	34.4	37	35.6
		low	8.1	9.5	6.3	9.6	8.38	12.6	12.3	9.3	11.6	11.5	11.9	11	12.4	12.9	12.1
	3	high	10.5	10.4	10.6	9.8	10.3	22.8	23	22.6	19.2	21.9	38.6	39.2	38.6	41.2	39.4
		low	9	5.8	6.6	7.4	7.2	11.1	11	9.2	13.6	11.2	11	12.1	9.3	13.7	11.5
	4	high	9.1	9	9.4	9	9.13	20.1	19.7	22	18.5	20.1	36.7	35.5	40	32	36.1
		low	7.8	9.6	7.1	8.6	8.28	11.6	14.4	10.8	11.8	12.2	16.1	14.5	10.7	11.9	13.3

Ramet No.	Blck.	Fert.	Three Months				Mean	Four Months				Mean	Five Months				Mean
			Seedling Heights (cm)														
355R2T9	1	high	8.2	7.1	9.4	10	8.68	20.5	21.2	15.3	18	18.8	36.2	28.7	26.9	29.1	30.2
		low	7.4	10.1	8.3	10.2	9	12.4	12.7	11.8	11.3	12.1	13.6	13	12	11.2	12.5
	2	high	8.2	8.5	7.3	8.3	8.08	18	19.4	15.6	18.3	17.8	32.2	35.3	27.6	31.7	31.7
		low	8.2	8.4	9.4	8.1	8.53	14.5	15.1	12.6	12.7	13.7	15.5	16.5	12.6	13.1	14.4
	3	high	9.6	9.2	10.2	8.7	9.43	20.2	22.5	25	20.3	22	36	39.7	43.2	29	37.0
		low	6	7.4	6.3	9	7.18	9.6	9	8.5	12.6	9.93	10.1	9.3	8.2	13	10.2
	4	high	11.6	10.4	7.2	9.1	9.58	27.8	24.8	19.4	21.3	23.3	46.9	44	35.1	37.7	40.9
		low	7.7	7.1	6.6	9.1	7.63	11.2	10.3	10.2	13.6	11.3	11.2	10.3	10.6	14	11.5
355R3T11	1	high	7.4	9.5	8	9.9	8.7	20.5	21.2	15.3	18	18.8	37	29.4	34.4	27.3	32.0
		low	8	7.8	8.1	7	7.73	14.5	11.5	11.6	9.8	11.9	16.5	11.5	11.9	9.8	12.4
	2	high	7.5	8	9.1	11	8.9	16.4	18.7	20.3	20.9	19.1	34.9	32.5	33.3	22.2	30.7
		low	7.5	7.7	7.1	6.3	7.15	8.9	9.6	10.7	12.1	10.3	9	9.6	11.1	12.1	10.5
	3	high	10.8	7.2	11.2	8.7	9.48	22.8	18.1	23.7	18.6	20.8	39.2	33.1	39.3	33.3	36.2
		low	9.5	7	8	6.9	7.85	12.4	10.6	10.5	9.7	10.9	12.2	10.3	10.4	10.2	10.8
	4	high	9.4	8.1	9.8	8.2	8.88	19.6	17.4	19.4	14.7	17.9	32.4	33	22	25	28.1
		low	7	8.6	7.6	6.5	7.43	9.7	12.8	11.5	10.2	11.1	10	13	11.7	10.4	11.3
355R7T7	1	high	10.6	8.7	10	10.3	9.9	23.5	21.4	21.2	22.1	22.1	40.5	36.3	37.1	33.8	36.9
		low	9.3	7.6	8.3	8.7	8.48	12.6	11.2	12	11.5	11.8	13	11.6	12.6	11.8	12.3
	2	high	9.2	7	9.8	8.6	8.65	20.7	14.5	20.3	20	18.9	29	32.1	27.4	30.5	29.8
		low	8.6	8.1	7.1	9	8.2	12.4	12.7	10	12.2	11.8	12.6	12.9	10.2	12.4	12.0
	3	high	10.4	10.6	6.4	10.3	9.43	20.6	22.3	11	27	20.2	36	35.8	14.3	42.9	32.3
		low	7.7	8.6	6.1	8.1	7.63	11.6	11.9	9.8	11.1	11.1	11.6	12.2	12	11.5	11.8
	4	high	7.4	6.7	8.1	10.1	8.08	16.9	13.7	15.4	17.6	15.9	30.6	28.1	19	33	27.7
		low	7.6	7.6	7.1	6.4	7.18	9.9	12.3	11.1	10	10.8	10.7	12.7	12	10.9	11.6
367R1T8	1	high	8.9	7.6	11.1	7.3	8.73	16.4	23.5	12.7	17.4	17.5	30.5	40.3	13.5	18.4	25.7
		low	9	8	11.8	9.1	9.48	12.6	13.4	16	11.3	13.3	10.9	16.6	16.1	11.1	13.7
	2	high	10.3	10.5	9.2	10.7	10.2	24.2	22.8	19.7	21.6	22.1	36.1	26.9	30.6	30.2	31.0
		low	7.4	8.2	7.5	8.2	7.83	10.4	11.1	11.1	10.5	10.8	10.7	11.1	11.2	10.8	11.0
	3	high	9.6	9.2	9.6	10.6	9.75	24.8	23.5	20.7	21.5	22.6	44.4	24.5	22	38	32.2
		low	9.7	7.4	9.1	8.7	8.73	13.2	11.1	11.9	11.6	12.0	13.1	11.2	12.1	12	12.1
	4	high	9.5	9.7	11.2	12.2	10.7	20.1	14.8	18.5	23.2	19.2	21.1	15.2	31.4	36.6	26.1
		low	8.6	8.6	10.2	9	9.1	12.3	12.8	14.9	13.1	13.3	11.7	13	15.1	13	13.2
367R4T9	1	high	9.6	10	9.4	9.6	9.65	19.2	18.4	20.1	21.7	19.9	30.2	19.5	34	32.1	29.0
		low	8.6	11.3	10.1	9.5	9.88	11.1	15.4	12.8	12.3	12.9	11.9	15.5	13.2	12.6	13.3
	2	high	9.4	11	9	9.5	9.73	18	21.6	19.6	21	20.1	32.1	25.1	35.1	37.5	32.5
		low	9.5	7.7	8.1	10.7	9	11.1	8.9	9	12.2	10.3	10.8	8.8	9.2	12.1	10.2
	3	high	10	10.3	13.1	9	10.6	21.7	24.6	28.3	20.2	23.7	37.8	42.7	47.5	36.7	41.2
		low	9.7	7.4	8	7.9	8.25	12.7	10.6	10.7	10.4	11.1	12.7	10.7	10.8	10.3	11.1
	4	high	9.4	10.7	8.4	9	9.38	20.6	22.3	16.7	16.5	19.0	22.5	40	17.4	18.3	24.6
		low	8.7	8.2	8.5	11.6	9.25	12.5	12.8	12	14.9	13.1	13	13.1	12.1	15	13.3
367R6T8	1	high	10.8	11.2	9.1	11	10.5	22.3	14.4	22	22	20.2	34.8	25.1	37.2	28.1	31.3
		low	7.5	7.3	8.2	8.4	7.85	9.1	9.7	10.7	12.3	10.5	9.2	10.1	11	12.3	10.7
	2	high	8.2	11	11	10.1	10.1	22.9	24.1	24.7	19.1	22.7	38.2	38.9	37.6	25.2	35.0
		low	9	7.8	9.5	9.8	9.03	13.5	11.2	9.4	9.9	11	13.6	11.5	9.2	10.4	11.2
	3	high	10.7	9.8	9.4	8.8	9.68	24.6	23.8	23.6	18.7	22.7	41.3	42.4	43.2	21.7	37.2
		low	7.9	7.6	9.5	9.6	8.65	10	10.7	11.8	13.1	11.4	10.4	11.1	11.7	13	11.6
	4	high	6.6	9.9	10.3	6	8.2	14.7	19.6	19.2	11	16.1	38.2	39	37.4	20	33.7
		low	8.2	10.2	8	7.3	8.43	10	10	14.1	10.9	11.3	10.2	9.9	14.1	10.6	11.2

Seedling Heights (cm)

Ramet No.	Blck.	Fert.	Three Months				Mean	Four Months				Mean	Five Months				Mean
369R6T11	1	high	9	8.3	8.4	9.3	8.75	21	19.3	16.9	17.3	18.6	33	32.1	27.6	27	29.9
		low	8.6	7.8	6.5	7.7	7.65	13.5	12.5	8.8	11.9	11.7	14	15.1	9.1	11.4	12.4
	2	high	9.1	9.4	8.6	9.5	9.15	20.3	17.8	21	20.5	19.9	32.7	28.1	14.9	14.5	22.6
		low	6.2	6.4	8.5	7.6	7.18	9.8	7.6	12.3	11.7	10.4	10	7.6	12.4	11.8	10.5
	3	high	10.8	9.7	5.8	10.2	9.13	22.2	23.4	14	22.1	20.4	31.1	39.3	25.6	39.9	34.0
		low	8.6	8.2	7.3	7.2	7.83	11.6	12	12.1	11.1	11.7	12.2	12.6	13.5	12.6	12.7
	4	high	8.7	7.6	5.1	8.1	7.38	18.1	18.8	17.4	18.3	18.2	31.4	18.6	33.7	30	28.4
		low	6.5	8.1	8.3	8.1	7.75	9.7	10.3	11.2	10.6	10.5	10.2	14.6	11.5	10.8	11.8
369R10T4	1	high	9.6	8.7	6.7	7.5	8.63	20.6	15	15.1	18.6	17.3	32.5	28	31.8	27	29.8
		low	7.1	7.1	8.7	7.1	7.5	10.6	11.3	12.7	11.1	11.5	11.7	12.4	13.4	11.5	12.3
	2	high	8.6	8.2	7.1	8.3	8.05	20.6	18.7	16.6	19.7	18.9	34.9	29.4	32.1	34.2	32.7
		low	7.1	6.6	7.8	7.2	7.23	9	11.2	9.7	11	10.2	9.2	14.1	9.3	13.6	11.6
	3	high	8.1	10.1	8.3	9	8.88	15.9	23.4	17.2	20.4	19.2	23.5	39.5	29	33.8	31.5
		low	7.1	6.5	6.2	8.3	7.03	11.7	10	9	10.8	10.4	14.6	11.4	9.8	11.2	11.8
	4	high	7.6	8.6	9.8	8.3	8.58	17.4	18.5	21	19.2	19.0	30	33.2	34.1	36.8	33.5
		low	6.2	8.1	6	7	6.83	10	13.4	8.1	10.2	10.4	11.3	14.1	8	10.3	10.9
369R11T1	1	high	9.2	8.1	8	9.4	8.68	18.2	17.9	19	18.3	18.4	28.5	32	32.3	32.3	31.3
		low	10.2	7.5	8.6	9.3	8.9	13.2	11.5	12	11.6	12.1	14.6	11.4	12	11.6	12.4
	2	high	8.1	8.9	9.1	9.2	8.83	21.1	22.1	16.5	8.8	17.1	36	35.2			35.6
		low	8.1	8	7.3	7.8	7.8	13.7	10	11.3	11.5	11.6	15.3	10.4	11.5	11.7	12.2
	3	high	7.2	11.3	8.3	11.2	9.5	17	25.1	20.3	25.2	21.9	31.4	40.3	35	42.2	37.2
		low	7.2	6.1	6.2	6.1	6.4	10	9.3	11.2	8	9.63	10.6	9.4	11.7	8.1	9.95
	4	high	8.3	8.5	7.5	9.2	8.38	17.3	19.6	15.5	18.4	17.7	28.3	34.2	30.4	27.1	30
		low	6.5	7.1	8.6	7.7	7.48	11	12	11.1	9.5	10.9	11.1	12.6	11.5	10.3	11.4
370R5T1	1	high	9.1	9.6	9.3	8.2	9.05	16.8	20.5	19.6	19	19.0	26.3	31.5	30.5	28.3	29.2
		low	8.4	7.8	9	7.8	8.25	11.7	11.3	14.3	11.3	12.2	14.2	11.9	17.6	11.8	13.9
	2	high	9	10.3	9.7	9.5	9.63	18.6	21.6	21.6	22.3	21.0	36.8	38	36.5	34.5	36.5
		low	7.4	7.8	8.7	8	7.98	9.4	10.1	11.3	11.5	10.6	9.8	10.3	11.5	12.1	10.9
	3	high	9.8	9.3	10.8	9.3	9.8	21.8	20.7	22.9	18.1	20.9	33.4	36.2	38.7	29.8	34.5
		low	9.3	6.6	7.5	7.6	7.75	12.7	10.2	10.6	11.6	11.3	14.4	14.1	10.6	14.7	13.5
	4	high	9.3	9.7	9.9	9.1	9.5	20.7	20.7	21.1	18.5	20.3	35.5	34.2	37.7	35.4	35.7
		low	7.9	8.2	8	7.7	7.95	12.7	12.7	11.3	12.2	12.2	13.2	13.1	14	13	13.3
370R12T5	1	high	9.2	7.5	8.6	7	8.08	14.6	16.4	14	19.3	16.1	26.4	29.7	21.5	28.2	26.5
		low	7.8	8.1	5.2	11.1	8.05	11.7	12.5	7.3	16.2	11.9	13.9	13.1	8	18.2	13.3
	2	high	12.5	10.9	8.1	11.7	10.8	19.5	23.7	17.3	23.6	21.0	29.9	37.8	28.9	37.7	33.6
		low	8.5	7.8	6.7	7.8	7.7	10.9	10.6	9.6	11.7	10.7	11.3	10.8	10.1	12	11.1
	3	high	9.5	11.3	9.2	8.3	9.58	19.7	24.1	20.2	18.1	20.5	33.5	41.3	32.2	31	34.5
		low	7.6	7	7.6	7.3	7.38	9.5	9.6	10.9	12.2	10.6	9.6	10.1	11.2	16.5	11.9
	4	high	8.1	9.7	9.7	7.8	8.83	16.6	19.1	21.5	16	18.3	40.2	34	37	25.3	34.1
		low	7.9	6.7	9	7.5	7.78	12.1	10.4	11.1	11.5	11.3	18	14.4	11.3	11.8	13.9
370R12T8	1	high	9.4	9.6	12.2	10.6	10.5	21.9	23.6	15.1	18.3	19.7	39	33.9	19.8	27.5	30.1
		low	8.8	9.2	7.5	7	8.13	11.1	14.2	11.5	9.7	11.6	11.5	18	11.1	12.5	13.3
	2	high	10.6	7.8	9.1	9	9.13	19.2	15.7	18.6	19.8	18.3	31.6	25.8	32	34	30.9
		low	8.6	8	9	8.2	8.45	11.6	14.3	12.1	13.6	12.9	18.3	12.1	17.7	11.5	14.9
	3	high	12.2	9.7	9.3	10.5	10.4	27	20.7	19.6	21.6	22.2	39.9	34.2	35.1	37.4	36.7
		low	8	7.5	7.6	7.4	7.63	12.3	11.7	10.1	11	11.3	15.7	13.4	10.6	12	12.9
	4	high	8.6	9.6	10.8	8.1	9.28	18.6	19.3	22	16.1	19	33.6	33	35.2	36.4	34.6
		low	8.9	8.8	8.2	7.2	8.28	13.6	13.6	12.4	10.6	12.6	19.8	17.2	16.9	10.7	16.2

Seedling Heights (cm)

Ramet No.	Blck.	Fert.	Three Months				Mean	Four Months				Mean	Five Months				Mean
383R4T3	1	high	9.6	8.2	9	9.7	9.13	19.1	18.6	18.8	18.6	18.8	30.8	36.5	34.7	23.2	31.3
		low	8.6	7.3	8.6	7.8	8.08	12.2	9.5	11.2	11.3	11.1	12.3	9.5	11.1	11.8	11.2
	2	high	10.2	9.4	8.4	9.1	9.28	20.5	20	21.1	26.1	21.9	36.3	33.3	34.5	42.6	36.7
		low	9	7.1	9.2	8.9	8.55	12.2	10	13.6	13.1	12.2	12.2	10.1	13.7	13.4	12.4
	3	high	9.9	10.4	8.8	9.4	9.63	19.7	23.4	18.7	21.8	20.9	21.7	40.2	23.3	37.7	30.7
		low	9.2	8	7.4	7.6	8.05	11.2	11.3	10.7	13.6	11.7	11.7	11.1	11.4	13.9	12.0
	4	high	10.2	9.1	11.6	11.2	10.5	19.6	19.6	23.7	20.5	20.9	33.7	31.1	40.5	23.3	32.2
		low	9.6	7.8	8.5	10.2	9.03	14.5	11.5	9.9	13.6	12.4	14.6	11.6	10	14.1	12.6
383R9T3	1	high	7.9	9.7	10.1	4.1	7.95	16.9	19.6	20.5	7.1	16.0	26.5	35.7	32.5		31.6
		low	8.1	8.4	8.1	8.2	8.2	11.6	11.7	10	10.3	10.9	12.5	12	10.2	10.3	11.3
	2	high	11.9	9.6	8.7	11.7	10.5	23.1	20.6	20	20.5	21.1	28.4	33.7	33.2	27	30.6
		low	9.3	8.7	9.6	7.8	8.85	14.8	12.6	12.5	11.7	12.9	15.2	12.7	13	11.6	13.1
	3	high	10.3	8.6	10.3	9.7	9.73	20.2	20.6	21.6	22.4	21.2	35.7	38.2	34.9	32.8	35.4
		low	8.4	7.1	8.2	7.6	7.83	10	11.3	9	12.2	10.6	9.9	11.8	9.2	12.1	10.8
	4	high	9.6	8.5	7.8	9.5	8.85	20.7	21.2	17	18.8	19.4	35.7	38.9	29.9	33.9	34.6
		low	9.7	8.9	8.1	8.7	8.85	12.3	12.9	11.1	13.1	12.4	13	13	11.4	13.7	12.8
383R9T7	1	high	9.4	8.4	8.6	7.5	8.48	15.7	19	17.2	17.5	17.4	29.6	34.5	20.5	31.5	29.0
		low	8.4	10.1	8.7	8.2	8.85	13.5	14.6	10.3	10.7	12.3	14.5	14.6	11.1	11.2	12.9
	2	high	9.7	9.1	9.1	8.7	9.15	19.2	17.4	19.7	20.3	19.2	27.1	29.5	35	33.6	31.3
		low	9.2	7.1	6	9.6	7.98	12.9	10.1	8.4	13.9	11.3	13.2	10.1	8.4	14.2	11.5
	3	high	8.6	10.4	10.6	7.3	9.23	18.4	21.7	22.5	16.2	19.7	31.2	37	37	26.6	33.0
		low	8	6.4	8.9	7.7	7.75	12.2	9.5	12.5	10.6	11.2	12.6	9.7	12.6	10.8	11.4
	4	high	9	9.7	8	11.1	9.45	17.2	17.6	14.4	22.2	17.9	32.5	18.1	16	37	25.9
		low	8.6	6.8	8.6	7.4	7.85	12.3	8.6	12.2	10.3	10.9	12.2	8.7	12.1	10.7	10.9
385R2T2	1	high	9.3	6.5	9.2	5.6	7.65	13	20.1	15.5	22.6	17.8	24.7	35.2	26.1	33.7	29.9
		low	8.1	8.6	10.1	9.3	9.03	11.2	12.1	15.2	14.3	13.2	11.2	12.3	15.2	14.4	13.3
	2	high	9.3	10.1	8.6	10	9.5	21.7	20.3	23	21.2	21.6	36.6	33.1	36.9	36.8	35.9
		low	9	7.5	8	9.7	8.55	12	10	10.6	13	11.4	11.8	10	10.7	13	11.4
	3	high	7.5	12.2	8.1	8.4	9.05	17.3	26.2	21	19	20.9	19.8	43.5	37.1	32.5	33.2
		low	8	7.2	9.5	7.9	8.15	11	9.8	14.1	10.3	11.3	11.3	10.1	14.7	10.5	11.7
	4	high	10.4	8.3	10.4	10.3	9.85	22.1	18.5	22.3	20.9	21.0	34.6	33	37.6	35.6	35.2
		low	8.8	7.8	7.4	9.7	8.43	13.1	10.1	10.3	12.4	11.5	13.2	9.9	10.4	12.9	11.6
385R8T5	1	high	9.7	10.1	9.4	9.7	9.73	22.4	19.6	19	18	19.8	38.5	32.4	32.1	18.4	30.4
		low	10.4	9.3	9.9	8.2	9.45	16.2	13.1	12.4	12	13.4	16.6	13	13	11.9	13.6
	2	high	9.6	8.6	9.8	8.2	9.05	21.1	19.7	18.7	19.3	19.7	34.6	28	33.2	33.3	32.3
		low	7.8	7.8	9.3	8.7	8.4	13	13.3	10.6	11	12.0	13.4	13.5	10.6	10.8	12.1
	3	high	12.1	12.5	12	10.2	11.7	26.9	25.2	25.6	21.2	24.7	42.7	43	43.2	37.4	41.6
		low	7.1	6.6	7.2	7.6	7.13	13.6	12	10.6	11.2	11.9	13.6	13	11.5	11.6	12.4
	4	high	11.1	10	8.1	7.8	9.25	25.2	23	18.2	18.8	21.3	41.5	37.9	33	32.6	36.3
		low	9.2	9.1	9.6	9.3	9.3	15.2	13	13.4	15.3	14.2	16	12.9	13.4	16.6	14.7
385R11T2	1	high	8.7	9.1	9.6	8.6	9	10.7	18.7	18.8	18.9	16.8		29.5	29.1	25.3	28.0
		low	6.6	9.2	7.8	12	8.9	12.4	11.7	10.8	16.1	12.8	10.3	12	11.1	16.2	12.4
	2	high	8.4	9	8.3	10	8.93	23.6	18.7	18.1	18.6	19.8	32.3	32.7	22.1	35.8	30.7
		low	8.2	7.8	6.7	8	7.68	11.5	8.6	10.8	13.6	11.1	11.5	8.6	11	18.2	12.3
	3	high	8.7	9.7	10.3	10.8	9.88	20.1	22	23.2	24.6	22.5	31.4	43.4	38.4	39	38.1
		low	6.3	8.1	8	8.1	7.63	9.8	10.1	10	11.2	10.3	10.5	10.4	10.2	11.6	10.7
	4	high	10.9	8.6	10	9.7	9.8	20.7	19.2	21.4	20	20.3	35.7	35.9	37.2	23.4	33.1
		low	7.6	7.8	10.3	8.9	8.65	11.5	14	12.1	11.7	12.3	11.7	14.2	13.2	12.3	12.9

Seedling Heights (cm)

Ramet No.	Blck.	Fert.	Three Months				Mean	Four Months				Mean	Five Months				Mean
387R7T6	1	high	10.2	9.2	9.3	10.5	9.8	20.4	17	16	21	18.6	32.9	31.4	23.8	34.6	30.7
		low	9.3	8.9	7.5	8.9	8.65	15.1	14	10.6	12.2	13.0	16.3	15.1	10.6	11.9	13.5
	2	high	6.8	11	9.4	10.2	9.35	14.6	20.3	18.7	21.9	18.9	19.6	23.6	32.1	33.8	27.3
		low	8.7	8.1	8	7.8	8.15	9.9	10.5	9.5	9.4	9.83	9.7	10.4	9.3	9.6	9.75
	3	high	9.6	9.8	11.3	9.5	10.1	20	19	24.3	26.6	22.5	30.7	31.8	42.9	21	31.6
		low	8.6	7.6	7.3	7.7	7.8	10.2	11	10.4	11	10.7	10.6	10.4	11.3	10.4	10.7
	4	high	10	9.7	8.5	7.2	8.85	20.7	20.7	18.1	16	18.9	37	35.8	31.3	25.3	32.4
		low	9	8.3	7.4	7.9	8.15	12.5	10.2	9.9	11	10.9	12.7	11.1	10.3	11	11.3
387R8T3	1	high	9.7	8.9	9.8	10.1	9.63	17.2	20.6	17	13.5	17.1	18	32.3	29.5	14.5	23.6
		low	8.6	8.6	9.7	9.3	9.05	13	11.4	13.8	12.7	12.7	13.4	11.4	14	12.9	12.9
	2	high	10	8.2	8.5	9	8.93	18	16.1	16.1	15.6	16.5	24.2	30.2	29.1	30.3	28.5
		low	9.7	9.1	7.5	8.2	8.63	12	12.3	9	12.3	11.4	12.3	12.4	9	12.4	11.5
	3	high	8.2	10.6	9.4	11.1	9.83	17.2	20.3	20.2	23.5	20.3	25.2	33	35.5	42.3	34
		low	8.2	8.1	7.4	8.7	8.1	10.9	11.4	10.5	11.6	11.1	10.8	11.6	10.7	11.7	11.2
	4	high	8.1	8.1	4.2	9.7	7.53	17	17.1	5.1	18.2	14.4	31.3	30.1		35.6	32.3
		low	8	4	8.1	7.4	6.88	11.3	4.8	11.7	9.6	9.35	14.3	9.9	11.7	10.3	11.6
387R9T1	1	high	8.4	8.3	8.6	9	8.58	13.1	16.7	15.1	11.4	14.1	15	28.4	26	11.2	20.2
		low	10.5	9.7	7.6	8.6	9.1	13.7	11.8	9.6	11.1	11.6	13.7	11.5	9.6	11.3	11.5
	2	high	10.7	10.5	9.1	9.4	9.93	20.6	19.1	24.2	21	21.2	33.2	33.6	42.2	27.5	34.1
		low	8.5	7.1	8.3	8.5	8.1	10	8.4	10.5	10.6	9.88	10	8.5	10.4	10.7	9.9
	3	high	8.3	10	9.7	9.2	9.3	18.4	21.2	22.1	18.8	20.1	31.6	23	36.6	33.8	31.3
		low	5.7	9.3	7.7	7.2	7.48	7.5	12.7	10.5	10.6	10.3	8.1	13.2	11.3	10.9	10.9
	4	high	9.6	7	7.2	8.1	7.98	17.4		15.2	14.8	15.8	31		29.4	28.3	29.6
		low	9.6	8	7.1	8.5	8.3	14.4	9.7	10.5	11.5	11.5	14.3	9.9	10.3	11.7	11.6
393R6T9	1	high	8.2	8.4	8.6	8.1	8.33	16.1	16.2	18.6	16.6	16.9	29.3	20.3	27.1	25.1	25.5
		low	8	9.3	9.2	8.9	8.85	11.6	14.2	13	11.2	12.5	11.7	16	13.1	11.3	13.0
	2	high	10.6	7.5	7.4	10.1	8.9	18.9	19.7	17	21.2	19.2	29.2	32.4	28.5	29.5	29.9
		low	7.6	6.4	8	7.9	7.48	12.6	13.9	10	11.3	12.0	11.6	14.2	10.3	11.8	12.0
	3	high	8.7	10.5	9.5	8.2	9.23	19	22.4	20.7	17.3	19.9	24	36.7	36.2	32.5	32.4
		low	7.3	8	8.2	9	8.13	12.7	12.1	11.2	12.8	12.2	14.1	12.2	11.5	12.7	12.6
	4	high	7.7	8.6	8.5	8	8.2	14.3	16.7	18.5	14.1	15.9	27	31.5	32.1	25.6	29.1
		low	8.4	8.6	7	6.7	7.68	12.3	12.1	11.2	10.5	11.5	12.5	12.5	11.7	10.5	11.8
393R10T8	1	high	7.6	9.1	9.6	7.1	8.35	15.3	18.8	19	15.7	17.2	24.2	27.2	31	22	26.1
		low	7.1	7.1	8.3	7.4	7.48	11.9	10.3	11.6	11.1	11.2	12.6	10.5	11.6	11.4	11.5
	2	high	8.5	9.2	8.5	10.4	9.15	21	14.6	18.6	18.1	18.1	36.6	25.5	22.5	33.6	29.6
		low	6.5	8	7.1	6.3	6.98	9.1	11	13.8	9.8	10.9	10.2	15.3	11.5	9	11.5
	3	high	9	8.6	8.7	11.6	9.48	19.3	18.1	19.2	23.4	20	29.3	29.7	32.7	36.4	32.0
		low	8.1	7.8	8.9	6.2	7.75	10.9	12.2	12	10.5	11.4	12.5	12.2	12.1	10.7	11.9
	4	high	9.9	9	8.9	9	9.2	21.6	19.8	20.5	21.2	20.8	37.7	34.6	34.1	36.8	35.8
		low	7.8	9	6.5	8.8	8.03	12	13.2	11.5	13.8	12.6	12.4	13.2	12.7	14	13.1
393R11T6	1	high	9.2	7.9	9.6	8.1	8.7	9.5	15.4	16.3	21.1	15.6		26.6	28.1	33.8	29.5
		low	8.3	9.4	8.2	7.5	8.35	12.7	13.2	12	11.6	12.4	16.6	14.2	12.5	11.9	13.8
	2	high	7.9	7.7	9.6	10.3	8.88	18.2	17.7	19.1	20.8	19.0	32.3	30.9	32.8	31.1	31.8
		low	7.5	8.7	7.5	8.6	8.08	12.6	12	11.7	12.7	12.3	12.2	12.1	12.2	12.9	12.4
	3	high	10.6	9.3	9.7	10.4	10	20.4	20.6	21.6	19.3	20.5	32.5	34.7	31.8	33.6	33.2
		low	7.3	9.2	6.4	7.6	7.63	11.7	12.8	10.6	10.3	11.4	16	13.1	11.1	10.7	12.7
	4	high	8.8	8.2	7.7	8.7	8.35	17.6	15.3	17.7	16.8	16.9	34.3	28.7	32.5	27.7	30.8
		low	7.6	8.4	7.4	7.9	7.83	13.1	11	11.6	9.5	11.3	13.7	11.6	11.9	9.8	11.8

Ramet No.	Blck.	Fert.	Three Months				Mean	Four Months				Mean	Five Months				Mean
491R7T6	1	high	9.3	7.9	10.6	8	8.95	16.1	21	17.3	19.4	18.5	26	31.9	27.9	31.4	29.3
		low	8.8	7.7	7.5	10.1	8.53	12.8	12.4	11.3	15.4	13.0	13.2	12.5	11.6	18	13.8
	2	high	8.8	9	10.6	9.2	9.4	16.5	18.2	21.3	18.4	18.6	24.5	30	36.5	30.5	30.4
		low	8.3	8.3	8.2	8.9	8.43	14.1	13.2	12.3	14.6	13.6	16.3	14.9	12.5	17.9	15.4
	3	high	8.7	12.5	10.1	8.3	9.9	17.9	24.3	23	18.4	20.9	27.3	40	34.7	28.9	32.7
		low	10.7	7.4	8.1	8.2	8.6	16.5	12.4	13.5	12.9	13.8	22.5	14.7	18.1	14.2	17.4
	4	high	7.6	11	8.6	8.7	8.98	16.4	22.3	18.1	15.1	17.5	29.5	37.6	18.6	24.3	27.5
		low	9.9	7.8	9.1	9.6	9.1	14.7	12.8	11.6	14.2	13.3	15.6	17	12	14.5	14.8
491R7T12	1	high	8.6	7.7	8.7	7	8	15.2	20.2	17	18.3	17.7	26.3	33.2	28.1	28.1	28.9
		low	9.4	6.6	7.6	8.3	7.98	13.1	9	11.8	12.7	11.7	14.2	9.1	12.1	14.9	12.6
	2	high	9.3	10.6	8.6	8.6	9.28	21	21.9	22.7	20.1	21.4	32.7	37.2	33.6	30	33.4
		low	9.3	7.6	8.7	9.5	8.78	14.5	12.6	11.1	12.9	12.8	14.7	12.8	11.5	13.2	13.1
	3	high	8.4	9.5	10.7	9.3	9.48	17.7	18.8	21.8	19.1	19.4	20.4	30.1	35.4	32.6	29.6
		low	8.7	9.3	7.8	9.2	8.75	13.1	14	11.9	14	13.3	14.3	14	13.8	14.6	14.2
	4	high	5	9.2	9.5	8.8	8.13	8	20.3	19.2	11.6	14.8		33.3	33.3	23.8	30.1
		low	7.3	6.7	8.1	7.5	7.4	12.1	10.3	13.2	12	11.9	12.9	10.4	14.3	12.4	12.5
491R10T6	1	high	11.7	10.5	7.6	8.6	9.6	19.4	9.1	21	21.8	17.8	28.4		29.7	31.3	29.9
		low	9.3	7.8	9	8.7	8.7	13	13.3	13.1	12.5	13.0	14.1	13.6	13.8	13.1	13.7
	2	high	8.9	9.6	12.2	10.5	10.1	22.6	26.1	19.3	21.3	22.3	36.8	40	31.2	35.2	35.8
		low	7.2	7.8	8	9.8	8.2	14.1	11.2	10.6	10.1	11.5	14.8	11.6	11	10.1	11.9
	3	high	10.1	10.7	10.8	9.4	10.3	22.7	24	23.8	20.3	22.7	38.5	39.8	39.3	30.2	37.0
		low	7.6	7.1	7.3	8	7.5	11.4	10.7	10.7	10.8	10.9	11.9	11.6	11	11	11.4
	4	high	7.7	8.6	10.7	9.6	9.15	17.2	19	21.3	20.7	19.6	31.4	32	36.2	33.9	33.4
		low	6.5	8.1	6.1	8.2	7.23	11.2	12.2	8.3	12.9	11.2	12.3	16.7	8.8	17.3	13.8
492R7T6	1	high	10.3	9.6	9.2	8.2	9.33	17.3	19.5	20.1	21.2	19.5	26.3	32.4	34.6	23.2	29.1
		low	9.4	7.4	8.6	9.2	8.65	13.7	9.8	12.7	14.5	12.7	14.5	10.1	13.3	17.3	13.8
	2	high	9.3	9.4	9.5	7.8	9	19	18.2	18.4	15.1	17.7	25.5	35.4	32.5	32.4	31.5
		low	8.7	7.6	8.3	9.6	8.55	13.6	12	13	12.9	12.9	13.6	12.2	14.4	13.3	13.4
	3	high	9.6	10.1	10.4	10.2	10.1	21.2	22.5	23.6	18.2	21.4	35	39.3	39	27.9	35.3
		low	8.5	8.6	9.7	8.2	8.75	12.8	14.4	12.5	11	12.7	13.4	14.3	13.2	11.5	13.1
	4	high	9.1	9.1	8.2	7.1	8.38	16.3	17.3	16.5	13.4	15.9	31.5	33.1	29.2	27.3	30.3
		low	10.5	8.6	8.1	7.5	8.68	14.1	12.7	11.1	12.1	12.5	14.1	13.4	11.6	15.4	13.6
492R12T7	1	high	9.2	12.5	7.5	8.8	9.5	18.1	13.7	25.7	19.3	19.2	29.9	22.5	37.1	27.6	29.3
		low	8.3	10.2	9.3	9.5	9.33	9.9	13.3	12.4	11.7	11.8	10.6	13.6	12.7	12.1	12.3
	2	high	8.9	9.1	11.5	11.7	10.3	25	22.6	19.6	19	21.6	38.4	34.2	31.5	31	33.8
		low	7	9.5	10.1	10	9.15	9.9	16.2	15.3	12.8	13.6	10	17.6	15.6	13	14.1
	3	high	8.6	8.9	9	10	9.13	16.6	18.2	17.7	21.7	18.6	28.2	31.4	39.1	33.2	33.0
		low	6.7	7.6	9.7	8.7	8.18	12.8	14.5	10.4	10.2	12.0	13.3	16.6	10.5	10.7	12.8
	4	high	10.7	8	9.8	12.5	10.3	22.7	18	20.5	25.5	21.7	37.6	31.5	36.1	39.4	36.2
		low	8.2	7.2	8.7	8.7	8.2	11.2	10.6	12.4	12.5	11.7	11.8	13.6	12.6	15.6	13.4

Seedling Heights (cm)

Ramet No.	Blck.	Fert.	Three Months				Mean	Four Months				Mean	Five Months				Mean
			Seedling Heights (cm)														
493R3T9	1	high	8.3	7.7	9.4	7.4	8.2	15.6	22.3	17.9	18	18.5	28.5	35.9	32.3	32	32.2
		low	8.3	8.3	8.7	7.6	8.23	13.6	10.4	12.8	11.8	12.2	16.6	10.6	13.2	12	13.1
	2	high	11.1	8.5	8.4	9.3	9.33	23.2	19.7	21.4	25.1	22.4	38.3	24.1	30.1	39.6	33.0
		low	7.6	8	7.5	8.1	7.8	12.6	11.7	12.9	12.8	12.5	12.2	12	13.4	17.3	13.7
	3	high	7.6	7.7	8.9	9.1	8.33	20.1	19.1	19.3	22.4	20.2	34.1	32.4	33.3	36.7	34.1
		low	6.9	9.3	7.4	7.4	7.75	10.6	12.4	12	12	11.8	11.1	12.6	12.7	12.6	12.3
	4	high	8.7	9.1	8.6	8.7	8.78	20	20.6	18.3	18.7	19.4	33.3	35.8	19.5	32.3	30.2
		low	7.6	6.8	7.6	6.9	7.23	13	11.4	9.5	9.7	10.9	13.4	11.4	9.5	9.7	11
493R5T9	1	high	8.4	8.9	9.6	9.3	9.05	20.6	18.9	16.3	18.5	18.6	34.6	33.5	29.4	31.2	32.2
		low	8.2	7.6	10.6	6.2	8.15	12.5	12.4	15.6	9.7	12.6	13.6	13.5	16.4	10.1	13.4
	2	high	7.6	7.6	10.1	8.1	8.35	15.6	18.4	22.1	20	19.0	26.5	32.8	36.9	35.1	32.8
		low	9.7	7	6.4	7.8	7.73	15	12.4	10.5	11.5	12.4	15.9	12.8	1.7	11.7	10.5
	3	high	9.5	10.4	12.2	10	10.5	20.6	24.6	26.6	21.4	23.3	36	38.7	44.1	32.6	37.9
		low	5	5.2	7.4	10	6.9	7.5	10.6	10.8	15.6	11.1	7.6	14.7	10.9	17.1	12.6
	4	high	8.1	9.1	8	9	8.55	19.1	21	18.9	15	18.5	32.4	35.2	32.6	19.3	29.9
		low	8.4	6.9	7.4	8.3	7.75	11.7	9.4	11.1	12.7	11.2	11.5	9.5	11.6	13.4	11.5
493R11T6	1	high	11	7.6	8.4	7	8.5	15.2	19.3	16.5	24.5	18.9	26.4	33.4	27.1	33.4	30.1
		low	7.1	6.6	5.7	9.7	7.28	9	9.8	9	12.3	10.0	9.9	9.9	9.4	12.5	10.4
	2	high	7.2	8.2	9.5	8.6	8.38	15.2	17.5	20	18	17.7	25.8	31.6	33.2	29.1	29.9
		low	5.8	7	5.6	6.6	6.25	8.7	7	8.6	6.7	7.75	8.5	7	8.6	6.8	7.73
	3	high	8.5	8.5	8.1	8.7	8.45	20.2	20.2	18.3	22.7	20.4	33.6	33.9	30.2	40.7	34.6
		low	7.1	7.3	6.1	7.6	7.03	10.3	10.6	10.7	12.7	11.1	10.4	11	11.1	13.1	11.4
	4	high	8.9	8.3	9.1	9.6	8.98	19.2	18.1	18.3	21.6	19.3	33.6	31.9	31.6	34	32.8
		low	7.6	6.3	6.2	7.7	6.95	12.9	10.5	10.2	12.8	11.6	13.3	11.2	12.1	13.1	12.4