



Article

Dynamics of Polyamines, Proline, and Ethylene Metabolism under Increasing Cold in Winter Oilseed Rape

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Abstract: Cold stress is among the most important environmental factors reducing the yield of crops. The present study aimed to investigate the impact of increasing cold stress conditions on winter oilseed rape polyamines, proline, and ethylene metabolism in acclimated and non-acclimated winter oilseed rape. This study was carried out under controlled conditions in the laboratory. The winter oilseed rape hybrid ‘Visby’ was used in the experiment. Acclimated and non-acclimated plants were subjected to a two-day-long increasing cold (from $-1\text{ }^{\circ}\text{C}$ to $-3\text{ }^{\circ}\text{C}$) treatment. HPTLC, RT-qPCR, spectral analysis, and gas chromatography methods were used to analyse the levels of polyamines, gene expression, proline, and ethylene, respectively. This study showed a decrease in putrescine, spermidine, and spermine content during cold acclimation and a decrease in putrescine and spermidine levels at sub-zero temperatures. There were intensive changes in ADC2 gene expression, proline, and ethylene levels in non-acclimated plants: a substantial increase after exposure to $-1\text{ }^{\circ}\text{C}$ temperature and a sharp decrease after exposure to $-3\text{ }^{\circ}\text{C}$ temperature. The changes in these parameters were lower or absent in acclimated plants. The phenomena observed in this study add new insights to the knowledge about the plant stress response and suggest questions to be answered in the future.

Keywords: *Brassica napus*; cold stress; ethylene; oilseed rape; polyamines; proline; stress markers



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1. Introduction

Adverse environmental factors affect the growth, yield potential, and distribution of plants. Thus, research on the plant stress mechanism and its control is one of the most important scientific fields to date. Physiological–biochemical reactions are activated in plants under stressful conditions. These are the defence mechanisms of plants, which help them to survive in unfavourable conditions when the level of an environmental factor exceeds the limit [1,2].

Oilseed rape (*Brassica napus* L.) is among the oldest crops grown in the world and is currently one of the most widely cultivated representatives of the Brassicaceae family. Its distribution mainly depends on climatic conditions [3,4]. Autumn–winter climate conditions in countries within the temperate climate zone encompass a wide range of natural phenomena. Research has shown that the combination and duration of their episodes determine the quality of winter oilseed rape wintering [5–7]. The main factors contributing to poor winter oilseed rape overwintering include a mild autumn, which makes non-acclimated (NA) plants susceptible to frosts, large daily temperature fluctuations, insufficient snow cover (especially snowless periods), long periods of cold resulting in drought, the formation of

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