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Inoculation of Alder Seedlings to Improve Seedling Growth and Field Performance

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Abstract

Inoculation of *Alnus* seedlings with selected *Frankia* strains has been investigated. Nursery experiments and subsequent field trials have given results of sufficient significance for the inoculation technique to be recommended as a standard nursery practice. Although current research has been concerned primarily with inoculation of *Alnus rubra*, work with other alder species has shown comparable results.

Introduction

1. Alders (*Alnus* sp.) are able to extract nitrogen form the air through their symbiotic relationship with a bacteria-like micro organism of the genus *Frankia* which forms nodules on the roots. Plants raised in nurseries can develop nodules from *Frankia* occurring naturally in the soil. However, few plants are well nodulated before they are transplanted and they may be dependent upon nodules developing when planting.

2. Reclaimed land (ground restored following mineral working or dereliction) is often devoid of organisms from which colonisation can occur. Therefore, it is essential that alder plants raised for these sites should possess nodules before out-planting.

3. Improved nodulation in the nursery could produce 1+0 seedling planting stock 10-30 cm in height instead of the more usual 1+1 transplants, which can vary between 60 and 100+ cm in height and are often too tall for successful notch planting especially on upland sites.

Experiments and results

4. From 1985 to 1987, nursery experiments were established annually on sterilised seedbeds which were prepared and sown using standard practice. Each experiment compared three sources of *Frankia* inoculum (LCR, ArI4, Ar125q) with normal nursery fertilizer regimes. The inocula were applied to plots that received only PK basal fertilizer at recommended rates. Control plots received only basal fertilizer (PK and NPK) or basal fertilizer plus nitrogen top-dressing (NPK + T/D).

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5. The LCR inoculum was prepared from mature *Alnus rubra* crushed nodule homogenised in water, then strained through muslin to remove large particles before application. The ARI4 and Ar125q *Frankia* strains were cultured in sterile media in the laboratory, the cells being harvested by filtration then rinsed and homogenised in water. Both crushed nodule and cultured *Frankia* inocula were applied to the seedbeds as an aqueous suspension using a standard watering can. In the 1985 experiment inocula were applied soon after seed sowing; in the two subsequent experiments *Frankia* was applied when the seed started to germinate, it was considered more effective to inoculate when the seedling radicals were developing.

6. In the first 2 years, plants treated in the nursery were grown in isolated, unreplicated plots to guard against risks of cross-contamination. Results form field trials, and information from the destructive analysis of plants suggested that strain Ar125q was the most effective inoculum.

7. In 1987 a replicated nursery experiment compared Ar125q with four standard nursery treatments (PK and NPK fertilizers ± top dressing). At the end of the growing season, the plants in all treatments were assessed for height, root nodule number, nodule weight, root:shoot ration and root collar diameter. Results (Table 1) show that inoculum Ar125q is generally the best of the nursery treatments, particularly where numbers of nodules per plant are considered. The standard nursery regimes, which would include nitrogen top dressing, resulted in a reduction in the mean dry weight of nodules produced.

Table 1
Red alder inoculation – nursery experiment (Bush 13/87) data summary at the end of one season

1987 nursery experiment				
Treatment	Height (cm)	Root collar diameter (mm)	Nodule number/ Plant #	Nodule dry Weight/plant (g)
Ar125q	42.8	7.26	4.17	0.24
NPK	33.6	6.72	2.51	0.23
NPK+TD	43.7	6.85	1.15	0.04
PK	30.1	6.60	2.33	0.26
PK+TD	35.4	6.40	1.83	0.06
Significance	**	*	***	***

#Nodule numbers transformed before analysis

8. One-year seedlings from all of the nursery treatments in the 1985 and 1986 experiments were transplanted out in woodland trials to test for any continuing benefit from the original inoculations. Two main site types were selected – an upland peaty gley forestry restock area and a nutrient deficient opencast mine reclamation site. On both sites available nutrients, particularly nitrogen, could be limiting to tree growth.

9. Initial results showed differences in the effects of inoculation depending upon the site type. On the reclamation sites, the inoculated plants showed significant improvement in height growth over the non-inoculated controls. On these sites, the performance of plants inoculated with the ArI4 and Ar125q strains appears slightly better than that of plants treated with LCR. However, on the upland restock site, differences between treatments in height and height increment are non significant. This is possibly due to nodulation occurring fairly rapidly in the non-inoculated stock after planting out. Differences in survival are invariably non-significant.

Other species

10. Laboratory prepared inocula have been applied to *Alnus glutinosa*, *A. incana*, *A. cordata*, *A. sinuate* and *A. viridis* in the nursery. Significant improvement in nodulation over non-inoculated

controls was obtained for most species using *Frankia* strain ArI7. However, results for the native *A. glutinosa* were disappointing; another nursery experiment was established using UGL010708 inoculum prepared from nodules of this species. Results have shown that this inoculum produces well nodulated stock, with height growth over four times that produced by plants grown in non-inoculated and sterilised control plots.

Conclusions

11. There is sufficient evidence from experiments to recommend seedbed inoculation as a standard nursery practice for raising seedlings of several *Alnus* species. This provides advantages when stock is used on reclamation sites. Of those tested, strain Ar125q has been the most effective inoculant for *Alnus rubra* in terms of nursery and field performance combined; the availability and commercial production of this strain are being investigated. As an alternative, crushed nodules freshly collected from healthy, well grown, mature tree roots of the appropriate alder species can be used to ensure nodule production on seedlings in sterilised seedbeds.

12. Optimum application rates for crushed nodules are being examined. Further investigations are needed into the use of selected *Frankia* stains for a range of alder species.

Provisional recommendations

13. Until further information becomes available, nursery managers should use the crushed nodule technique described in paragraph 5 to ensure nodulation of alder seedlings.

14. Where alder are needed for reclamation sites and for those sites lacking organic matter as a result of top soil stripping, inoculated well nodulated plants should be specified.

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