Walking on the wild side: widening the phenological responsiveness of domestic chickpea

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Mediterranean climates are characterized by cool, wet winters and hot dry summers: stresses that impose considerable selection pressure on native annuals and crops alike. The key adaptation is appropriate phenology that fully exploits growing season rainfall to maximize resource capture and times the reproductive phase to avoid both early frost and terminal drought. Wild and domesticated *Cicer* have undergone contrasting evolutionary histories leading to divergent lifecycles/distributions with different temperatures, rainfall distributions and photoperiods impacting on the optimal flowering window and the environmental signals regulating phenology. Thus, we hypothesize that wild and domestic *Cicer* will differ in their responses to environmental triggers that regulate flowering, and that wild species may harbour a wider array of responses that can be exploited to broaden the habitat range of domesticated chickpea.

Wild and domestic *Cicer* with contrasting phenology was evaluated in factorial experiments examining:

- Vernalization response (Temperature (5-15^{o}C) x Time (5-40 days) in a constant temperature glasshouse (21.5^{o}C, ambient photoperiod (10.2-14.2 hr))
- Interactions between photoperiod (SD=8, LD=20 hrs), temperature (High=26^{o}C, low=15^{o}C) & vernalization (+/- vern) in controlled environment cabinets

At ambient short-medium photoperiods there is no vernalization response in domestic chickpea, whereas wild *Cicer* have 2 distinct temperature-dependent responses: a stronger, longer-term cold response invoked after 20 days at 5^{o}C, and a weaker, shorter-term cool response after 5-10 days at 10^{o}C.

Wild *Cicer* also have much more dynamic responses to temperature and photoperiod than domestic chickpea, with fascinating redundancy mechanisms regulated by the presence/absence of vernalization. Unvernalized wild *Cicer* are very photoperiod responsive, particularly at high temperatures, while temperature plays contrasting roles depending on day length: negatively correlated to flowering rate under SD, and strongly positively correlated to flowering rate under LD. Conversely, vernalized wild *Cicer* become *both* strongly photoperiod and temperature responsive, with some accessions flowering earlier than the earliest chickpea under warm LD conditions. Domestic chickpea is less responsive to all phenological drivers than wild *Cicer*.

These wild/domestic differences have arisen as a result of divergent evolution. The lifecycle of domestic chickpea is under control of man where the timing of sowing, vegetative and reproductive phases is proscribed by the interaction of climate and farming system, exposing the crop to a narrower, more predictable set of environmental phenology regulators. Conversely, because of physical dormancy, wild *Cicer* will germinate throughout the Mediterranean growing season and is exposed to a wide range of temperature and photoperiods. Accordingly, the regulation of wild *Cicer* phenology responds to manifold signals with considerable

redundancy. Thus, plants emerging in autumn receive the strong, longer-term low temperature vernalization that makes them very responsive to the increasing temperature and photoperiods during spring. In early spring, the weaker, shorter-term vernalization response adds a redundancy mechanism for later emerging wild *Cicer*. Finally, a stronger photoperiod response in unvernalized plants may allow some even later emerging wild *Cicer* to complete their lifecycle within the growing season. This level of redundancy gives the wild *Cicer* unparalleled phenological flexibility that has been lost in domestic chickpea but may help breeders target new environments for the crop.