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Clones in Finnish tree breeding

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Most tree breeding programmes utilize testing systems based on seedling stock to assess the additive genetic value of candidates and to select the best of them to breeding and seed production populations. Another alternative is to use vegetative propagules for genetic testing. Today, it is widely recognised that clones offer potential advantages over seedling testing, enabling more precise information on candidates (Fig. 1) and far more efficient genetic testing and selection in terms of space and time (Fig. 2). Furthermore, clonal propagules may be subjected to stress treatments and various other type of destructive measurements, thus enabling the breeder to obtain diverse multi-trait information on the candidates. On the other hand, it is also recognised that clone testing can lead to slightly distorted selection due to non-additive gene effects and non-genetic propagation effects (rooting problems and plagiotrophism) that may yield biased estimates of the additive breeding values. Such effects are, however, usually assumed to be small by comparison to the benefits of vegetatively reproduced test materials.

Because of the aforesaid advantages, clone testing is becoming a more important activity of the mainstream tree breeding in Finland. The breeding of hybrid aspen has already been based on the evaluation of clonal performance in field tests. Moreover, clone testing by means of stem cuttings will play the dominant role in the genetic testing of the 2nd cycle selections in Norway spruce, which will commence in the early 2010's.

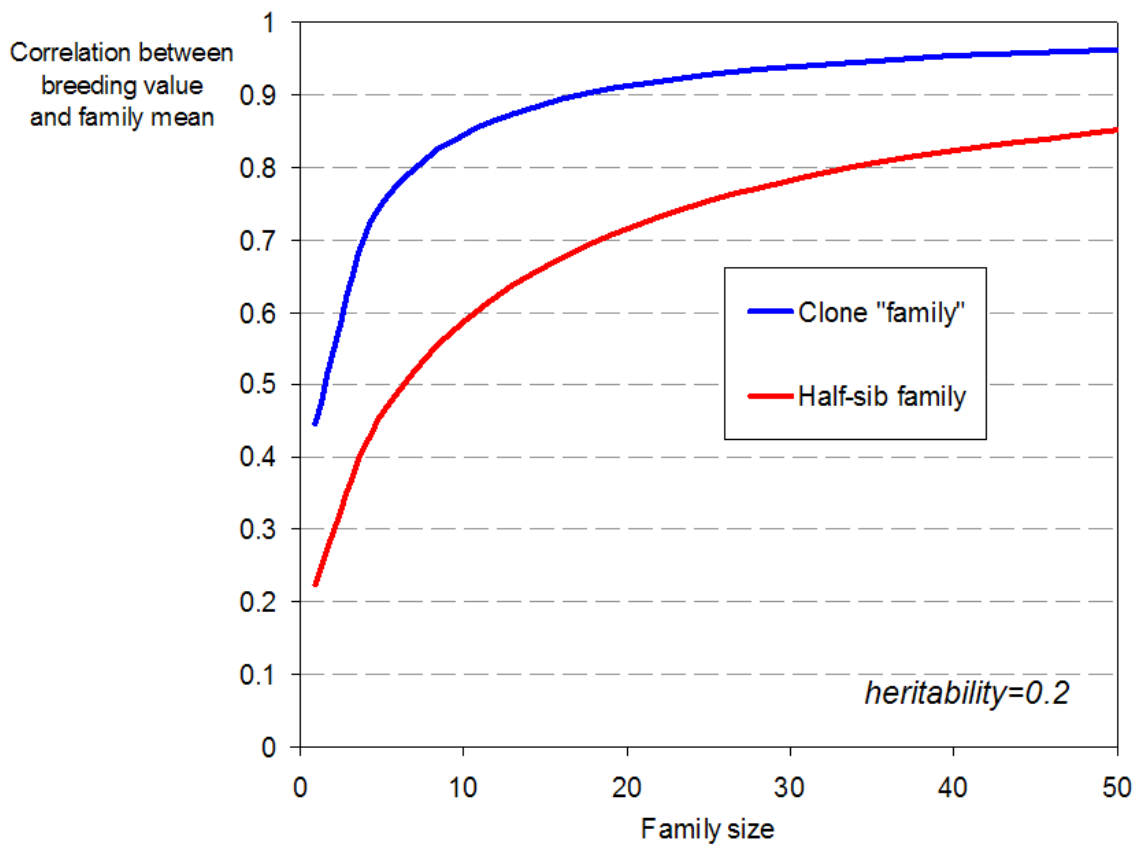


Fig. 1. The relationship between the accuracy of selection (measured as the correlation between the true breeding value and the family mean) and the family size applying either vegetative propagules or open-pollinated progenies of a candidate in genetic testing.

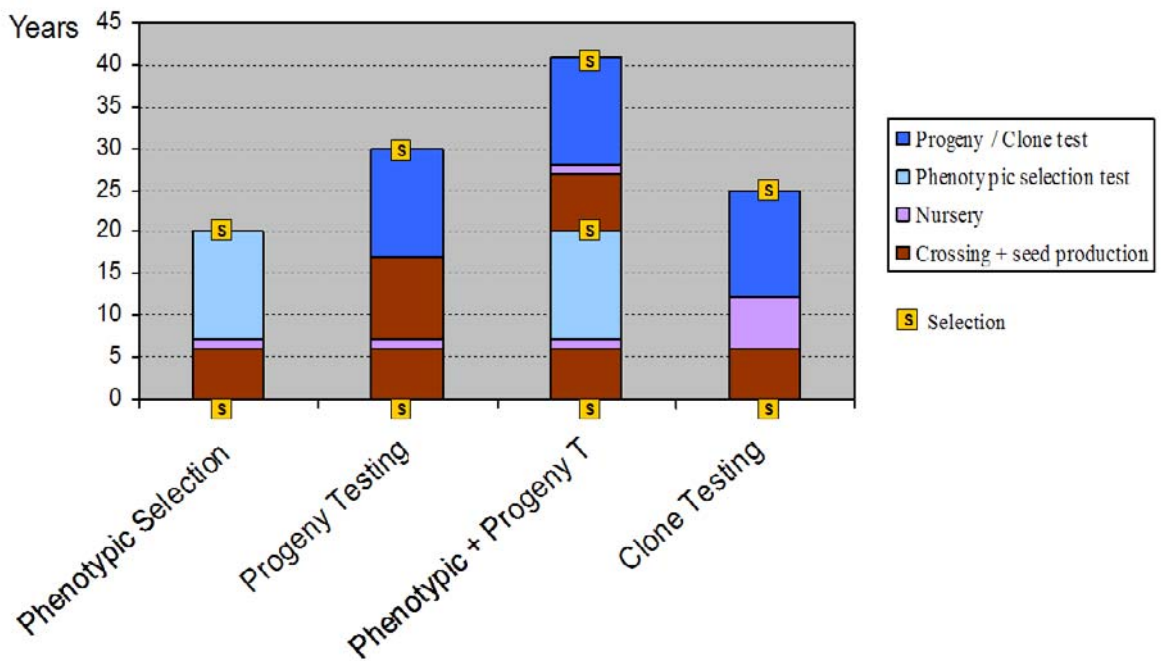


Fig. 2. Approximate lengths of breeding cycles in four alternative breeding strategies.

According to the current breeding plan for Norway spruce, the 2nd generation candidates are selected either from within full-sib families (offspring of the best tested plustrees) in a nursery-bed or in some cases, in 5 to 7 years old progeny trials which comprise open-pollinated offspring of untested plustrees. In these young progeny trials, all trees are measured for early height growth and screened for a number of traits such as branch angle, growth rhythm, frost damages, and the presence of diseases (Fig. 3). The most promising 10–15 trees within each family are selected as candidates to undergo a more careful clone testing. When candidates for clone tests are selected without the preceding visual screening in the field (i.e., in the nursery) double as many candidates are selected (30). Clone trials will be replicated in 4–6 locations, with 8 ramets per clone and per trial. The clone tests will provide the information used to form the 2nd generation breeding populations in Norway spruce in the late 2020's.



Fig. 3. Phenotypic selection of candidates in young progeny trials precedes clone testing in some breeding lines of Norway spruce. About 10–15 candidates are selected within each family. Preselection mainly focuses on vigor and traits of adaptive significance. For instance, all trees showing lammas growth (the inset photo) are rejected. (Photos: Matti Haapanen)

Table 1. The genetic testing strategies for various tree species involved in the Finnish tree breeding.

Species	Current testing strategy	Breeding cycle, years	Test material	Clone testing a viable option
Norway spruce	(Preselection +) Clone testing	25	Stem cuttings	Ongoing
Hybrid aspen	Preselection + Clone testing	20	Root cuttings / micropropagated	Ongoing
Scots pine	Preselection + Progeny testing	40	Seedlings	Yes?
Silver birch	Preselection + Progeny testing	30	Seedlings	Yes
Siberian larch	Phenotypic selection	17	Seedlings	Yes
Black alder	Phenotypic selection	20	Seedlings	Yes

Scots pine is a more difficult species to propagate vegetatively than Norway spruce. For the time being, Scots pine breeding in Finland is planned to be based on two-stage testing (preselection at age 15 followed by progeny testing) on seedling stock. Completing a breeding cycle in Scots pine is expected to take around 40 years, thus considerably longer than in Norway spruce (Table 1). Developing a workable clone testing system for Scots pine would therefore result in significant savings in time and faster realization of advanced generation tested seed orchards. A joint Nordic project to develop methods to obtain a sufficient number of rooted cuttings from young pine seedlings for clone testing is now underway. It is anticipated that clone testing could be adopted for use as a supplementary testing method in several breeding lines of Scots pine in the late 2010's, provided that the current obstacles in the vegetative propagation will have been resolved by that time.