Inhibition of root growth and carbon metabolism of apple M97337 rootstock under high nitrate stress is alleviated by adjusting potassium supply strategy

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Abstract

Nitrogen (N) is an essential element for plant growth, development, and metabolism. In apple production, the excessive use of N fertilizer may cause high N stress. Whether high N stress can be alleviated by regulating potassium (K) supply is unclear. A hydroponics experiment was conducted herein to test the influence of different N and K conditions on the root morphology and physiology of apple M9T337 rootstocks. The results showed that high nitrate-N conditions caused the dysregulation of N/K balance, hormone content, and antioxidant metabolism, resulting in damage to the root cortex structure. High nitrate conditions caused stomatal closure and reduced mesophyll conductance (g_m) and the maximum carboxylation efficiency ($V_{c,max}$), thus increasing photosynthetic limitations, and also reduced the expression of sugar transporter proteins (*MdSOT1*, *MdSOT2*, and *MdSUT1*), leading to a lower soluble sugar content in the root system, which was detrimental to root growth. Further analysis found that appropriately increasing the K supply (10 mM) enhanced the superoxide dismutase, peroxidase, and ascorbate peroxidase activities, reduced the malondialdehyde and H_2O_2 contents, and protected the root structure. It also optimized the net photosynthetic rate (A_n), increased sugar transporter protein expression and sugar-metabolizing enzyme activity in the roots, promoted the transport of photosynthetic products such as sorbitol and sucrose from the leaves to the roots, and increased the soluble sugar content in the roots. In summary, our data show that an appropriate increase in the K supply (10 mM) alleviated the root inhibition of high N through regulating physiological metabolic activities such as the antioxidant system and carbon metabolism. These findings support the use of N and K for alleviating high-N stress.

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