Local Application of Genetic Technologies using a Global Perspective

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Abstract:

The use of genetically improved trees in plantations is an effective way of lifting the productivity and quality of the forest resource. The objective of a tree improvement program is to breed and select genetic material with improved biological characteristics for traits of commercial importance. The STBA uses economic indices to describe the genetic worth of trees in the population. Breeders must work with growers, processors and economists to derive economic objectives and also update parameters over time. STBA and its partners work with multiple species adapted to different environments and production systems, including *Pinus radiata*, *Eucalyptus globulus*, *E. nitens* and other plantation species. A large amount of biological data has been collected on many trees over decades of breeding for these species. This data is collected for a range of purposes for use in tree improvement and associated research. STBA uses its web based DATAPLAN system to manage information, as well as facilitate access by breeders and other industry personnel. The TREEPLAN system has been developed for the genetic analysis of tree breeding data on a species wide or global basis. All performance data collected in hundreds of trials over time is combined in national genetic evaluations using full pedigree. This allows for the objective comparison of trees and genetic material for breeding and deployment. Results are reported on a regional basis, to ensure genotype by environment interactions are accounted for and the best genetics is identified for each situation. The TREEPLAN software is a joint initiative of the tree and livestock industries. This ongoing collaboration allows innovation to be developed with application across multiple plant and animal species. TREEPLAN has global utility, with its recent adoption in Sweden for national evaluations in Scots pine, Norway spruce, Lodgepole pine and Silver birch. Knowledge of genetic and economic merit is important for selection and mate allocation in the breeding program. However, it is also important for decision making in deployment activities of seed and plant production, as well as matching improved genetics to particular environments. Innovative software tools like SEEDPLAN are being used to deliver outputs of the tree improvement programs to industry. MATEPLAN software is also important for managing risk associated with population fitness across generations of breeding. It is important breeders, geneticists and researchers work together with industry to improve the efficiency of tree improvement programs for plantation forestry. The national cooperative provides a framework for facilitating this interaction, ensuring research is aligned with industry needs.

Keywords: tree breeding, genetic improvement, data analysis, economic worth

Bio-Economic Modelling as a Method for Linking Genetics to Plantation Economics

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Abstract:

Correctly set breeding objectives will determine how much improvement in different tree characteristics is needed to maximise profitability of a production system. A bio-economic model provides a framework for simultaneously considering breeding, management, and production decisions. Such a model should result in optimal breeding (and silvicultural) objectives if main goals of a production system are well defined. Historically estimation of economic weights for breeding-objective traits has been based on partial regressions and profit functions relating only to certain parts of the production system. A bio-economic model includes effects of growth rate, branching, form, and wood quality on all production system components and on overall profitability of an integrated production system. However, long rotation cycles in forestry make determination of relative economic values for the breeding objective traits particularly difficult. When modelling complex systems under uncertainty about future production goals, there are necessary trade offs between the complexity of the model and the use of simplifying assumptions.

Key words: tree breeding, wood quality, plantation economics, bio-economic model

Site Specific Genetics

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Abstract:

Bio-economic models, discounted cash flow analysis and risk analysis provide tools for establishing what may be important at the estate level to guide breeding for a species when more than one trait is of importance. These tools need to be easily customisable so that they can be applied to each site to allow the appropriate genetics to be put on that site. A simple case study of *Eucalyptus globulus* grown for wood chip export in the south-west of Western Australia shows the potential of site specific genetics. The descaled genetic values of 156 seedlots for basic density and harvest volume on different site types were calculated using TREEPLAN® breeding values and models of pollination incorporating seed orchard flowering time and distance. Bio-economic information was collected on 20 planting sites and trait site means predicted for reference genotypes using local growth and wood quality models. The seedlot values were then scaled for each site based on the site mean modified to the centre of the genetic values of the available seedlots. A wood chip export bio-economic model was then applied to derive a matrix of the net present value of each seedlot for each site. Linear programming then maximised the value of seedlot allocations to each planting site, resulting in an increase in the average net present value of $250/ha compared to mixing the seedlots and distributing them evenly across the planting sites. Application of this approach to the more complex situation of *Pinus radiata* is not currently possible. The bio-economic models are currently not flexible enough to be applied to the wide variety of sites planted. While much is known about variation in productivity, little is known about how the mean and variance of a number of key traits in the model (branch size, modulus of elasticity and sweep) vary in response to site and silvicultural characteristics. Without that it is not possible to scale the genetic values to each site to avoid, for instance, putting straight genotypes on a site that is already straight. While some work has started on gathering such information from forests, it seems there are still some steps before they can be routinely applied in conjunction with bio-economic models to allow site specific genetics (and silviculture). Integration of such optimisation with operational activities is also a challenge.

Keywords: tree breeding, genetic evaluation, breeding objectives, site variation