Regulating plant flowering

How to Cheat Wheat?

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Some plants don't flower unless they have experienced the chill of the previous autumn. Can we replace this need with a chemical?

Winter plants require periodical exposure to low temperatures, this being essential for passage from the vegetative phase of development (growth) to the generative phase (flowering). This unique group includes trees, biennial winter plants (carrots, beets, cabbage) and annual winter plants (cereals, rape). This process by which winter plants acquire the ability to flower is termed vernalization (Lat. *vernalis* - spring). In our climate, these plants have sufficient conditions for vernalization in autumn and they flower in the following spring, while those sown in the spring remain in the vegetative phase as a result of not having experienced a sufficiently long cold period.

Winter cropping is thus an adaptive feature, permitting a plant species to survive in a moderate climate by synchronizing its generative development with weather cycles. This feature is recent in the evolution of plants, for it emerged during the migration of primitive farming tribes into new territory with a colder climate, where conditions exceptionally unfavourable for the development of plants prevail on a regular basis. The forms of cultivable plants initially chosen to accompany the migrating tribes were more likely those with greater resistance to cold, than those that used the unfavorable season of the year to synchronize their own development processes.

Flowers without chill

The key difficulty in studying vernalization is that low temperature has multifaceted effects, and simultaneously modulates many physiological processes. It seems that low temperature can increase tissues' sensitivity to chemical or biological growth stimulators, e.g. by encouraging the production of the appropriate receptors.

Researchers have as yet been unable to fully replace the inductive action of low temperature with any other agent, particularly chemical substances. This is in fact surprising because the existence of a hypothetical chemical agent called vernalin, acting like the flowering hormone, was already posited in the 1930's.

The Plant Physiology Institute in Cracow is continuing research into the possibility of substituting vernalization with substances of biological origin (tissue extracts), or chemical compounds that have the properties of plant growth and development regulators. Such research frequently applies *in vitro* techniques, which ensure precision in controlling the external environment and provide better insight into how individual organs, tissues or even single cells respond to modifications in the substrate composition.

We have performed studies on embryos of the winter wheat var. Grana isolated from mature grains, the verna-

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Without any period of low temperatures, winter wheat is unable to flower, and resembles common grass

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Winter wheat form ears even after a brief 14-day vernalization period if zearalenone is administered

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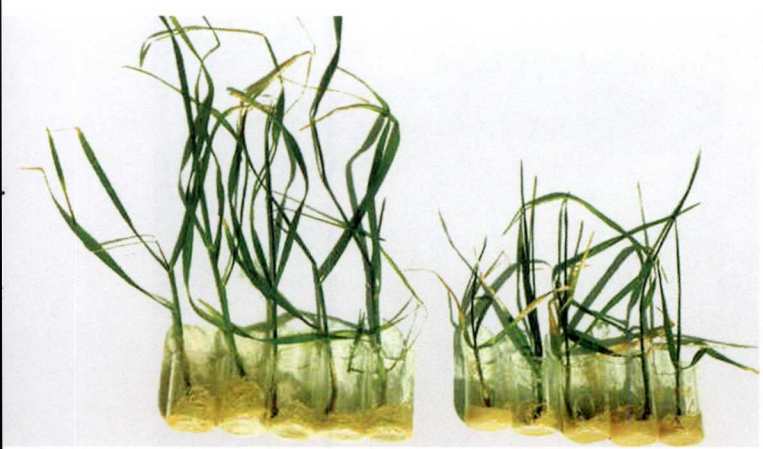
lization requirements of which were known with precision. This model variety requires a long, 8-9 week vernalization period to flower, while without exposure to reduced temperatures it will not flower at all.

Results have shown that some extracts contain substances that stimulate the generative development of plants by increasing the percentage of heading plants and by accelerating this process. The composition and concentration of these active substances varies with plant age. Vegetative tissues contain substances that inhibit ear emergence, while generative tissues contain flowering stimulators. The stimulators' activity is greatest in the initial phase of the generative organs' emergence, and then falls as plant development progresses. The presence of winter wheat flowering stimulators is surprisingly common among various plant species, for their presence was discovered in the inflorescences of plants belonging to different systematic groups, exhibiting different flowering-initiating mechanisms, such as maize, pumpkin, cucumber or rape. Results have also demonstrated that in heterosexual plants, i.e. those that grow separate male and female flowers, extracts from female flowers are much more active.



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Seedlings of Grana winter wheat after 14 days of veranlization, treated with zearalenone (left) and without treatment (right)

Reports of chemical substances affecting plant flowering efficiency have been appearing for many years now. One paper has also been published about the identification of zearalenone, a substance of key importance for the control of generative development. This is a strongly toxic metabolite of the fungus *Gibberella zeae*, occasionally encountered in animal fodder.

Toxin as flowering stimulator

A true surprise was the finding that there are many similarities between the properties of the plant extracts we have studied and those of zearalenone. Appropriately selected concentrations of zearalenone combined with considerably shortened vernalization periods broke through the thermal flowering barrier in almost all winter wheat specimens. Adding only 2 mg of zearalenone to 1 dm^3 of medium with embryos induced ear emergence in all plants after only 14 days of vernalization (instead of 9 weeks), while only 20% of the specimens vernalized without zearalenone flowered under the same conditions. zearalenone also accelerated flowering by up to 50 days. Some zearalenone derivatives, especially α-zearalanol, induce and accelerate ear emergence in winter wheat to an even greater extent

We have tested a broad spectrum of other growth and development regulators in studies aimed at breaking the thermal flowering barrier of winter plants, but no substance has been sufficiently active purely on its own, i.e. without even a very brief chilling of the plants. Thus winter plants cannot be cheated, but they can be "led to believe" that the cold period was longer than it actually was. ■

Further reading:

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