# Will Crop Breeding Keep Up With the Requirement for Change?



*Examples of durum wheat genotypes sensitive to heat shock compared to a less sensitive type in the centre (2a). An example of a breeding nursery to identify experimental lines that differ in their response to heat stress with a sensitive type in the center foreground (2b).*

(credit: R.M. DePauw)

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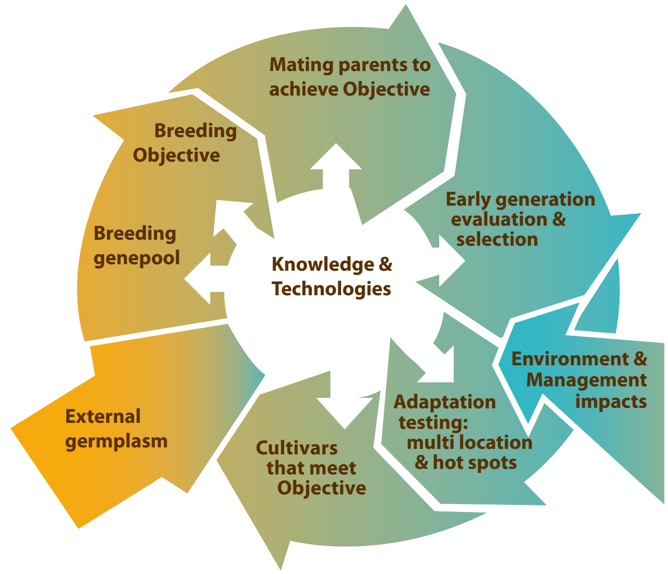
## What's coming up?

The projected climate change for Alberta to 2050 offers some opportunities and challenges for Canadian crops, with warmer summers, milder winters, limited growing season moisture change from April to September, and wetter autumns and winters (October to March). The killing frost-free period is expected to increase sufficiently to enable arable annual crops to be grown over a larger area of the Peace River Region, Parkland, and foothills of the Canadian Rockies. However, increases in the frequency and intensity of severe weather could cause major local damage, such as during heat waves and intense precipitation. The primary abiotic stresses will be heat, drought, waterlogging, salinity, elevated carbon dioxide, and acidic soils developed under coniferous forests. Abiotic stresses under dryland farming scenarios may be both persistent stresses such as dryness and/or above-average temperature, but also a period of heat shock coupled with very high evaporative demand. These shocks are considered to be extremely damaging and have been under-estimated by previous crop models. Consequently, "plasticity" will be a key feature of wheat cultivars to be responsive to variable weather conditions. Biotic stresses are expected to result in shifts of biotrophic and necrotrophic pathogens, insects and weeds.

## How does it matter?

Producers want reliable profitable top performers, such as high grain yield that can be sold at a profitable price. Achieving high, consistent, grain yield in a cultivar will entail selection for traits that result in consistency of performance. In crops, genetic enhancement through breeding is an appropriate adaptation response where it complements management changes, or when management changes are too expensive or too impractical. Prioritization of traits to breed for will be essential to allocate investments. For many Canadian crops, the following gaps need to be addressed: the effectiveness of genetic response to the abiotic and biotic stresses, the magnitude of genetic variation for these traits, and a value-capture mechanism to return an investment to off-set research and development costs.

Genetic enhancement takes time and resources. In the case of wheat it takes about 8 to 10 years from designing and making a new genetic combination through to releasing a new cultivar to seed companies. Breeding is predicated on clear targets, genetic variation, and genetic tools and nurseries to incorporate the traits. Targets that move in one direction, such as warmer weather, may be easier for breeding than those that need to consider more variability, such as increased extremes.




*Components of a breeding program. Solid curved arrows show germplasm flow as it is introduced, hybridized, selected for traits during inbreeding, and delivered as field-ready cultivars. White arrows show knowledge and technology points of impact in the breeding cycle (phenotyping methods, DNA analysis, statistical prediction, crop prediction models). Environment and cultural practices impact phenotyping and selection.*

## What can we do about it?

Breeding new cultivars with adaptation to the climate of 2050 will require:

i) Assessing the potential incidence and intensity of new environmental challenges,

ii) Identifying traits and the physiological basis of the trait for adaptation to the new environmental challenge,

iii) Locating genetic variation for the traits,

iv) Understanding the genetic control, genetic expression and heritability of the traits,

v) Selecting for these new genes to develop cultivars through conventional, molecular or genetic engineering technologies,

vi) Evaluating success in target environments and releasing the cultivar for adoption by growers.

> *“For wheat it takes about 8 to 10 years from designing and making a new genetic combination through to releasing a new cultivar to seed companies”*

Selection for a trait can be either direct or indirect. The physiological traits associated with adaptive responses to abiotic stresses are examples of “indirect” selection for grain yield. To be effective, indirect selection requires the trait to be highly heritable, easily measured, and have a high genetic correlation with the trait of interest: grain yield. Under these circumstances, molecular breeding could be valuable, especially, if “perfect” markers, become available.

Breeding and selecting highly “plastic” cultivars adapted to future climate change will require locations that:

i) reflect overall trends of climate change for the region,

ii) provide high association between parameters at the breeding site and the target region yield variation, and

iii) have a relationship with abiotic stresses at the breeding site that reflect the dominating abiotic stresses in the target region.

The opportunities to respond to climate change using a multidisciplinary approach with plant breeding at the core, using the combined potential of conventional, molecular and genetically modified technologies, could be capitalized in the provision of cultivars with greatly enhanced nutrient and water-use efficiency, enhanced tolerance to heat and drought, resistance to diseases and insects, appropriate end-use and nutritional quality, and, possibly most important, increased ability to cope with the increasing extremes in temperature and precipitation occurring at one location over years.