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Impact of low temperature during ripening stage, amylose content and activities of starch biosynthesis in rice endosperm

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Abstract

This research study was conducted to analyze the characteristics of different rice cultivars in abnormal temperature conditions (low temperature) for ripening period abnormalities, and to investigate the physiological causes behind the abnormalities. Four Korean high quality japonica-type rice cultivars, Jinbu (JB), Junamjosaeng (JJ), Geumyoung (GY), Hwawang (HW) were used in the experiment. The following day after flowering, they were then moved into two phytotrons under natural daylight with 65% RH but controlled at different temperatures – one at 19/29°C (night/day) and the other at 13/23°C as the low temperature study on ripening. For the cultivars at 13/23°C (low temperature study), JB and JJ had a ripening rate of 93% which is similar to the ripening rates of cultivars at 19/29°C at 45 days after heading (DAH). In contrast, GY and HW recorded lower ripening rates of 86% and 57% respectively. However, when the cultivars at 13/23°C were harvested at 61 DAH (when the accumulated temperature reached 1100°C), the difference in ripening rates compared to the 4 cultivars of 19/29°C harvested at 45 DAH was not obvious (JB 94%, JJ 97%, GY 97%, HW 88%). Starch content showed little difference among the 4 cultivars at different temperature conditions while amylose content was higher for cultivars at 13/23°C compared to those at 19/29°C. In addition, the enzyme activities of starch biosynthesis were about 5~10 days slower in cultivars at 13/23°C compared to cultivars at 19/29°C. The grain-filling rate showed highly significant correlations with the enzyme activities of Sucrose synthase ($R^2=0.70^{***}$), ADP glucose pyrophosphorylase ($R^2=0.63^{***}$), UDP glucose pyrophosphorylase ($R^2=0.36^{***}$), Starch synthase ($R^2=0.51^{***}$), and Starch branching enzyme ($R^2=0.59^{***}$). Among the enzymes, Sucrose synthase activity had the highest correlation coefficient with grain-filling rate. In conclusion, the activity of enzymes such as Sucrose synthase, UDP glucose pyrophosphorylase, ADP glucose pyrophosphorylase, Starch synthase, Starch branching enzyme in starch biosynthesis is proven to be highly related to the grain filling process. Notably, the decrease in the activity of Sucrose synthase and Starch branching enzyme and the late increase in ADP glucose pyrophosphorylase activity at low temperature in the ripening stage are considered to be disadvantageous as they delay ripening and increased amylose content.

Keywords: low temperature, ripening stage, amylose, starch biosynthesis

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