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The long and the short of it: Genetic strategies to improve canola establishment

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Background:

Canola (*Brassica napus L.*) is a valuable oilseed and rotational crop globally. However, canola suffers from unreliable establishment in many of the major growing areas. In Australia and elsewhere, the problem is being amplified by a changing climate and the related adaptations in farming systems (e.g., earlier sowing into hotter, drier conditions).

Objective:

Our team seeks to improve the genetic potential of canola to establish effectively. Through an extensive review of scientific literature1 and a survey of Australian canola growers, we identified two promising genetic targets to improve establishment: longer hypocotyls to enable deeper sowing, and greater early vigour to emerge quickly and rapidly develop a canopy.

Methods:

We developed high-throughput phenotyping methods to measure seed, hypocotyl, and post-emergent vigour traits. Seedlots for 255 diverse accessions of *B. napus* from 21 countries were produced in a common garden nursery, and seedlots for 41 current Australian cultivars were provided by breeding companies. Genetic control of establishment-related traits was assessed through a genome-wide association study (GWAS) in Tassel software, with population structure accounted for using STRUCTURE groupings (k1-k7). RNAseq and hormone analyses were performed on 20 phenotypically contrasting accessions at three early growth stages. The same set of 20 contrasting accessions (with five commercial cultivar controls) were sown in short rows at two seeding depths (20 and 50 mm) in eight field experiments in NSW and WA in 2021 and 2022, with emergence rates and biomass (4-leaf stage) recorded.

Results:

The new phenotyping methods were highly accurate with repeatability estimates ranging from 0.59 (hypocotyl cross-sectional area) to 0.95 (germination index). When applied to 255 international accessions and 41 current cultivars, they revealed a diverse range of early growth behaviours. It was particularly evident how short the hypocotyls were in current Australian cultivars compared to many international accessions. Field experiments confirmed that longer hypocotyl accessions were able to emerge more reliably and with greater success from deeper sowing. Greater seed vigour (measured in controlled conditions) was also predictive of enhanced field vigour at the four-leaf stage irrespective of sowing depth. GWAS using 146,749 single nucleotide polymorphism (SNP) loci in 255 accessions revealed that all establishment-related traits studied were controlled by many independent genes. RNAseq and hormone analyses provided insights into the biology underlying different early growth behaviours.

Conclusions:

The long hypocotyl trait was identified as a priority target to introgress into Australian canola cultivars from international germplasm including accessions from Canada, Europe and Japan. We recommend the germination index method to assess vigour of commercial seedlots and for breeding purposes due to its extremely high repeatability, time-efficiency and predictive ability for early vigour in field conditions. Breeding methods are currently under development to transfer key early growth traits into commercial canola lines for delivery to canola breeders.

Reference:

1. Nelson MN, Nesi N, Barrero JM, Fletcher AL, Greaves IK, Hughes T, Laperche A, Snowdon R, Rebetzke GJ, Kirkegaard JA (2022) Strategies to improve field establishment of canola: a review. *Advances in Agronomy* 175:133-177