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Probabilistic patterns of drought, heat and frost stress for canola in Australia

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Background:

Drought, heat and frost stress limit canola production. Agronomically adaptive traits and practices must be tailored to the specific timing, intensity, and duration of prevailing stresses in relation to sensitive crop development stages. Probabilistic patterns of drought and heat in Australia have been reported previously for both wheat and pulses, but not for canola.

Objective:

The aim of this paper was to quantify the patterns of drought, heat and frost stress for canola across Australia, accounting for soil and climate, and for agronomic drivers influencing the timing and intensity of these stresses (sowing date, cultivar phenology and nitrogen rate).

Methods:

We used a crop model (APSIM-Canola Next Generation) to quantify daily drought (water supply/demand ratio), heat (Tmax > 30 oC) and frost (Tmin < 0 oC) on a phenological scale from sowing to maturity at 77 sites (with representative soil types across the cropping regions of Australia) over 60-year of historical climatic data. We assessed the impact of several agronomic management practices including 3 cultivars of contrasting maturity, 4 sowing dates from March to June and 7 nitrogen input rates. In total, 388080 simulations were generated from the factorial combination of 77 locations × 3 cultivars × 4 sowing dates × 7 nitrogen rates × 60 years.

Results:

Cluster analysis from the 388,080 simulations identified four patterns for drought stress, two for heat stress and three for frost stress. Early sowing and fast maturing cultivars reduced the frequency of severe drought and heat but increased the frequency of severe frost in most regions. High nitrogen rates increased the frequency of severe drought stress. Severe heat was a more frequent (24% of seasons) and yield-limiting (70% reduction) than drought (19-15% of the frequency and 23-50% of yield reduction under 'moderate-severe' stress) or frost (5-2% of the frequency and 8-34% of yield reduction under 'moderate-severe' stress) but this varied with site. The best, site-specific combinations of sowing time, variety and N rate across sites increased modelled yield by 60% (1.45 t/ha) compared to alternative combinations.

Conclusions:

Our environmental characterization can assist agronomists to match practices and environment and breeders to match crop phenotype and environment.