

## Comprehensive analyses reveal the regulatory network of carbon and nitrogen metabolism in rapeseed under waterlogging stress

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### Background:

Rapeseed (*Brassica napus* L.) is the oil crop with the largest planting area as well as total oil production in China. Sustainable production of rapeseed for high yield and high production efficiency is crucial for security of edible oil. However, the quality and yield of rapeseed are seriously affected by waterlogging stress in the main producing areas of winter rapeseed.

### Objective:

To characterize the growth and developmental patterns of rapeseed under waterlogging stress, to elucidate the physiological and molecular mechanisms of carbon and nitrogen metabolism and photosynthesis, and to clarify the regulatory network of carbon and nitrogen metabolism, which will provide theoretical support for rapeseed cultivation and yield increase.

### Methods:

Two rapeseed varieties were used in this study, one sensitive to waterlogging (ZY39) and the other tolerant to waterlogging (ZYZ501). Physiological, biochemical analysis, 15N isotope tracer, transcriptome, iTRAQ proteomic analysis and metabolite profiling were conducted to evaluate the effect on root activity, root biomass, root structure, nitrogen absorption and distribution, ROS accumulation, chlorophyll content, the photosynthetic parameters of carbon assimilation, stress response genes in leaves and roots, as well as the metabolic pathway under waterlogging stress.

### Results:

We found that the germination rate of ZY39 decreased to 40%, while that of ZYZ501 still reached more than 90%, after 24h of waterlogging treatment. During seed germination, the soluble sugar content of seeds after waterlogging treatment was 4-5 times higher than that under normal condition. According to the transcriptome analysis, mitochondrial electron transport, protein degradation, and nitrogen metabolism signals in roots responded rapidly within 6 hours of waterlogging stress. Root biomass, root activity, chlorophyll content, photosynthetic rate, ROS accumulation and carbon and nitrogen metabolic enzyme activity were significantly changed after waterlogging treatment for 5-10 days. Moreover, after 10 days of waterlogging treatment and 5 days of recovery, new roots were generated from the hypocotyl, the young leaves recovered growth, chlorophyll content increased, root activity and carbon and nitrogen metabolism enzyme activity increased gradually.

### Conclusions:

In this study, we characterized the growth and developmental pattern of rapeseed under waterlogging stress and elucidated the physiological and molecular mechanisms of carbon and nitrogen metabolism and photosynthesis. The regulatory network of carbon and nitrogen metabolism in rapeseed under waterlogging stress was clarified for the first time. It provides important insights into the improvement of waterlogging stress tolerance for rapeseed.