RECIPROCAL GRAFTING BETWEEN THREE SPRUCE SPECIES

R. VAN DEN DRIESSCHE
Research Division, British Columbia Forest Service,
Victoria, Canada

(Received for publication 13 September 1973)

ABSTRACT

Reciprocal grafting of Sitka spruce (**Picea sitchensis** (Bong.) Carr.), white spruce (**P. glauca** (Moench) Voss), and Norway spruce (**Picea abies** (L.) Karst.) was carried out so that young and old scion material of each species occurred on rootstocks of all three species. Most mortality took place in the first 18 months; half or more of the ramets bearing young material survived for 5 years regardless of combination. Survival of ramets involving old material was generally poor, although 60% of old Norway spruce scions survived on white spruce stocks, and 40% of old Sitka spruce scions survived on Norway spruce stocks.

Coning began in the fourth year on three old Sitka scions. Norway spruce rootstock reduced the number of branches per ramet, but no significant effect of rootstock on height or diameter was detected. Foliar nitrogen and potassium concentration of young material was related to scion species, but foliar calcium concentration was related to stock species.

Inter-specific grafting within the genus **Picea** is possible although definite rootstock effects have so far been small.

INTRODUCTION

Selected rootstocks have been used to obtain dwarfing and enhance fruiting in apples and citrus (Rogers and Beakbane, 1957). Any technique which results in dwarfing and enhancement of cone production in conifers would be of value to a breeding programme or in seed orchards. With the recent establishment of a spruce (*Picea* spp.) breeding programme in British Columbia it was decided to examine rootstock effects. Clonal rootstock material, as used in fruit-tree work, was not available, so the best way of making such tests was by inter-specific grafting. It seemed likely that grafting between different species of spruce would not be difficult (Sheat, 1948) and, in particular, successful union of white spruce (*Picea glauca* (Moench) Voss) scions on Norway spruce (*Picea abies* (L.) Karst.) rootstocks and vice versa had already been reported (Holst, 1956). Consequently a small experiment was set up to test the effect of grafting of Sitka spruce (*P. sitchensis* (Bong.) Carr.), white spruce, and Norway spruce scions on to rootstocks of each of these species.

The primary object was to obtain information on incompatibility, growth, and cone

production. A secondary object was to see how mineral nutrition might be influenced by rootstock, with a view to explaining any observed rootstock effects on growth.

METHODS

Fifteen young scions and 15 old scions of each of the three species, Sitka spruce, white spruce, and Norway spruce, were grafted onto 30 two-year-old rootstocks of each of the same species. This produced 270 ramets representing nine species combinations. Young scions and rootstocks were of the same provenance as follows: Sitka spruce, Smithers, British Columbia; white spruce, Hixon, British Columbia; Norway spruce, an unspecified origin in Austria. Old scion material was obtained from Sitka spruce (estimated age 70 years) at Sooke, white spruce (estimated age 80 years) at Francois Lake, and Norway spruce (estimated age 35 years) in Victoria. Five scions were cut from each of three trees to obtain the 15 required for each species and age combination.

Pocket grafting (Holst *et al.,* 1956) was carried out in April 1968 onto rootstocks which had been placed in the greenhouse a month earlier to hasten flushing. The ramets remained in the greenhouse for a further month and were then placed in the open. They were planted out at 1.8 m spacing on a fertile silt loam site in April 1969. A count of surviving ramets and a check for cones was made every year. In November 1972 measurements of height, mean stem diameter above and below the graft, and the number of branches per ramet were made. At the same time foliage from the upper whorl of each plant was collected and analysed to determine concentrations of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg); 95% confidence limits were calculated for all means relating to young scion combinations, but not for old scions, where numbers of particular combinations were frequently low.

RESULTS

Ramets which grafted successfully, and were healthy after 18 months, survived for five years with few exceptions (Table 1). Ramets with young scions survived better than ramets with old scions.

TABLE 1—Spruce ramet survival*

Rootstock	Scion					
	Sitka		White		Norway	
	Young	Old	Young	Old	Young	Old
	Survival after 1.5 years					
Sitka	12	3	11	1	11	5
White	8	0	12	4	11	9
Norway	7	6	9	1	12	3
	Survival after 5 years					
Sitka	12	3	11	1	11	4
White	8	0	10	4	10	9
Norway	7	6	9	1	12	3

* Initial number of ramets for each scion, rootstock, age, combination was 15.

The only coning so far, in 1972, was on three different scions obtained from one old Sitka spruce. Two scions on Sitka rootstock produced a male and a female cone, and two male cones, respectively. The third scion was on a Norway rootstock and produced one male cone.

Ramets with young white spruce scions tended to be shorter than ramets with Sitka or Norway spruce scions, but rootstock had no clear effect on height (Fig. 1). There were no significant differences between stem diameter measured above and below the graft, but young white spruce scions generally had smaller diameters than Sitka or Norway spruce scions.

The only detectable effect of rootstock on growth was the reduction in number of branches per ramet occurring when young scions of any of the three species were grafted onto Norway rootstocks. Mean growth measurements made on old material suggested

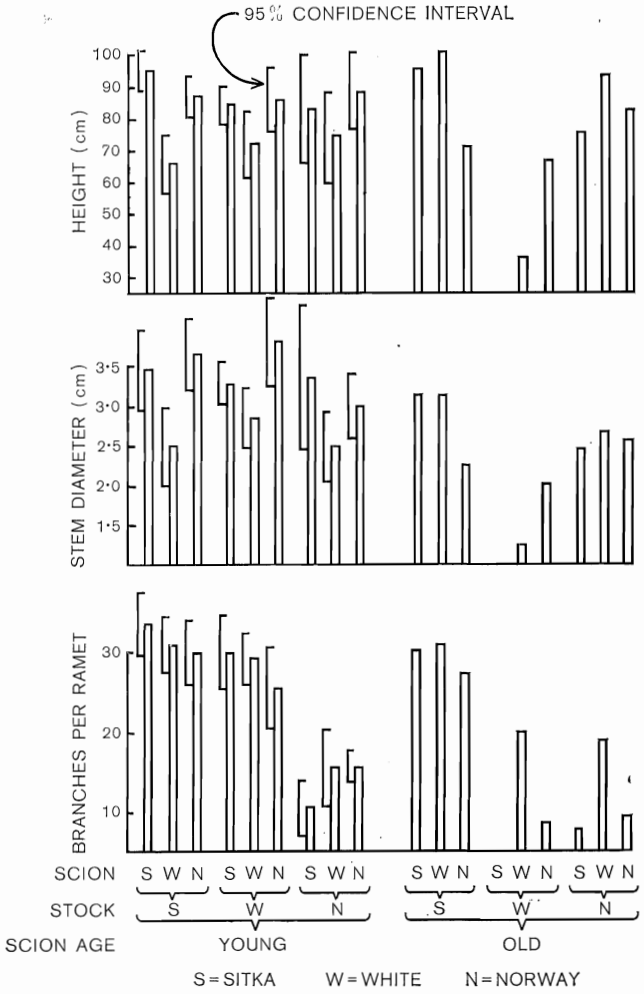

FIG. 1—Growth measurements of ramets

growth was more vigorous on Sitka spruce and Norway spruce rootstocks than on white spruce rootstocks.

Foliar N concentration of young ramets appeared related to scion species, with Norway spruce showing significantly higher values than Sitka spruce on both Sitka and Norway rootstocks (Fig. 2). Scion species was clearly the factor which determined foliar K concentration of young ramets, with highest values being associated with Sitka scions, and lowest values with white scions. There was no indication that the pattern of N and K concentrations discernible in the young material was the same in the old material. Neither did rootstock species seem to have any major effect on foliar N and K concentrations, but foliar Ca concentration did appear related to rootstock species.

The lowest, intermediate, and highest mean foliar Ca concentrations were found in

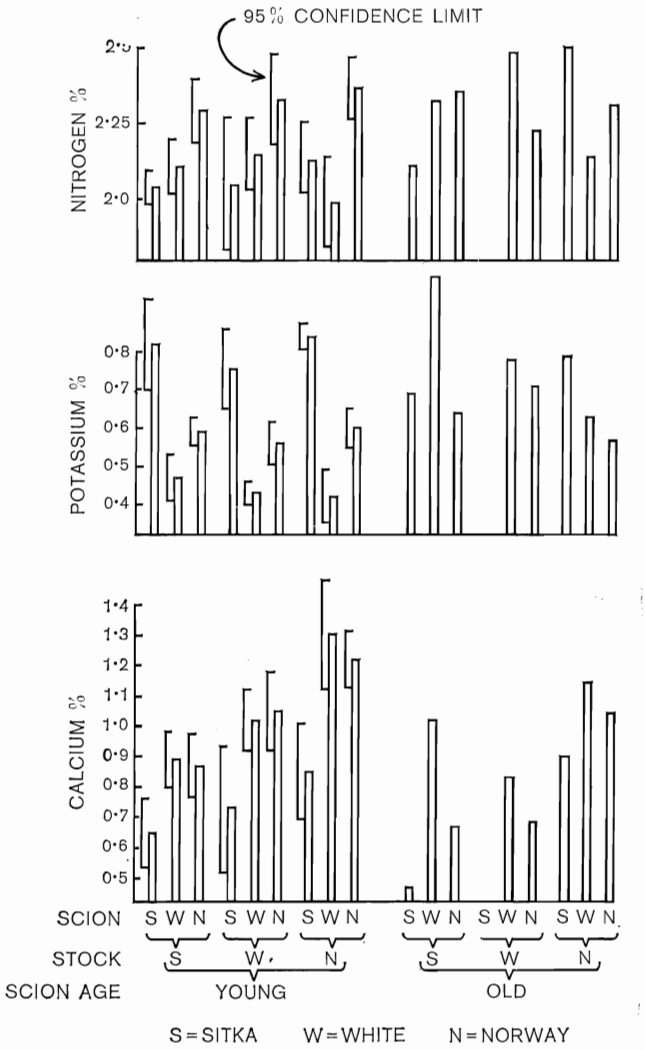

FIG. 2—Foliar nutrient concentration

scions grafted onto Sitka spruce, white spruce, and Norway spruce rootstocks respectively. Significant differences in foliar Ca concentration only occurred between Sitka and Norway spruce rootstocks. No significant differences were detected in the foliar P and Mg data, where mean foliar concentrations were 0.23% P and 0.14% Mg respectively.

DISCUSSION

Mortality of ramets occurred mainly during the first 18 months. No evidence of incompatibility was noted in the following 3½ years, although it may still show up in the future. Graft unions could be established between all three species regardless of which was stock or scion, but success was low with old Sitka and white spruce scions.

Obvious effects of rootstock on height and diameter growth were not detectable in this study, although species of scion did appear to affect these measurements. However, this may not be general in conifers: in a study in which five pine species were used as scions on five other species of pine rootstocks, it was observed that *Pinus strobus* L. stocks were frequently associated with rapid scion growth and *P. resinosa* Ait. stocks with slow scion growth (Ahlgren, 1972). The reduction of number of branches occurring in ramets with Norway spruce rootstocks seemed to be a definite rootstock effect. This might prove a disadvantage in terms of cone production if it represents a reduction in the number of sites where reproductive bud initiation can occur. The point can only be verified when coning occurs, and indeed the study is incomplete until coning takes place widely on all ramets.

The importance of scion species in determining foliar concentrations of K, and to a lesser extent N, showed that the rootstock did not have an overriding effect on the nutrition of the ramets. The ramets were grown in fertile soil, and an adequate supply of N and K at all times may have hidden differential nutrient uptake ability existing between the rootstocks. An effect of rootstock on foliar Ca concentration was observed, but this could not be related to any growth differences. Possibly, rootstock effects on mineral nutrition, and therefore growth, would have become more evident on soils of lower fertility.

Concentration of a number of elements was found to be significantly less in foliage of Cembran pine (*Pinus cembra* L.) scions grafted onto Scots pine stocks than in foliage of ungrafted individuals of either species (Tomcuk *et al., 1969).* In the present experiment, foliar nutrient concentrations were not obviously lower than values normally reported for these spruce species (cf. Leyton, 1957, van den Driessche, 1969), indicating that the graft did not represent a serious obstacle to uptake of mineral nutrients.

This trial shows that grafting of spruce for breeding work or seed production need not be confined within a species, but more extensive testing would be necessary to establish superiority of a particular rootstock for achieving dwarfing or greater seed production.

REFERENCES

AHLGREN, C. E. 1972: Some effects of inter- and intraspecific grafting on growth and flowering of some five-needle pines. **Silvae Gen. 21 (3-4):** 122-216.

HOLST, M. J. 1956: Phenology of rootstocks and grafts. **Canad. Dept. N. Affairs and Nat. Res. Forest Res. Div. Tech. Note 48:** 1-17.

HOLST, M. J., SANTON, J. A. and YEATMAN, C. W. 1956: Greenhouse grafting of spruce and hard pine. **Canad. Dept. N. Affairs and Nat. Res. Forest Res. Div. Tech. Note 33:** 1-24.

LEYTON, L. 1957: The mineral nutrient requirements of forest trees. **Ohio J. Sci. 57:** 337-45.

ROGERS, W. S. and BEAKBANE, A. B. 1957: Stock and scion relations. **Ann. Rev. Plant Physiol. 8:** 217-36.

SHEAT, W. G. 1948: "Propagation of trees, shrubs and conifers". MacMillan and Co. Ltd., London. 479 pp.

TOMCUK, R. I., MOJSEEV, R. G. and MOJSEEVA, V. Z. 1969: Change in the content of certain chemical elements in needles of **Pinus cembra** as a result of grafting on to **P. sylvestris.** **Ukr. bot. Z, 26 (5):** 126-28. **In For. Abstr. 1970, 31: 522** No. 4404.

VAN DEN DRIESSCHE, R. 1969: Forest nursery handbook. **Brit. Col. For. Serv. Res. Note 48:** 1-44.