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Impact of abiotic stress on grain yield, antioxidant activity, and nutritional quality of black rice

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Abstract

Abiotic stresses, including salt, water, and temperature extremes, pose significant challenges to crop growth, yield, and nutritional quality. Black rice, renowned for its high antioxidant content, is particularly vulnerable to these stresses, which can negatively affect both grain quality and antioxidant activity. Additionally, elevated levels of phytic acid in black rice can reduce its nutritional value by binding to essential micronutrients, thereby decreasing their bioavailability. This study examines the effects of three types of abiotic stress—salt stress (control vs. different levels of salt stress), water stress (continuous flooding, alternate wetting and drying, and aerobic rice system), and temperature stress (normal vs. elevated temperature)—on grain yield, antioxidant compounds (flavonoids and phenolics), phytic acid content, and grain colour appearance. Two pot experiments and three-year field experiments were conducted to assess these factors.

Our results indicate that while salt stress reduced grain yield, it increased antioxidant activity, leading to higher levels of flavonoids and phenolics in rice grain under mild to moderate salt conditions. In addition, salt stress enhanced the grain colour appearance of black rice, which further improves the market quality. In contrast, elevated temperatures decreased both grain yield and antioxidant activity, while increasing phytic acid levels. Interestingly, the aerobic rice system, despite yielding similarly to continuous flooding, significantly reduced phytic acid concentrations, enhanced antioxidant activity, and improved grain colour. However, temperature stress caused undesirable changes in grain colour, negatively affecting the appearance of black rice. These findings highlight the complex interactions between abiotic stresses and the functional properties of black rice, underscoring the challenge of balancing grain yield with nutritional quality when cultivating black rice under stress conditions.

Keywords: Abiotic stress, antioxidant activity, black rice, grain quality, phytic acid