Paclobutrazol regulates hormone and carbon-nitrogen nutrition of autumn branches, improves fruit quality and enhances storage nutrition in ‘Fuji’ apple

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Abstract

Inhibiting the overgrowth of autumn branches during the fruit enlargement stage is one important way to improve the quality of apple fruits. Here, four levels of paclobutrazol (PBZ) (0, 500, 1000, 1500, and 2000 mg·L^{-1}) were applied to the autumn branch leaves of five-year-old ‘Fuji’ apple (*Malus × domestica* Borkh.) trees at the fruit enlargement stage in 2018 and 2019. The results showed that increasing PBZ levels decreased indole-3-acetic acid (IAA) and gibberellic acid (GA_3) contents and increase abscisic acid (ABA) contents in the autumn branch leaves. PBZ also reduced the leaf area, branch length, leaf number, and Rubisco enzyme activity in the autumn branches, but had no significant effect on chlorophyll and net photosynthetic rate. Obvious changes occurred when the concentration of PBZ exceeded 1500 mg·L^{-1}, including the inhibition of autumn branch growth. ^{13}C and ^{15}N isotope labeling results indicated that PBZ coordinated the carbon–nitrogen nutrition of autumn branches in the fruit enlargement stage, reduced the $\delta^{13}C$ and nitrogen derived from fertilizer (Ndff) in the leaves of autumn branches. PBZ also coordinated the carbon–nitrogen nutrition of fruits, reduced the accumulation of nitrogen in the fruit and increased the accumulation of carbon in the fruit. PBZ increased the content of soluble sugar, starch, soluble protein, and free amino acids in the roots to varying degrees in early spring the following year (2019 and 2020). These results indicated that a moderate PBZ (1000–1500 mg·L^{-1}) application could reasonably regulate carbon-nitrogen nutrition of autumn branches and fruits, then improve fruit quality and the storage nutrition of apple trees.