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Development of speed breeding protocols for cereal crops

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Today, a variety of molecular genetic and biotechnological approaches exist that can streamline certain stages of the breeding process. However, despite advancements in modern genetic techniques, the time required to develop promising cereal varieties from crossing to propagation can still take 10 to 15 years. Most agricultural crops have lengthy growth periods, which significantly impacts the rate at which new varieties can be developed. Research focused on the phenotypic manifestations of new genes is often conducted using model plants, such as Arabidopsis, due to their rapid growth and development. However, the findings from these studies do not always translate effectively to agricultural crops, as the effects of a gene can vary unpredictably in different plant species. Recently, speed breeding technology has gained prominence as a potential solution to the lengthy duration of the breeding process. The core principle of speed breeding involves utilizing physiological factors that shorten the time from sowing to flowering, reduce the generative stage of development, and overcome post-harvest dormancy, thereby minimizing the time required to grow a single generation. This method, which aims to reduce the vegetative period of plants to just two months, enables the production of six consecutive generations of spring cereals within a single year. The objective of this study is to develop speed breeding protocols for various cereal crops.

Materials and methods: Promising varieties and lines of spring bread wheat, durum wheat, barley, and spring triticale included in the collections were utilized as plant material. The plants were grown in artificial climate rooms (Climbiotech phytotrons) and climate chambers (Weiss Technik), which allow for the adjustment of various plant growth parameters. A comparison of the efficiency of plant growth was conducted based on the following parameters: photoperiods of 22 hours of light and 2 hours of darkness, and 16 hours of light and 8 hours of darkness. Nine different variations of light intensity were employed, ranging from 115 to 792 nm. For plant growing, a comparison was made between the use of cassettes of varying volumes and three substrate options: soil mixture, peat, and mineral wool. The degree of influence of far-red light was assessed by growing plants under three lighting conditions that differed in the ratio of radiation levels at 660 nm (R – red) and 730 nm (FR – far red), with ratios of R/FR = 3.75, 0.8, and 0.3.

Results: The earliest flowering dates for spring cereals occur under the following conditions:

1) When utilizing a photoperiod of 22 hours light and 2 hours dark, the number of days from sowing to flowering is statistically significantly reduced by 17.7 to 37 days, depending on the genotype, compared to a photoperiod of 16 hours light and 8 hours dark.

2) When employing a spectral composition of light with a ratio of R/FR = 0.3, plants come to flowering statistically significantly earlier by 3.4 to 4.3 days, depending on the genotype, compared to the control variant (R/FR = 3.75). Additionally, a negative effect of far-red light on triticale productivity has been observed.

3) When using light intensity in the range of 300 to 650 $\mu mol/m^2/s$, flowering time for durum wheat vary from 48.3 to 54.5 days after sowing, while triticale flowers between 34.4 and 38.2 days after sowing. Low light intensity results in a delay in the onset of flowering.

4) When using high-moor peat or a soil mixture as a substrate.

5) When utilizing cassettes with a cell volume of 30 to 80 ml, barley plants grown in these cassettes bloom statistically significantly earlier by 2.7 to 4.3 days, depending on the genotype, compared to plants grown in cassettes with a larger volume.

Conclusions: The development of efficient plant-growing protocols can significantly reduce the time required for a plant to fully grow and develop, allowing for the production of up to six generations of spring cereals in a single year. This advancement can shorten the time needed to develop new varieties to just 5 to 6 years. The integration of speed breeding with molecular genetics, such as DNA markers, and biotechnology techniques, such as embryo rescue, can potentially expedite the creation of new varieties with economically valuable traits.

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