

Going Beyond the
Upland NERICA:
Another
New Rice for Africa
is Born

Breaking Story



Power of effective networking: the ROCARIZ network played a central role in the development of the new rice for lowlands

In contrast to NERICA, which was designed for the upland (rainfed) rice ecology in SSA, the new rice has been developed for the African lowlands, one of the most complex rice ecologies in the world.

Given the high potential of the lowlands in Africa, the new rice, which has already got farmers' stamp of approval, is expected to make an even bigger impact than the NERICA.

Let's call this product *the New Rice for African Lowlands*, until it is officially christened. It was developed in close partnership with the national programs in West Africa.

The Uniqueness of Africa for Rice

There's a special reason why Africa has become the hotspot for developing new rice plants and why the Africa Rice Center is in the vanguard of this development.

Africa is the only continent, where the two species of cultivated rice are grown—*Oryza glaberrima* (African rice) and *Oryza sativa* (Asian rice).

It is a boon for the Africa Rice Center to be located in the region where the African rice originated about 3500 years ago. This gives its scientists a unique opportunity to exploit the biodiversity that this center of origin offers.

NERICA—the Technology versus NERICA—the Product

NERICA is more than just a product; it's a technological process, which has opened up a world of opportunities for scientists to develop hundreds of rice varieties suitable for various niche ecologies.

The NERICA technology refers to the successful crossing by researchers from the Africa Rice Center of the two species of cultivated rice to produce plants (known as interspecifics) that combine the best traits of both parents: high yields from the Asian parent and the ability to thrive in harsh environments from the African parent. The NERICA name was trademarked in 2004.

Through the crossing of the two rice species, the NERICA technology gives researchers access to new genetic combinations. Indeed, a major spin-off of the NERICA technology is the incredible diversity it has generated, releasing genes previously unavailable to the rice world.

At the Africa Rice Center, rice breeders are using the NERICA technology to go beyond the present NERICA product, which has been a remarkable breakthrough for upland rice ecologies, but has had little impact in the lowland and irrigated ecologies. The NERICA technology is thus spilling over into research for developing suitable rice plants for high-impact ecologies.

In the same way as for NERICA, developing the *New Rice for African Lowlands* posed a formidable scientific challenge because it is exceedingly difficult to produce viable offspring by crossing the two rice species, since they are generally incompatible.

Constraints and Opportunities of Lowland Ecologies

The upland or dryland ecology, where rainfed rice is grown without standing water, was rightly the initial focus of the Africa Rice Center, because it represents about 40% of the total area under rice cultivation in West and Central Africa—the rice belt of Africa—and employs about 70% of the region's rice farmers. But its potential is limited compared to that of lowland and irrigated ecologies.

The lowlands—where rice is grown in banded fields that are flooded for at least part of the growing season—are more fertile than the uplands and have the added advantage of providing opportunities for irrigation. In West and Central Africa, lowlands account for about 30% of the area under rice cultivation. They are often suited to cropping intensification, with the possibility of growing two or more crops per year. Rice thus becomes economically a more valuable crop.



African lowlands: one of the most complex rice ecologies in the world

In West Africa alone, the lowlands represent about 20–50 million hectares, depending on the definition used, of which only about 10–20% are now under cultivation. If only 2 million hectares of this area is grown to rice, producing an average yield of 3 t per hectare, West Africa could easily stop its costly rice imports. The lowlands, therefore, offer great potential for the sustainable expansion and intensification of rice and can help to feed the growing population in the region.

However, with high potential comes high risk. The biggest of the challenges is that the lowlands in the region are not of one kind; they are very heterogeneous. So it is very difficult for researchers to develop a rice variety that would be suitable for all lowlands. Lowlands are in fact a combination of both upland and irrigated rice ecologies.

The other major challenges are lack of water control, iron toxicity, weeds, and highly destructive diseases and pests, such as the rice yellow mottle virus (RYMV), the African rice gall midge (AfRGM), stemborers and nematodes, among others. Labor constraints for weeding is another important problem for poor farmers.

Rice producers and scientists have been constantly in search of rice varieties that can withstand these stresses and produce stable and high yields. Yields from traditional rice varieties in this ecology are low, usually less than 1.5 t per ha or around 40% of the world average.

Search for a Robust Rice for African Lowlands

Networks and farmers show the way

A striking feature of the research-for-development work in the Africa Rice Center is the seamless integration between the activities carried out by scientists from the Center and those from the national programs with support from the Center-coordinated networks, such as the Réseau ouest et centre africain du riz (ROCARIZ), International Network for the Genetic Evaluation of Rice (INGER-Africa) and Inland Valley Consortium (IVC). This integrated work brings out a great synergy that leads to remarkable results.

The other striking feature is that the Center scientists are ever willing to learn from farmers' practices and experience and incorporate traditional wisdom into their research. This approach has been a major factor in the success of upland NERICAs.

The research work on lowland rice carried out by Dr Moussa Sié, Lowland Breeder at the Africa Rice Center, in association with his partners, perfectly epitomizes these two approaches. As Associate Scientist (1994–97) and Visiting Scientist (1998–99) at the Center's Research Station in Senegal, Dr Sié was actively involved in the breeding process of the new plant type under Dr Kouamé Miezan, Leader of the Irrigated Rice Program.

On his return to Burkina Faso, he maintained close collaboration with the Center's Irrigated Rice Program and continued to actively pursue the work on the new plant type for lowlands as Head of the Rice Improvement Division at the Institut de l'environnement et des recherches agricoles (INERA), Burkina Faso. He was keen to improve the productivity of the lowland ecology, because 70% of the area under rice in the country is grown on lowlands, but it accounts for only 48% of rice production. The project was carried out with support from ROCARIZ from 2000 until 2003 when he joined the Africa Rice Center as a Principal Scientist.

As part of his research on lowland rice varieties, Dr Sié has been keenly studying farmers' process of selecting rice varieties. "Farmers know very well which variety to use, when and where to use it," he said. "They don't necessarily go in for just high-yielding varieties, what they prefer are robust varieties."

Traveling across Burkina Faso to evaluate rice varieties that are well adapted to African conditions, he collected over 600 traditional varieties, including about 50 varieties belonging to the African rice species. It was during this period that he developed a great fascination for the African rice, which was fast losing ground to the Asian species, because of its low yield and problems of lodging (falling over).



Assessing the needs of rice farmers, many of whom are women, is the first step in plant breeding

Like Dr Monty Jones, *Father of NERICA*, he was struck by the higher capacity of the indigenous varieties to tolerate stresses than those of the more productive but susceptible Asian species. He also took note of the fact that the African rice was appreciated by the rural Africans for its taste. “Unfortunately until the Africa Rice Center focused on improving it, scientists during the colonial period in West Africa, had deliberately neglected it,” he remarked.

Charting a New Course

Most of the traditional lowland rice varieties grown in the region have a narrow genetic base, which leads to their vulnerability to diseases and pests. Some of the stresses, such as AfRGM and RYMV are spreading fast in the region because of the predominant cultivation of susceptible rice varieties. The main objective of Dr Sié and his partners was, therefore, to tap into the African rice for traits of resistance to major stresses, especially RYMV, in order to intensify lowland rice cropping.

RYMV is a major scourge of lowland rice and can sometimes lead to total crop failure, contributing to famine in areas where rice is an important food staple. It is indigenous to Africa. Interestingly, some varieties of the African rice have been found to be immune to RYMV. Therefore, the scientists focused on crossing specific varieties of the African rice that were known for their resistance to RYMV with popular—but susceptible—Asian rice varieties.

The other difference was in the selection of the Asian rice varieties for the crossing. The Asian rice *O. sativa* has two main strains, *japonica* (traditional rainfed or ‘upland’ rice) and *indica* (traditional irrigated or ‘lowland’ rice). In the creation of NERICA, *japonica* varieties were used in the crosses, while for developing the new lowland rice, the *indica* varieties were used.

The New Rice for African Lowlands is Born

As can be envisaged, the initial problem was hybrid sterility (infertile offspring of the crosses), because the two rice species have evolved separately over millennia and are so different that often attempts to cross them do not lead to reliable variety development. “This problem is greater when we cross *indica* than with *japonica*,” Dr Sié explained. The sterility blockage was overcome by backcrossing (crossing the hybrid to *O. sativa* to restore fertility).

Some of the progeny combined the best features of both parents: the droopy leaves and vigorous early growth (associated with weed-competitiveness) typical of the African rice and the high number of spikelets (indicating productivity) of the Asian rice.

A major scientific milestone was achieved when the screening for resistance to RYMV under artificial infestation showed that the crosses had successfully transferred resistance to RYMV into some of the progeny.

A new plant type with high potential for lowlands was now available, endowed with resistance to local stresses, particularly the dreaded RYMV. But it still needed to be evaluated by scientists in multilocational trials on station and by its ultimate judges, the rice farmers under their conditions.



Evaluating the new rice for its adaptation to lowland ecology

Evaluating the New Plant Type

Scientists' Verdict

In Burkina Faso, about 500 lines belonging to the new plant type were tested in the lowlands of Banfora research station for 3 years from 2000 to 2002. Their overall agronomic performance was examined to determine their adaptability to lowland conditions based on a set of criteria including their resistance to insects, diseases and fluctuations in water control. At the end of 3 years of testing in Banfora, about 20 of the most promising lines were selected.

Lines of the new plant type were also evaluated in important rice-growing countries in West Africa—Mali, Burkina Faso, Togo, and Senegal—as part of a regional evaluation process with support from ROCARIZ. A multinational team of scientists from the region accompanied by the ROCARIZ Coordinator visited these countries and jointly selected over 70 promising lines.

The three most preferred lines of the new plant type were: WAS 122-IDSA-1-WAS-B-FKR-B-1, WAS 122-IDSA-1-WAS-2-FKR-B-1, WAS 122-IDSA-1-WAS-6-1-FKR-B-1. With a yield potential of 6–7 t per ha, good tillering ability, growth duration of 120 days and acceptable plant height, all the three varieties showed good resistance to major lowland stresses. The varieties also responded well to nitrogen fertilizer application.

“The shuttle-breeding approach between the Center and the national programs, which was adopted in the development of the new plant type was very successful,” explained Dr Miezán, who was involved in evaluating the new lines under irrigated systems as part of the shuttle-breeding process. “The breeding material was shuttled back and forth among scientists to evaluate it under different conditions, which not only helped accelerate the selection process and increase its efficiency, but also helped achieve wide adaptability.”

The on-station evaluation confirmed the hypothesis that the progeny of *O. glaberrima* and *O. sativa* subspecies *indica* is better adapted to lowland and irrigated rice, while that of *O. glaberrima* and *O. sativa* subspecies *japonica* is more suitable for rainfed rice.

Farmers' Verdict

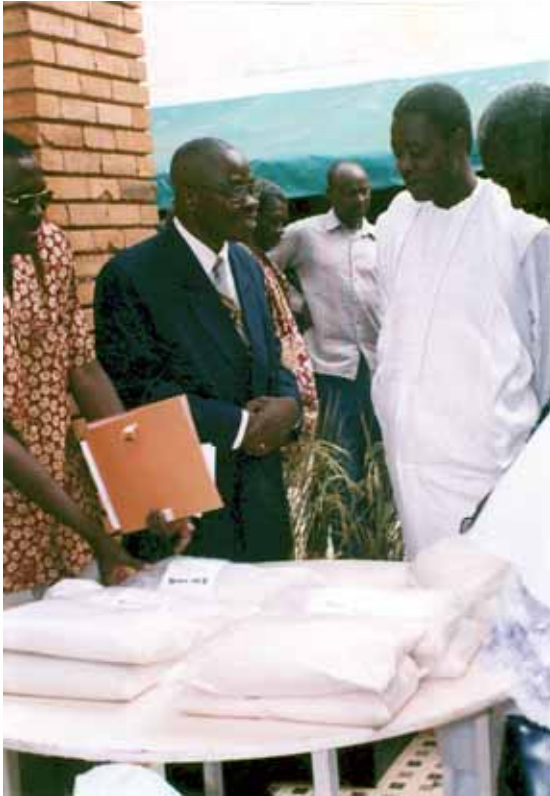
Following WARDA's extremely successful model of accelerating the development and dissemination of NERICA through farmer participatory methods, Dr Sié adopted a similar method for the new plant type for lowlands. This exercise was done to allow farmers to choose varieties that meet their needs and obtain feedback from them regarding their preferences for plant and grain characters, which would help speed up the fine-tuning, adoption and dissemination of the new material.

In the lowlands of Badini, Burkina Faso, over 550 farmers of which 80% were women, were invited at different phases of the plant's development to evaluate about 45 varieties including 18 belonging to the new plant type as part of participatory varietal selection (PVS), with the help of the Departments of Agriculture, Water and Wind Resources (DRAHRH).



Farmers' acceptance of the new lowland rice, evaluated through the participatory varietal selection (PVS) approach

The PVS exercise showed clearly that men and women farmers use different criteria to evaluate varieties. For instance, men gave importance to short growth duration and plant height, whereas women preferred traits such as good emergence, seedling vigor and droopy leaves that indicate weed competitiveness, since they are mostly involved in sowing and weeding operations.



Dr Moussa Sié (2nd from left), WARDA Lowland Rice Breeder, with the present Chair of WARDA Council of Ministers Prof Laya Sawadogo, Minister of Secondary and Higher Education and Scientific Research, Burkina Faso (right) at a display of lowland rice samples

This exercise was very decisive for Dr Sié's research; he experienced one of his greatest moments of fulfillment when the farmers chose six of the varieties belonging to the *New Rice for African Lowlands*. "The development of this new rice type for lowlands and farmers' positive response to them mark an important advance in R&D achievements of the Africa Rice Center," Dr Sié observed.

Future Outlook

However, a plant breeder's work is never completely over. The promising varieties chosen by researchers and farmers will be further subjected to on-station and on-farm multilocational and regional evaluations through networks and PVS trials in close collaboration with national programs—a partnership-based approach that is a hallmark of the Africa Rice Center.

The *New Rice for African Lowlands* offers a powerful new weapon for rice farmers in their management of lowland stresses. However, to be most effective, it should be used as part of the integrated crop management approach (ICM) developed by the Center's irrigated rice team under the leadership of Dr Miezán. The ICM package includes improved fertilizer, weed, and water management, efficient post-harvest technologies, and decision-making tools, in addition to improved varieties.

Meanwhile, molecular tools, such as marker-assisted selection will be used to make the development of the new plant types more efficient in time and effort. Work will continue on the development of suitable lowland varieties, both interspecific (crosses between the two cultivated species of rice) and intraspecific (crosses within the species, i.e., between *O. sativa* varieties), that is being carried out by other scientists of the Center. The Africa Rice Center will continue to collaborate with national, international and advanced research institutes, adopting an approach that will help integrate different activities in this area and avoid duplication.

"We are delighted that our prophetic vision is coming true and another amazing breakthrough has been achieved, thanks to the initiative taken by our scientists and the valuable contribution of the national programs," Director General Dr Kanayo F. Nwanze commented. "The lowlands are indeed the most promising environments for rice expansion in Africa and the *New Rice for African Lowlands*, within a sustainable and diversified land use systems approach, has a high potential for transforming the prospects for food security in the region."

As we go to press, four varieties of the new rice for lowlands, now officially known as the *Lowland NERICAs*, have been released in Burkina Faso and two in Mali. ❖