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Stable genetic and phenotypic correlations among early-vigour traits in field and glasshouse reveal opportunities for indirect selection in canola breeding

Background:

Higher grain yield is a primary objective for breeding programs of Brassica oilseed crops, and is known to be affected directly or indirectly by several growth-associated traits which can be measured in the glasshouse and field in early generations. Indirect genomic selection for such traits may ultimately help to increase the rate of genetic gain for grain yield.

Objective:

The objective was to determine if genomic estimated breeding values (GEBV) for early-vigour traits measured in the glasshouse were correlated with vigour and grain yield in the field. Correlated traits are useful to improve the accuracy of genomic selection, which means that indirect genomic selection in early generations of canola breeding may improve genetic gain in canola breeding.

Methods:

We measured vigour-related traits in the field and glasshouse in a population of doubled haploid lines in the Australian *Brassica napus* Homozygous Diversity Set, genotyped with 12,197 Infinium Illumina SNP markers. We measured area, biomass and shape of the 4th leaf in the glasshouse and field, and compared this to whole-plant traits such as normalized difference vegetation index (NDVI), biomass and grain yield. Phenotypes were adjusted for the fixed effects (spatial effects in the glasshouse and field) to get the BLUEs for genomic best linear unbiased prediction (GBLUP) analysis. Genetic parameters including heritabilities and genetic correlations between traits were estimated.

Results:

Early-vigour traits showed low to moderate narrow-sense heritabilities. Phenotypic means and GEBV of several traits in the glasshouse were positively correlated with similar traits (and also with biomass and NDVI) in the field. GEBVs for dry biomass and area of the 4th leaf (as a representative of a fully functional leaf during early vigour) were highly correlated across lines within experiments, and between glasshouse and field. These traits showed moderate to high genotypic correlations with biomass and NDVI in field trials at several locations. Leaf shape characteristics such as roundness and aspect ratio also showed consistent correlations with other vigour traits including NDVI. Petiole length of the 4th leaf showed a moderate negative correlation with grain yield for the field trials at Wagga Wagga in 2021 and 2022, but correlations between early vigour traits and grain yield were weak and inconsistent.

Conclusions:

High genetic correlations for early vigour traits occurred across the glasshouse and field, and seedling vigour-related traits were correlated with whole-plant vigour traits such as NDVI and biomass. Genomic regions that control seedling vigour-related traits such as petiole length and leaf shape can have potential pleiotropic roles for controlling other traits such as NDVI. However, early-vigour traits were less useful for predicting final grain yield, since grain yield is affected by other traits such as flowering date and ability to set seeds under stress. The accuracy of GEBV for vigour-related traits can also be improve with multivariate genomic analysis that includes glasshouse measures of seedling vigour. Our results suggest that breeding systems will benefit from early vigour evaluations during “speed breeding” (rapid single seed descent) in the glasshouse.