The next green revolution of organic rice

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Professor Apichart Vanavichit, PhD, Rice Genomic Breeding Expert at Rice Science Center, heralds the next green revolution of organic rice

Rice is a major food crop for more than half of the world's population and a crucial export commodity for Thailand. Despite the success story of the first Green Revolution in 2005, new rice varieties developed in Thailand negatively impact the environment and well-being of rice farmers in irrigated areas. On the other hand, based on chemical-free cultivation practices, organically grown rice conserves the environment and genetic diversity, and enhances the nutritional properties of harvested rice. Nevertheless, grain yield generally makes up half of chemical-rich irrigated rice.

Most importantly, the lack of resistance to diseases, insect pests and environmental stressors makes organic rice vulnerable and risky for crop loss. As a result, rice prices are significantly higher, with lower outputs from organic cultivation than non-organic rice. However, significantly increased productivity and enhanced resistance in organic cultivation sustain organically-grown rice and benefit consumers by reducing the market price.

Breaking the plateau of grain yield in organic rice is a grand challenge for rice breeders to comprehend any limitations and provide genetic solutions to enhance the efficiency and productivity of organically-grown rice.

One approach involves the high genetic diversity of Indica x Japonica crosses to maximize heterosis, the genetic phenomenon when progenies outperform their parental lines in grain yield and productivity. The recent gathering of rice scientists and breeders around the world at the 19th International Symposium on Rice Functional Genomics in Phuket, Thailand reports an understanding of precision breeding for organic rice.

New ideotypes of organic rice breeding

We have designed a new rice ideotype to fit into organic cultivation. The key features are high productivity, high water and nutrient use efficiency WUE, intermediate plant height, intermediate maturity, strong stem, resistance to all biotic and abiotic stresses, resiliency to climate change and pyramiding. All resistance genes in elite rice varieties are achieved by pyramiding into existing nutrient-rich rice, high-yielding cultivars with a good broad-spectrum resistance to both diseases and insect pests, tolerance to abiotic stresses, improved agronomic traits, increased photosynthetic efficiency and enhanced interaction with microbiota.

Climate-ready, nutrient-rich rice

Thailand Rice Science Center has relentlessly developed the first four rice models for organic farming since 2000 until today. We have undertaken four organic breeding programs selected under organic cultivation systems: Super Riceberry-Rainbow Rice, Super Low GI White Rice, Super Jasmine Rice and Super Waxy Rice. Our main goal is to choose new rice varieties to significantly outperform local varieties of the same quality type under high pressure from diseases and insect pests in multiple target organic areas. The ultimate goal is to maximize yield and quality under optimum organic agricultural practices.

To conclude, 50 rice varieties have broad-spectrum resistance to bacterial leaf blight, leaf blast, brown planthopper, and tolerance to flooding, extreme heat, salinity, acid sulfate soil and drought. In addition, rice varieties with improved water use efficiency, resistance to sheath rot, brown spots, and bacterial leaf streak have recently developed. These innovative rice varieties are key success stories of the green revolution in organic rice.

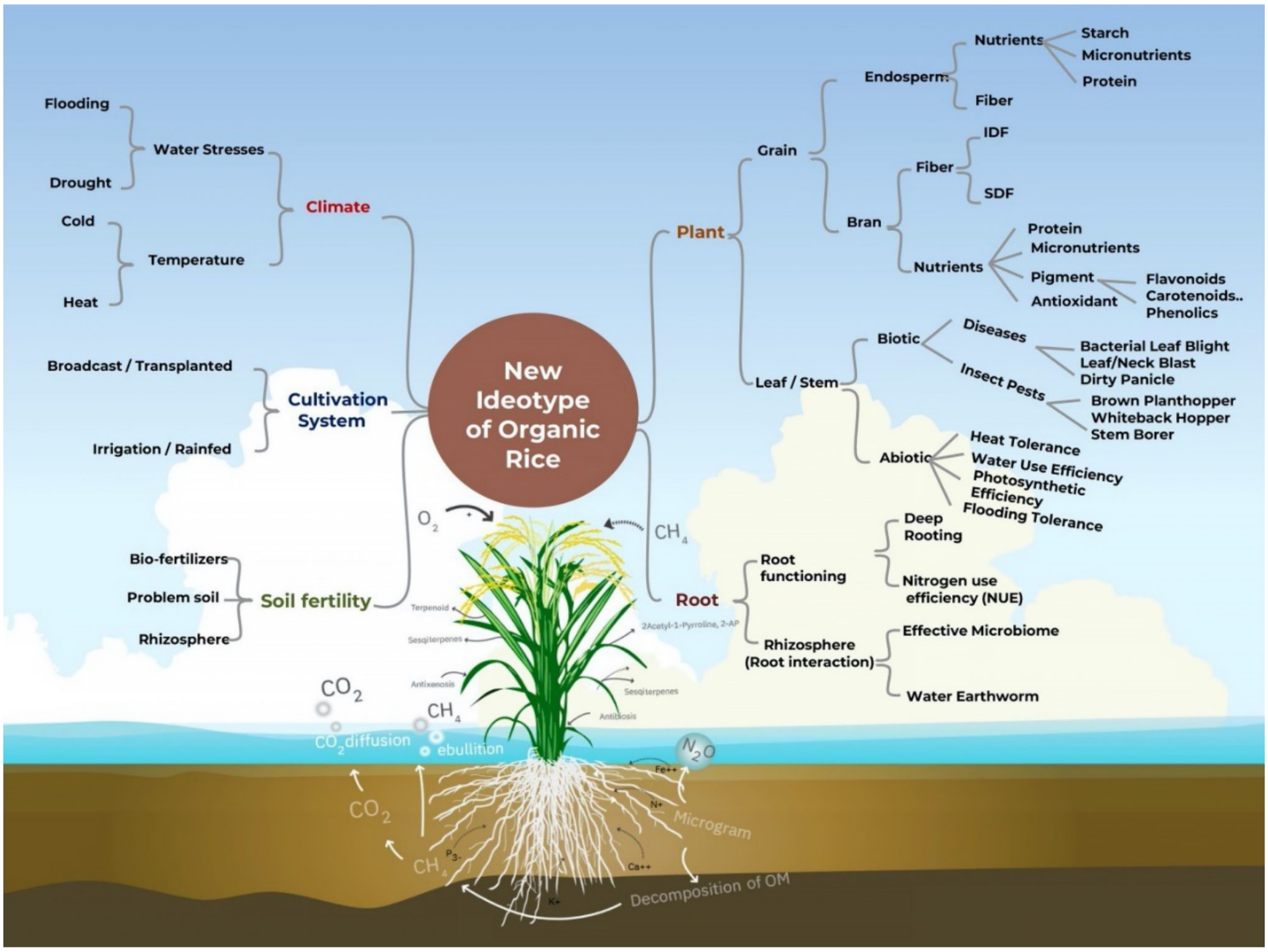

Figure 1: A new ideotype of organic rice

Rhizosphere-microbiome interaction – key to productivity

Despite no addition of chemical fertilizers, rice can be pretty productive under organic cultivation, albeit with lower grain yield in many cases. Nature's secret depends on the genetic makeup of rice and soil microbiome. The rhizosphere and the soil environment near the rice root surface are crucial interfaces for water and nutrient absorption, releasing root exudates and interacting with soil microbiota. Gaseous exchange between roots and microbial community occurs here, enabling methane to escape from submerged soil to the atmosphere and become a greenhouse gas. The rice rhizosphere accommodates large numbers of microbial communities, including endophytes, rhizosphere bacteria and fungi.

However, the intensive application of N-P-K fertilizers adversely affects the abundance and diversity of the microbial community in the rhizosphere responsible for nitrification, N2 fixation, and tolerance to problematic soil. On the other hand, the main advantage of organic rice cultivation is more diversity of soil microbiota associated with rice rhizosphere. Recently, there have been reports on PGP and plant growth promotor microbes, including endophytic stenotrophomonas and Piriformospora indica. To conclude, we have detailed the success story of organic rice breeding by precision rice breeding involving multiple gene pyramiding to generate sustainable, productive, nutritious rice varieties that are resilient to climate change.

Acknowledgement

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