

Enhancing rice production in sub-Saharan Africa: characterization of rice blast pathogen and establishment of a rice breeding strategy for durable disease resistance

Authors:

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Project summary

Rice is steadily becoming a staple food to the majority of people in Africa, yet its production is outstripped by demand, resulting in net imports from abroad. Rice blast disease is a major factor that has led to decline in rice production in Africa. This international collaborative research for development project is aiming at overcoming rice yield losses caused by blast disease and hence increasing rice production in sub-Saharan Africa. Breeding for durable blast resistance requires knowledge about the genetic diversity of the pathogen population and its virulence spectrum; durable resistance represents the most sustainable rice blast control strategy. The project has characterized blast pathogen collections from East and West Africa using genomics, and a panel of rice genotypes including those carrying the 24 known resistance genes (R-genes). Based on the results, the project has initiated a breeding program which combines the most promising R-genes into adapted African cultivars. In addition, the project is establishing a biobank of the pathogen collections at BecA-ILRI Hub for use by African scientists and their partners.

Outputs

1. Pathogen genetic relatedness was found to be associated with virulence. Lineages differed in average disease reaction scores (Fig. 1).
2. Pathogen collections from West Africa were 1.5x more likely to cause blast disease compared to those from East Africa.
3. The most promising R-genes were identified for introgression into adapted cultivars in East and West Africa. None of the rice genotypes were resistant to all isolates. The most promising African rice cultivar was resistant to 93% of isolates while a cultivar (75-1-127) carrying a known R-gene (*Pi9*) was resistant to 95% of the pathogen collections (Fig. 2).
4. **A resistance breeding strategy was identified to pyramid R genes based on overall analyses.**
5. Breeding populations were developed by combining rice genotypes which complemented to confer resistance against the entire pathogen collection for East and West Africa (Fig. 3).
6. Identification of additional R-genes from African and Asian rice germplasm is underway at The Ohio State University, USA.
7. A biobank of rice blast isolates ($n=234$) from nine African countries is being established at the BecA-ILRI Hub.
8. The project is building capacity by training African PhDs and postdoc researchers who will lead in the future disease management.

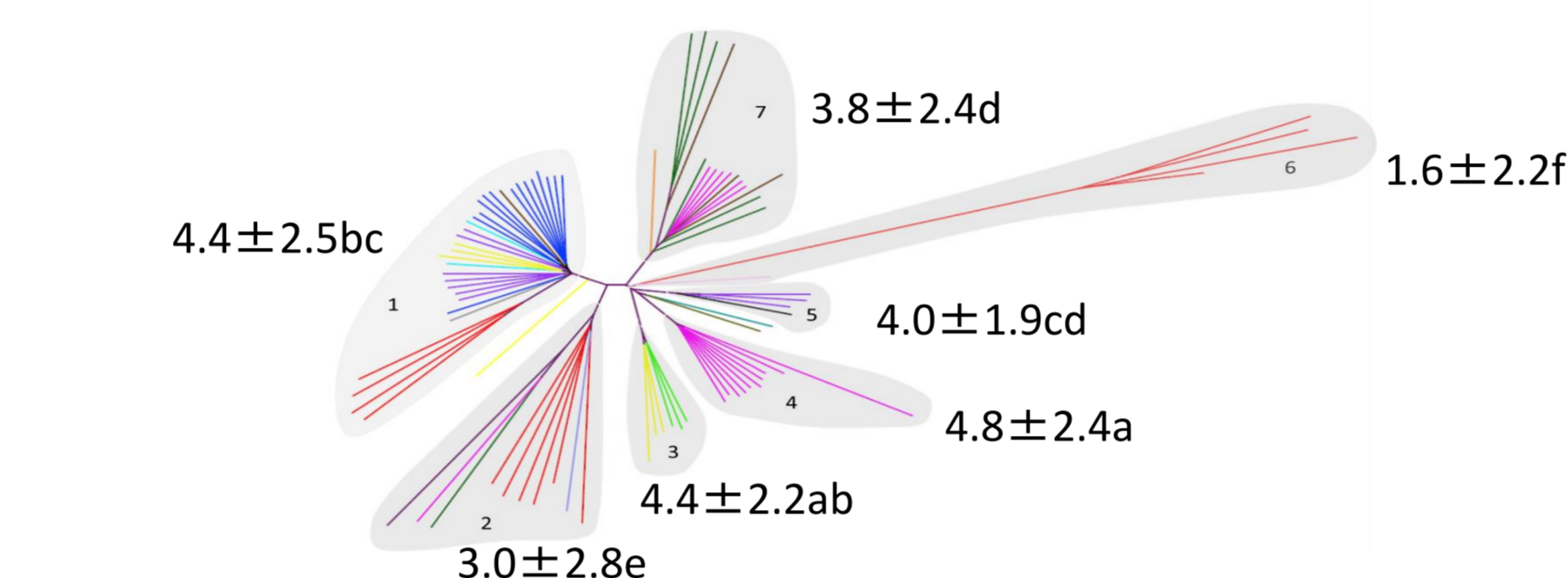


Fig. 1. Genetic relatedness of isolates of rice blast pathogen ($n=78$) from nine African countries and the mean disease reactions (0-9 scale; 0-3=Resistance; 4-9=increasing disease severity) of individual lineages. Characterization was based on genotyping by sequencing derived single nucleotide polymorphisms. (Colors denote countries: Benin, Burkina Faso, Ghana, Kenya, Mali, Nigeria, Tanzania, Togo, Uganda).

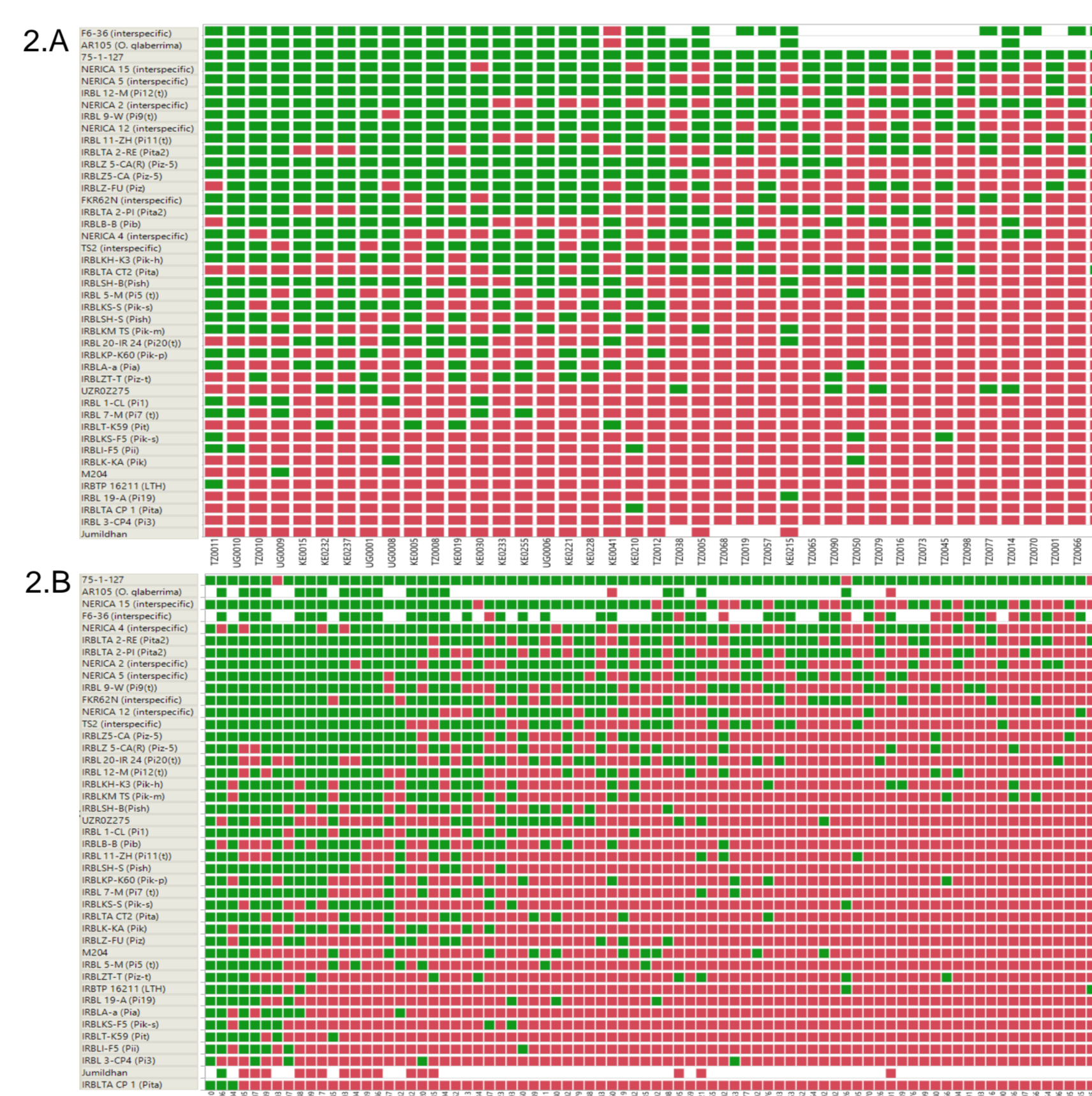


Fig. 2. Disease reactions on rice genotypes ($n=43$) inoculated with blast pathogen isolates from East ($n=41$; A, top graph) and West Africa ($n=81$; B, bottom graph). Rice genotypes in the Y-axis, and Isolate names in the X-axis. Colors: Disease and Resistance. White spaces denote missing data.

Regional blast resistance breeding strategies

1. East Africa:	<i>Pi9</i> bred into NERICA 2
2. West Africa:	<i>Pi9</i> + <i>Pita</i> 2 bred into F6-36
3. Both regions:	<i>Pi9</i> bred into aromatic varieties e.g., Basmati 217 & 370

Fig. 3. Development of blast resistance breeding populations. Strategies 1 and 2 are based on the isolate characterization in Fig. 2 above, while strategy 3 introduces blast resistance into the consumer-preferred commercial rice varieties.

Partnerships

1. BecA-ILRI Hub, Kenya
2. University of Arkansas - Fayetteville, USA
3. Ohio State University - Columbus, USA
4. Kenya Agricultural and Livestock Research Organization (KALRO)
5. Environmental Institute for Agricultural Research (INERA), Burkina Faso
6. Africa Rice Center (AfricaRice), Benin
7. International Rice Research Institute (IRRI), Philippines
8. University of Exeter, UK (overall project lead)

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Outcomes

1. **An integrated research for development team, including African national program pathologists and breeders, has coalesced around a major agricultural improvement problem, and is making key advances to addressing it.**
2. **Broad geographic collaboration to investigate rice blast disease and to establish appropriate breeding strategies.**

Additional expected outcomes

1. Durably blast-resistant rice varieties will be made available to rice growers in sub-Saharan Africa for effective disease control and hence increased rice production, leading to **increased food security**.
2. **Reduced reliance on rice imports** due to increased production by African farmers, driving increased food and economic security.
3. **Regional disease monitoring** and future breeding efforts can be developed and informed by the observed relationship between pathogen genetics and virulence spectrum.
4. **Phytosanitary strategies** could be adopted based on the observed pathogen virulence spectrum to safeguard regions from introduction of new virulent strains through rice trade. This needs better established plant quarantine systems.
5. **Regionally-tailored blast resistance breeding efforts**, for East and West Africa, will proceed with field evaluations in selected blast hotspots.
6. **African scientists will be better equipped** to conduct further pathogen characterization and screening of local rice germplasm for resistance to blast, making use of the biobank at the BecA-ILRI Hub. Identification of additional R genes is expected.
7. **African national rice breeders and their partners will be better equipped** to address short- and long-term disease resistance challenges using appropriate high-end biosciences tools.

Potential to scale-up

- Globally, rice blast disease destroys an amount of rice sufficient to feed 60 million people annually. Africa is among the regions faced with frequent food shortage due to crop losses caused by diseases, including rice blast. Effective blast control would lead to reduced hunger and malnutrition in Africa.
- The efforts of this project were highly commended by African rice breeders and pathologists during a workshop in Kenya (June 2015). The scientists have received the seed of the breeding populations from this project, and will conduct hotspot evaluations.
- African rice production (2.1 t/ha) is well below the world average (3.5 t/ha). Because blast disease is a major constraint in Africa, durably blast resistant varieties developed in this project hold the potential of enabling African farmers to almost double their rice production.