Breakthrough in lowland rice breeding targeting submergence tolerance

Flooding in some parts of the African continent is now a recurrent phenomenon that may be attributable to climate change. It is causing rice production losses especially in rainfed lowland areas. In Nigeria, for example, 22% of rice production loss in 2012 was a result of flooding. In simple terms, rice varieties grown in the flooded areas could not tolerate prolonged submergence. With rainfall predicted to increase in frequency and intensity in parts of the continent, submergence tolerance is a key trait for rice breeders to target.

AfricaRice's response to this challenge was the initiation of breeding activities for submergence tolerance in 2010, within the context of Phases 2 and 3 of the 'Stress tolerant rice for poor farmers in Africa and South Asia' (STRASA) project. This was motivated by persistent requests from national partners with major flood-prone rice areas such as Madagascar, Mali, Nigeria and Sierra Leone.

In 2017, the first two submergence-tolerant varieties, bred through marker-assisted selection, were released in Nigeria as FARO 66 and FARO 67. This was a result of the introduction of the *Sub1* gene for submergence tolerance into popular rice varieties in the country. FARO 66 is based on the high-yielding FARO 52 (a.k.a. WITA 4, which is widely grown in Africa), appreciated for its good grain quality. The new variety is submergence tolerant but otherwise almost identical to FARO 52.

FARO 67 (*see* photo) is based on FARO 60 (a.k.a. NERICA-L 19, also widely grown in Africa) which, because it grows tall under very fertile conditions, is prone to lodging. The new variety is not only submergence tolerant, but also shorter and earlier maturing than the older version (making it less susceptible to lodging) and higher-yielding under both flooded and non-flooded conditions.

"These varieties are so popular that demand — both local and international — is exceeding supply from Nigerian seed production," says lowland rice breeder Ramaiah Venuprasad. "Liberia, Sierra Leone and Uganda have all requested seeds."

To help meet this demand, the two submergence-tolerant varieties are also being multiplied at the AfricaRice M'bé station in Côte d'Ivoire.[3] Meanwhile, upgraded varieties carrying the same *Sub1* gene are in advanced field testing in Madagascar.

Further progress made in breeding for irrigated and rainfed lowland agro-ecosystems are highlighted below.

Senegal. Out of a total of 15 new varieties released in Senegal in 2017, six of them were introduced through AfricaRice (Table 1): (i) AfricaRice aromatic hybrid AR051H,[4] (ii) two other AfricaRice-developed varieties (WAS 73-B-B-231-4 and WAB 2098-WAC3-1-TGR2-WAT 85), (iii) IRRI variety IR 72593-B-3-2-3-8-2B promoted through the STRASA project, (iv) variety OH10 from the Chinese Academy of Agricultural Sciences, and (v) FAROX 521-288-H1 from the Nigerian national program.

All of these varieties were advanced through the evaluation network of the Africa-wide Rice Breeding Task Force. Two of them (WAS 73-B-B-231-4 and the IRRI variety) are salinity tolerant and therefore suitable for both saline irrigated lowlands and mangrove-swamp agro-ecosystems, and three (08 FAN 10, WAB 2098-WAC3-1-TGR2-WAT 85 and FAROX 521-288-H1) are adapted to both irrigated and rainfed lowland systems.

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3. *See* 'Pan-African breeder and foundation seed capital in M'bé' in the Foreword to this annual report.
4. *See* 'Senegal set to release hybrid rice cultivars', *AfricaRice Annual Report* 2016, pages 13–14.

Table 1. Lowland varieties released in 2017

Country	Total	Origin
Ethiopia	4	AfricaRice (2); CIRAD Madagascar (2)
Ghana	6	AfricaRice (1); Nigerian NARS (1); Ghanaian NARS (4)
Nigeria	2	AfricaRice (2)
Senegal	6	AfricaRice (3); CAAS (1); IRRI (1); Nigerian NARS (1)

CAAS, Chinese Academy of Agricultural Sciences; CIRAD, Centre de coopération internationale en recherche agronomique pour le développement; IRRI, International Rice Research Institute; NARS, national agricultural research system.

Ethiopia and Ghana. Between these two countries, a total of 10 lowland varieties were released in 2017 (Table 1). Six of them were introduced through AfricaRice and four were developed by the national program of Ghana. The six varieties released in Ghana are tolerant to iron toxicity and four are aromatic (AGRA-CRI-LOL-1-7, AGRA-CRI-LOL-2-27, CRI-1-11-15-5 and CRI-1-11-15-21), while among the four varieties released in Ethiopia, two are cold tolerant and the other two are drought tolerant.

By becoming a member of the CGIAR Excellence in Breeding platform, which was launched in 2017, AfricaRice now has more scope for assessing its breeding program and, by acting on the resulting recommendations, improving the efficiency of its breeding efforts, especially those geared towards the rapid replacement of old mega-varieties. The platform includes Queensland University (Australia) and other members of the CGIAR Research Program on Rice (RICE: CIAT, IRRI and national partners). RICE will undergo assessment in 2018.

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Submergence-tolerant 'NERICA-L 19–sub1–tall', the line destined to become FARO 67, at a field day in Nigeria