# A MORPHOLOGICAL GENETIC MARKER FOR EARLY GROWTH IN *Eucalyptus deglupta* BLUME

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***Summary:*** In two progeny trials of *Eucalyptus deglupta*, purple leaves and green leaves were respectively genetically associated with slower early growth and faster early growth. As leaf colour is manifested early in the nursery production phase, leaf colour, particularly on a family mean basis, can be used a marker for elimination of slower growing genotypes. It is suggested that the phenomomen is possibly due to a provenance-mixing effect; consequently, the association and therefore the utility of the marker will be transient, tending to disappear as the purple strain of the species is gradually purged from the local base population.

## Introduction

Time is a major constraint on the genetic improvement of forest trees (3), both for reproductive reasons and because many economic traits are not expressed for several years (8). For these reasons, tree breeders have long been interested in the possibilities for marker-aided selection (8), under which traits are improved not through direct selection but by selection on another correlated trait. Such indirect selection is effective when $r_{X,Y}h_Y > h_X$ (where $r_{X,Y}$ = the genetic correlation between the trait (X) to be improved and the trait (Y) selected , $h_Y$ = the square root of the heritability of trait Y) (6). Attention has been directed principally at early selection on the basis of juvenile expression of the trait to be improved (e.g. 10, 11). Morphological markers not based on age-to-age correlations are rare (9). Here we present an example of such a marker in *Eucalyptus deglupta*, a timber tree commonly planted in Central America.

## Materials and methods

We collected open-pollinated seed from 48 plus-trees in the Atlantic zone of Costa Rica and established in two progeny tests in distinct climatic and soil conditions in Upala, Alajuela province and Turrialba, Cartago Province, Costa Rica. A randomized complete blocks design (11 blocks in Turrialba, 12 in Upala with three-tree line plots) was used. In the nursery and early field stages, pronounced variation in leaf colour was noted, corroborating both earlier subjective impressions and some references in the literature (3, 7). Because of this, at age sixteen months, both the total height (cm) and the leaf colour (1=green or more green than purple, 2=intermediate, 3=purple, or more purple than green) of each tree were evaluated. Data were analyzed using a mixed model analysis of variance with the GLM procedure of SAS (12). Significance of differences in height growth between families with high (>2.5) and low (<1.5) leaf colour scores was tested using the SAS CONTRAST statement (12,13). A more detailed account of the analysis procedure, the treatments and sites, as well as the other aspects of the work not reported here, is given elsewhere (4).

## Results

Phenotypic correlations between leaf colour and height growth were positive at Tuis and negative at Canalete, and in both cases close to zero. By contrast, genetic correlations were strongly negative (-0.4 at Tuis, -4.43 at Canalete). Across the two sites, the mean height of the 'green' group (2.6 m) was significantly greater ($F=9.2$, $p=0.002$) than that of the purple group (2.4 m). Six of the 15 tallest treatments were amongst the 15 greenest whilst six of the 15 shortest were drawn from the 15 most purple families. Only one of the 15 shortest families was drawn from the group of 15 most green, and only two of the 15 tallest were amongst the 15 most purple. Both family effects and block effects on leaf colour were significant, but the contribution of block effects to total variance was much smaller than the contribution of family effects.

## Discussion and conclusions

The strongly negative genetic correlations and the significant superiority of the 'green' families indicates that families with fast initial growth genotypes tend also to be of green leaf-colour genotype. Purple-leaved families are easily evident soon after transplanting in the nursery (i.e. before outplanting), whereas the prediction of early field growth from nursery performance tends to be problematic. Leaf colour therefore has potential for use as a marker for early growth. However, the estimates of the phenotypic correlation and the presence of block effects indicate that the relationship may not be fully reliable on an individual-tree basis, except in extreme cases (see below). This problem can be overcome in the nursery by sowing by family and eliminating purple families. Alternatively, when this is not possible, all strongly purple trees could be culled, thus relying on the 'average effect' of the relationship, whilst accepting some loss of non-inferior genotypes.

The existence of a few slow-growing green families and fast-growing purple families possibly gives a clue to the origin of the observed correlation. There are known to be provenance-related differences in leaf colour in *Eucalyptus deglupta* (5), whilst the Costa Rican base population of the species is also known to originate from widely separated parts of the species range (1). When two (or more) provenances with different leaf colours and growth rates are mixed, then both growth rate and leaf colour of an individual tree may reflect the contribution of the two provenances to its allelic composition, without this necessarily implying that the same genes which influence leaf colour also influence growth rate. In this case, the genetic correlation between leaf colour and growth rate, although important for practical purposes, may be spurious; it may be that within each provenance there is little or no additive genetic variation in leaf colour and/or no genetic correlation with growth rate. Fast-growing 'purple' families and slow-growing 'green' families are then explained respectively as fast- and slow-growing families within their respective provenances., Some weight is lent to this hypothesis by the appearance of trees representing 'extreme' examples of the purple phenomenon; these have flattened leaves, alate and cross-sectionally squarish stems, shallow, flat-topped crowns, and appear to be far more divergent from the green-leaved form than would be normal were the differences based solely on within-population variation. If correct, the provenance-mixing hypothesis would also imply that, as the purple strain is progressively eliminated from the Costa Rican base population, the correlation will disappear.

## Literature Cited

CATIE (Centro Agronómico Tropical de Investigación y Enseñanza). 1994. Records of seed imports by the Latin American Forest Seed Bank. Held on file by the CATIE Tree Improvement Project, CATIE, Turrialba, Costa Rica.

Cheliak, W.M. and Rogers, D.L. 1990. Integrating biotechnology into tree improvement programs. Can J. For. Res. 20: 452-463.

Combe, J.; Gewald, N.J. (eds.). 1979. Guia de campo de los ensayos forestales del CATIE en Turrialba, Costa Rica. Turrialba. Costa Rica, Centro Agronómico Tropical de Investigación y Enseñanza. 378 pp.

Cornelius, J.P.; Corea, E.A.; and J.F. Mesén. 1995. Additive genetic variation in height growth and leaf colour of *Eucalyptus deglupta* at ages up to 16 months in Costa Rica. *Forest Ecology and Management* 75 (1995) 49-59.

Eldridge, K.; Davidson, J.; Harwood, C.;Wyk, G. van. 1993. Eucalypt domestication and breeding. Oxford, Clarendon Press. 288 pp.

Falconer, D.S. 1989. Introduction to quantitative genetics. 3 ed. Harlow, G.B., Longman Scientific and Technical, 438 p.

FAO, 1979. Eucalypts for planting. Forestry Series No. 11. Rome, FAO.

Greenwood, M.S. and Volkaert, H.A. 1992, Morphophysiological traits as markers for the early selection of conifer genetic families. Can J. For. Res. 22: 1001-1008.

Haines, R. 1994. Biotechnology in tree improvement. FAO Forestry Paper 118. Rome. 230 pp.

Lambeth, C.C. 1980. Juvenile-mature correlations in Pinaceae and implications for early selection. For. Sci. 26: 571-580.

Li, B.; Williams, C.G.; Carlson, W.C.; Harrington. C.A.; Lambeth, C.C. 1992. Gain efficiency in short-term testing: experimental results. Can. J. For. Res. 22: 290-297.

SAS Institute Inc. 1988. SAS/STAT User's Guide, Release 6.03 edition. Cary, N.C.: SAS Institute Inc., 1988. 1028 pp.

Stonecypher, R.W. 1992. Computational Methods. Pp195-228 in L. Fins, S.T. Friedman and J.V. Brotschol (Eds.). Handbook of quantitative forest genetics. Dordrecht, Kluwer Academic Publishers, 403 p.