

Learning to tolerate flooding, a major problem in inland valleys that's worsening as the climate changes

One feature of the global climate catastrophe as it is unfolding in the tropics is the irregularity of precipitation. In particular, while rainfall events are becoming fewer they are tending to be increasingly intense. This brings a greater risk of flooding, especially in areas with limited water-control infrastructure. One notable response to this has been the development of the Smart-valleys approach. Another is to develop flood/submergence-tolerant rice varieties.

History in brief

AfricaRice started breeding work with the flooding/submergence-tolerance gene *Sub1* in 2010 under the 'Stress tolerant rice for poor farmers in Africa and South Asia' (STRASA) project. Near-isogenic lines carrying the *Sub1* gene were developed using marker-assisted selection from the popular 'mega-varieties' WITA 4 and NERICA-L 19,¹ culminating in one of each being released in Nigeria in 2017, as FARO 66 and FARO 67, respectively.² These two varieties produce 6–29% higher yield under non-submergence conditions than their recurrent parents, but if submerged for a week or two, they can amazingly produce 10–80 times more yield than their recurrent parents under the same conditions. They also have shorter growth durations. Moreover, they retain their recurrent parental characteristics of good grain quality with medium-long slender grains and moderate iron-toxicity tolerance.

Getting the new varieties to those who need them

Although these varieties have been adopted in some rice areas in Nigeria, and their seeds were requested

by Liberia, Madagascar, Sierra Leone and Uganda, large-scale adoption is still a challenge.

The next step is to promote them first where the mega-varieties NERICA-L 19 and WITA 4 are already adopted and popular among lowland-rice farmers.

To prioritize target areas, AfricaRice is using the flood-risk assessment map developed in 2015–2016³ and alerting governments in the identified countries of the available *Sub1*-introgressed materials, especially in countries where WITA 4 and/or NERICA-L 19 have already been released. The varieties are also being disseminated via the Africa-wide Rice Breeding Task Force to countries where the parent varieties are not currently used. Interest in the varieties has already been expressed by national programs and/or farmers in Benin, The Gambia and Senegal.

There is a saying that 'every cloud has a silver lining': that may be stretching a point, but emergency seed provision has proved a useful route for delivering submergence-tolerant varieties to countries in crisis (*see* Box 'Sub1 to the rescue in Guinea').

Refining recommendations for coping with early-season flash-floods

Rice is typically transplanted into prepared inland-valley lowland fields, especially in West Africa, after it has grown in nurseries for about 21 days. However, early-season flash-flooding is an increasingly common occurrence in many inland valleys and is likely to occur as early as 1 month into the season, potentially hitting the transplanted plants before they have fully established. With the aim of refining

1. See 'Managing stresses on rice for the benefit of African farmers', *AfricaRice annual report 2015*, page 10.

2. See 'Breakthrough in lowland rice breeding targeting submergence tolerance', *AfricaRice annual report 2017*, pages 8–9.

3. See Zwart SJ and Hamady M. 2016. Finding flood-prone rice areas in West Africa. *Rice Today*, 2 March. <<http://ricetoday.irri.org/finding-flood-prone-rice-areas-in-west-africa/>>



Mature direct-seeded rice that experienced early-season flooding for 7 days: non-Sub1 variety WITA 9 (foreground) compared with Sub1 varieties of NERICA-L 19 and WITA 4 (background)



Transplanted rice that experienced early-season flooding for 7 days: non-Sub1 WITA 9 (foreground) compared with Sub1 mega-variety (background)

***Sub1* to the rescue in Guinea**

In the 2017 wet season, Guinea experienced heavy rainfall, resulting in flooding which caused failure of some rice crops, including those grown for seed, which in turn could have exacerbated social instability. Guinea is still recovering from the Ebola crisis and the social situation in the country is extremely fragile.

Demonstration plots of the *Sub1* varieties were established in Guinea in 2018 to accelerate variety dissemination. During that cropping season, heavy rainfall again afflicted some rice-growing areas in the country, with rice plants suffering 10 days of flooding. Farmers were particularly impressed as the *Sub1* varieties withstood the flooding and continued normal growth.

Abou Camara of Koba, who has been farming rice since 1998, received seed of the new climate-smart varieties NERICA-L 19-*Sub1* and WITA 4-*Sub1*. During a monitoring visit by AfricaRice and Institut de recherche agronomique de Guinée (IRAG) when the crop was mature, Camara indicated that he has been receiving rice seed from AfricaRice since 1998, including NERICA-L 19 in 2016. The NERICA-L 19 he received in 2016 does not have the flood-tolerance gene. However, he reported that the new NERICA-L 19-*Sub1* and WITA 4-*Sub1* were able to tolerate the 10 days of flooding during the vegetative stage, and they showed normal growth. “Both NERICA-L 19-*Sub1* and WITA 4-*Sub1* showed high promise of a very good harvest despite the flooding in my farm,” said Camara, “something I have never experienced in the past with the AfricaRice varieties. I am proud of this scientific achievement.”

Through the Japan Emergency Seed Project in collaboration with Technologies for African Agricultural Transformation (TAAT), AfricaRice produced 10 tonnes of foundation seed of four varieties – local mangrove landrace Mbapeya, popular mangrove variety ROK5, WITA 4-*Sub1* and NERICA-L 19-*Sub1*. From that foundation seed, at least 400 tonnes of certified seed is expected to be produced by farmer seed producers, with technical support from IRAG in 2019. The expected certified seed, which will cover 8000 ha, should reach 32,000 smallholder rice farmers and benefit an estimated 160,000 individuals.

recommendations for flash-flood-prone areas for choice of variety and crop-establishment method, AfricaRice has initiated experiments to determine the effect of crop-establishment method combined with submergence-tolerant *Sub1* varieties on tolerance and resilience to early-season flash-flooding.

Consequently, experiments were set up at the AfricaRice main research station at M'bé, Côte d'Ivoire. Pre-germinated rice seed was 'wet direct-seeded': broadcast or sown in lines in puddled soil. This was compared with typical transplanting. Fields were flooded for 7 days to a depth of 10 cm above the top of the plants, starting 35 days after sowing or 15 days after transplanting.

Under direct-seeded conditions, flooding resulted in the loss of 15% of submergence-susceptible WITA 9 plants, but no loss of FARO 66 and FARO 67 plants. Transplanted rice experienced greater plant losses (49% for WITA 9, 21% for FARO 66 and 29% for FARO 67). This indicated that direct-seeding is better for flood tolerance than transplanting. The *Sub1* varieties yielded 18% more grain than WITA 9 under direct-seeding, and 69% more when transplanted –

demonstrating the superiority of the *Sub1* varieties under early-season flash-flooding.

Thus, ideally farmers should adopt the new submergence-tolerant varieties. However, where these are not yet available, switching to direct-seeding should significantly decrease the impact of early-season flash-flooding on final yield of susceptible varieties such as WITA 9, as long as the crop is established 15–30 days before the flooding occurs.

Since its introduction to the AfricaRice breeding program, the submergence-tolerance *Sub1* gene has proved its worth. With increasing likelihood of flash-flooding of inland-valley lowlands, its value in the drive to make rice cultivation sustainable in the face of the climate emergency is high indeed. AfricaRice is continuing to promote the adoption of the *Sub1* varieties and to verify recommendations for crop-establishment in inland valleys.

Contact: Krishna Devkota, Agronomist
<k.devkota@cgiar.org> and

Saidu Bah, Seed Unit coordinator <s.bah@cgiar.org>