(HAHN *et al.*, 1989). The most-probable-number of *F. alni* genomic units (GU) was calculated from replicate PCR results for dilutions of soil DNA samples. *Frankia* GU g^{-1} soil were not affected by treatments, and the proportion of the total soil *Frankia* population that was infective increased 16-fold with liming.

HAHN D., LECHEVALIER M. P., FISCHER A. & STACKEBRANDT E., 1989. – Evidence for a close phylogenetic relationship between members of the genera *Frankia, Geodermatophilus* and "*Blastococcus*" and emendation of the Family Frankiaceae. *System. Appl. Microbiol.*, **11**, 236-242.

HUSS-DANELL K., LUNDQUIST P.-O. & OHLSSON H., ***Alnus incana* in field: Nitrogen fixation, and distribution of biomass and nitrogen among plant parts and soil nitrogen.** *Department of Plant Physiology, Umeå University, S-901 87 Umeå, Sweden*

Although *Alnus* spp. are widely recognized as good nitrogen fixers, there are only few data on N_2-fixation by *Alnus* at high latitudes. The aims of the present study were to quantify N_2-fixation by *Alnus incana* in field, and to measure biomass and N distribution within the alders and the soil.

Seedlings of grey alder, *Alnus incana* (L.) Moench, were planted into a nutrient poor soil in northern (63.8°N, 203°E) Sweden. The alders had been inoculated with the "local source" of *Frankia*. This *Frankia* gives rise to N_2-fixing root nodules with the phenotype Hup^-, Spore+ on a number of *Alnus* host genotypes (HUSS-DANELL, 1991). Each root system was enclosed in a plastic cylinder which was temporarily closed to form an open-ended cuvette for nitrogenase activity (ARA) measurements (HUSS-DANELL *et al.*, 1989). ARA was measured repeatedly over two growing seasons to map diurnal and seasonal variations. The use of a Hup^- *Frankia* and the measurements of relative efficiency of nitrogenase validated conversions of ARA into N_2-fixation. Biomass and N content of alders were determined at planting and at the end of each of the two seasons. N content of the soil was measured at planting and at the end of the second growing season.

The average N_2- fixation was 0.23 and 2.83 g N alder-1 year-1 in the first and second season, respectively. The average height of the alders was 0.5 and 1.3 m at the end of the first and second season, respectively. The alders lost nearly one fifth of their biomass as leaf litter each year. The use of intact alders for ARA made it possible to relate N_2-fixation to N distribution within the alders and the soil. Leaf litter N and soil N increment corresponded to 23 and 17%, respectively, of the N_2 fixed in the two years. Already at a young age, N_2-fixing *A. incana* can apparently contribute to an improved fertility of N deficient soils.

ACKNOWLEDGEMENTS. – Financially supported by the Swedish Council for Forestry and Agricultural Research. Thanks to A. EKBLAD and A.-S. HAHLIN for valuable assistance.

HUSS-DANELL K., 1991. – Influence of host (*Alnus* and *Myrica*) genotype on infectivity, nitrogen fixation, spore formation, and hydrogenase activity in *Frankia*. *N. Phytol.*, **119**, 121-127.

HUSS-DANELL K., LUNDQUIST P.-O. & EKBLAD A., 1989. – Growth and acetylene reduction activity by intact plants of *Alnus incana* under field conditions. *Plant Soil*, **118**, 61-73.

LUMINI E. ([1, 2]), BOSCO M. ([2]), FAVILLI F. ([2]) & WHEELER C. T. ([1]). **Production of spores in nodules of *A. glutinosa* inoculated with non-host *Frankia* strains.** ([1]) *Department of Botany, University of Glasgow, Glasgow G12 8QQ, Scotland, U.K. and* ([2]) *DISTAM-Sezione di Microbiologia Applicata, Universita di Firenze, P. le Cascine 27, 50144 Firenze, Italy.*

Introduction

Although most *Frankia* strains sporulate readily in culture, sporulation within the nodule is a more variable characteristic (SCHWINTZER, 1990). Strains from Sp^+ nodules generally are difficult to isolate and to

maintain in culture capable to induce the formation of sp^+ nodules (TORREY, 1987). Experimental evidence suggests that sporulation *in vivo* is a genetic trait of the microsymbiont but that the degree of sporulation may be affected by the environment and also by the host genotype (TORREY, 1987; SCHWINTZER, 1990). Our objective was to obtain more information concerning the genetic basis of the sporulation process from a study of the occurrence of spores in nodules of *Alnus glutinosa*, inoculated with the following heterologous *Frankia* strains: UFI 13270215 and UFI 13270241 from *Elaeagnus* sp., UGL 140101 from *Hippophae rhamnoides* and ORS 060501 from *Colletia spinosissima*. Sections of root nodules of *A. glutinosa* were examined for the presence of vesicles and spores.

Results and discussion

Frankia strain ORS 060501 was able to infect *Alnus glutinosa* but not effectively. The nodules showed low occurrence of vesicles and no spores and C_2H_2 reducing activity was not detected. Nodules effective in N fixation were induced on *A. glutinosa* by inoculation with UFI 13270215. They showed C2H2 reducing activity and vesicles were evident. Spores were not observed in sections and the nodules were deemed to be sp^-. The two strains UFI 13270241 and UGL 140101 were isolated from nodules of *Elaeagnus* or *Hippophae*, from bushes on which the nodules were deemed to be sp^- by microscopic examination. These strains induced sp^- nodules when inoculated onto their respective host plant species. However, the effective nodules induced on *A. glutinosa* following inoculation with these strains were typically sp^+ (Table 1).

TABLE I. – *Nodulation data for* A. glutinosa *inoculated with* Frankia *strains.*

Strain	No. nodulated plants [1]	No. plants showing ARA [2]	Presence of vesicles [3]	Presence of spores [3]	Sporulation in the original host
UFI 13270215	7 (14)	2	++	–	–
UFI 13270241	1 (14)	1	++	+++	–
UGL 140101	8 (15)	2	++	+++	–
ORS 060501	4 (8)	0	+	–	–
Control	0 (8)	0	–	–	–

[1] The Number of plants examined for nodulation is reported in parenthesis.

[2] Acetylene Reduction Activity.

[3] +, –, respectively mean presence or absence of vesicles and spores in the sections of examined nodules.

The data show that sporulation can be initiated in heterologous infections by some *Frankia* strains that are normally sp^- in homologous association. These findings indicate that in some instances, host plant factors alone can initiate sporulation in strains that would otherwise be considered to have a sp^- genotype. In *Alnus* infected with UFI 13270241 and UGL 140101, some facet of incomplete compatibility must contribute to the expression of sporulation. However, the absence of spores from nodules induced on *Alnus* by UFI 13270215 shows that sporulation is not an absolute requirement of poor incompatibility. Our findings reinforce the suggestion of TORREY (1987) that sporulation can be influenced not only by the microbial genotype but also by the physiological state of the host plant. In this instance, it is presumed that sporulation is initiated by unfavourable conditions produced by a degree of incompatibility between the host plant and the microsymbiont. However, the specific nature of the factors that switch on the sporulation response in such associations remain to be determined.

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TORREY J. G., 1987. – Endophyte sporulation in root nodules of actinorhizal plants. *Physiol. Plant.*, **70**, 279-288.