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Pre-Harvest Sprouting (PHS)/Vivipary Resistance in Rice: Implications for Crop Yield and Climate Resilience

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Rice is a staple food for more than half of the world's population. It is an essential crop that provides vital nutrients to billions of people. However, rice production is under threat due to various biotic and abiotic stresses such as drought, salinity, pests, and diseases. One of the lesser-known major threats to rice production is vivipary, a condition in which the rice seed germinates while still attached to the parent plant. Vivipary/Preharvest sprouting (PHS) is a rare condition that occurs in rice, where the seed germinates prematurely while still attached to the parent plant. In normal conditions, the seed remains dormant until it falls to the ground, where it can grow into a new plant. However, in vivipary, the seed germinates while still attached to the parent plant, resulting in the growth of a shoot or embryo, often referred to as a "pre-germinated seed" or "sprouted seed" (Mohapatra and Kariali, 2016). Excessive dormancy loss may impair PHS, reducing crop yield and causing economic loss (Black, 2006).

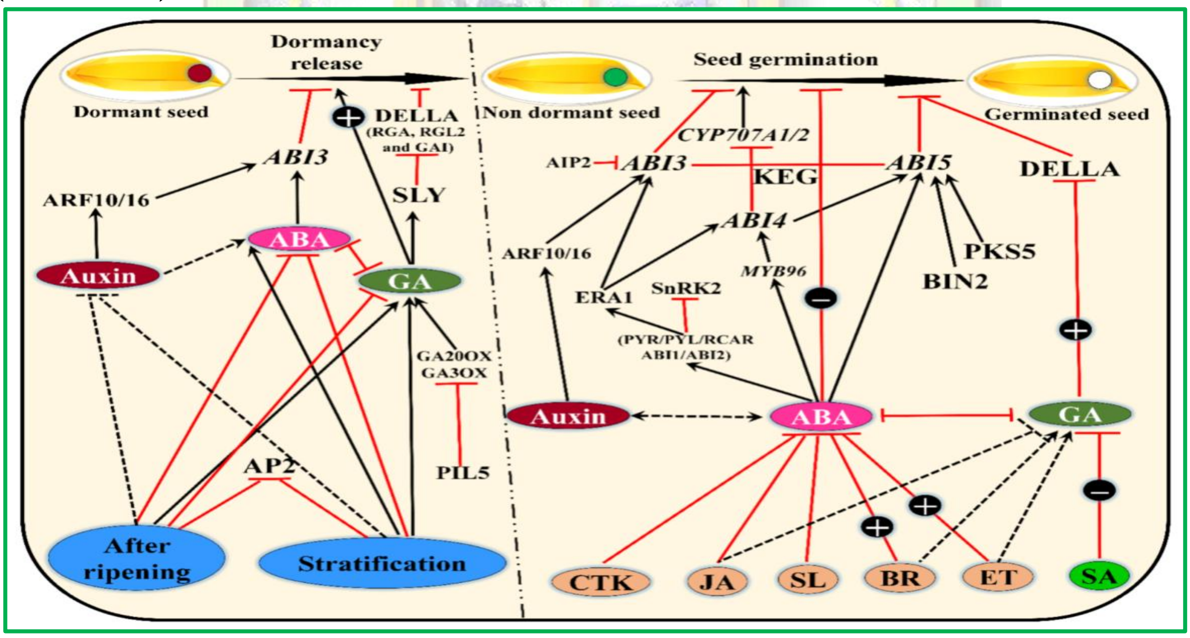

Figure 1. Resistance mechanism of rice vivipary through hormonal balance (Sohn *et al*., 2021)

This condition is caused by a hormone imbalance in the rice plant, which triggers the seed to germinate prematurely. Vivipary is often linked to environmental stress such as prolonged exposure to high humidity, rain, and flooding, as well as genetic factors. While vivipary might seems like an interesting phenomenon, it can have serious implications for rice production. Vivipary can lead to a significant reduction in rice yields, as the sprouted seed is less likely to grow into a healthy and productive plant and degrades eating, cooking, and processing quality by modifying starch physicochemical features, such as amylose and amylopectin content and granule shape (Zhu, 2019; Zhang, 2020). PHS is reported in Japan, China, India, the United States, Canada, Australia, North Africa, and Europe (Fang *et al.*, 2008). The pre-germinated seed is more susceptible to pests and diseases, and the resulting plant is often weak and stunted. Moreover, vivipary can reduce the quality of the rice grain, as the sprouted seed alters the nutritional composition of the rice, making it less nutritious.

To combat vivipary in rice, researchers are focusing on identifying the genetic factors that contribute to this trait. Understanding the mechanisms underlying vivipary resistance could help to develop more effective breeding strategies to produce rice varieties that are more resistant to this condition. In addition, the development of new technologies such as genome editing and gene silencing may offer new opportunities to manipulate the genetic makeup of rice to enhance its resistance to vivipary.

While the development of vivipary-resistant rice is an important goal, it is also essential to consider the potential environmental and social impacts of such innovations. Careful consideration must be given to issues such as access to resources, the potential for unintended consequences, and the ethical implications of genetic modification. With careful planning and a collaborative approach, it may be possible to develop vivipary-resistant rice that can help to ensure food security for future generations while also addressing pressing environmental challenges (Redfern et al., 2016; Fuentes-Dávila et al., 2019)

Rice vivipary resistance refers to the ability of rice plants to resist vivipary, which is a physiological disorder characterized by premature seed germination within the grain before seed maturity. Rice vivipary resistance can be influenced by various genetic and environmental factors. Genetic factors include the presence of specific genes that control seed dormancy, while environmental factors include temperature, humidity, and water logging conditions (Basbouss-Serhal *et al*. 2016). Rice varieties with high levels of vivipary resistance are desirable for cultivation in areas prone to high humidity and rainfall, where the risk of vivipary is greater.

To counter the threat of vivipary in rice production, researchers have been working to develop rice varieties that are resistant to vivipary. These resistant varieties are designed to withstand environmental stress and hormonal imbalances that trigger vivipary. The development of vivipary-resistant rice has the potential to significantly increase rice yields, improving food security and livelihoods for millions of people worldwide. The main hormones involved in regulating rice vivipary are abscisic acid (ABA), gibberellins (GA), and ethylene. ABA is responsible for maintaining seed dormancy, while GA promotes seed germination. Ethylene is involved in regulating various developmental processes in plants, including seed germination (Tejakhod and Ellis 2018).

In order to induce vivipary, there must be a reduction in ABA levels and an increase in GA levels. This can be achieved through various mechanisms, including:

1. Regulation of ABA biosynthesis: ABA biosynthesis can be regulated by various environmental factors such as temperature, light, and water availability. In rice, vivipary can be induced by exposing the seeds to high humidity, which reduces ABA biosynthesis and promotes GA production.
2. Regulation of ABA catabolism: ABA catabolism can also be regulated to reduce ABA levels. This can be achieved by activating specific enzymes that break down ABA in the seed.

3. Regulation of GA biosynthesis: GA biosynthesis can be promoted by various environmental factors, such as light and temperature. In rice, vivipary can be induced by exposing the seeds to red light, which promotes GA biosynthesis.
4. Regulation of ethylene levels: Ethylene levels can also be regulated to promote vivipary. Ethylene inhibitors, such as 1-methylcyclopropene, can be used to reduce ethylene levels in the seed, which promotes GA production and seed germination.

Conclusion

In conclusion, PHS/vivipary is a serious threat to rice production, and developing vivipary-resistant rice is crucial for ensuring food security and sustainability. By understanding the causes and implications of vivipary, researchers can develop effective strategies to mitigate the risk and improve rice yields. As rice remains a crucial crop for millions of people worldwide, we must continue to invest in research and development to safeguard its production for future generations.

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