

NERICA – TAILOR-MADE INNOVATION FOR AFRICA'S RAINFED RICE ECOLOGY

The organisation AfricaRice has committed itself to supporting African countries in their efforts to achieve self-sufficiency in the rice sector. In 1992, the organisation started working on interspecific hybridisation to develop varieties that combine the high yield potential of Asian rice with the local adaptation of African rice. In order to optimally consider the needs of smallholder farmers, a participatory approach was chosen for varietal selection. The farmers are also trained in seed production.

By Savitri Mohapatra

Africa is the only continent where the world's two species of cultivated rice are grown: Asian rice (*Oryza sativa*) and African rice (*O. glaberrima*). While Asian rice is cultivated universally, African rice is unique to Africa. An international study published in 2018 led by the French Research Institute for Development (IRD), and co-authored by the Africa Rice Centre (AfricaRice) among others, revealed that the African rice was domesticated over 3,000 years ago in the Inner Niger Delta in northern Mali. Asian rice was introduced in East Africa over 1,000 years ago, and about 450 years ago, it reached West Africa. It quickly became popular because of its high yield potential and has largely displaced African rice in the region, which is relatively low-yielding, because it is prone to lodging and shattering. According to a study by Olga F. Linares, published in 2002, isolated pockets of *O. glaberrima* cultivation remain in Guinea Bissau, Guinea, Sierra Leone, and in the Casamance region of southern Senegal.

A GENETIC GOLDMINE

African rice is still grown in these areas for ceremonial and cultural values and appreciated for its taste and nutritional qualities. Some farmers in difficult environments continue to grow it in preference to the higher-yielding Asian rice because it is much better adapted to various local stresses. The hardiness of African rice results from its strong ability to compete with weeds and to withstand rice pests and diseases, drought, flood, infertile soils, iron toxicity and severe climates. This ability makes it an especially useful genetic resource for developing stress-tolerant rice varieties for rainfed ecosystems in Africa.

In contrast to Asia, most rice in sub-Saharan Africa (SSA) is grown under rainfed conditions, where production is risky. About 33 per cent of land under rice cultivation in SSA



The Upland Nerica-1 variety is popular in Cote d'Ivoire and Nigeria.

Photo: AfricaRice/ Rama Raman



Nerica L-19 is the most widely adopted lowland Nerica in sub-Saharan Africa.

Photo: AfricaRice/ Rama Raman

represents the rainfed upland ecology, and 40 per cent belongs to the rainfed lowland ecology. Many of the poorest rice farmers depend on the upland ecosystem, where rice is grown without standing water and yield is very low.

In its work, AfricaRice, which has a pan-African mandate to develop the rice sector, has focused more on the resource-poor rainfed rice farmers, who had not benefited from previous research work to the same degree as those in more favourable rice-growing ecologies. It is also supporting efforts of African countries to achieve self-sufficiency in the rice sector. In 1992, the organisation decided to work on interspecific hybridisation to develop varieties that combine the high yield potential of Asian rice with the local adaptation of African rice. AfricaRice's collection of about 2,500 different kinds of African rice has served as a goldmine for this work.

COMBINING THE BEST OF BOTH WORLDS

Several attempts to access the African rice genome through interspecific crossing had been made by rice scientists in the past. However, most failed as crossing different species is complicated because of incompatibility barriers, so the probability of sterility in the offspring is high. AfricaRice circumvented the sterility barrier between the two species by using anther culture and embryo rescue techniques, coupled with back-crosses to the Asian rice parent. Several hundred interspecific progenies with promising agronomic performance were generated, increasing the biodiversity of rice.

The interspecific lines were evaluated across Africa by farmers through participatory varietal selection (PVS), which is an innovative approach that allows farmers to select their



The AfricaRice genebank holds the largest collection of African rice in the world.

Photo: AfricaRice/ Rama Raman

preferred varieties that match their needs and growing conditions. PVS also generates valuable feedback on farmers' preference criteria for rice breeders (see upper Box on page 15).

The most successful lines, based on their performance and popularity among farmers, were named the New Rice for Africa (Nerica) varieties. Nerica is now a household name in Africa – synonymous with the work that earned AfricaRice several international awards including the World Food Prize conferred in 2004 to plant biologist Monty Jones, who was Sierra Leone's Minister of Agriculture from February 2016 to March 2018.

HIGH-YIELDING, EARLY-MATURING, STRESS-TOLERANT, RICH IN PROTEIN

The first Nerica varieties were released in Côte d'Ivoire in 2000. Upland Nerica varieties give yields that are generally as good as the Asian rice varieties. They are early-maturing (75–100 days) and are relatively tolerant to major stresses of Africa's harsh growth environment. However, not all these characteristics are found in one single Nerica variety. Early maturity for example is much appreciated by farmers, especially women farmers, as it allows them to have food during the 'hunger period' while waiting for the harvest of other crops. Additionally, studies show that some Nerica varieties have on average a 25 per cent higher protein content than imported Asian varieties. Currently, there are 18 Nerica varieties (Nerica-1 to Nerica-18) suited for upland growth conditions. Nerica-4, which is tolerant to drought and phosphorus deficiency, is the most widely adopted upland variety, grown in more than ten SSA countries.

In 1998/1999, AfricaRice started to extend its Nerica programme to the rainfed lowland ecosystem. The lowlands – where rice is grown in

bunded fields that are flooded for at least part of the growing season – are generally more fertile than the uplands. In West Africa, the lowlands represent about 20–50 million hectares, so they offer great potential for the sustainable expansion and intensification of rice. The development of the lowland varieties was facilitated through the shuttle-breeding approach (see Insert below) in partnership with national programmes in West and Central Africa through a task force mechanism to accelerate the selection process and achieve wide adaptability of the lowland Nericas.

Sixty rainfed lowland Nerica varieties (Nerica-L) were selected by farmers in several African countries through the PVS process, including over 550 farmers in Burkina Faso. The varieties have a yield potential of six to seven tonnes per hectare and a good resistance to major lowland stresses such as iron toxicity and weed infestation or highly destructive diseases (e.g. the rice yellow mottle virus – RYMV) and pests (e.g. the African rice gall midge – AfRGM, stemborers or nematodes). The first lowland Nericas were released in 2005. Nerica-L-19 is the most widely adopted lowland Nerica in SSA.

Shuttle breeding uses diverse ecological environments to develop improved varieties with higher adaptability. Alternate generations of early breeding materials are grown under different environments.

In total there are now 82 Nerica varieties – 18 upland, 60 lowland and four irrigated. The success of these varieties has now expanded beyond the African continent, with Nericas being used by farmers and breeders for rice production and varietal improvement programmes in Bangladesh, China, India and several other countries around the world.

A BROAD-BASED PARTNERSHIP

A project like the Nerica breeding programme cannot be implemented by one organisation alone. Various research and development partnerships were forged to support the development and dissemination of Nericas (see lower Box on page 15). A major landmark was the launching of the African Development Bank (AfDB)-funded Multinational Nerica Rice Dissemination Project (2005–2010). The project sought to widely establish Nerica and other

improved varieties in seven countries: Benin, The Gambia, Ghana, Guinea, Mali, Nigeria and Sierra Leone. Through these programmes, policy-makers were encouraged to support the effective dissemination of Nericas and other improved rice varieties as well as complementary technologies across Africa.

Many studies have shown the wide adaptation of Nerica varieties and their impact on farmers' livelihoods in SSA. An impact study in 2018 demonstrates that the adoption of Nerica varieties had brought food security to 7.2 million people and lifted about eight million people out of poverty in 16 African countries. Today, Nericas cover over 1.4 million hectares in SSA.

Despite this progress, the project has been confronted with a number of bottlenecks, the most important with regard to Nerica diffusion being the lack of seed. In many SSA countries, national seed regulatory bodies do not function efficiently. Therefore, AfricaRice adopted the community-based seed system (CBSS) approach, whereby farmers are trained to produce 'seed of acceptable quality' (see Box on the right). The other constraints are the desperate lack of capacity at all levels in the rice value chain, lack of access to fertiliser and credit as well as inadequate rice production, processing, distribution and marketing infrastructure.

WHAT'S NEXT?

AfricaRice's breakthrough in developing the Nericas offers a great opportunity for sustainable agricultural development in the rainfed environments, where most of Africa's rice farmers earn a living. They are, however, just part of the portfolio of AfricaRice to help SSA achieve rice self-sufficiency. The Center and its partners are developing the next generation of rice varieties that can respond to consumer demand and adapt to both current and future climate scenarios.

The Center is increasingly focusing on an integrated seed-to-plate value chain approach to achieve a sustainable linkage between rice production, processing and marketing. Upgrading the rice value chain will reduce reliance on imports, increase food security, increase gender equity, reduce urban migration and give Africa's youth valuable employment opportunities.

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INVOLVING FARMERS IN THE BREEDING PROCESS

A **participatory varietal selection (PVS)** approach was adopted to enable farmers and plant breeders to collectively identify improved varieties, including Nerica varieties, best suited to the producers. The PVS process takes three years. In the first year, 'rice gardens' are established in villages by research and extension, associated with leading and innovative farmers or farmers' organisation. These gardens have a large selection of rice. Around 60 lines are presented to farmers in the form of a village-based demonstration plot.

At the end of the first year, the researchers ask the farmers to name up to five varieties that attract them most, and to state the reasons for their choices. Trials on cooking characteristics and taste are also carried out at this stage. During the second year, the farmers are given seed of the varieties they have named and are invited to try it out for themselves, comparing it with their traditional varieties. In the third year, the farmers are asked to pay for the seed if they wish to continue using it.

Within an agro-ecological zone, the most popular four or five lines selected are then multiplied and diffused to up to 500 farmers for evaluation over two seasons. The lines most appreciated by the farmers are recommended for zonal release. In the PVS process, special attention is paid to getting feedback from women farmers, whose preferences often turned out to be quite different from those of men. PVS revealed that men gave importance to plant height, whereas women preferred traits such as good emergence and seedling vigour. PVS worked well for the Nerica programme, giving farmers the varieties they wanted, and generating valuable feedback for the breeders. PVS trials were linked to varietal release mechanisms where possible and seed production projects to speed up adoption. A participatory approach involving farmers is still being used by AfricaRice throughout Africa.

In the absence of a formal seed sector in many sub-Saharan countries, farmers remain dominant as seed sources. AfricaRice adopted the **community-based seed system (CBSS)** approach to stimulate farmers in taking the lead in ensuring adequate supplies of quality seed for rapid dissemination of the improved varieties once they were officially approved for release.

CBSS is designed to enable smallholders to meet their seed requirements by improving their knowhow in basic seed production and quality constraints. Seed production and distribution are done according to the farmers' practices and capabilities, with some simple guidance given to help farmers maintain the purity of seeds for a period of three to five years. CBSS was instrumental in the production of seed used in the PVS trials. It became a powerful mechanism in integrating traditional knowledge systems into modern technologies, partnering with farmers and national extension services to respond to a major gap in the seed sector.

RESEARCH PARTNERS AND DONORS

The Interspecific Hybridization Project launched in 1996 brought together the national rice research programmes in SSA, the International Rice Research Institute (IRRI), China's Yunnan Academy of Agricultural Sciences (YAAS), the University of Tokyo, the Japan International Research Center for Agricultural Sciences (JIRCAS), the International Center for Tropical Agriculture (CIAT), the French Institute of Research and Development (IRD), Cornell University and the UK-based Natural Resources Institute (NRI).

The African Rice Initiative was launched in 2001 to promote the widespread and rapid diffusion of the Nericas. AfricaRice's work on interspecific hybridisation and Nerica development, testing and dissemination has been generously supported by the African Development Bank (AfDB), the Consultative Group on International Agricultural Research (CGIAR), the European Union, Belgium, Canada, France, Germany, Japan, the Netherlands, Norway, Sweden, the UK, the USA, the Food and Agriculture Organization of the United Nations (FAO), the Gatsby Foundation, the Rockefeller Foundation, the International Fund for Agricultural Development (IFAD), Sasakawa-Global 2000, the United Nations Development Programme (UNDP), the United Nations Office for South-South Cooperation (UNOSSC), the World Bank, the World Food Programme and World Vision International.