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West Africa Rice Development Association

NERICA

Rice for Life

NERICA—New Rice for Africa—is the product of interspecific hybridization between the cultivated rice species of Africa and Asia. Rice breeders in West Africa have finally been able to combine the local-stress adaptation of African rice with the high yield potential of Asian rice. The result is something that can revolutionize rice farming in Sub-Saharan Africa: rice that will produce a crop with minimal inputs in Africa's stress-afflicted ecologies, and that will respond bountifully as soon as farmers have the means to apply additional inputs. By 2000, over 20,000 farmers were growing NERICA varieties in Guinea alone, and the varieties look set to spark a rice-based agricultural revolution in West and Central Africa in the early years of the Third Millennium.

New Rice for Africa

Two distinct rices

Rice is a well-known cereal crop throughout most of the world. What is not so well known is that two distinct species are grown, especially in Africa. Long before Asian rice (*Oryza sativa*) reached Africa's shores, local farmers had domesticated a local species to develop African cultivated rice (*O. glaberrima*). The domestication of *O. glaberrima* took place at least 3500 years ago. Thus, its local ancestry and numerous generations of selection *in situ* have made *O. glaberrima* well adapted to the African environment. On the other hand, Asian rice—especially the Green Revolution semi-dwarf varieties—has been bred for intensive production and high yield, but outside of the African continent. The first Asian varieties arrived in Africa about 450 years ago, and they have subsequently replaced the local species over much of the rice-cultivated area.

The cultivated rice of Africa (*Oryza glaberrima*): adapted to the African environment, but prone to lodging and grain-shattering

However, despite their popularity (as a result of their higher yields), Asian rices are poorly adapted to many of the African environments where rice is grown. By 1990, rice breeders at the

The Asian cultivated rice (*Oryza sativa*): high yielding, but susceptible to the stresses of African ecologies

West Africa Rice Development Association (WARDA) realized that they were making little headway in terms of yield, simply because genes for adaptation to the African environments were not available in any of the Asian varieties. Meanwhile, *glaberrima* varieties continued to be grown in areas where Asian *sativas* were decimated by disease, pests, drought or soil problems.

Putting the two together

Rice breeders had long since dreamed of combining the best traits of the two species, but previous attempts had failed, as the resulting offspring were all sterile. In the early 1990s, WARDA breeders turned to biotechnology in an attempt to overcome the infertility problem.

After cross-fertilization of the two species, embryos were removed and grown on artificial media in a process known as embryo-rescue. The resultant plants are frequently almost sterile, so they are re-crossed with the *sativa* parent wherever possible (known as back-crossing). Once the fertility of the progeny was improved (often after several cycles of back-crossing), anther-culture was used to double the gene complement of male sex cells (anthers) and thus produce true-breeding plants.

The first of the new rices was available for field testing in 1994. Since then, the techniques have been refined and streamlined, so that many new lines are generated each year.

The best of both worlds

Once the progeny were field tested, it became clear that the dream had come true—the new plants combined the traits of their parents in various combinations. As hoped, some of the progeny combined yield-related traits of the *sativa* parent with local-adaptation traits from *glaberrima*. The basic characteristic of the new plant type that we have dubbed 'New Rice for Africa' (or NERICA) is profuse early vegetative growth giving rapid ground cover, followed by upright growth at reproductive stage. The profuse tillering is characteristic of *glaberrima*. The rapid ground cover enables the rice crop to smother, and therefore out-compete, weeds. Upright growth, especially at reproductive stage, is a characteristic of *sativa*; it enables the plant to support heavy seed heads through maturity to harvest—the African species has weak flower- and seed-bearing stems which are prone to falling over (or lodging) before harvest.

In addition to the weed-suppressing trait, other advantageous traits from *glaberrima* that occur in some progeny are:

- Early maturity—NERICAs typically mature in 90–100 days, compared to typical improved upland *sativas* that mature in 120–140 days in West Africa—this is another layer of defence against weeds
- Drought tolerance
- Resistance to African rice gall midge, the region's most devastating insect pest

- Resistance to rice yellow mottle virus, a major disease in lowland rice
- Resistance to blast disease
- Taste, aroma and other grain qualities favored by farmers.

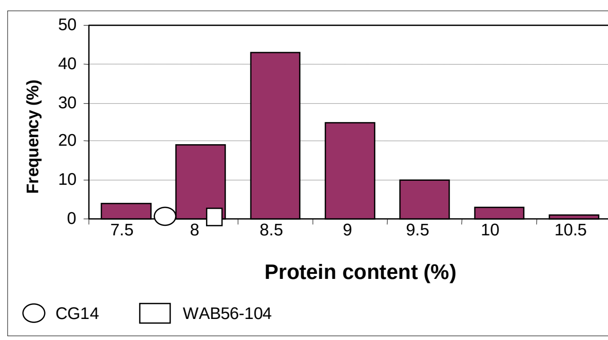
Meanwhile, the *sativa* parents have also given of their best to the NERICAs:

- Non-shattering grains—not only do *glaberrima* panicles lodge, their grains shatter too
- Secondary branches on panicles—more branches, more grains!
- Responsiveness to mineral fertilization.

Even better

Hybridization is known to generate heterosis, or hybrid vigor—a condition in which a progeny is 'better' than either of its parents. The interspecific hybrid progeny are no exception, showing transgressive segregation in the following traits.

- Protein content: over 70% of progeny from the first successful cross had higher protein content than either parent—some as much as 10.5% protein compared to the *sativa* parent's 8% (graph right).
- Grains per panicle—with the *sativa*-type secondary branches, NERICAs may have over 400 grains per panicle, compared to about 250 for *sativa* (illustration below).



CG14 = *O. glaberrima* parent; WAB56-104 = *O. sativa* parent

Farmers choose for themselves

At a meeting of rice stakeholders—scientists from national research programs, extension workers, farmers and non-governmental organizations—organized by WARDA in March–April 1996, the decision was made to adopt participatory varietal selection (PVS) to get the new rices to farmers.

Outlines of panicles of NERICA line with secondary branches (center), compared with its parent varieties: *sativa* (left) and *glaberrima* (right)

Participatory Varietal Selection

An approach to impact-oriented and demand-driven technology generation and dissemination

Three-year program

■ Year 1: Farmers select from centralized rice garden of 60–100 varieties
■ Year 2: Farmers grow selected varieties in their own fields in comparison with their traditional varieties
■ Year 3: Farmers purchase seeds of their preferred varieties for their own use.

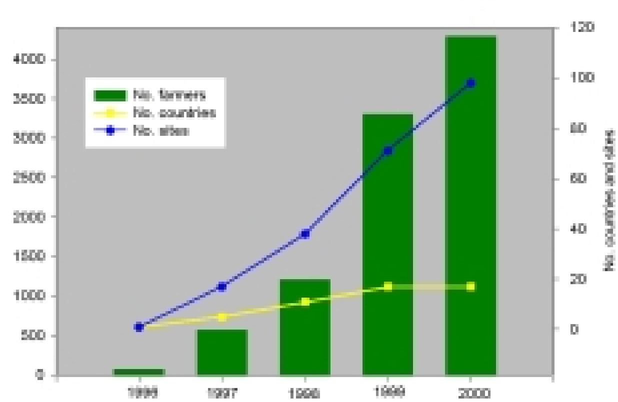
Three formal evaluation visits (farmers, extension agents and researchers together):

■ Maximum tillering: for vegetative characteristics, e.g. weed competitiveness
■ Maturity: for cycle length, plant height, panicle structure, plant type
■ Post-harvest: for yield and quality characteristics, e.g. grain quality, processing and cooking ability, aroma and taste.

Post-harvest evaluation of rice varieties in PVS: farmers have shown interest in characteristics such as yield, grain quality, aroma, cooking ability and taste

The basic PVS adopted by WARDA is a three-year program. In the first year, WARDA and extension-agency staff establish a 'rice garden' in a target village, often in the field of a leading or innovative farmer. The rice garden is composed of NERICAs, modern, improved *sativas*, popular local and regional varieties, and a few *glaberrimas*. Farmers from the host and surrounding villages are encouraged to visit the garden as often as they wish to monitor progress (*see* Box).

Having started the approach in Côte d'Ivoire in 1996, and then taken it on to Ghana, Guinea and Togo in 1997, WARDA decided to 'spread the news' among its other member states. Training workshops were organized in 1998 and 1999, in which two-person teams from each WARDA member country were trained in the PVS methodology. Subsequently, the PVS has been applied successfully in all 17 WARDA member states, and a regional network established that meets annually at WARDA to discuss progress. By this means, NERICAs have been grown by at least a few farmers in each of the 17 countries.



Participatory Varietal Selection activities have grown rapidly in West and Central Africa since their introduction by WARDA in 1996

Farmers become seed-producers

Having achieved a certain level of acceptance of the new varieties among farmers, seed supply was identified as a bottleneck to wider distribution. To overcome this problem, WARDA imported and adapted a community-based seed system (CBSS) developed in Senegal. The system builds on farmers' own seed-saving practices, with some training input on selecting panicles for seed harvest and methods of preparation, storage and maintenance. With the adoption of CBSS, new varieties can be made available to farmers in 4 years, as opposed to the 7 normally required with formal seed systems. With initial success in Côte d'Ivoire, the system was adapted further and adopted in Guinea, and is expected to be of use elsewhere in the region in the near future.

Major gains in Guinea

A visit to WARDA by an official from the World Bank's Special Program for African Agricultural Research (SPAAR) in 1996, led to WARDA's involvement in a program to revitalize the upland-rice sector of Guinea. Guinea is one of the top five rice-producing countries in terms of area cropped, and 70% of that is upland. Given the background of the development of the NERICAs, this was an opportunity not to be missed. The program involved Guinea's agricultural research institute and extension service, Guinean farmers, WARDA and the Japanese-funded NGO, Sasakawa Global 2000. A combination of on-station, on-farm and PVS trials was used to determine the best-adapted varieties, and to get the farmers' views. In addition, Sasakawa Global 2000 undertook seed multiplication and established demonstration plots of selected varieties. CBSS was introduced in 1998 as the principal means of seed production. In 2000, it was estimated that NERICAs covered some 8000 ha in Guinea, of which 5000 ha grown by 20,000 farmers was under the supervision of the national extension agency. It is estimated that enough NERICA seed for over 200,000 ha will be produced in 2002—sufficient to meet the country's own seed needs, with surplus for export to neighboring countries.

SG2000/Guinea

NERICAs are playing a lead role in the revitalization of the upland-rice sector in Guinea

In April 2001, WARDA hosted an interna-tional workshop that led to the creation of the NERICA Consortium

The future—rapid and wide dissemination

The first seven NERICA varieties have been released: five in Guinea, and two in Côte d'Ivoire.

In 1999, the WARDA member states imported about 3 million tonnes of rice, or some 16% of the world rice trade, to meet the shortfall between local production and consumer demand. This cost a staggering US$ 850 million—a heavy toll for one of the poorest regions in the world. In the same year, Sub-Saharan Africa imported a total of 3.6 million tonnes of rice. It is estimated that the financial value of a 10% adoption rate of NERICAs in just three countries—Côte d'Ivoire, Guinea and Sierra Leone—would amount to nearly US$ 8 million per year. At 25% adoption rate—a not unlikely scenario given the trend in Guinea—this would rise to nearly US$ 20 million per year!

In April 2001, WARDA hosted an international workshop on the NERICAs and their potential contribution to poverty alleviation and food security in Sub-Saharan Africa. This workshop culminated in the creation of a Consortium aiming at the widespread and rapid diffusion of the NERICA and complementary technologies throughout the rice-growing areas of Africa.

Commitment has been received from major donors, in addition to ministers and national partners in the region. Pilot activities will focus on the upland ecology in selected countries for the first two years. Broad representation will be sought from the rice stakeholder community, including farmers' organizations, extension, NGOs, research institutions and private sector. These partners will not only evaluate the available technology and help generate new technology, but also identify constraints to effective adoption and scaling-up.

Meanwhile, the Consortium mechanism will enable PVS and CBSS activities to start in East and Southern Africa.

The enthusiasm with which the workshop delegates adopted the consortium approach to scaling-up the NERICA and associated technologies attests to the potential for wide-scale productivity gains in the African rice sector in the short to medium term.

The first NERICAs were developed to address the problems of the upland environment; however, WARDA believes that the medium- to long-term future of rice farming in the region is in the more robust lowlands. By 2004, WARDA expects NERICAs to be available for rainfed lowlands and irrigated systems. As the uplands become stabilized and slash-and-burn practices are reduced, WARDA foresees a movement of rice farmers into the valley bottoms—an ecology covering at least 20 million hectares in West and Central Africa, and largely unexploited—where rice intensification and crop diversification will produce a sustainable agricultural system with significantly higher potential rice yields than that of the uplands. Here there is the potential for rice self-sufficiency in the region, and maybe even export, especially as production in Asia is going to be increasingly consumed by that region's own growing populations.

WARDA believes that inland valleys hold the key to rice food-security in West and Central Africa in the medium to long term: NERICAs for rainfed and irrigated lowlands are expected to come 'on line' in 2004

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