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The role of FLC and PHP in warm winter bud dormancy activation in *Brassica napus*

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Background:

To adapt to climate change, we need to understand how crop development is influenced by the environment. In northern Europe, warmer winters have been statistically and experimentally linked with low yield, induction of flower bud dormancy and abnormalities in inflorescence development in Brassica napus.

Objective:

Experimental work sought to characterise the phenotype associated with temperature variation during early reproductive development in late autumn and early winter. We then set out to discover the genetic regulation of this response in order to uncover potential avenues for crop improvement.

Methods:

To quantify how warm winters affect B. napus and understand potential genetic mechanisms we grew a diversity panel of 96 lines of oilseed rape, from diverse geographical and ecological backgrounds, and exposed them to control and mimic warm winter conditions.

A genome wide association study identified a key gene associated with warm winter induced developmental delay. To validate this finding, sequencing and RNA-seq work probed differences between multiple isoforms of this gene. This was validated by mutation analysis in Brassica rapa and will be tested in a complementation study in Arabidopsis thaliana.

Results:

Following floral initiation, warmer winters induce reproductive development delay in Brassica napus. Transcriptomic work indicated this resembles dormancy: abscisic acid levels are higher, BRANCHED-1 dormancy genes are upregulated and cell division is downregulated. Two copies of the floral repressor FLC remain active after floral initiation. These are associated with control of bud dormancy. Different haplotypes of these FLC copies respond differently to warm winters and both have increased deposition of the active chromatin mark H3K4me3 in warm winters (Lu et al., 2022).

I uncovered genetic variation in warm winter dormancy. This correlates with crop type, suggesting genetic control of dormancy. I identified that variation in the Plant Homologous to Parafibromin (PHP) gene is correlated with warming-associated bud dormancy. In A. thaliana PHP is associated with greater FLC expression through deposition of H3K4me3. I've shown loss-of-function PHP varieties are earlier flowering and respond to winter chilling more rapidly. I've also discovered three haplotypes of BnPHP within Brassica napus that vary in temperature responsiveness and flowering time.

Conclusions:

We have characterised a novel bud dormancy phenotype in the valuable oilseed crop, Brassica napus, where warm winters induce dormancy and low yields. Haplotype variation in BnPHP can facilitate earlier flowering and development during chilling.

References:

Lu, X. et al. (2022). "Winter warming post floral initiation delays flowering via bud dormancy activation and affects yield in a winter annual crop," Proceedings of the National Academy of Sciences, 119(39). https://doi.org/10.1073/pnas.2204355119.