BREEDING BIRCHES FOR RESISTANCE TO RODENT AND HARE DAMAGE

MATTI ROUSI, Finnish Forest Research Institute, SF-58450 Punkaharju, Finland.

JORMA TAHVANAINEN and **RIITTA JULKUNEN-TIITTO**, University of Joensuu, Department of Biology, P.O. Box 111, Joensuu, Finland.

ULRIKA KURTEN, Technical Research Center, Laboratory of Biotechnology, Tietotie 2, SF- 02150 Espoo, Finland.

ABSTRACT: Rodents and hares are very harmful pests in forest plantations in the Holarctic zone. No effective way to control damages by these pests is known. There is large variation in resistance of different birch species, origins and families. The resistance does not seem to be correlated to growth of seedlings, thus the prospects for resistance breeding are considered good. There seem to be large variation even within birch families which can partly be explained by morphological differences between seedlings. Also the nursery treatment seems to determine the palatability of seedlings to herbivores. Ways to produce resistant genotypes for the use of practical forestry are discussed.

Proc. Vertebr. Pest Conf. (A.C. Crabb and R.E. Marsh, Eds.),
Printed at Univ. of Calif., Davis. 13:180-182, 1988

INTRODUCTION

Mammalian herbivores, especially voles, are destructive pests of silviculture in the Holarctic zone. In many areas they have almost prevented the cultivation of otherwise economically profitable tree species, e.g., Japanese larch (Larix leptolepis) in Japan and birch (Betula pendula) and Populus species in Fennoscandia (Kanervo and Myllymaki 1970, Takahashi and Nishiguchi 1966). At the moment there seems to be no effective way to control vole and hare damage. Thus, if genetic differences in resistance of different tree species, origins or genotypes exist, the resistance breeding might turn out to be an effective way to decrease the browsing by mammalian herbivores.

The mammalian herbivores are obligate polyphages (Bryant et al. 1985). Thus, if economically important tree species were bad enough, the mammals would turn to other browse plants. The reproductive capacity of mammals as compared, e.g. with fungi, microbes and invertebrate animals is much lower so that the process of adaptation to new, resistant tree types should be very slow. Thus, theoretically, resistance breeding against mammalian herbivores should be successful.

Recently Finnish Forest Research Institute, University of Joensuu and Technical Research Center started a research project to study the mechanism and variation of mammalian resistance in some economically important forest trees. This work is intended to give basic information for the actual breeding programme to increase the resistance of birch, which is one of the most promising tree species in our silviculture.

VARIATION IN RESISTANCE OF BIRCH SPECIES, ORIGINS AND GENOTYPES

It is evident that the voles show strong selection between different tree species (Chiba 1977, Rousi 1983, Pigott 1985). Resistance differences between species can be used in breeding programmes when species hybrids are possible. Maybe the best results in this field have been obtained in Japan where it has been possible to combine in a hybrid the high growth rate of Larix leptolepis and very high vole resistance of Larix gmelini (Chiba 1963, Takahashi et al. 1968).

Birches, in general, are of low quality food for mammalian herbivores (Pigott 1985, Helle et al. 1987) and many authors have shown large variation between birch species in resistance to hares and voles (Chiba 1968, Bryant et al. submitted). Species hybrids may show heterosis in growth characteristics also in the case of birch. One of the most promising crosses between birches in forestry of Scandinavian countries has been a hybrid between resistant B. japonica (Chiba 1968, 1969; Rousi et al. unpubl.) and good quality B. pendula. This hybrid has, at least at juvenile age, outgrown other birch species and hybrids (Johnsson 1966).

Our results with B. pendula show that there is a large variation in vole resistance between different geographic origins of the same species (Rousi, submitted). It is possible that there are to be found resistance centers where the pressure from herbivores has been high and where the resistance has consequently evolved. In birch there is evidence that species and origins from Japan, Siberia and certain parts of Alaska are very resistant (Bryant et al., submitted). Anyway it must be kept in mind that before the use of exotic tree species or provenance transfers are applied in practical forestry long-term experiments of climate adaptedness are mandatory. This is to avoid large-scale damages by mammalian herbivores which, in addition to damages by fungi and insects, may follow because of the use of unadapted material.

The breeding of birch has been going on in Finland for years. Thus there are experiments with third and fourth generation trees which have been bred for growth and quality. Between these full-siblings there is also a large variation in

resistance against hare damages. The variability even between full-sisters seem to be considerable.

RESISTANCE IN RELATION TO GROWTH CAPACITY AND ENVIRONMENTAL FACTORS

If we are going to use resistant plant types in practical forestry operations, it is a necessity to combine fast growth rate and resistance. Fast growth in itself helps the seedlings to escape from the reach of hares and moose within a few years. The bark of B. pendula becomes thick enough to prevent vole feeding when the basal diameter of seedlings is more than 4 cm (Raulo 1981).

The vole does not show any preference on fast-growing trees. On the contrary the fastest growing provenance hybrid was also the most resistant in the material recently studied (Rousi, submitted). Anyway, it seems that the vole clearly shuns exceptionally small seedlings. Also our experiments with hares show that the birches show no tendency to lose their variability in resistance when subject to long-term breeding for growth.

The nursery treatment may have an effect on the resistance of birches to voles. For example, hot growth temperature in plastic house has strongly decreased the resistance of small seedlings to vole damages (Rousi, submitted).

MECHANISMS OF RESISTANCE AND THE WAYS TO PRODUCE RESISTANT MATERIAL

Several secondary metabolites have been shown to affect the palatability of woody species (young trees, low shrubs etc.) to herbivores (e.g., Palo 1985, Palo et al. 1985, Bryant et al. 1985). The buds of Betula pubescens contain appreciable amounts of antifeeding terpenoid compounds (Helle et al. 1986) and the glandular extract of the twig surface of the Alaska paper birch (B. papyrifera humilis) yields hare-repellent papyriferic acid as the main component (Reichardt et al. 1984).

The secondary chemistry of even very closely related species is quite different, and several environmental as well as plant intrinsic factors may modify the quantity of these constituents.

Our present studies are concentrated on the resistance pattern of secondary products in the seedlings of B. pendula and B. japonica. The main emphasis has been put on phenolics (total phenolics, tannic phenolics, pilenolic glucosides and flavonoids) and on terpenoid compounds (triterpenes).

Since birches can make flowers in greenhouses as one-year seedlings, it is relatively easy to produce material for practical forestry purposes. Unfortunately there seems to be a large variation in susceptibility of full-siblings to hare damage. Thus we may have to produce only some very resistant genotypes. Exceptional genotypes of, e.g., B. pendula, are easily produced by micropropagation. Unfortunately this method is very expensive to be used in practical scale. At present our interest is focused on an alternative way of vegetative propagation, i.e., production of somatic embryos through cell and tissue cultures. Somatic embryogenesis has been repeatedly observed in cell cultures of birch and culture conditions are now optimized. The investigation will show whether this technique can be used as a breeding tool to create new genotypes, due to soma-clonal variation, or in case true to type progenies, as a method for vegetative mass propagation of a desired genotype. In the latter case the formed embryos could be coated to prevent dessication and used as artificial seeds.

THE CORRELATION BETWEEN RODENT AND HARE RESISTANCE

The empirical results indicate that the same plant compounds are effective against voles and hares, namely pinosylvin monomethyl ether (Bryant et al. 1985). It seems that there is a strong positive correlation between vole and hare damage in many tree species (Chiba 1977). At the moment our studies concern this correlation in the cultivar level.

LITERATURE CITED

BRYANT, J.P., F.S. CHAPIN, P. REICHART, and T. CLAUSEN. 1985. Adaptation to resource availability as a determinant of chemical defence strategies in woody plants. In: Chemically mediated interactions between plants and other organisms, G.A. Cooper-Driver, T. Swain and E.E. Conn (eds.), Plenum Publishing Corporation. pp. 219-237.

BRYANT, J.P., J. TAHVANAINEN, M. SULKINOJA, R. JULKUNEN-TIITTO, and P. REICHARDT. 1988. Evolution of chemical defense by boreal birch and willow: evidence for selection by vertebrate herbivores. (Submitted).

CHIBA, S. 1963. Studies on the breeding of Larix-species. (1) Variation between species on the gnawing by mountain hares and the wild mice. Technical Note 29. Oji Institute for Forest Tree Improvement.

CHIBA, S. 1977. Prospects of the breeding of resistance to mountain hares and field mice in forest trees. Technical Note 167. Oji Institute for Forest Tree Improvement.

CHIBA, S. and Y. NAGATA. 1968. Resistance to field mouse and mountain hares in Betula-species and hybrids. (1) Comparison between species. Technical Note 68. Oji Institute for Forest Tree Improvement.

CHIBA, S. and Y. NAGATA. 1969. Resistance to the field mice and mountain hares in Betula-species and hybrids. (2) Comparison between parental species and hybrids. Technical Note 88. Oji Institute for Forest Tree Improvement.

CHIBA, S., Y. NAGATA, and K. TOMAKI. 1982. Variation of vole resistance in Larix leptolepis and comparison with the hybrid of L. gmelini and L. leptolepis. Technical Note 209. Oji Institute for Forest Tree Improvement.

HELLE, E., J. TAHVANAINEN, R. JULKUNEN-TIITTO, and I. UOTILA, 1986. How and why does the mountain hare select its winter diet? Suomen Riista 33:111-120. (English Summary).

JOHNSSON, H. 1966. Avkommeprovning av bjork [Experi-

ments with birch origins]. Foreningen Skogstradsforadling och Institutet for skogsforbattring. Arsbok , Uppsala.

KANERVO, V. and A. MYLLYMAKI. 1970. Problems caused by field vole, Microtus agrestis (L.) in Scandinavia. EPPO Bulletin 58:11-26.

PALO, R.T. 1985. Chemical defense in birch: Inhibition of digestibility in ruminants by phenolic extracts. Oecologia (Berl.) 68:10-14.

PALO, R.T., K. SUNNERHEIM, and O. THEANDER. 1985. Seasonal variation of phenols, crude protein and cell wall content of birch (Betula pendula Roth) in relation to ruminant in vitro digestibility. Oecologia (Berl.) 65:314-318.

PIGOTT, C.D. 1985. Selective damage to tree-seedlings by bank voles (Clethrionomys clareolus). Oecologia (Berl.) 67: 367-371.

RAULO, J. 1981. Koivukirja (Birch book). Gummerrus. Jyvaskyla.

REICHARDT, P.B., T.P. CLAUSEN, and G.D. WIELAND. 1984. Defense of winter-dormant paper birch against snowshoe hares. Oecologia (Berl.) 65:58-69.

ROUSI, M. 1983. Vole damage in tree species trials in northern Finland in the winter of 1981/82. Folia Forestalia 569.

ROUSI, M. 1988. Resistance breeding against voles in birch: possibilities to increase resistance by provenance transfers. (Submitted).

TAKAHASHI, N. and C. NISHIGUCHI. 1966. Studies on the resistance of forest trees to red-backed vole, Clethrionomus rufocanus bedfordiae (Thomas). (I). Relative feeding preference of the vole for seedlings under laboratory conditions. Bulletin of the Tokyo University Forests 62:153-172 (English summary).