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Proxy traits for drought avoidance and high yield under water-limited conditions in canola

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Background:

Water deficit (drought) stress is the major limitation of canola production, especially in Australia. Current and anticipated high temperatures and vapour pressure deficit due to anthropogenic global warming further exacerbate drought stress risks on canola productivity and meeting global demands for food, feed and bio-energy markets.

Objective:

This study aims to uncover genetic variation and prioritise component traits underlying drought tolerance for improving canola yield under water-limited conditions.

Methods:

We evaluated canola germplasm, comprising a diversity panel and biparental doubled haploid (DH) populations under field/rainout shelter/glasshouse conditions. Several agronomic and physiological traits such as normalised difference vegetation index (NDVI), shoot biomass, days to flower, plant height, seed yield, intrinsic water use efficiency (photosynthesis rate: A/stomatal conductance: G), carbon isotope discrimination (Δ13C) - the proxy for transpiration efficiency, leaf thickness and stomatal density, were assessed from multilocational trials grown in New South Wales (4 sites) and Western Australia (Kellerberrin) across two years. Stomatal density was investigated using a machine-learning algorithm. We also evaluated canola accessions for variation in root-pulling force - a potential drought avoidance trait involved in transpiration efficiency. Some of the physiological parameters were measured only in one experiment.

Results:

Our results showed substantial variation in agronomic and physiological traits investigated in this study. Δ13C values varied from (21.4 to 22.5‰) between accessions and showed high correlations across environments (r>0.9). Δ13C showed a range of correlation with yield (r = - 0.08 to 0.42) and other traits across environments in 188 diverse accessions. We verified that phenotypic variation in agronomic and/or physiological attributes is genetically determined using three DH populations. The plasticity of seed yield and its related traits in response to water deficit stress imposed at the flowering time was investigated using 226 DH lines derived from BC1329/BC9102 across well-watered and water-deficit treatment blocks. A moderate correlation was observed for seed yield across water treatments, possibly due to genotype × environment interaction.

Genetic variation in vegetative and whole plant-based WUE was described in 16 DH lines from BC1329/BC9102, along with their parental lines and 6 commercial check varieties in two contrasting water regimes in a glasshouse. Seed yield was positively correlated with shoot biomass, leaf water content and Δ13C (r = 0.35 to 97). At the same time, it showed negative correlations with specific leaf weight and days to flower (r = - 0.8) and root length and biomass across both experiments. Limitations of large-scale phenotyping traits across environments will be discussed.

Conclusions:

Based on the available data, our findings suggested that plant vigour, early flowering, high Δ13C, and root biomass/root pulling force contribute to high canola yield under test environments.