West Africa Rice Development Association

Annual Report 2001–2002

About the West Africa Rice Development Association (WARDA)

The West Africa Rice Development Association (WARDA) was formed as an autonomous intergovernmental research association in 1971 by 11 countries, with the assistance of the United Nations Development Programme (UNDP), the Food and Agriculture Organization of the United Nations (FAO), and the Economic Commission for Africa (ECA). Today, the Association comprises 17 member states: Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo. Since 1987, WARDA has also been a member of the Consultative Group on International Agricultural Research (CGIAR), a network of 16 international research centers supported by more than 50 public- and private-sector donors.

WARDA's mission is: to contribute to food security and poverty alleviation in poor rural and urban populations, particularly in West and Central Africa, through research, partnerships, capacity strengthening and policy support on rice-based systems, and in ways that promote sustainable agricultural development based on environmentally sound management of natural resources.

WARDA's research and development activities are carried out in collaboration with the national agricultural research systems of members states, academic institutions, international donors and other organizations, to the ultimate benefit of West and Central African farmers—mostly small-scale producers—who cultivate rice, as well as the millions of African families who eat rice as a staple food.

WARDA Headquarters are at M'bé, 35 km north of Bouaké, a major commercial center in Côte d'Ivoire. WARDA also operates research stations at N'Diaye, near Saint Louis, Senegal, and at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Donors to WARDA in 2001 were: the African Development Bank, Belgium, Canada, CGIAR (Finance Committee), Common Fund for Commodities (CFC), Côte d'Ivoire, Denmark, the European Union, the Food and Agriculture Organization of the United Nations (FAO), France, the Gatsby Foundation (UK), Germany, the International Development Research Centre (Canada), the International Fund for Agricultural Development, Japan, the Netherlands, Norway, the Rockefeller Foundation (USA), Sweden, the United Kingdom, UNDP, the United States of America, the World Bank and WARDA member states.

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ISBN 92 9113 239 X

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Association pour le développement de la riziculture en Afrique de l'Ouest

WARDA (West Africa Rice Development Association), 2002. WARDA Annual Report 2001–2002. Bouaké, Côte d'Ivoire, 103 pp.

Cette publication est aussi disponible en français, sous le titre : ADRAO Rapport annuel 2001-2002.

ISBN 92 9113 239 X

Cover: Children, The Gambia

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Printing and binding: Pragati Art Printers, Hyderabad, India

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Message from the Director General and Chairman of the Board of Trustees

WARDA'S PAST Annual Reports were written to reflect a calendar year of events. Over the years, we have realized that this approach was a limitation to what research topics and events were reported, particularly as it meant that exciting themes, research results or events that occurred in the early part of the year of publication became 'stale' news in the following year when they were reported. The present report therefore covers a 'biennial' period from January 2001 through April 2002 and attempts to capture events and features that are the hallmark of our Association. Future reports will cover a 12-month period, but not a calendar year; in this respect, the present report forms a bridge to the new reporting period. We hope that you will enjoy reading our feature stories with as much pleasure as we have experienced in the process of preparing them.

Our highest oversight body, the Council of Ministers, held its regular biennial meeting at Dakar, Senegal, on 23 and 24 August 2001. In particular, this year, the Council expressed its strong political support for the Association, stressing the fact that WARDA is in fact 'owned' by its Member States, and therefore worthy of full support from the national governments. The resolution encouraging Member States to meet their financial obligations to the Association in regular and timely manner refers to "the importance of the contributions being made by WARDA-developed technologies in reducing dependency on rice imports in Member States."

In relation to rice research and development, the Council passed the following resolution.

"Considering the importance of mineral fertilization, improved seed, mechanization and conservation of plant genetic resources on sustainable high levels of rice production in the region;

"[The Council of Ministers] Endorses:

"(i) Continued research on rock-phosphate with the view to determining the long-term effect of rock-phosphate application on the accumulation of heavy metals in soils (e.g. cadmium);

"(ii) Timely seed release in each Member State in order to maintain the momentum and spread of improved varieties in the subregion;

"(iii) Further development of activities in mechanization and to continue to develop, disseminate and encourage the use of appropriate machinery such as ASI [thresher–cleaner] in the sub-region;

"(iv) The liaison of Member States with the African Union to utilize the OAU [Organization of African Unity] Model Law in their efforts to formulate laws protecting their nations' plant genetic resources."

The year 2001 also marked the 30th Anniversary of the Association, which was formed in 1971 by 11 founding Member States. We have come a long way in 30 years, and held a modest celebration at Headquarters in September. The celebration was attended by representatives of Member State Governments, research and development partners, the diplomatic community in Côte d'Ivoire, local village chiefs, and donors. The Prime Minister of the Republic of Côte d'Ivoire, HE Mr Pascal Affi N'Guéssan, attended on behalf of the President of the Republic, HE Mr Laurent Gbagbo. HE the Prime Minister honored several WARDA staff, saying "Côte d'Ivoire, WARDA's host country, feels it a duty to express its recognition on behalf of all the Member States." The Director General was conferred with the title of "*Commandeur dans l'ordre du mérite ivoirien*" ("Commander in the Ivorian Order of Merit") for services to West and Central Africa through his leadership of WARDA since 1996. Additional details are provided in 'The Year in Review: 2001' (page 71).

Director General Kanayo F. Nwanze was made "*Commandeur dans l'ordre du mérite ivoirien,*" receiving his award from the hand of Amani N'Guéssan Michel, Minister of National Education, on behalf of HE Pascal Affi N'Guéssan, Prime Minister of the Republic of Côte d'Ivoire at WARDA's 30th Anniversary celebration

We now have new faces in the management team at WARDA. In July 2001, Michel P. Dubé took up post as Director of Administration and Finance (DAF). A Canadian national from Quebec, Michel joined WARDA with over 20 years multidisciplinary experience in finance and operations management, including a strong private-sector perspective for 'small business.' He is no stranger to Côte d'Ivoire, having worked in Abidjan between 1993 and 1994. Highly comfortable in both English and French, Michel's past international experience includes Africa, Asia, South America and Eastern Europe. Then, in November 2001, Günther Hahne arrived to take up the post of Director of Research. A German national, Günther lived in France from 1987 to 2001, where he was last employed by the *Centre national de la recherche scientifique* (CNRS) as Group Head at the *Institut de biologie moléculaire des plantes* in Strasbourg. He comes to WARDA with strong connections in the European research community and funding institutions, and a rare perspective to research, research opportunities and research management.

New men near the top: Günther Hahne (Director of Research, left) and Michel Dubé (Director of Administration and Finance, right)

The reporting period also saw the arrival of: Emmanuel Abo (Virologist, Visiting Scientist), Enoch Boateng (GIS Specialist, Visiting Scientist), Péféry Coulibaly (Information and Communications Technology Manager), Toon Defoer (Technology Transfer Agronomist), Howard Gridley (Lowland Rice Breeder), Nurdin S. Katuli (Head of Operations), Harouna Koré (Vegetable Economist, Visiting Scientist), Aline Lisette-Vidal (Head of Training, Information and Library Services), Andreas Oswald (Cropping Systems Agronomist), Sidi Sanyang (ROCARIZ Coordinator) and Aïssata Sobia Camara (Agricultural Economist, Visiting Scientist).

It is appropriate that the start of the new millennium sees the NERICA rices launched onto a new plane. First, in April

2001, WARDA hosted an international conference on the role of NERICAs in Africa's food security that led to agreement for the establishment of a Consortium for NERICA-based Food Security in Sub-Saharan Africa. Then in March 2002, the 'NERICA Consortium' was operationalized with the launching of the African Rice Initiative (ARI). This Initiative should provide a fast-track for NERICA dissemination and adoption throughout the rice-growing regions of the continent. The story behind the Initiative and its operation are detailed in our first feature (page 9).

Exciting things have been happening in our Irrigated Rice Program over the last few years, especially in the Sahel. Having highlighted that multidisciplinarity is essential for progress in this ecology through integrated crop management last year, this year we focus on one particular component, namely breeding. The irrigated-rice breeding program has lots of good things to offer and there are more varieties in the pipeline today than ever before (page 15).

A major problem to rice cultivation in the inland-valley lowlands is iron toxicity. West African soils have high concentrations of iron, and these can cause serious problems for the rice plant. We look at the problem holistically, and some solutions that may help improve productivity in these difficult environments (page 29).

The production of new technologies is all well and good, but if the policy climate does not favor domestic rice production, rice farmers are not going to have any incentive to help bridge the deficits currently filled by imports. We take a look at the economic trends in rice in the region, and what can be done to encourage producer- and consumer-friendly policies that make the goal of food-security attainable (page 38).

The whole African continent is being rocked by the pandemic of HIV/AIDS. Last year, we mentioned that the CGIAR Center Directors Committee (CDC) was to develop a System-wide initiative on the impact of HIV/AIDS on agriculture. WARDA has taken a lead role in this activity, and the progress to date is highlighted in our fifth feature article (page 46).

This year's *Donor Country Profile* looks at The Netherlands. From capital input, through research overseers, seconded staff to trainees, The Netherlands has been a staunch supporter of WARDA's activities for many years. A major success has been the Inland Valley Consortium (IVC), jointly funded by The Netherlands and France. All these and more are covered in this year's feature (page 53).

We wish to take this opportunity to express our thanks to our donors, particularly in the light of the downward trend in funding to agricultural research, especially from certain major donors, in 2001 and 2002. We thank you for your faith in our work and support to us, and look forward to continued fruitful collaboration in the years ahead.

We cannot conclude this statement without a word to our Member States. *You* are the reason that we are here: WARDA was established by Member States and continues its mission to serve you in the area of rice research and development. We thank you for your political support when so many of your economies are suffering in an economically 'liberalized' world, and we thank you for the partnership we share as we work together to improve the well-being of rice farmers and rice consumers throughout the region.

Kanayo F. Nwanze
Director General

N. Lindsay Innes
Chairman, Board of Trustees

Turning Challenges into Opportunities and Solutions

SUCCESS GENERATES new challenges. The wide recognition of WARDA's achievements and breakthroughs, in particular in the field of generation of new, adapted and powerful technology that helps fight poverty in Sub-Saharan Africa and helps increase food security—this same recognition bears with it the challenge of securing the achieved progress, to make it accessible to all those who are in need and to satisfy the expectations of those who share with us the enthusiasm about the stepping stones that WARDA has laid on the way to a brighter future for Africa's children.

During the year 2001, the most visible manifestation of the appreciation of our stakeholders for WARDA's work and the tangible results came during the celebration of WARDA's 30th anniversary and the awards bestowed by the President of Côte d'Ivoire on WARDA's Director General and four other staff members (Drs Monty P. Jones, Kouamé Miézan, Sitapha Diatta, and Mr Mark Etsiba); these four were honored with the title *"Officier dans l'ordre du mérite ivoirien,"* or "Officer in the Ivorian Order of Merit." These awards were undoubtedly the most prestigious sign of appreciation of WARDA's efforts towards the improvement of the livelihoods of the region's poor.

Other signs are more subtle, but also highly appreciated by WARDA's staff; they contribute much to the strong motivation of all, scientists and support staff. For example, the increasing number of requests for NERICAs by farmers, farmers' organizations and NGOs; the demands for participation in workshops and other training activities organized by WARDA; the wish of many of our stakeholders to play an active role in WARDA's activities; and simple statements by farmers like the following: "the NERICAs must have water integrated in their tissues, how else could they survive and yield under drought conditions where all other varieties fail?" We see these signs and take them as encouragement to continue our scientific endeavors in the way that past research activities and planning exercises have outlined.

On the other hand, WARDA cannot ignore those voices that call for more involvement, for more and new products in order to solve problems that have not been tackled before or for which solutions are still pending. More farmers, more extension agents would like to reap the benefit that comes from cultivating NERICAs. Those who are not concerned by varieties specifically developed for the rainfed upland ecologies are waiting for varieties that will do for rainfed or irrigated lowland ecologies what NERICAs have done for the uplands. It becomes more and more obvious that genetic improvement alone cannot ensure top yields: the farmers must also understand and apply the cultivation techniques for which the new cultivar has been optimized. These cultivation practices must be integrated with the needs of other crops and of the environment. This requires training at the farmers' level. It is equally obvious that high yields do not guarantee high returns in monetary terms: too many obstacles exist that prevent access to the market or at least make such access difficult for many farmers in the region. In many cases, progress suffers from a general environment that does not stimulate personal initiative and investment. And last, but under no circumstances least, there is the alarming health situation with the HIV/AIDS pandemic threatening to annihilate all other efforts geared towards the improvement of living conditions.

These challenges are not new and they are not unknown to WARDA. Many of them are being addressed by ongoing research activities; others are under consideration for new projects. Among the examples that are illustrated in some detail in this Annual Report is the African Rice Initiative that provides a powerful tool to make new varieties and rice-related technologies available to farmers throughout Sub-Saharan Africa. The Feature on irrigated-rice breeding illustrates the progress made with respect to the constraints of this particular production system. The chapters on the policy dialog, on HIV/AIDS and on iron toxicity—diverse as they are in their concerns—all illustrate the need for an integrated approach to solve the problems that limit productivity and progress in rice-based production systems in Sub-Saharan Africa. WARDA's research portfolio is obviously more widespread than these examples can illustrate, it addresses many issues that affect the different rice-based production systems at different levels, chosen for their strategic importance.

'Strategy' (and the related strategic planning) is one key word that takes its full importance at WARDA's headquarters. Strategic planning needs its tools. Among these, information that allows us to appreciating the state of the changing environment is of eminent importance, and so is information on the real (past) and potential (future) impact that WARDA's results and achievements will have on the real-life conditions of farming in Sub-Saharan Africa. Economic studies and impact assessment contribute to the understanding of WARDA's environment that is necessary for efficient planning and setting of priorities, in addition to the value they have for WARDA's partners. Much work has been invested over the years in establishing a solid basis for the strategic planning exercise for WARDA, and we are confident that the coming year will start with a formal plan that spells out the priorities and options chosen for the coming decade.

Preparation for the future has to start in people's minds, and it is an ongoing process that needs constant attention by those who are in charge of assuring that WARDA lives up to its mission in the most efficient way possible. Preparation for the future also requires physical installations that enable us to realize the ambitious tasks defined by WARDA's mission and stakeholders. WARDA has completed the construction of a containment facility that will allow the evaluation of transgenic rice plants produced in collaboration with our partners in Europe, once the legal framework is in place in Côte d'Ivoire that is required for the permission to conduct such experiments. WARDA is among the institutions that provide technical assistance and backstopping to the process leading to legislation on this subject: the existence of a clear, transparent and practical procedure for the work with this potent technology is of prime importance, not only for WARDA but also for all its stakeholders that must be able to exploit scientific advances to their entire potential and, at the same time, with full respect of all possible safety considerations. The containment facility at WARDA has been constructed in anticipation of the coming legislation, satisfying the stringent legal requirements in force in Europe, North America and elsewhere.

Future achievements are constructed on today's knowledge and on the accomplishments of the past. WARDA recognizes the importance of the existing genetic variety in rice and related species for its valuable contribution to rice breeding programs, be it by conventional means or with the help of one or the other discipline chosen from the biotechnology 'basket.' Long-standing efforts of collection and safeguarding of genetic resources will soon be crowned by the construction of a medium-term storage unit that will assure the conservation of unique samples of all available rice accessions at WARDA, under conditions that satisfy the international standards for gene-bank facilities. WARDA has entered the planning and construction phase of this storage unit.

As the challenges of the future cannot be tackled by WARDA alone, we cherish close collaboration with our partners in Africa and all over the world that helps to transform the opportunities into realities that will benefit the farmers and, ultimately, the people in WARDA's mandate region and beyond. The African Rice Initiative (ARI) described in this issue is a new and particularly exciting example of the collaborative networks and consortia that are hosted by WARDA. ARI is expected to lead to a measurable and sustained impact on food security in the region through widespread adoption of NERICA and other high-performance rice varieties. It will help guide related research and diffusion, improve information exchange among stakeholders, raise public awareness, and provide an effective monitoring and evaluation mechanism. Other networks that are well established at WARDA and have proven their efficiency through concrete results include the Inland Valley Consortium (IVC; *see also* the feature on The Netherlands, page 53), ROCARIZ (*Réseau ouest et centre africain du riz,* the WARDA/CORAF Rice Research and Development Network for West and Central Africa) and INGER-Africa (International Network for the Genetic Evaluation of Rice in Africa). These networks provide efficient vehicles to coordinate the efforts of most scientists concerned with rice in the region and beyond, and thus contribute in an essential way to the optimization of resource use for identifying and solving the most urgent problems. Our collaboration with colleagues from advanced research institutions and from international agricultural research centers are equally valuable, and together we feel well armed to tackle the challenges of the future. We would like to express our appreciation to all colleagues for their collaboration and contributions on the way to accomplishing WARDA's mission.

In the present Annual Report, the reader will be able to enjoy some fine examples that illustrate the achievements that contribute, collectively, to WARDA's success. Individually and collectively, they call for continued attention and research in the areas that are illustrated, and it is obvious that the challenges go beyond the scope of the examples provided. However, they demonstrate how challenges can be transformed into opportunities and solutions through research and development, thanks to the dedication of the people involved—scientists, administrators, support staff, extension agents and, in some noteworthy cases, the farmers themselves. We are confident that the present report will prompt continued support from those who know and appreciate WARDA already, and will win new friends among those who discover WARDA through these pages.

The African Rice Initiative: Taking the NERICAs to Sub-Saharan Africa

A DYNAMIC strategy to alleviate poverty and bring food security to Sub-Saharan Africa—the African Rice Initiative—was launched by Pascal Affi N'Guéssan, Prime Minister of Côte d'Ivoire, at a special ceremony in the Ivorian capital Yamoussoukro on 27 March 2002. The launching ceremony was the climax of a year of intense activity on the part of WARDA and its partners. We look at the development of the Initiative and what it hopes to bring to the beleaguered rice farmers of Africa.

At the turn of the millennium, WARDA's work on the New Rice for Africa (NERICA) was reaching a watershed. Two species of cultivated rice had been successfully crossed for the first time in history, and a 'new biodiversity' was born in the shape of rice plants that combine the rugged adaptation to the local upland ecology of the African parent with the yield potential of the Asian parent. Numerous on-station and on-farm evaluations had confirmed everybody's dreams: the NERICAs competed with weeds better than their Asian parents, they didn't fall over or shed their grains before harvest like their African parent, and they frequently out-yielded the best of the Asian varieties on farmers' fields.

Participatory varietal selection (PVS) had then taken NERICAs straight to the farmers, who voiced their approval loud and clear. As one farmer said at the launching ceremony, "Local farmers call the NERICAs 'ADRAO rice' [ADRAO is the French acronym for

The product: NERICA in a farmer's field

The goal: happy and food-secure rice farmers

WARDA] ... I especially like the taller ADRAOs because they are easier to harvest. They compete well with weeds... [they] have good cooking quality ... In fact, I like to eat the ADRAOs better than the glaberrimas." The glaberrimas are the indigenous African varieties that are usually favored over the Asian varieties for their taste and eating quality!

When PVS demanded more seed, the community-based seed system (CBSS) enabled farmers to produce their own seed and enough for their communities. The PVS methodology had spread to all 17 WARDA member states, and NERICAs were also being tested elsewhere on the continent, in such countries as Uganda and Zimbabwe. In December 2000, the first two official releases of NERICA varieties occurred—in Côte d'Ivoire, WARDA's host country. Meanwhile, five NERICAs were under wide-scale production in Guinea. In fact, in 2000, Guinea was on schedule for rice self-sufficiency by 2002 through a government-supported drive to revitalize the rainfed rice sector with a program that relies heavily on NERICAs.

"NERICAs had proved their worth and were growing beyond all expectations," says a proud Monty Jones, WARDA's Deputy Director for Research, Rainfed Rice Program Leader, and spearhead of the NERICA research activity. "In fact, the NERICAs were fast out-growing WARDA and taking on a life of their own."

Thus, in late 2000 and early 2001, Jones and other research leaders in WARDA started to work on a framework to take NERICAs onto a higher plane. In April 2001, WARDA hosted an International Workshop on NERICA-based Food Security in Sub-Saharan Africa. The workshop brought together over 90 participants, including ministers and deputy ministers from WARDA member states, the President of the Rockefeller Foundation, senior officials from the World Bank, the African Development Bank and the United Nations system, and agricultural researchers. The workshop participants endorsed the creation of a new consortium partnership—the Consortium for NERICA-based Food Security in Sub-Saharan Africa, or NERICA Consortium for short. "With all the stakeholders and donors behind us, we spent the next year developing the consortium concept into a realizable project," says Jones. The result is the African Rice Initiative, or ARI.

Political support at the launch

On 26 March 2002, rice stakeholders from Sub-Saharan Africa came together at WARDA Headquarters to discuss the project proposal. The day ended with representatives of the seven designated 'pilot' countries signing the ARI agreement document.

The launching ceremony itself was held on 27 March at the Houphouët-Boigny Foundation for Peace at Yamoussoukro, Côte d'Ivoire. The more than a hundred delegates comprised governmental ministers, diplomats, agricultural scientists and farmers, and representatives of donor agencies, NGOs and the ARI participating countries.

"The fact that WARDA is an intergovernmental association of member states plays a significant role in assuring political support for our work," explains Director General Kanayo F. Nwanze. "The ARI is no exception. The Guinea experience showed us that the potential of the NERICAs can only be achieved when there is strong political support and relevant policies to make the rice sector work." WARDA member states were represented at the launch by ministers and deputy ministers from Benin, Côte d'Ivoire, The Gambia, Guinea and Togo. One of the key speakers at the launch was Théophile Nata, Minister of Agriculture, Animal Husbandry and Fisheries in Benin, and Chairman of the WARDA Council of Ministers—WARDA's highest governing body. "Results of 30 years of research are before us," Nata said, alluding to WARDA's recently celebrated 30th anniversary, "let us succeed together at something that is at our fingertips."

Foci of the Initiative

"The ARI is more than just the NERICA varieties," explains WARDA Director of Research Günther Hahne, "there are also complementary technologies to enhance soil fertility and make rice farming more sustainable."

"In addition, the Initiative will address the broader issues of policy environment and agro-industry," explains WARDA Policy Economist Frédéric Lançon. "After all, there is no point in increasing farm yields if the surplus rice cannot be sold!"

Many of these technologies have been reviewed in the pages of earlier Annual Reports—for example, the

Signing the Project document



From left to right: Bino Teme, Director General, *Institut d'économie rurale*, Mali; Hassan Sallah, Secretary of State, Department of State for Agriculture, The Gambia; Sery Bailly, Minister of Higher Education and Scientific Research, Côte d'Ivoire; Théophile Nata, Minister of Agriculture, Animal Husbandry and Fisheries, Benin; Elie Fassou Damey, Secretary General, Ministry of Agriculture and Animal Husbandry, Guinea; Kanayo. F. Nwanze, Director General, WARDA; Comla E. Paka, *Directeur de cabinet*, Ministry of Agriculture, Animal Husbandry and Fisheries, Togo; P-Justin Kouka, Assistant Director for Corporate Services, WARDA (assisting) use of rock-phosphate as an alternative to expensive mineral fertilizer, and the WARDA-promoted thresher–cleaner to improve the quality of locally produced rice.

The focus of the first few years of the Initiative is the rainfed upland ecology. It is here that 40% of the West African rice area is found, and the first generation of NERICAs was developed for just this ecology. "From the third year of the Initiative, we expect to have new NERICA material for the rainfed lowlands," explains Jones, who worked with crop ecophysiologist Koichi Futakuchi to develop and test lowland material during the period when there was no lowland-rice breeder at WARDA, from mid-1999 to mid-2001.

What is more, "the ARI goes beyond the NERICAs even at the variety level," Jones explains. "We do not want to replace local varieties, but rather to encourage farmers to integrate NERICAs, and other new varieties, into their existing varietal portfolios." In this way, the Initiative should increase on-farm biodiversity. Consultant writer and long-time rice enthusiast, Tom Hargrove notes: "the strategy differs significantly from the Green Revolution in Asia where, initially, only one rice variety was spread widely. ARI advocates the introduction of a multitude of varieties, giving the farmers the option of choosing distinct rices for different needs."

Although the ARI is open to any Sub-Saharan African country, the initial focus is on seven West African 'pilot' countries: Benin, Côte d'Ivoire, The Gambia, Guinea, Mali, Nigeria and Togo. "Selection of pilot countries was based on each country's proportion of upland rice ecology, progress in NERICA evaluation and diffusion, experience in PVS and CBSS, and potential linkages to other food-security and poverty-alleviation projects, especially for women farmers," explains Nwanze. At the same time, NERICAs will be promoted—principally through PVS activities—in the remaining 10 WARDA member states, and in eight countries in East and Southern Africa.

Structure and function

"Each year, there is an increasing number of rice-related research-and-development activities in the region," explains Jones, "and there are opposing risks of either overloading some workers or else promoting disparate activities with no interrelation or communication among them." For this reason, the ARI seeks to use the most appropriate structural components from partnerships that have already proved successful, and to work alongside existing structures. "In particular," Jones notes, "we have adopted the Consortium Management Committee from phase 2 of the Inland Valley Consortium (IVC), and intend to work very closely with colleagues in ROCARIZ [*Réseau ouest et centre africain du riz*, the Rice Research and Development Network for West and Central Africa]."

Each pilot country is expected to establish a NERICA team from its existing pool of rice workers, and to identify a national coordinator. This is a structure essentially borrowed from the IVC, but its composition will be rather closer to that of ROCARIZ.

Meanwhile, a Consortium Coordinator will be appointed and a Secretariat established at WARDA's headquarters. The Secretariat will help develop training materials on ARI-promoted technologies and organize 'train the trainer' courses, it will also promote and facilitate information exchange among participating countries and players.

The ARI will have two main components: a Stakeholders' Platform and a Research Network. The Stakeholders' Platform will determine the goals of the Initiative and promote wide dissemination of NERICAs and complementary technologies. It will be composed of research and extension personnel from national programs, NGOs and farmers. The Research Network will play the complementary role of evaluating technologies in farming systems, and monitoring how farmers perceive them. The Research Network will also integrate components to improve farming systems still further, and be responsible for on-going technology development of both biological and socio-economic components.

The Research Network will share its findings with the Stakeholders' Platform, so that they can be adapted on target farms. The Network will also provide feedback into research and development in the national programs and WARDA. The Research Network will comprise two coordinators—one for each of two research themes—and 10 PhD students recruited from within the region (not all necessarily from pilot countries). In addition, the ARI will seek additional funding for full-time communications specialist and technology module developer.

In the first year, each pilot country will hold a stakeholders workshop to identify existing knowledge and technologies, and identify key research sites. The key sites should overlap with those of existing programs, so as to maximize research efficiency. Rapid surveys will be conducted to identify (potential) bottlenecks to technology dissemination, on the basis of which scaling-up strategies will be developed. Strategies will be reviewed and input from the Research Network integrated at a second stakeholder workshop in the third year.

On the ground

"PVS and CBSS will be principal mechanisms for the wide-scale dissemination of NERICA and complementary technologies," explains WARDA Technology Transfer Agronomist Toon Defoer. However, under the guidance of Defoer and WARDA's Participatory Rice Improvement and Gender/user Analysis (PRIGA) network, PVS has evolved. "Now, instead of stopping at the third year with farmer adoption through seed purchase," continues Defoer, "we initiate a new two-year extension-led PVS at the same time as the research-led phase moves into its final year."

In PVS-extension, development and extension agents from the national program, research organizations, NGOs and the private sector take the lead in taking new varieties to 'new' farmers (that is, farmers not previously involved in the PVS-research). "This is truly scaling up," enthuses Defoer, "as these extension teams work with 400 to 500 farmers at a time—a scale at which the research-led phase couldn't possibly hope to operate." (*See* Box.)

PVS-extension: A first step in scaling up

As its name suggests, PVS-extension is led by development and extension agents, rather than by researchers.

PVS-extension starts in the third year of the PVS-research process, so that it runs simultaneously with the final year of PVS-research in a given site (agro-ecological setting).

The extensionists take the top four varieties selected by farmers at a specific PVS-research site to groups of 400–500 previously unexposed farmers in the same general area as the PVS-research (varieties are selected for site-specificity). They also provide the farmers with simple evaluation forms, highly illustrated for ease of communication and recording with illiterate farmers. These forms list the selection criteria for varieties identified by farmers in the research phase.

PVS-extension participants grow the varieties in their own fields next to their usual varieties (much as in PVS-research year 2). They are then asked to evaluate the new rices at maturity and post-harvest. The farmers are encouraged to meet and discuss their observations and views of the new material.

Thus, PVS-extension provides a check on the validity of data gathered through PVS-research. The results are compiled and distributed to breeders, national seed boards, and community-based seed producers.

As larger groups of farmers are involved in PVS-extension than in PVS-research, the PVS-extension provides further validation of the outcome of the research phase. Breeders can use this feedback to refine their breeding goals for appropriate varieties. All the information generated from PVS-research and PVS-extension, combined with data from formal variety evaluation on station, are compiled and provided to the relevant seed-release body. The release board can then see at a glance exactly which varieties are popular among the farming communities and promote them to pre-release demonstration trials and subsequently release them. For CBSS practitioners, it is clearly advantageous to know which varieties are preferred by their communities, so that they can be targeted for seed-multiplication.

Prospects

Given the success and rapid impact of NERICAs in Côte d'Ivoire and Guinea, the United Nations Development Programme projects that 1.7 million farmers will be growing almost 210,000 ha of NERICAs in West and Central Africa by 2006. This would provide savings of up to US$88 million per year that would otherwise be spent on rice imports.

The first phase of the ARI is expected to cost $15 million for five years. Donors already 'on board,' inasmuch as they have expressed interest in funding certain aspects of the work, include the Government of Japan, the United Nations Development Programme, the World Bank, the Rockefeller Foundation, the African Development Bank, the United States Agency for International Development, the International Development Research Centre (Canada) and the Food and Agriculture Organization of the United Nations. However, ARI activities can only start in earnest when that money is in the bank.

"With the launching of ARI, we are releasing control of the NERICAs to other stakeholders who can take them to the next plane," says Nwanze. "Our job is to produce technologies that will make the lives of poor rice farmers easier. The evidence shows that the NERICAs clearly fit into that category. Now it is time to hand them over to those who can best put them to their intended use."

Nassa Dacoury, Prefet of Yamoussoukro; Yuji Kurokawa, Japanese Ambassador to Côte d'Ivoire; Sebastien Danon Djedje, Minister of Agriculture and Animal Resources, Côte d'Ivoire; Théophile Nata, Minister of Agriculture, Animal Husbandry and Fisheries, Benin; Pascal Affi N'Guéssan, Prime Minister of Côte d'Ivoire; N. Lindsay Innes, Chairman, WARDA Board of Trustees; Safiatou Ba-N'Daw, Director, TCDC, UNDP, New York, USA; Sery Bailly, Minister of Higher Education and Scientific Research, Côte d'Ivoire; Kanayo F. Nwanze, Director General, WARDA; Elie Fassou Damey, Secretary General, Ministry of Agriculture, Animal Husbandry and Fisheries, Togo

Breeding Rice for the High-Potential Irrigated Systems

ABOUT 50% of the world's rice area is irrigated, but that area produces more than 75% of the world's rice. The equivalent figures for West and Central Africa may not be so impressive, but there is no doubt that irrigated systems have the potential to produce the highest yields, and breeding rice plants for these systems has useful spin-offs for the remaining lowlands with less than complete water control.

Evolving priorities

"The history of WARDA's breeding for irrigated systems is complicated by the fact that until 1997 the program division structure was not simply divided between rainfed and irrigated," explains WARDA Irrigated Rice Breeder and Irrigated Rice Program Leader Kouamé Miézan. Formerly, the Sahel Station was a program in its own right, and only in 1997 did it become the main base for an expanded program on irrigated rice for the whole of West Africa. Thus, as we look at the breeding activities, we start by looking only at the Sahelian irrigated system.

"When I came to Senegal in 1990," continues Miézan, "our main concern was to increase the available options for double-cropping." That is, planting two rice crops in the same field in one year, one in the wet season and one in the dry season. "We were looking either for varieties tolerant to the extreme temperatures in the Sahel, or else varieties with a cycle length which would allow them to avoid the extreme temperatures." The need for detailed understanding of varietal responses to climatic differences led the Sahel team to develop the crop model RIDEV (Rice Development) to predict a variety's development and the level of temperature-induced sterility given its location and sowing date.

The other main concern for the Sahel was salinity, which is a major problem in the Senegal River delta—a major rice-producing area in the region. Here, tolerant varieties could directly contribute to reduced yield losses.

One major difference between irrigated systems and rainfed ones is the fact that the former are invariably market oriented. Thus, irrigated-rice farmers are looking to make profit. They are prepared to invest in their crop in ways that are rarely feasible options for farmers in subsistence systems, in particular in mineral fertilizers and herbicides. Consequently, any variety that is responsive to such inputs will be favored over one that is not, so that farmers may maximize the returns to their investments. Another important aspect of marketing is the preferences of the consumers, or rather how the farmers can increase the market value of their produce. Even at local markets, consumers will pay a premium for quality rice, such as long and slender or aromatic grains.

Since 1997, the irrigated-rice team has also been looking south to the savanna and forest zones. Where water is well controlled, the considerations are similar to those in the Sahelian systems, since fully irrigated systems only pay off with high-input, high-output, market-oriented production. However, additional problems rear their heads in the humid zones (both southern savanna and forest), such as African rice gall midge and iron toxicity.

One major complication south of the Sahel is the definition of 'irrigated systems.' The degree of water control may vary from one farmer's field to the next, or from one year to the next in the same field. As water management becomes less 'tight' and the risks increase, it is necessary to adjust management strategies, including the use of adapted varieties with characteristics such as weed competitiveness, height (in case of flooding) and tillering capacity.

Evolution of the breeding strategy

First, or short-term, strategy: *Introduction* of exotic material from Asia and elsewhere; primarily for direct release, later to provide raw material for the breeding (crossing) program. Traits: earliness (for double-cropping), extreme-temperature tolerance, salinity tolerance.

Second, or medium-term, strategy: *Crossing* of introduced materials (*Oryza sativa* subsp. *indica*); to combine useful traits. Traits: as for short term, plus grain quality.

Third, or long-term, strategy: *Intra- and inter-specific crossing* of introduced *indicas* with traditional *O. sativa* subsp. *japonica* (intraspecific) and with indigenous *O. glaberrima* (interspecific); for traits not available in *indica* material, also to generate diversity for the breeding program. Traits: resistance to rice yellow mottle virus.

Raw material

"In the early days," says Miézan, "it was generally assumed that irrigated rice in West Africa—especially in the Sahel—was much like irrigated rice elsewhere in the world." Consequently, the strategy was to introduce varieties that had been successful elsewhere, and test them under Sahelian conditions. A key player in this was the International Network for Genetic Evaluation of Rice (INGER) under the auspices of the International Rice Research Institute (IRRI). INGER provided a lot of material from all over Asia, but also from elsewhere (for example, Brazil). IRRI also provided a second channel of material, as Miézan had contact with their principal breeder, Dr Gurdev Khush, who sent some material for testing in the Sahel.

Of course, WARDA was not the only institution introducing and testing exotic rice varieties for the irrigated systems; other players in the 1970s and 1980s included the International Institute for Tropical Agriculture (IITA), the *Institut de recherches agronomiques tropicales* (IRAT) and the national agricultural research institutions (NARIs). Thus, a plethora of exotic rice was 'given a chance' in the Sahel. Subsequently, the WARDA, IITA, IRAT and IRRI rice testing programs in Africa were merged into a unified International Rice Testing Program (IRTP, now the International Network for Genetic Evaluation of Rice in Africa, INGER-Africa).

Notable successes of WARDA's introduction and screening activities have been the Sahel varieties: Sahel 108 (IR 13240-108-2-2-3) from IRRI, Sahel 201 (BW 293-2) from Sri Lanka, and Sahel 202 (ITA 306) from IITA. Between them, these varieties now dominate the irrigated rice area of the Senegal River valley both to the north (Mauritania) and to the south (Senegal). Sahel 108 has also been released in Burkina Faso, and Sahel 202 in Cameroon, Ghana and Nigeria. We reported on the adoption of these varieties last year (*see* Box 'Sahel 108 and other Sahel rice varieties,' *WARDA Annual Report 2000*, page 11).

"Even today," Miézan notes, "introductions are still of value and will continue to be so. We are no longer looking for material for direct release only, since exotic material can bring useful traits and diversity into the breeding program." In fact, the team continues to screen about 300 such introductions every year.

Breeding in earnest

In the early 1990s, when the Sahel Station was established, there was neither infrastructure nor staff to carry out crosses or even to handle segregating populations. Consequently, when Miézan launched his breeding activities he was obliged to use a rather circuitous route. "I identified suitable parents here in Senegal," he explains, "but then sent them for crossing to WARDA's lowland-rice breeder based at Ibadan, Nigeria [WARDA's Nigeria Station, hosted at IITA's headquarters]. I then received second-generation material, which I grew and selected here at N'Diaye [WARDA's Sahel Station]." These selections were designated as the 'WAT' series to show that they were **W**ARDA–**A**DRAO crosses made at II**T**A.

These early crosses made at IITA were between exotic parents of *Oryza sativa* subspecies *indica*, using essentially material from Asia. A similar crossing program continued at N'Diaye once the Sahel Station had the resources to do the work. These 'indigenous' crosses, however, are designated 'WAS' for **W**ARDA–**A**DRAO **S**ahel.

The main goals of these *indica–indica* crosses were to improve the plant type (height and panicle exsertion), tolerance to salinity, and grain quality, and to reduce duration without significantly affecting yield potential.

Intraspecific (*indica–indica*) line at N'Diaye, Senegal

Looking further afield

Rice yellow mottle virus (RYMV) is a major viral disease of irrigated and rainfed lowland rice in Africa. None of the widely grown, popular irrigated-rice cultivars in West Africa is resistant to this disease.

"When we started to think seriously about breeding for resistance to RYMV, we hit a problem," explains Miézan. "In the mid-1990s, we had only one *indica* variety [Gigante (Tete) from Mozambique] that was highly resistant to RYMV, but it has a poor plant type (too tall and poor grain quality), is susceptible to blast disease, and doesn't yield well."

"To make matters worse," explains WARDA Pathologist Yacouba Séré, "the RYMV itself is highly variable, so we could not, and cannot, rely solely on one source of resistance." Fortunately, screening activities at IITA (Ibadan) and at WARDA (M'bé) had identified resistant and tolerant material among both *Oryza sativa* subspecies *japonica* and *Oryza glaberrima*.

Thus, the pieces were in place for a breeding program for RYMV resistance in irrigated rice. "The only remaining hurdle was the crossing itself," laughs Miézan. At that time, WARDA's upland interspecific breeding program (involving *Oryza sativa* subsp. *japonica* and *O. glaberrima*) was still in its infancy—the first NERICAs were still to be developed. However, IRRI, the *Institut français de recherche scientifique pour le développement en coopération* (ORSTOM, now *Institut de recherche pour le développement*, IRD), and Japanese institutions had made experimental crosses, mostly for genetic studies. In particular, ORSTOM had found *glaberrima–sativa* hybrids highly sterile. However, the WARDA-Sahel team did not give up, and the fruits of their efforts were reported last year ('Rice Yellow Mottle Virus,' *WARDA Annual Report 2000*, pages 27–37). Despite the fact that some of the original 'upland' NERICAs have shown promise in the lowlands, evaluations—by Miézan and his team—of several interspecific (*sativa–glaberrima*) progenies have shown that *indica*-based progenies are most appropriate for irrigated and rainfed lowlands.

"A major spin-off of the interspecific hybridization work," enthuses Miézan, "is the diversity that it has generated." Any single cross can generate amazing variation among the progenies, but the interspecific crosses bring in genes previously unknown in irrigated rice. "Somewhat surprisingly, but most useful, is the variety in plant type that the interspecific work has produced," says Miézan. "Plants with different stature and structure opened up the possibility of using this material in 'rainfed' lowlands, where water control is not ideal. Thus, *Oryza glaberrima* can contribute significantly to improving irrigated and lowland rice cultivation in the region. However, hybrid sterility with *Oryza sativa* is still a problem." This issue is currently being addressed by Sigrid Heuer (*see* Box 'Investigating hybrid sterility at the molecular level,' page 20).

Sorting through the mass of material

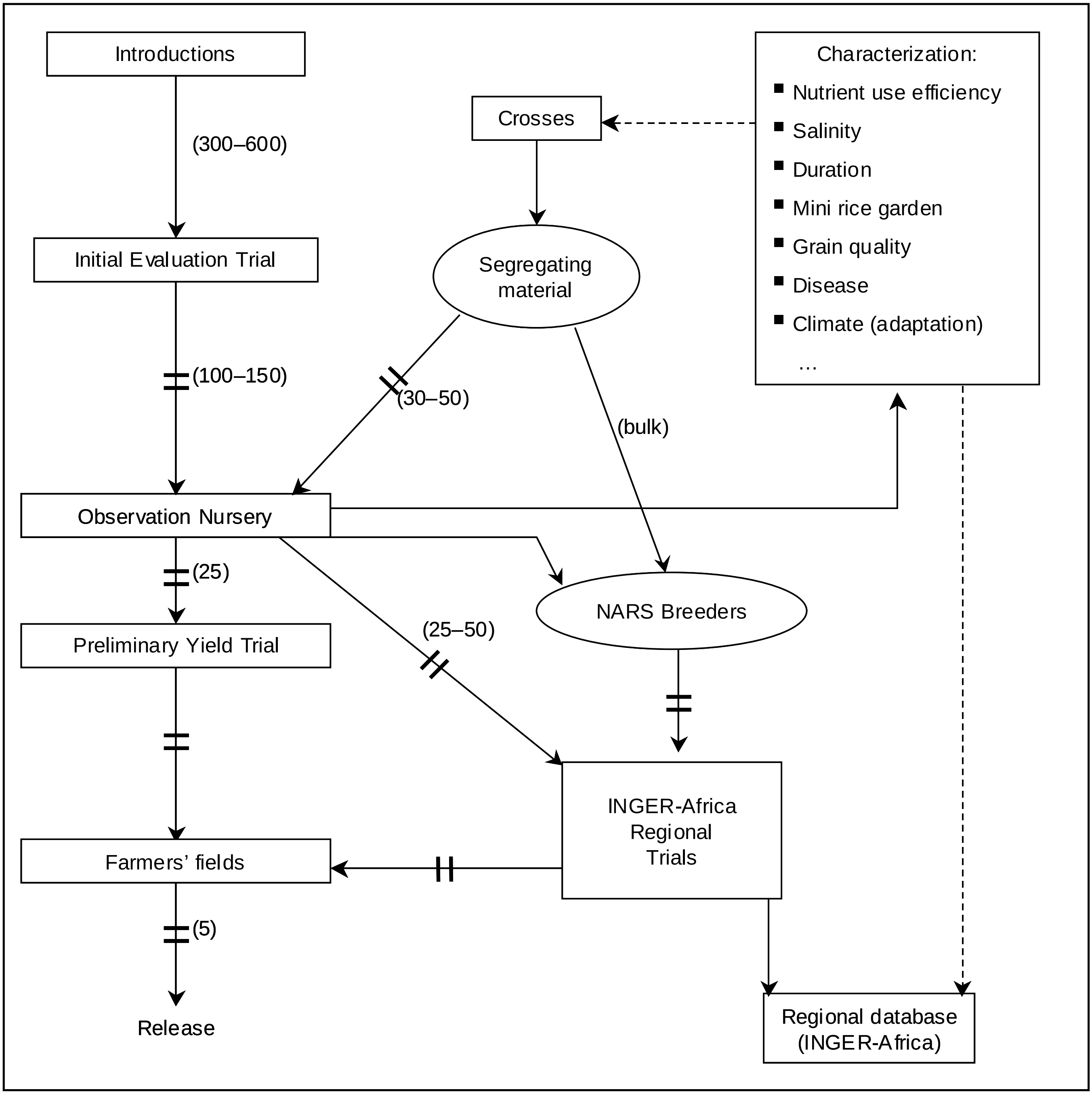
Given the wealth of material that is now available to the program on a yearly basis, Miézan and his team have a lot of screening and selecting to do. The network of activities is depicted in Figure 1. "The system looks very complicated," explains Miézan, "simply because we want to make the best use of the available material—we don't want to lose anything potentially valuable. However, at the end of the day we are looking at introducing between 300 and 600 new lines into the system each year, and hopefully seeing five to ten of those go right through to release in one or more of our target countries."

The process starts at N'Diaye. The Senegal River valley is considered a good place to start, because the selection pressure is not strong. The philosophy in the initial screening (Initial Evaluation Trial) is not so much to select the best, but rather to eliminate the worst material that is not at all suited to the environment. In this way, the 300–600 entries are reduced to between 100 and 150. These selections are divided into two groups on the basis of cycle length: short and medium duration.

The short-duration material is given the toughest time, since it is from these lines that the team wants to select varieties for the dry season. Consequently, these lines are almost immediately re-sown in the following dry season. The selection pressure is high, and many will not flower. Those that do survive and produce seed go

Two interspecific lines derived from a single cross: one with awns (left), the other with long glumes (right)

Figure 1. Breeding and selection of new varieties of irrigated rice by WARDA and its partners



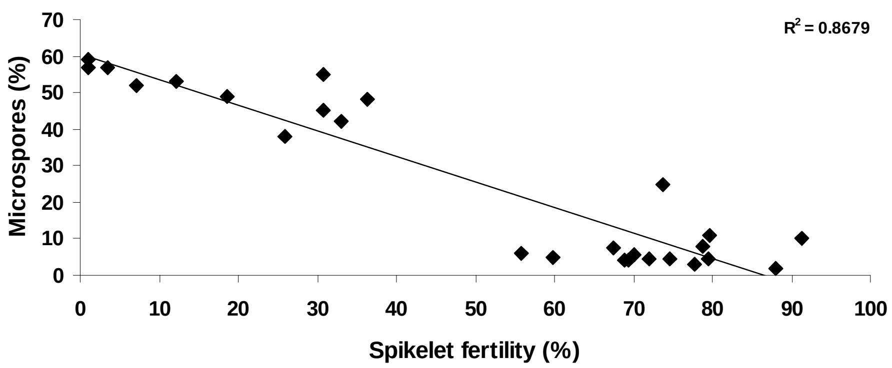
Investigating hybrid sterility at the molecular level

A major problem in interspecific hybridization work is the very poor fertility of the first hybrid generation and its progenies. This was not only true in the production of WARDA's upland NERICAs, but also in the crosses conducted by the irrigated-rice team involving *indica* varieties and *Oryza glaberrima*.

Sigrid Heuer was awarded a post-doctoral scholarship by *Deutscher Akademischer Austauschdienst* (DAAD) in early 2000 to look at the processes underlying the crossing barriers between the two cultivated rice species. "My first problem," she explains, "was to get some sterile plants to work on." For obvious reasons, breeders only select fertile plants. "Having screened hybrids for sterility in the dry season," Heuer continues, "we needed to re-check our results in the wet season—heat also induces sterility, and the dry season is very hot in the Senegal River delta!" A major advantage of working in the Sahelian zone is the ability to advance breeding material by two generations per year, by growing in both wet and dry seasons; however, the dry-season plants always risk heat- (and cold-) induced sterility. "In the dry season of 2001," Heuer continues, "I had the privilege of being able to use the climate-controlled greenhouse and laboratory facilities of the *Centre d'étude régional pour l'amélioration de l'adaptation à la sécheresse* (CERAAS) at Thiès (western central Senegal)." With the climate control, the temperature can be kept below sterility-inducing levels.

Detailed studies finally centered on one line that was segregating for sterility—that is, it was still producing a mixture of fertile and sterile offspring in the third generation after the second backcross to the parents. "I have classified the 33 plants I was working with," explains Heuer, "into fertile (>60% seed set), semi-fertile (30–60% seed set), and highly sterile plants (<30% seed set). Looking at the pollen, it became clear that the spikelet sterility correlated well with pollen sterility" (*see* Fig. 2). A large proportion of the pollen of sterile plants stops developing at an early stage and is therefore sterile. The higher the number of sterile pollen grains (microspores), the lower was the seed-set.

Figure 2. Correlation between pollen and spikelet fertility of BC2F3 progenies



"Apart from our interest in better understanding the processes underlying crossing barriers," Heuer continues, "we wanted to identify markers that would allow us to predict whether hybrids will be fertile or not. Those markers would also enable us to identify parents from which fertile hybrids could be produced." In Asia, a particular gene locus for sterility, known as *S5*, has been shown to be important in *indica–japonica* sterility. Recent analyses conducted by the *Institut de recherche pour le développement* (IRD) in Montpelier, France, suggested that another locus, called *S10*, is linked to sterility in *sativa–glaberrima* hybrids.

"On the basis of this information," says Heuer, "several markers close to the *S10* locus were tested in order to determine whether there was a correlation of the markers with sterility in our material. The two markers provided by IRD associated well with sterility: with one marker we can clearly distinguish highly sterile plants from semi-fertile and fertile ones; with the second marker, we can additionally differentiate two groups of semi-sterile plants, namely those with and without microspores (immature pollen grains)." This confirmed a role for *S10* in the sterility of *glaberrima–indica* hybrids.

To test whether other sterility genes were involved, Heuer obtained 'wide compatibility varieties' (WCVs) from IRRI. These are lines that have neutral alleles at the loci of various sterility genes (e.g. *S5*). "The theory is simple," explains Heuer, "if any of these other genes were involved in the sterility process of our crosses, then the offspring from crosses involving the WCVs would be fertile. We obtained 112 grains from 165 crosses with various *O. glaberrima* accessions and cultivated a subset of the hybrids at CERAAS. All of the resulting hybrids were 100% sterile and we did not find a single grain. These experiments assured us that *S10* is important for sterility in *glaberrima* hybrids rather than the WCV loci which were so important in Asia."

Why do we bother? The *glaberrima* 'goldmine'

Given the sterility problem, just why does the breeding team bother with such difficult material?

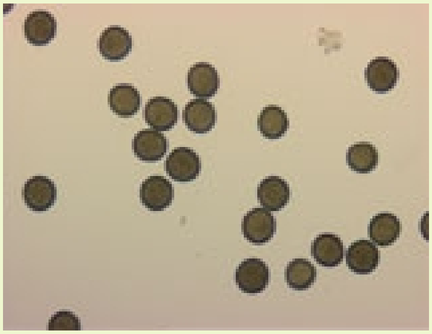
Just as the upland-rice breeding team found at WARDA headquarters, the irrigated-rice team is finding all sorts of interesting things in their interspecific hybridization work. "Some characters are subject to segregation distortion (that is, a bias in the hybrids to express the character like only one of the parents)—for example, all hybrid grains are white, whatever the color of the *glaberrima* grains," explains Heuer, "while some other characters show transgressive segregation." That is, the character differs qualitatively or quantitatively from both parents. "For example," continues Heuer, "many progenies have awns (long, hair-like projections on the grains), whereas none of the parents we used have them." In themselves, awns are neutral—some farmers like them because they make it difficult for birds to eat the grain, while others complain that awns make threshing difficult. Other examples of transgressive segregation, already seen in NERICAs, are number of secondary branches and number of grains.

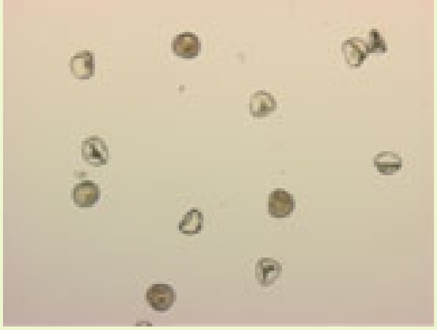
"Sterility reduces yield," says Heuer, "but otherwise the interspecifics show great potential for improving the yield of irrigated rice. What is more, a single back-cross to the *sativa* parent can restore the fertility of *individual* plants. However, a second backcross to *O. sativa* generally increases fertility even more, and breeders prefer this plant material since desirable *sativa* traits are better represented." The value of this interspecific plant material cannot be overlooked given the success of the first set of NERICAs.

"Herein lies the value of Dr Heuer's work," says Irrigated Rice Program Leader Kouamé Miézan, "she has shown that the *S10* locus is (at least partially) responsible for the hybrid sterility. So, now, if we want to improve the fertility of future interspecific crosses, we need to find *Oryza glaberrimas* which do not have the sterility allele at *S10*, so that when these are crossed with *indicas*, or even *japonicas*, the resultant hybrids will not be sterile." The search goes on.

Meanwhile, the team continues with developing material the hard way. "Important goals for the breeding program," explains Heuer, "are weed-competitiveness and disease resistance." As in the upland NERICAs, the irrigated-rice team wants to transfer the profuse early growth of droopy leaves from *glaberrima* to their new material, in the hope that the plants will suppress weeds, and therefore out-compete them.

For rice yellow mottle virus (RYMV) resistance, the team uses its shuttle-breeding approach. "RYMV is not a serious problem in the Senegal River delta and valley," explains Miézan, "so we do initial screening here for plant type and other characteristics. Eventually, we plan to conduct rigorous screening for RYMV at WARDA headquarters, but that work has been put back by delays in the establishment of the containment facilities there. Meanwhile, our NARS partners in Mali and Burkina Faso are ideally placed to screen the material under natural RYMV infection, and we hope that they will play an active role in the selection work when the new irrigated interspecifics are sent out in nurseries in 2002 and beyond."





Comparison of fertile (left) and sterile (right) pollen back to join the medium-duration selections for a more serious Observation Nursery in the following wet season. The cycle of observation nurseries continues for three years—that is, three seasons for the medium-duration lines, and six for the short-cycle ones. The output is the best-yielding lines—usually about 10 selections from each maturity-group—which are then 'promoted' to Preliminary Yield Trials.

Partnerships and characterization

We mentioned earlier, however, that the goal is to maximize the use of the material. To achieve this, the same material that goes into the Observation Nursery is also sent to those national programs that have breeders with the resources to handle a large amount of material. These 'strong' national programs also receive bulked (unselected) segregating material—that is, material that is not yet fixed—from the breeding program. Meanwhile, the observation nursery entries are also subjected to detailed characterization, both at N'Diaye and at WARDA headquarters (mainly for RYMV).

"The detailed characterization work at such an early stage provides two benefits," explains Miézan. "First, it provides a wealth of data for those entries that are eventually sent for regional screening through INGER-Africa and, second, it provides information for the breeding program, enabling us to select suitable parents for new crosses."

Meanwhile, the network approach comes into its own in the selection of breeding material. "Effectively, we do something that we call 'shuttle breeding,'" explains Miézan. "If you look at some of our more advanced lines, you will see a mixture of acronyms within the names, which designate where they were selected." So, a line designated WAS122-IDSA-10-WAS-3-B-1, would indicate a cross made by WARDA Sahel Station, subsequently selected by the national program in Côte d'Ivoire (formerly known as IDESSA), and selected again at the Sahel Station. Details of how the process has been working with one national program—that of Burkina Faso—are given in the Box 'Working together: WARDA and Burkina Faso.'

Those national programs that do not have much capacity for screening and selection reap the benefit of the detailed program conducted by WARDA and its 'strong' partners. And all the national programs benefit from the crossing program conducted by the WARDA irrigated-rice team, since none of them would have the capacity—neither infrastructural nor financial—to handle as many crosses as Miézan and his team do.

Down on the farm

Does this mean that the team excludes farmers from the variety development process? "By no means!" responds Miézan, "but in the initial selection process for hundreds of varieties, we have to rely on our good grasp of the farmers' needs." In addition to the fact that the irrigated ecology itself is more homogeneous than other ecologies in the region, market orientation streamlines the characteristics needed and most farmers are looking for yield, short to medium duration, and grain quality. Then for the Senegal River delta (Senegal and Mauritania) and similar coastal sites, salinity tolerance is essential.

Later, participatory selection of a reduced number of varieties is coordinated by the national institutions. Take, for example, the mechanism as it operates in Senegal. It is the national research institute (ISRA) that takes and multiplies the seed of promising varieties, and then coordinates the on-farm trials prior to release of any variety. "In fact," says Miézan, "a participatory release mechanism was in place in Senegal before WARDA ever arrived on the scene. However, today, the pre-release trials coordinated by ISRA involve not only farmers, but also the local extension agency (SAED) and ourselves. After two or three years of such trials, we all meet to make recommendations to the national release committee."

Working together: WARDA and Burkina Faso

In terms of rice breeding, Burkina Faso has one of the 'strong' NARS in the region. The close collaboration between the two breeding teams illustrates the value placed by both WARDA and the national programs on partnership.

As part of a PhD research program, Sié Moussa of the *Institut de l'environnement et des recherches agricoles* (INERA) Farako-Bâ Station initiated a number of *indica–indica* crosses at WARDA's Sahel Station in 1994–1996. These were essentially to study the genetics of photo-thermal constants (as used in RIDEV—*see* main text, page 15); however, since several crosses appeared agronomically promising, they were advanced by standard selection methods.

After obtaining his doctorate, Sié returned to the Sahel Station in 1998 for a further year as Visiting Scientist. However, one of the features of Sié's work has been the almost seamless integration of activities that he has conducted under the auspices of WARDA with those for his national program. Sié identifies three kinds of breeders on the basis of the resources they have available and their experience: these correspond to 'weak' NARS, 'strong' NARS and WARDA. "WARDA breeders are equipped," says Sié, "with biotechnology, staff, infrastructure and scientific environment. This allows them to undertake in-depth research activities. My stays at WARDA allowed me to initiate work that I could not have accomplished in my home country." This work included the intraspecific *indica–japonica* and interspecific *glaberrima–indica* crosses that are beginning to produce progeny that are looking promising in the field.

The aim of Sié's on-going research program may be summarized as "increasing the genetic diversity of irrigated rice in the sub-region through a combination of direct introduction, and intra- and inter-specific crossing." More specific targets comprise varieties specifically adapted to double-cropping; improving grain quality; improving salinity tolerance; and, introducing tolerance to rice yellow mottle virus (RYMV).

In 2000, Sié evaluated 571 fixed lines from the intra- and interspecific material under various degrees of lowland water management and along the toposequence in south-west Burkina Faso—irrigated in Banzan and Karfiguela, and rainfed in Banfora. At flowering, Sahel Station Research Assistant Souleymane Gaye visited Burkina Faso and assisted Sié in the selection process. These selections were duplicated at the Sahel Station for advancement and further selection. The resulting fixed lines form the WAS-FKR-WAS series. For example, WAS161-B-6-FKR-1-WAS-1, and WAS122-IDSA-6-WAS-B-FKR-1-WAS-1; the 'IDSA' designation in the WAS122 line shows that the first NARS selection of this line was made in Côte d'Ivoire (at IDESSA), and demonstrates the value placed on 'recycling' the material among the NARS in the search for the best material.

"The participation of NARS breeders in the breeding activities of the program has contributed tremendously to accelerate the selection process as well as increasing efficiency," says Irrigated Rice Program Leader Kouamé Miézan. "This has enabled us to advance generations more rapidly and obtain many excellent fixed new *indica* lines." Some of the lines coming out of this shuttle-breeding process have been nominated for evaluation in regional observational yield nurseries through the INGER-Africa network.

Interspecific lines bieng screened at Banzan, Burkina Faso

Looking south

In 1997, WARDA's Sahel Irrigated Rice Program became simply the Irrigated Rice Program. This has meant a broadening of horizons for the team based in Senegal.

In some respects, irrigated systems in the savanna and forest zones of the region were largely ignored prior by 1997, at least in terms of targeted breeding. The then lowland-rice breeder based at Ibadan was producing material for the rainfed lowlands, but many of the varieties developed by that program were found suitable for fully irrigated systems (*see* Box 'The WITA rice varieties'). Unfortunately, the irrigated-rice varieties developed in the Sahel were not evaluated in the humid zones at that time.

With the expansion of the mandate of the irrigated program to the humid zones, material developed for irrigated systems in the Sahel has been increasingly tested at WARDA's main research station in the forest–savanna transition zone of Côte d'Ivoire. "Several of the varieties are very promising," says Inland Valley Consortium Scientific Coordinator Marco Wopereis, who supervised the initial screening at M'bé, "and we expect to see them in multilocational testing, at least in Côte d'Ivoire, Burkina Faso, Mali and Nigeria, in 2002."

A major aspect of moving into the humid zones is the issue of water control. Pierrick Fraval, Water Management Economist with the International Water Management Institute (IWMI)/*Cemagref*/WARDA at WARDA's Sahel Station, explains: "While in the Sahel, irrigation is essential for rice cultivation and irrigated systems are clearly defined—you either have complete water control or you do not have rice—irrigated systems in the humid zones (savanna and forest) cannot always be clearly delimited. In these agro-ecological zones, the term 'irrigated' is sometimes used strictly for irrigated lowland with full water control, sometimes it includes the important surface areas of lowlands with some degree of water control. In addition, it is quite possible to have a field where a farmer is managing tight control of the water supply adjacent to another field where a farmer is exercising almost no control of the water. The same thing can happen from one year to the next in the same field, depending on a particular farmer's resources, and the overall water supply." This range of environmental conditions makes breeding for irrigated rice in humid zones a bit more complicated and may require a slightly different strategy.

"For this reason," Miézan continues, "we are increasingly looking at irrigated systems in the humid zones as an intensified lowland continuum based on the level of water-management in the lowlands" (*see* Figure 3). Although an irrigated-rice variety may grow well in any zone provided that water control is maintained, the minute—or rather season—that water supply gets out of control due to limited irrigation infrastructure, the crop may become exposed to traditional rainfed lowland constraints. Therefore, varieties as well as crop management options need to be adjusted accordingly.

"For irrigated systems in humid zones," says Miézan, "what we are looking for is an irrigated rice plant type with wider adaptability to lowland systems." This will require close collaboration between irrigated rice breeding and rainfed lowland breeding for sharing of genetic material and developing new screening methodologies. "For example," says WARDA Lowland Rice Breeder Howard Gridley, "some of the *indica*-based interspecifics may be too tall for fully irrigated ecologies, but may be useful for rainfed lowlands that face a flooding hazard."

Dynamic present and promising future

A major impact of the 'breeding' work for irrigated systems in recent years has been the success of the three 'Sahel' varieties released in 1994, but even more exciting things are in the pipeline. In 2002, Senegal will release five new varieties from the breeding program. These are two short-cycle varieties introduced from IRRI, and three medium-duration varieties—two from IITA and one from Cuba. The same varieties are also doing well in Mauritania, and should be released there, too, either later in 2002 or in 2003. The interspecific and intra-specific

The WITA rice varieties

"Until 1997, the WARDA Sahel Station was breeding irrigated-rice varieties for the Sahel ecology *only,*" explains WARDA Deputy Director for Research, Monty Jones. "However, the breeding effort for the rainfed lowlands—based at IITA in Nigeria—was generating material that was suitable for irrigated lowlands in the forest and savanna zones of the region."

"The lowland varieties from the pre-1997 era are known as WITAs, for **W**ARDA at I**ITA**," explains WARDA's Lowland Rice Breeder, Howard Gridley, who joined WARDA in 2001. Several WITAs were released in Côte d'Ivoire in 1998, most of them for both irrigated and rainfed cultivation. Details are given in the following table.

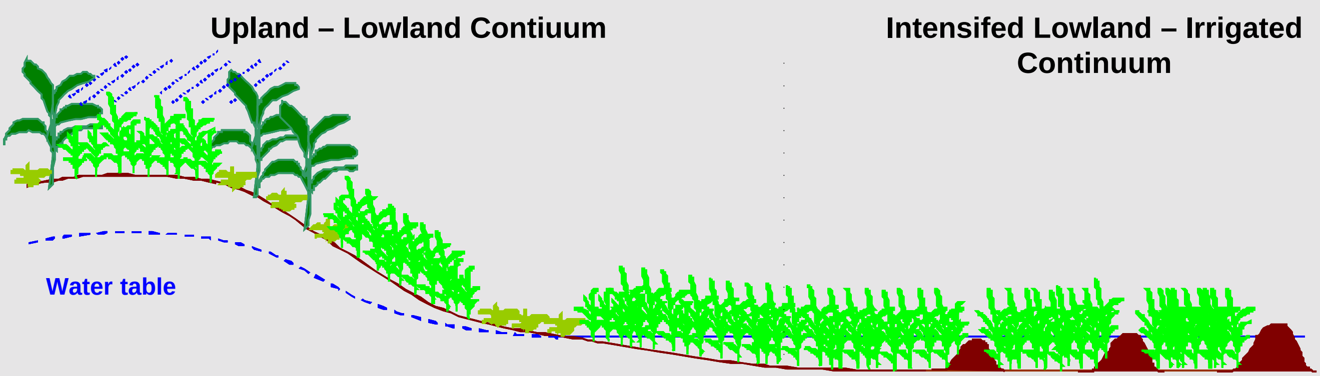
Name (local)	Yield potential (irrigated, t/ha)	Height (cm)	Cycle length (days)	Characteristics
WITA 1 (Yabra)	9	110	130	Iron-toxicity tolerant; Blast resistant
WITA 3 (Kossou)	9	90	125	Iron-toxicity tolerant
WITA 7 (Gagnoa)	8	115	125	Good grain quality
WITA 8 (Sandela)	8.5	120	120	RYMV tolerant
WITA 9 (Nimba)	10	92	120	Early; RYMV resistant

crosses made by the team are also bearing fruit: "In the 2002/03 season," explains INGER-Africa Coordinator Robert Guei, "we will have *indica*-based interspecific lines from the Sahel Station in regional yield trials through INGER-Africa for the first time, together with intra-specific lines (*indica–indica*)."

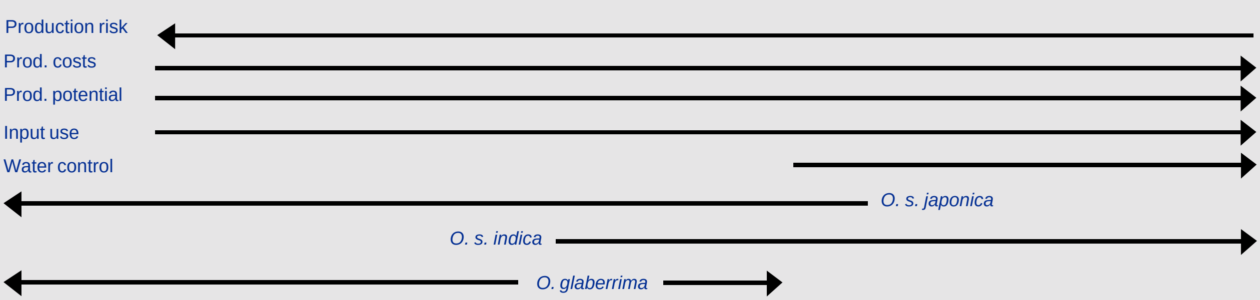
Among the new targets of the irrigated-rice breeding work are increased nutrient use efficiency at different input levels (i.e. nitrogen and phosphorus) and good weed competitivity. Here, a strong link between breeders and agronomists is needed. Stephan Häfele, WARDA Agronomist for Irrigated Systems, explains: "Concurrently with the selection process, we characterize about 30 varieties each season for nutrient use efficiency, weed competitiveness, salt tolerance and photo-thermal constants. The results will help us later to choose appropriate varieties for different environments. For example, we found that the yield of Sahel 108 is very low under weed pressure, although it is one of our best short-duration and high-yielding varieties. Therefore, we would not recommend that variety in highly weed infested areas or where farmers have problems with weed management. But where weeds can be controlled, Sahel 108 does give highest yields combined with high grain quality."

The team has found varieties that are highly weed competitive. The use of varieties that compete well with weeds will enable farmers to save money by reducing the quantities of herbicides applied, which in turn will protect the environment. Results of preliminary evaluations are promising—some cultivars, such as Jaya and new *indica*-based interspecific progenies, had only small yield losses when grown without weeding. Such characteristics are extremely valuable, particularly in direct-seeding systems, where weeds are a major yield-limiting constraint.

Figure 3. Conceptual model of topographical and intensification continua of rice-growing ecologies



Upland	Hydromorphic slope	Lowland	Intensified lowland	Irrigated lowland
Main water supply: rainfall	rainfall + water table	rainfall + water table + flood water	regulated flood water	irrigation
Agro-ecological zone: Guinea savanna to humid forest zone	Guinea savanna to humid forest zone	Sudan savanna to humid forest zone	Sudan savanna to humid forest zone	Sahel to humid forest zone
Main stresses: drought weeds pests and diseases low soil fertility soil erosion soil acidity	drought weeds pests and diseases low soil fertility soil erosion, soil acidity Fe toxicity	drought / flooding weeds pests and diseases Fe toxicity	drought / flooding weeds pests and diseases Fe toxicity	weeds pests and diseases salinity, alkalinity Fe toxicity



The need for varieties that can use fertilizer efficiently and enable the farmers to get more crop and more money out of their investment is increasingly voiced by irrigated-rice farmers. Preliminary evaluations have indicated that progenies of inter- and intra-specific crosses have a lot of potential to satisfy this need.

"The hope for an African agricultural revolution lies in the intensification and diversification of the lowlands," says WARDA Director General Kanayo F. Nwanze. The fully irrigated systems that are the target of the breeding efforts discussed above should represent the pinnacle of lowland intensification for rice cropping. "The potential for lowland rice cropping is estimated at 20 to 40 million hectares in West and Central Africa alone," continues Nwanze. "Our long-term strategy addresses the issue of NERICAs in this most robust and promising ecosystem."

Painting the Rice Red: Iron Toxicity in the Lowlands

IRON TOXICITY is a serious problem affecting lowland rice in West and Central Africa. It is particularly prevalent in inland valleys, where iron can run into the lowland from the upland and slopes. In 1994, the *Centre de coopération internationale en recherche agronomique pour le développement* (CIRAD) seconded a Plant Physiologist to WARDA to look into the problem in detail.

A question of balance

Soil nutrients are essential for plant growth. Plant a crop on a soil that is deficient in nutrients, and watch it struggle and most likely die. However, there is more to plant nutrition than simply adding nitrogen, phosphorus or other fertilizers. There are also the 'trace elements,' like zinc, manganese and iron. These are required in tiny amounts to sustain normal plant growth. The balance is a fine one: too little of the element and the plant will not grow, too much and... Well, this is the story of what happens when there is too much iron in the rice field.

A preliminary survey by WARDA in 2001 suggested that as much as 60% of the lowland rice area in West and Central Africa may be at risk from iron toxicity (*see* map, Figure 4). Average yield loss due to iron toxicity amounts to 50%, and in fact ranges from 10 to 100%. That makes iron toxicity a very serious problem for lowland rice farmers in the region indeed. "Iron toxicity is a typical soil nutrient problem," explains WARDA/CIRAD Plant Physiologist Alain Audebert. "Excess iron in solution is absorbed by the rice plant and accumulates in its tissues. Typical symptoms of iron toxicity are small brown spots, which start appearing at the leaf tips. These spread, merge and result in reddish-colored leaves. In addition, the iron toxicity alters the root structure, plant development, and leads to sterility." (*See* Box 'Iron-toxicity symptom scoring,' page 31.)

"Iron is the most important element in the earth's crust. It is especially concentrated in the lowland soils of the region," explains Audebert, "but many of the upland slopes also have high concentrations of iron." But, just because iron is present in the soil does not necessarily mean that there will be a toxicity problem. WARDA Soil Physicist Sitapha Diatta takes up the story: "In the uplands and on the slopes, iron is typically in what we call the ferric form [Fe^{3+}]. This form is non-soluble, and therefore not available to the plants." In other words, ferric iron is harmless to rice, and iron toxicity is not a problem on the upper slopes. Meanwhile, if the fields are not adequately flushed with fresh water, iron in the lowlands is subjected to an environment depleted of oxygen, and tends to become converted into ferrous [Fe^{2+}] iron. Ferrous iron is soluble in water, and so is available for uptake by the rice plants. "In a typical iron-toxic valley," Diatta continues, "ferric iron is washed down into the valley lowland, either by seepage through the

Figure 4. Map of western Africa showing iron-toxicity risk in three countries

soil (known as interflow), or else by run-off and erosion of the upper slopes into the valley bottom. Either en route (for interflow) or else upon arrival in the valley bottom (for run-off), the ferric iron encounters waterlogged conditions, and becomes ferrous iron" (*see* Figure 5, page 32). Thus, the already high concentrations of ferrous iron in the valley bottom are increased by the iron coming down the slope.

Combating iron toxicity at the field level

"Given what we know about the build-up of iron-toxic conditions, we can propose some field-level management options that may help alleviate the problem," says Audebert. "To do this, we have several possible points of intervention. We might try to block the movement of iron from the uplands, flush fields to wash out excess iron, look for ways of converting ferrous iron to the ferric form, try to minimize plant uptake of iron, or find varieties

Close-up of ground-water resurgence zone at edge of lowland field, where the slope and stationary water meet. Note reddish ferric iron on soil surface becoming paler under the process of reduction

Iron-toxicity symptom scoring

In studies of plant problems, it is always useful for researchers to have a quantitative method of assessing the effect of the constraint (in this case iron toxicity) on the plant. Yield is only one component of this.

For some years, disease, pest and nutrient disorders of rice have been assessed on a numerical scale developed by the International Rice Research Institute (IRRI). This Standard Evaluation Score (SES) uses a nine-point scale, where 1 is given for near-normal growth and development, and 9 is given for a plant that is almost completely dead; a mid-range score of 5 refers to a plant with retarded growth and tillering, and many discolored leaves.

Rice plant with iron-toxicity SES score of 7 as the plants are starting to flower. Note the bronzed flag leaves and small panicles

of rice tolerant to high concentrations of iron in the soil." Possible interventions are summarized in Figure 6 (page 32) at the level of the inland valley and in Figure 7 (page 33) for field level.

In many upland situations, farmers leave the soil bare after harvesting of their rice crop. Since sowing is only done after the first rains, dry bare soils are prone to erosion at the start of the rainy season. "We are already promoting the use of legumes in the uplands to diversify rice-based cropping systems, improve soil fertility, reduce soil erosion and alleviate weed pressure," explains WARDA Cropping Systems Agronomist Andreas Oswald. "They also help in the iron-toxicity problem by stabilizing the upland soils, so that they are not washed down the slope in the first rains." In addition, deep-rooted plants used as intercrops between rice plants in the uplands will capture more of the water, thereby reducing interflow. "The next logical step," continues Audebert, "would be to intercept the interflow and runoff in the lower slopes—the hydromorphic zone." However, this latter idea requires a management program for the whole toposequence, and is impractical at the current state of development of the vast majority of inland valleys in the region.

"We know that water in the field becomes increasingly depleted in oxygen the longer it stays there," says Audebert. "One possible solution might be to increase the circulation of water within the field, to keep it aerated, and thereby help to keep iron in the ferric form. Similarly, regular flushing of fresh water through the fields would tend to wash away the iron rather than have it accumulate. The problem here is that the management of many of the valleys is such that there is no available surplus water for doing this."

"It is important for us to view iron toxicity holistically," continues Audebert. "For example, if iron were the only issue, we might easily recommend flushing of fields and thorough draining to below the soil surface. However, one of the basic principles of improved water management in lowlands is the use of standing water to control weeds—a situation that clearly has the potential

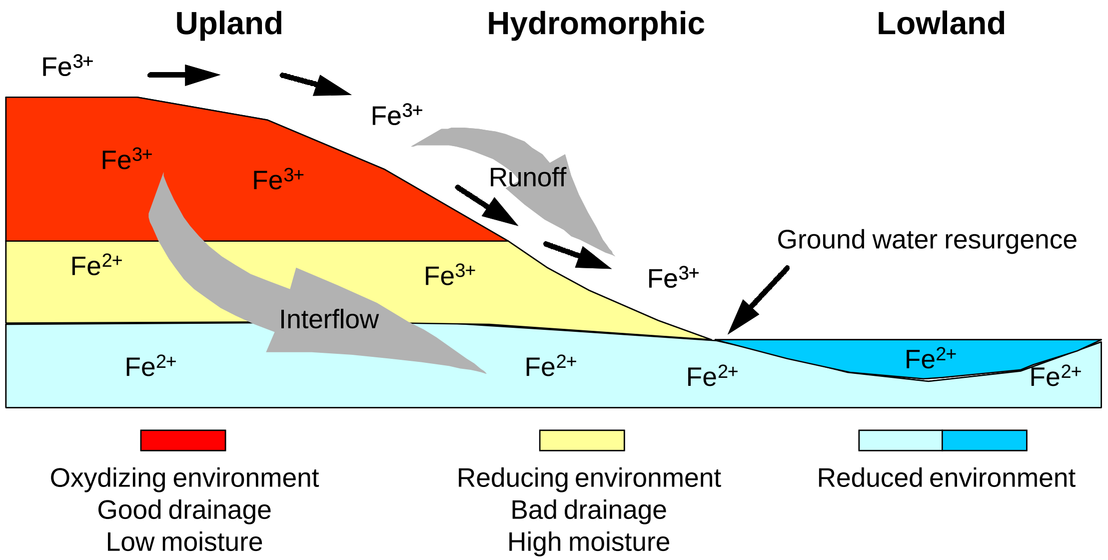


Figure 5. Cross-section of toposequence showing movement of iron and reduction process

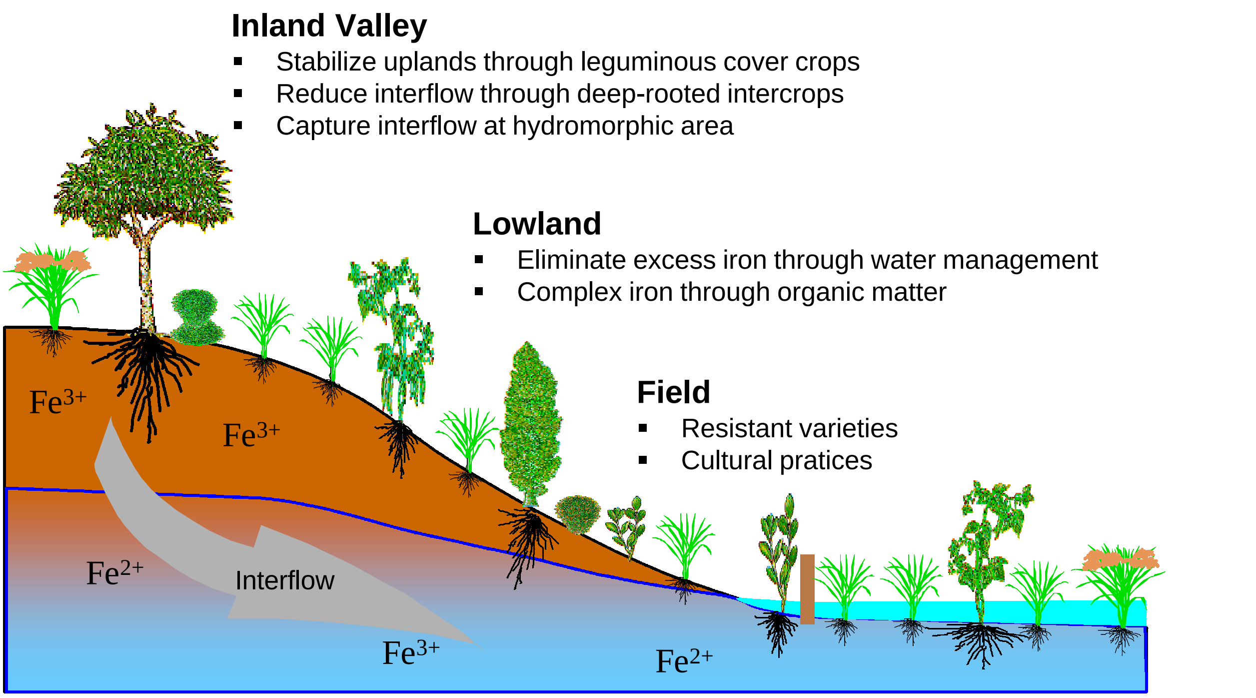


Figure 6. Toposequence diagram showing options for reducing iron movement and toxicity

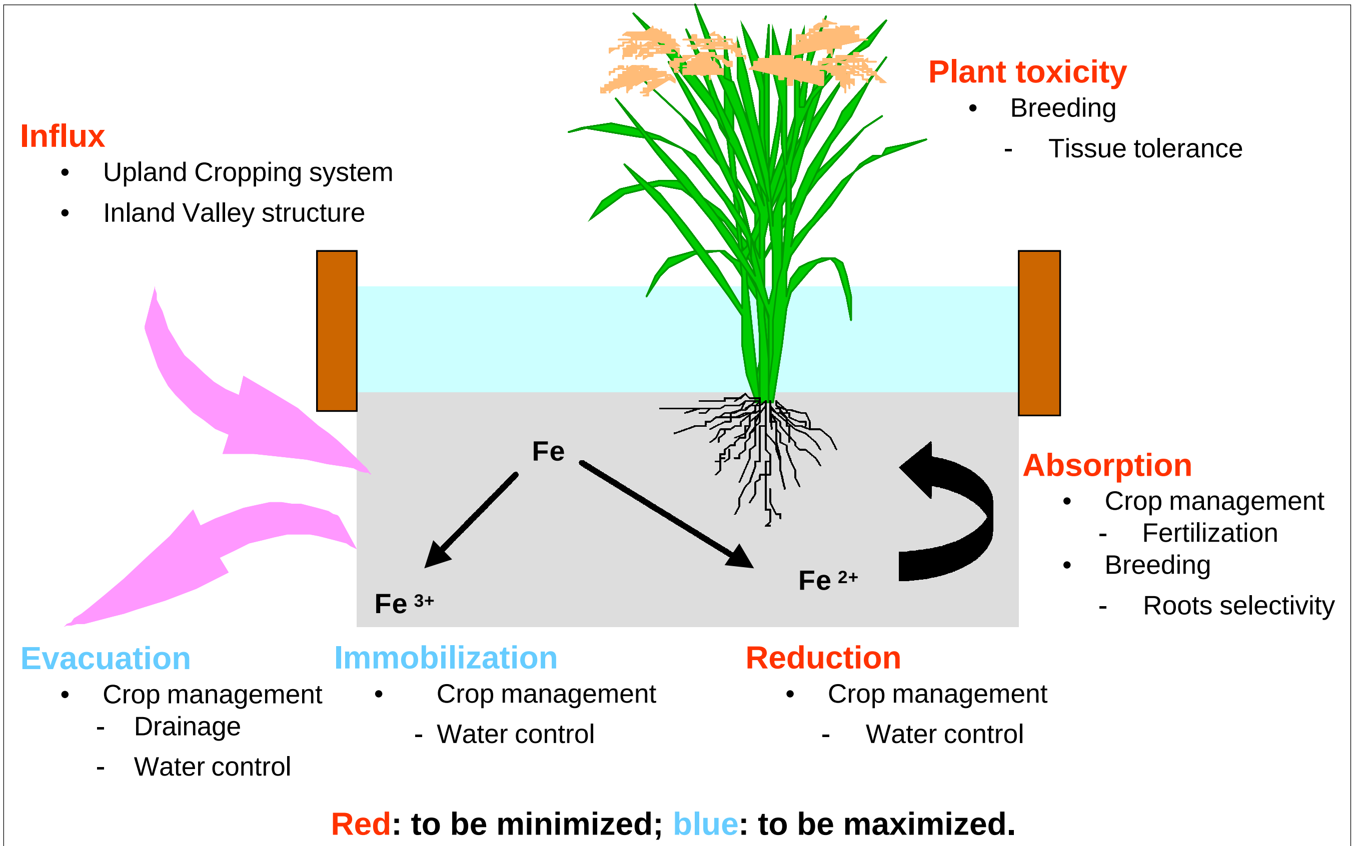


Figure 7. Summary concept of field level processes and sites of intervention to alleviate iron toxicity

to exacerbate iron-toxicity problems." Improved water control in the field would enable better drainage, taking some of the ferrous iron out of the rice root zone, but the infrastructure required for deep drainage is too expensive for most farmers in the region. Audebert and his team have shown that planting on ridges in iron-toxic sites can improve rice yields. This is a result of the rice roots being in an aerobic soil environment above the waterlogged level. In fact, this technique is already used by farmers in Guinea, Guinea Bissau and Senegal to increase yields on iron-toxic fields. Again, however, in those areas where ridge-planting is not a traditional practice, the different field preparation would incur costs (especially labor) that farmers can ill afford.

The team tested the effects of improved water control through bunding at the Korhogo test site. Four varieties tested gave average yield gains of 0.7 t/ha in bunded fields (*see* Table 1). "Since we did not have a non-toxic check plot, we cannot attribute this yield increase to any effect of bunding on iron toxicity itself," explains Audebert. "However, bunding is improving yield at the iron-toxic site by an average of 30%, and that is significant."

Table 1. Effect of variety and bunds on rice yield in iron toxic condition (Korhogo, Côte d'Ivoire, 2001).

Variety	Yield (t/ha)		
	No bunding	Bunding	Difference
TOX 3069	3.28	4.39	1.11
CK4	3.44	4.11	0.67
Bouaké 189	2.55	3.03	0.48
CG14	2.70	3.17	0.47
Mean	2.99 b	3.88 a	0.68

Flooded field with high iron concentration

Since iron toxicity is a nutrient disorder, one might reasonably expect some impact of improved soil-fertility management on rice yields at iron-toxic sites. Former WARDA Soil Chemist Kanwar Sahrawat investigated this issue in the 1990s. "It is much easier to add nutrients to the field, than to take something away," he explains. "Therefore, we looked at the effect of various fertilizer regimes on rice yield of a susceptible variety at the iron-toxic site of Korhogo in northern Côte d'Ivoire." When the variety was fertilized with a 'complete' fertilizer—nitrogen, phosphorus, potassium and zinc—at Korhogo, a yield increase was achieved, but modeling showed that this level is still way below potential (*see* Box 'Computer simulation of iron toxicity,' page 35). "Rather better results were obtained from the use of organic matter," says Sahrawat, "but organic matter (in the form of manure) is not easy to find in many parts of the region, so cost considerations mean that lowland-rice farmers are unlikely to use it."

What does the plant have to offer?

"It is quite depressing," sighs Audebert, "to know that there are several ways of reducing the iron problem, while at the same time knowing that few, if any, of the options are currently practical on a typical West African lowland rice farm." As is so often the case when dealing with resource-poor farmers, much of the burden for finding a solution gets pushed back to breeders. After all, a rice that can cope with a problem like iron toxicity needs only to be distributed to farmers in affected areas, and they can improve their yields almost immediately.

"The problem is," explains WARDA Lowland Rice Breeder Howard Gridley, "that breeding takes time. However, some progress has been made, and there are useful varieties out there for the breeding program. For example, 'traditional' varieties [that is, varieties that have been grown and selected by farmers for many years—what some call 'landraces'] tend to have a reasonable level of iron-toxicity tolerance." The main problem is that some of the initial varieties to come out of breeding and introduction programs, and that are now popular and widespread, are susceptible. For example, Bouaké 189, which is the most widely grown lowland variety in Côte d'Ivoire.

The WARDA lowland breeding program that began in Nigeria had some success. WITAs 1, 3 and 4 are all considered moderately tolerant of iron toxicity, or it may be more accurate to say that they are adapted to sites with moderate iron toxicity. They have each been released

Computer simulation of iron toxicity: what can it teach us?

In the early 1990s, members of the then Problem Soils Task Force (now part of the expanded Natural Resource Management Task Force of ROCARIZ) identified iron toxicity as one of the major soil problems in rice throughout the region. "Despite the unanimous vote by Task Force members to include iron toxicity among the regional research priorities," explains WARDA/CIRAD Plant Physiologist Alain Audebert, "there were no available data on the impact of the problem, or its effect on rice yields."

At that time, WARDA already had experience of adapting the crop model Oryza, which predicts potential yield of a variety from climatic data and variety-specific photothermal constants. Consequently, Oryza was adapted for variety Bouaké 189 and simulations run with climatic data for the two test sites in Côte d'Ivoire—Korhogo (iron toxic) and M'bé (non iron toxic)—to predict potential yield from sowing in each month of the year. The iron-toxicity effects were *not* built into the adapted model, which predicted that potential yields for the two normal growing seasons (sowing in February and July) were similar at the two sites. Subsequently, Bouaké 189 was itself grown in the field at the two sites for four seasons.

It can be seen from the graph (Fig. 8) that actual yield at M'bé was in fact 1.7 tonnes per hectare less than full potential. If we take this as a standard difference between potential and farm-realizable yields, and apply the same to the results from Korhogo, we discover a further yield gap of 3.3 t/ha, which can mainly be attributed to the effect of iron toxicity at the Korhogo site.

"These simulations were made using optimal fertilization," explains Audebert. "When he altered the fertilizer doses in the field, Sahrawat noted a significant increase in yield with full fertilization (*see* main text), but the final yield was still a long way below potential as demonstrated by the simulation of optimum fertilizer application at M'bé (*see* Fig. 9). In fact, the fertilizer is acting as a yield-enhancer *despite* the presence of iron toxicity. In this way, it operates like the improved water management through bunding (*see* main text)."

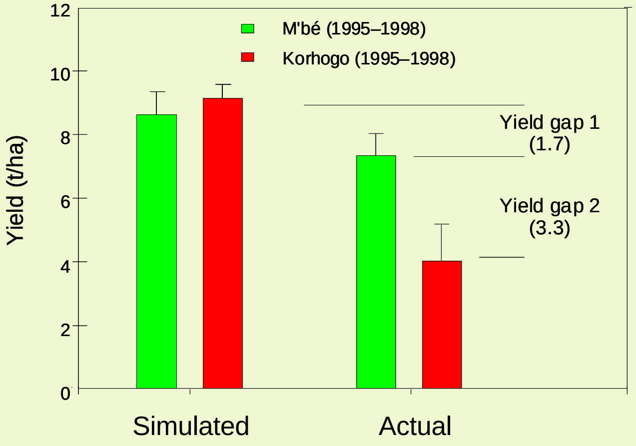


Figure 8. Yield losses due to farm practice (modelled) and iron toxicity (actual)

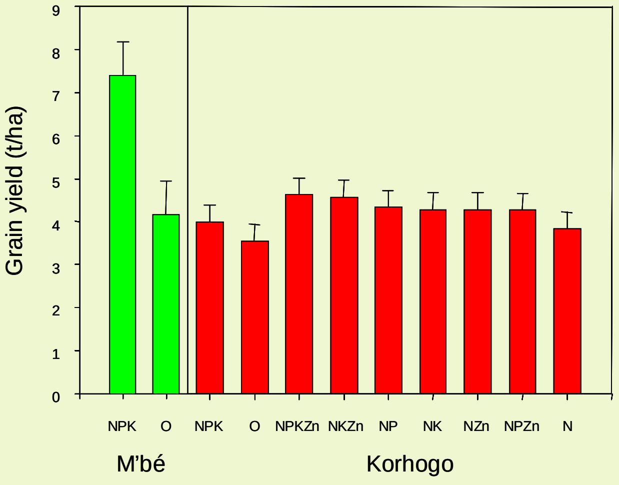


Figure 9. Actual yield of fertilized plots under iron toxicity (Korhogo) compared to potential yield without toxicity (M'bé)

in one or more of the countries of the region for such situations. “Even better,” says Gridley, “is WITA 12, which is undergoing advanced trials in several sites in Côte d’Ivoire.”

Meanwhile, characterization of the *Oryza glaberrima* genepool used in the NERICA program has shown that CG14 is highly resistant to iron toxicity. “Initial screening of NERICAs has revealed several that are iron-toxicity tolerant,” says Gridley, “but iron-toxicity will be a more important target for the ongoing development of lowland NERICAs from *indica* (lowland) varieties of *Oryza sativa*.”

What is going on inside the plant?

As modern plant breeding becomes increasingly complex, researchers want to know exactly how resistance or tolerance to a stress works. Finding out the mechanism behind a variety’s resistance is the first step in working out which combinations of plants should produce high levels of resistance by blending their mechanisms. It is for this reason that iron-toxicity research was given its own project back in 1997, and one of the main foci of Alain Audebert’s eight years at WARDA.

“If two plants can produce different yields in the same iron-toxic field,” says Audebert, “we hypothesized that the tolerant/resistant plant may be preventing the entry of ferrous iron at the roots, it may be distributing the iron among its own parts differently, or else is expressing some tolerance mechanism at the tissue level. So, these are the approaches we have adopted: uptake, partitioning and tissue tolerance.” For breeders who want to combine resistance mechanisms, the ideal situation would be that all three types of mechanism occur in different varieties. “We have discovered that some varieties ‘create’ oxidizing conditions around their roots,” says Audebert. “This causes some of the ferrous iron to be converted into ferric iron. Consequently, such plants may show a crust of insoluble ferric iron in the root zone.” Varieties with this characteristic are the subject of on-going studies into genetic variability of this trait.

To investigate the role of distribution of iron among plant parts, a tolerant variety (CK4), a susceptible variety (Bouaké 189) and a very susceptible one (TOX 3069) were grown in adjacent plots in an iron-toxic field. Results were consistent over three years of study. “The total uptake of iron did not differ significantly among the cultivars,” says Audebert, “showing that for this particular tolerant variety there was no barrier to absorption at the roots. However, there were significant differences in the partitioning among the plant organs.” While the varieties had similar iron concentration in their roots, the tolerant variety partitioned more iron into its stem and dead leaves, leaving the green leaves significantly freer of iron than those of either the susceptible or the very susceptible varieties (*see* Figure 10). What is more, a direct correlation was evident between iron concentration in green leaves and final grain yield.

“Iron is an important component of a plant’s energy-powerhouse chlorophyll,” says Audebert, “it also interacts with all the major enzymes and proteins that make up a plant’s biochemistry. We should therefore expect iron toxicity to affect photosynthesis and other biochemical processes one way or another.” The same experiments that showed the differential partitioning of iron among plant organs, also revealed that the green leaves of the susceptible variety became thinner at higher green-leaf concentrations of iron, whereas those of the tolerant variety did not. This leaf-thinning may result from, or in, reduced photosynthesis, and therefore reduced plant growth. Audebert again: “We are currently working on a hypothesis that an excess of iron in the green leaves disrupts photosynthesis. This may be via disruption of chlorophyll synthesis, or by direct action of the process of photosynthesis itself.” This is the work of PhD student Chérif Madougou from the University of Cocody (Abidjan, Côte d’Ivoire), who started working with the WARDA physiology team in 2001.

Audebert continues: “We are also looking at the form that iron takes within tolerant varieties. What we call ‘tissue tolerance’ may well be related to the tissues’ and

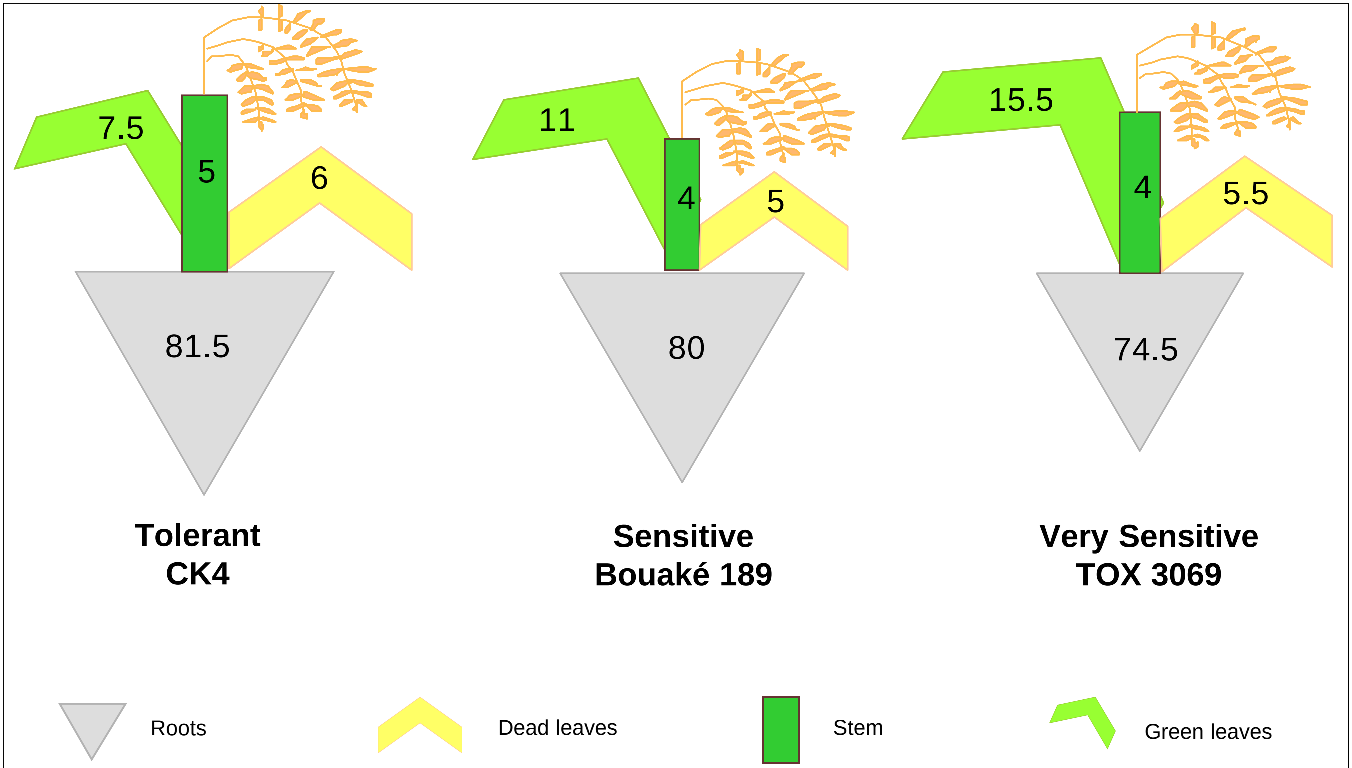


Figure 10. Differences in iron partitioning in different varieties (% total iron content in each organ)

cells' abilities to immobilize the ferrous iron through, for example, chelation—that is, binding of the metal molecule (in this case iron) to an organic compound, thereby rendering the metal unreactive."

"The work of Drs Audebert, Sahrawat and others over the past eight years or so has been crucial to our understanding of iron toxicity," says WARDA Director General Kanayo F. Nwanze. With the upcoming departure of Audebert in 2002, we will be closing a significant chapter on basic research into this issue."

"Given the weight placed on research into this issue by our national partners through the ROCARIZ Task Forces, we plan to wrap-up this phase of the work with a workshop in the second half of 2002," says Audebert. The workshop will be hosted by WARDA at its headquarters in Bouaké, and should result in a detailed state-of-the-art summary of iron toxicity in rice in West Africa.

"From 2003, it is likely that our emphasis on iron-toxicity research will move from strategic to adaptive," explains WARDA Director of Research Günther Hahne. "In practical terms for WARDA, this will mean moving the work from its own special project into the broader projects on lowlands and watersheds."

Policy Dialog in Rice Food-Security in West and Central Africa

IN THE wrong economic environment, any 'economic' activity may not be viable—rice farming in West Africa is no exception. WARDA is ideally placed to influence governmental policy in its member states, simply because it is a political Association in its own right. WARDA economists investigate the whys and wherefores of every aspect related to rice farming and marketing, with a view to providing vital information to help national governments provide good policies for their rice farmers. It is a political tightrope, but somebody has to be there to represent the lowly farmers at the highest levels, and we feel it is our duty to fulfill this role.

The problem of the 'new' crop

As recently as 1993, an external review of WARDA felt it necessary to answer the question: "Is there a need for an international effort in rice research in West Africa?" The question had been asked many times before, and arose partly from the misconception that rice was not an indigenous crop of the African continent, but had rather been introduced from outside. Even today, many people still consider rice to be a 'new,' or non-traditional, crop in Africa. All the time, the reality is that rice—at least the indigenous African rice (*Oryza glaberrima*)—has been cultivated on the continent for at least 3500 years. What is more, the populations of the countries of the western coastal belt—The Gambia, Guinea Bissau, Guinea, Sierra Leone, Liberia and western Côte d'Ivoire—have been consuming rice as a staple for a long time. Rice made up 46–85% of their cereal intake in the 1960s!

Still today, however, the label of 'new' dogs efforts to promote rice-sector development in the region, while the people themselves make demands on the market that local production cannot match.

However old rice might be as an African crop, there is no denying the sharp upturn in consumption in West Africa since the 1970s. While most developing countries around the globe were experiencing 'stable' growth in rice demand at 3% per year between 1975 and 1983, the *average* growth rate in West Africa was over 10%. This figure, however, masks a great diversity among the countries. Demand grew rapidly in some non-traditional rice consumers—for example, Nigeria experienced 25% per year growth rate. Yet, even some traditional rice-consuming countries experienced fast growth, such as Côte d'Ivoire at 15%.

Causes and effects

If we compare these figures with those for population growth over the same period, it is clear that simple population growth is not responsible for these huge increases in demand, as that averaged 2.5–2.7% annually.

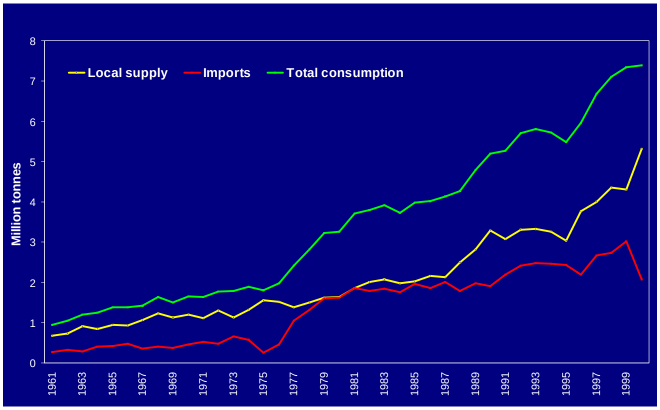


Figure 11. Rice trends in WARDA Member States, 1961–2000 (Source: FAO-STAT 2001)

One major feature of the 1970s was the droughts that affected the sub-region. The worst affected zone, the Sahel, is where many of the traditional cereals are grown—for example, millets and sorghum. The droughts inflicted widespread crop failure, so large quantities of cereal had to be brought in just to keep people alive. Rice was a major component of the cereal imports at that time.

The droughts also resulted in a certain amount of migration from rural to urban areas, especially in the coastal areas. Migration imposes major changes on a person's lifestyle. For example, the immigrant is almost always no longer in close contact with his (or her) extended family. This has an immediate effect on the foodstuffs of choice—for example, processing a traditional staple food such as yam is time-consuming; if it is being done for a large family it may be worth the investment, but for just a few people it may reasonably be considered too time-consuming. Time is a valuable commodity to an urban dweller. First, he (or she) has less of it, because he is working to earn a living and also has to travel to and from the place of work. So urban dwellers tend to opt for foods with short preparation times. Second, 'natural' resources easily available in a rural village context—such as wood for fuel—are not so abundant in towns. If fuel is suddenly a scarce commodity, it makes sense to opt for foodstuffs that use less of it, in other words, foods that cook quicker. In addition to everything else, most urban dwellers have to buy their food where their rural counterparts produce their own. Thus, at least initially, an extra attraction of rice was the low cost of the imported grains.

"The importance of the time factor in townspeople's preference for rice over traditional staples," explains WARDA Policy Economist Frédéric Lançon, "is shown in the fact that preference is retained even if the price of rice increases." For example, a consumption survey carried out in Burkina Faso after the devaluation of the CFA franc showed that even after the price of imported rice increased, consumers maintained their consumption level at the expense of other food.

Between 1975 and 1985, rice imports to West Africa rose from 400,000 tonnes per year to 2 million tonnes. Meanwhile, the sub-region went from producing 72% of the rice it consumed in the 1960s, to 59% in the 1980s.

The response

Naturally, national governments became concerned about their countries' dependence on imports of a basic food commodity and set about revitalizing the rice production sector.

In the 1960s and 1970s, that pinnacle of agricultural success had been reached, as the Green Revolution swept the production of wheat and rice to new heights, especially in Asia. "Fortuitous," any agriculture minister in Africa might have thought, "that the crop we so want to revitalize is doing so well." The solution was easy: bring the Green Revolution rice varieties in to Africa, establish vast irrigation schemes, and watch it all take off!

In fact, the idea of importing exotic solutions to Africa's agricultural problems was nothing new. The same had been seen in the colonial days of the mid-1900s. However, the colonials had failed to provide a sustainable

High visibility was popular among national governments and donors alike

system, mainly because they imposed their ideas on the local farmers, and managed everything themselves. When they left, they took the know-how with them and everything collapsed. But, surely the Green Revolution was something different... or was it?

The construction of large irrigation infrastructures was equally supported by the donor agencies—after all, those were the days when donors wanted visibility in the recipient countries, and there's little more visible than a huge dam and associated irrigation structure!

So, national governments and donor projects established numerous irrigation schemes throughout the region, while providing overall management and support for each scheme. "One thing that history teaches us," a wise man once said, "is that we learn nothing from history." Farmers were 'taken on' much as employees of the schemes—they had no ownership stake in the fields they farmed and had no responsibility for management at the scheme level. With no responsibility, farmers had no experience of scheme management, being restricted as they were to their 'own' fields.

The whole concept of rice self-sufficiency was expensive: on one side, the governments were subsidizing the production through support and maintenance of the schemes and provision of inputs, while on the other side, they were controlling the market price of rice to ensure that consumers could afford to buy it! Thus, at various times from the mid-1970s onwards, governments faced economic crises and had to cut their allocations to scheme maintenance and production support. As governments and projects pulled out of scheme management, the fact that the farmers had no experience in scheme management meant that the systems deteriorated rapidly.

Then, in the 1980s, governments were 'forced' into economic reforms, especially those associated with Structural Adjustment. One immediate effect of these reforms was the liberalization of trade. This has been an on-going process since Structural Adjustment, and is becoming more and more regulated under the World Trade Organization. The effects of economic reforms were exacerbated when Indonesia attained rice self-sufficiency for the first time in the mid-1980s (up till then it had been a major importer of rice), which contributed to a major downturn in the world rice price, rendering domestic production difficult to support in the face of cheap imports. By the mid-1990s, international aid had been drastically reduced and the geopolitical climate in Africa had changed significantly; governments no longer felt the need for a 'soft' approach and hardened their economic reforms. By the end of 1995, most African governments had completely dismantled support to rice production. Thus, the whole issue of the competitiveness of local rice production against cheap imports was raised. Can local production without governmental subsidy compete with cheap rice on the world market?

When market liberalization began in the mid-1980s, the world price for rice was increasing. This provided an incentive for farmers, and resulted in an increase in domestic rice traders and retailers. Despite the devaluation of the CFA franc and other West African currencies, the price of rice imports dropped in 1998, favoring importation. Meanwhile, rural–urban migration fueled an increase in rice consumption. In addition, the removal of Nigeria's rice-import ban led to a sharp increase in rice imports into that country alone, from 300,000 tonnes in 1993 to about 1.5 million tonnes at the end of the 1990s.

Thus, projections of rice production and demand for the region predict an alarming increase in rice imports during the first decade of the twenty-first century, initially to about 4.5 million tonnes in 2010 to anywhere between 6.5 and 10 million tonnes by 2020. There are serious questions as to whether national economies will be able to sustain these levels of imports. So, the need to increase local rice production becomes both an economic and a political issue. Meanwhile, changes are underway in Asia that will seriously affect the volume of rice surplus that is exported. In particular, Asian countries are diversifying their agricultural production toward crops other than rice; limits are being set on rice areas, as increasing urbanization puts increasing demands on productive land and water; domestic demand continues to increase with increasing population levels (although per-capita consumption is stagnating). This is an additional incentive for West African states to diminish their reliance on the world market for staple food supply.

Enter WARDA...

WARDA was established in 1971 in the wake of the Green Revolution in Asia. Founding member states wanted a mechanism whereby the Green Revolution technology could be imported and used locally. The timing was fortuitous, as the boom in rice consumption in the sub-region really began in the mid-1970s.

As early as 1978, WARDA commissioned a team from Stanford University (USA) to conduct a comprehensive study on the competitiveness of domestic rice-production systems in five West African states. Subsequently, WARDA economists and students conducted repeat studies in the mid-1990s to see the evolution in competitiveness. One of the measures used was the Domestic Resource Cost ratio, or DRC, which measures the socio-economic profitability of domestic rice production (*see* Box 'Domestic Resource Cost ratio' for definition). Over 15 to 20 years, all countries studied showed a positive trend (that is, decreasing DRC, *see* Table 2). In that period, Côte d'Ivoire moved into a position of comparative advantage in rice production, while Mali and Sierra Leone improved theirs; only Senegal remained in a state of disadvantage.

Domestic Resource Cost ratio

The Domestic Resource Cost ratio, or DRC, measures the ratio of domestic factors used to produce one unit of rice (e.g. labor and capital invested in the production) to the added value generated by this unit of rice (i.e. the value of the production minus all the investment costs, e.g. seed, fertilizer, energy). The DRC is estimated using social prices—that is, prices that would prevail in the absence of government intervention on input and output markets (e.g. subsidies on fertilizer sales price, duty on rice imports) or market failure (monopoly). If the ratio is greater than one, more domestic resources are invested in producing the rice than the added value generated by the production activity—there is no comparative advantage in producing rice and the domestic resources would be more efficiently utilized if allocated to another productive activity. Conversely, if the ratio is below one, the rice is produced using less domestic resources than the added value generated—rice producers do have a comparative advantage.

Table 2. Changes in Domestic Resource Cost ratios.

Country	1978	1993	1995	1996
Côte d'Ivoire	1.68	1.02	0.73	
Mali	0.69			0.40
Senegal	1.66			1.12
Sierra Leone	0.89		0.55	

Sources: CERDI Université d'Auvergne; Stanford University; WARDA.

Drying rice on dusty streets exposes it to dust and stones, reducing the marketing quality

Improved processing technology exists, but it is not operated at optimum capacity because of lack of incentive to produce high-quality grain

The improved competitiveness of domestic systems may be partly explained by improved productivity, and partly by reduced production costs. Significant contributory factors have been the devaluation and depreciation of West African currencies against the US dollar, and the upward trend in world rice prices seen in the early 1990s.

"Competitiveness is a complex issue," says Lançon. "For example, transportation is a major expense for the market cost of any product, including imported rice. So, in coastal countries like Senegal, imported rice is highly competitive, while in landlocked countries like Mali the price of the imported rice is inflated by the overland transportation costs." Of course, these sorts of economics apply to all products almost everywhere in the world. "The same trend can work against producers in remote locations," continues Lançon, "whereby the cost of transportation to market may make marketing unprofitable for the unfortunate farmer." This, in turn, may be a major disincentive to remote farmers increasing their rice production.

"In many countries of the subregion, quality of local rice is a major issue," says WARDA Impact-Assessment Economist Aliou Diagne. "Local rice has acquired a reputation for being markedly inferior to imported rice, and so suffers as a result." Senegal is a case in point, where in recent years, local production has gone to waste, while consumers buy huge quantities of imported Asian rice.

The lesson here for WARDA, and the countries that it is trying to help, is that the rice sector has to be viewed and adapted holistically. "Policy on its own can contribute nothing," says Lançon, "although 'poor' policies may make aspects of the rice sector unattractive and ultimately untenable. Policy should be used rather to enable the rice sector to function. Farmers need encouragement, if not incentive, to improve their productivity and quality of their product. Processors need the same type of encouragement to improve the quality of their work, and the main incentive is going to be profit. If the consumers continue to view local rice as an inferior product, increasing production may not help. However, if governments step in at every level—to help farmers improve yields, to help processors improve quality, and to publicize the improved quality of local products to the populace—then everything should work together for everyone's benefit."

It is not enough, however, for WARDA to use its analysis tools and then hand over the results to those who should use them. The policy-makers themselves need to be able to understand, interpret and draw their own conclusions from policy analyses. "Participation is crucial," says Lançon. "It is important that all rice stakeholders understand the value of policy analysis, but also that they are involved in policy dialog. WARDA can provide the policy-analysis tools and training in their use and interpretation."

In the overall policy-dialog arena, WARDA has certain advantages over national systems, mainly because of its status and role within the subregion. Specifically, WARDA is a research center with a mandate to conduct rice research, including policy research; it is also an intergovernmental association of member states and, as such, has political support from its member nations. Despite this, however, it is physically *outside* of the national political boundaries. "From our position, we can bring together representatives from different ministries within countries who would otherwise not necessarily work together," says Lançon. "For example, we played an intermediary–facilitator role of bringing together ten types of stakeholder in Nigeria to discuss priorities for research and policy" (*see* Box 'Case Study: Nigeria').

Having won the battle againts diseases, insects and weeds in the field, local rice may still not be able to compete with imported products in the marketplace

Small-scale paddy dehullers provide the bulk of processing capacity in Nigeria

"WARDA and its partners have the technologies," emphasizes Director General Kanayo F. Nwanze. "For example, the NERICAs to improve productivity in the rainfed uplands, the Sahels and other varieties for the Sahel irrigated ecology, the thresher–cleaner to improve output quality at the farm level. The same concept of participation that has been used to develop and disseminate these technologies needs to be applied to policy dialog."

With USAID funding, WARDA has embarked upon a major rice-sector review for Nigeria with just this kind of holistic view (*see* Box 'Case Study: Nigeria'). "If we can achieve sub-sector integration in Nigeria, with appropriate policies in place for overall rice-sector development, we will have a model to apply elsewhere in the subregion and beyond," Lançon concludes.

Case study: Nigeria

"If WARDA cannot do something to help Nigeria, we might as well give up!" says Director General Kanayo F. Nwanze. "These words might sound harsh, but the potential for rice in Nigeria is huge, and for WARDA to ignore Nigeria would be to cut off half its potential impact." And this is no exaggeration from a native Nigerian. Half of the subregion's population lives in Nigeria and half of the subregion's rice area is there.

Thirty years ago, agriculture was the economic mainstay of the country, contributing 70% of the GDP. In the 1990s, it contributed a mere 30%. Rice itself has moved from being a luxury good to a staple food. Consumer demand has grown at an average of 6% per year. The country that was self-sufficient in rice in the 1960s, has become completely import-dependent. Imports of rice in 1999 alone amounted to one million tonnes, which cost the country half a billion US dollars.

Potentials and constraints

"Nigeria is like a miniature version of the whole subregion," says WARDA Production Economist Olaf Erenstein. "It stretches from the coastal rain forest in the south to the Sahel in the north." Within the agro-ecological zones, every type of rice farming known in the region is possible—mangrove-swamp and deep-water, rainfed upland and lowland, and fully irrigated. However, all rice ecologies in the country are plagued by low and decreasing yields, partly as a result of increasing production costs and lack of available inputs (mainly fertilizer). In the irrigated sector, there are reports of capital-intensive infrastructure established in the 1970s and 1980s having been abandoned!

"Another area of serious concern is marketing," says Erenstein. "Local rice has a very poor market image compared to imported rice." There are various reasons for this, not least of which is grain quality—post-harvest handling and processing of local rice introduce foreign bodies (especially stones), which consumers find unacceptable. Consequently, local rice suffers a 20–30% price penalty on the market. To make matters worse, compared to readily available imports, local rice supply is irregular. "The whole marketing system has become a vicious spiral," continues Erenstein, "with poor quality driving poor prices and market image, and consistently poor prices acting as a disincentive for producers to improve their product."

"Clearly, sweeping changes are needed," says Policy Economist Frédéric Lançon, "and many of these will need to be at the policy level, so that they can be enforced. Otherwise we stay with the status quo."

Rice sector study

WARDA is implementing a two-year rice-sector project, funded by USAID, with the aim of formulating a sound and economically viable strategy for the Nigerian rice economy. The specific objectives of the project are:

- to provide an up-to-date analysis of the Nigerian rice economy—to describe, document and analyze the major trends and underlying constraints, their causes and effects;
- to identify opportunities for developing the rice economy, including possible solutions to the major constraints, and 'windows' of opportunity;
- to develop a strategic plan for the development of the rice economy within a competitive world;
- to lay the groundwork for subsequent implementation of the strategic plan.

In the first year (November 2000 to November 2001), available published data were reviewed by Visiting Scientist Godwin Akpokodje of the Nigerian Institute of Social and Economic Research (NISER). Akpokodje also helped in an institutional and policy review. These reviews resulted in a state-of-the-art paper. At the same time, rice-sector stakeholders were identified and consulted with a view to forming a partnership. In November 2001, a first stakeholder workshop was held bringing together all the appropriate parties to review the outcome of the first year of project activities, and to plan the follow-up activities for year two.

Rice policy in Nigeria

"Over the past 30 years or so, the rice sector in Nigeria has been characterized by active government participation and serious inconsistency," says Akpokodje (*see* Figure 12). "The swings back and forth between liberal and protectionist policy are counterproductive for the rice sector, as stakeholders at all levels are unable to make long-term planning."

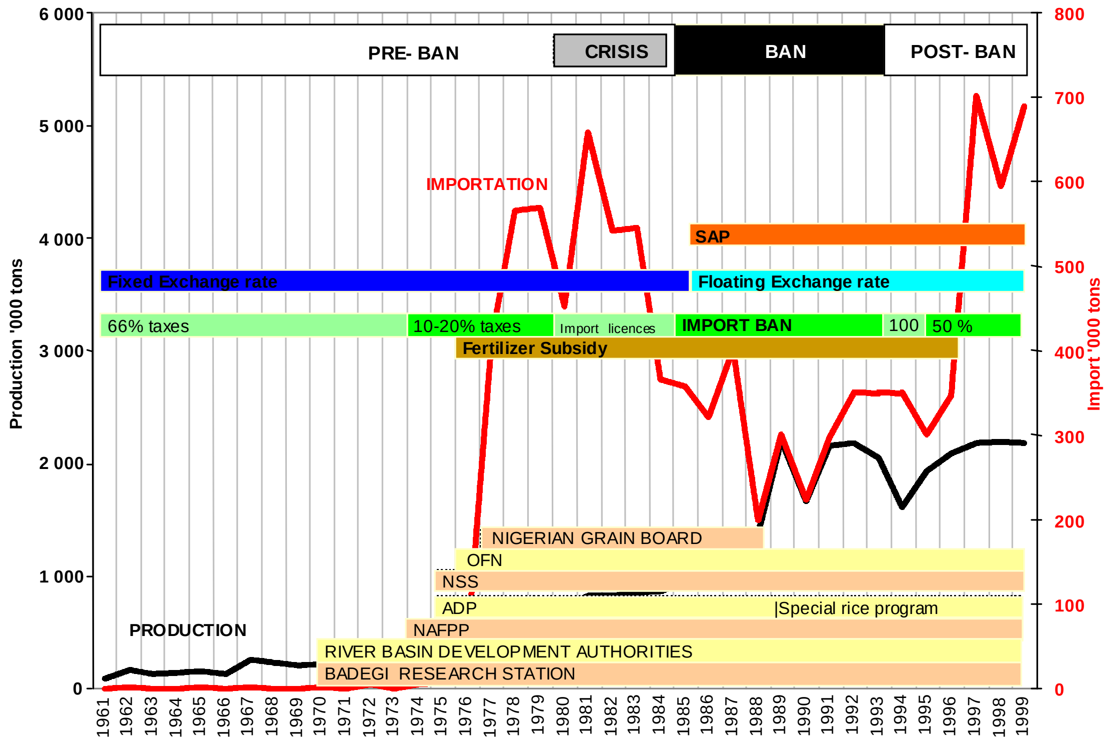
"While trade policy has been viewed as the major option for sector development," continues Lançon, "supporting policy to take advantage of the protection afforded at various times has been completely lacking."

The value of the rice sector project is that it should provide the basis for medium- to long-term stability. "WARDA has technologies and experience in many areas where improvement is needed in the Nigerian rice sector," says Nwanze. "Yes, policy has a major role to play, but it is in creating the enabling environment that policy plays its key role. Nigeria is already a pilot country within the African Rice Initiative (*see* 'The African Rice Initiative: taking the NERICAs to Sub-Saharan Africa,' pages 9–14) and NERICAs are a major component of what we have to offer, but there are crucial issues to address to make the whole rice sector viable and sustainable."

Given what has been learnt in the sector study so far, it is likely that WARDA will recommend targeting of policy and technology; all too often, blanket recommendations and policies do not allow the potential to be reached in any particular ecology or sector. Development of the whole rice sector will surely be dependent upon improving farmers' access to inputs, and making such access sustainable. Credit will also be a vital issue here. The issue of local rice marketability will require a major drive to improve processing capacity and quality, which itself may require financial support and training. At the same time, a massive awareness campaign is going to be needed so that consumers are made fully aware of the improvements in local rice quality and therefore become more inclined to buy it.

"This looks like a tall order," concludes Nwanze, "but I honestly believe that Nigeria can, and should, become a powerhouse of rice production in the subregion and set an example for other countries to follow."

Figure 12. Nigerian rice policy sequence



Mainstreaming HIV/AIDS into Agricultural Research and Development

HIV/AIDS IS a global catastrophe. It affects every sector of society, and agriculture is no exception. FAO estimates that 7 million agricultural workers have died of AIDS world-wide, without counting those debilitated by the disease or impoverished by the loss of labor. The CGIAR recognizes that the time has come to include HIV/AIDS in its agenda, and WARDA is playing a lead role in this System-wide initiative.

It is estimated that 25 million Africans are already infected with HIV. Most of those are in the 'prime' of their lives, in the age group 15 to 49 years old—the main labor force of agricultural economies. HIV and AIDS occur in every country, and numbers are increasing, with new cases of people becoming infected *daily*. Burkina Faso, Cameroon, Côte d'Ivoire, Nigeria and Togo have already reached the 5% 'threshold,' at which point a significant portion of the working population starts to succumb to the disease.

As the largest employer in the region, agriculture will suffer as much as any other sector. The labor force will be reduced due to death and debilitation of working-age people. Farming families will suffer from loss of labor and subsequent loss of income, the poorest will find it difficult to produce enough food to subsist on.

A case in point

The scene is one of apparent tranquility: Nancy Ngozo* sits in the shade of a kola-nut tree in the midst of her family's land. Close by, her mother cradles Nancy's baby daughter, while her niece hovers shyly within arm's reach. Yet only two years before, the Ngozo family's lives were turned upside-down by the death of Nancy's father. In just a few short years, they have gone from being moderately well off and almost self-sufficient in food to having meager income and not enough time to grow much in the way of food crops.

"When my father was ill," explains Nancy, "I had to give up secondary school to take care of the farm." She has never gone back to her education, and now runs a small marquee (food kiosk) in the village of Hakena to supplement the family income.

Hakena village did not exist until about 30 years ago. WARDA Agronomist and HIV Focal Point Frank Abamu explains: "In the early 1970s, the national Government invested in oil-palm plantations on a large scale. These villages, only 30 km from an international border, were a direct product of the scheme's need for laborers on site." Consequently, Hakena is cosmopolitan, with at least

*Names of people (except WARDA staff and collaborators), places and companies have been changed throughout to protect identities.

Case studies

Marie-France and Claudette were both married to Jean-Paul Ouattara, who was a relatively senior employee of Oilpalm, Inc. for about 20 years, until illness set in in 1994, resulting in his death in 1999. Marie-France and Claudette were 'lucky' in that, because Marie-France works in the oil-palm nursery of Oilpalm, Inc., they were able to stay in the village; however, Marie-France's position only entitles her to the lowest category of housing—a single room. "These two women have had to cope with a serious downgrade in their socio-economic position," explains Tveteraas, "they live in a smaller house, eat lower-value food, and are now separated from three of their children." Before his illness, Jean-Paul had maintained a 'cottage garden' with maize and yams, which provided the family's staple diet. Then, they were nearly self-sufficient in food, but they had to give up the vegetable growing because they had no time to do it, so now they have to buy all their food requirements. In Jean-Paul's days, the family regularly ate meat, chicken and fish; today, fish is a rare luxury, and they can never afford meat or chicken. The eldest son is a nurse in their home country, and now looks after three of the younger children, simply because schooling there is cheaper than it is in Hakena. Claudette—the younger widow—works in the Hakena market and so makes a daily income. She manages this by being a member of a savings club—she contributes 5000 CFA (about $7) per week to the club of ten women, then once every ten weeks receives her 'savings' as a lump-sum of 50,000 CFA (about $70).

"These women are coping well," explains Tveteraas, "partly because of the large social network associated with their former husband. These many friends were particularly helpful during the husband's five-year illness."

Annette's husband was a teacher at the Hakena school and, although not strictly an employee of Oilpalm, Inc., they lived in a good house and ate well. However, Annette is neither a teacher nor an Oilpalm, Inc. employee; thus, she had to give up her house when her husband died in 2000. Annette was able to return to Hakena, thanks to the fact that one of her aunts works for Oilpalm, Inc.; however, the aunt has only a two-room house. Annette returned to her former occupation of making and selling cakes in the market, but whereas this used to provide her with 'pocket money' over and above her husband's teaching salary, she now has to feed and clothe four growing children on her meager income.

five major ethnic groups represented in the population. "What is more," continues Abamu, "many of the workers are either transient or seasonal, and those that aren't will likely spend at least some time visiting their home villages. This makes the village a potentially high-risk area for HIV infection. And that's why we're here."

The Government of Norway sent Astrid Tveteraas to WARDA in August 2001 to do research for her Masters thesis on rural households' mechanisms for coping with HIV/AIDS-related problems. At the end of her third week in Hakena, Tveteraas is frustrated. "There is a whole array of major problems here," she explains, "not least of which is that HIV/AIDS is very much a taboo subject in this community and people simply won't, or can't, talk about it. When we look at coping mechanisms, Hakena is not a place where most bereaved families can actually cope." When a worker falls ill, Oilpalm, Inc. gives them up to 10 months sick leave. "So, if AIDS should strike, the family would most likely have to leave the village even before the employed family member is dead. It is only those who have other relatives employed by the plantation who can venture to stay on" (*see* Box 'Case studies'). To

make matters worse, there are more employees at Oilpalm, Inc's Hakena plantation than there is work to do, so some level of workforce attrition is of no consequence to the company.

"In the time I've been here," Tveteraas continues, "I have interviewed three families in which the male head of household has died during the past three years. To be honest, there's no proof and no real evidence that any of these men died of AIDS or related causes, so all we can do is generalize about the coping mechanisms and impact of death or incapacity of the main bread-winner on the family's financial and overall well-being."

The family Ngozo is one of these, but even there it is likely that Mr Ngozo died from heart-related problems rather than AIDS.

Hakena is hardly a typical African rural setup, where the villagers would be totally dependent on agriculture. This is where the Ngozo family helps with Tveteraas's work: "The Ngozos lived where they do now even before the oil-palm plantation was established," she explains. "They are in fact one of the few families here that *are* dependent on agriculture." But this doesn't make their situation any easier to interpret in the light of Tveteraas's thesis topic. "Their whole economic situation is incredibly complex," continues Tveteraas, "since it is quite possible that they would have suffered economically with the continued downward trend of coffee and cocoa prices, even if the father hadn't died." In the past, the family members ate well, or at least better than they do now; today, they blame a "lack of hands" in part for their reduced diet—Nancy senior is now quite old, and her five other children all live in the nearest big city (about 60 km away). "But even this situation is compounded," says Tveteraas, "as their customs prevent Nancy junior from going near a fire because of her young baby. Consequently, she cannot do any of the household cooking."

It is not all 'doom and gloom' for the Ngozos, however. They have adapted their agriculture to their new situation, and still manage to retain four laborers and their families to work what's left of the farm. They have stopped growing yam, and now only grow enough cassava for home consumption. With the decreasing value of coffee and cocoa, the main cash crop now is oil-palm. "We harvest about one tonne of coffee per year," says the younger Nancy, "and that is sold for about 200,000 CFA [about US$300]." Their cocoa production has been cut to a mere 15 kg a year. Oil-palm is favored because it

Perceptions of HIV and AIDS: challenges and obstacles to research

AIDS is a very sensitive subject that people in West Africa hesitate to talk about. The challenge is therefore to obtain relevant information *without* over-emphasizing HIV and AIDS.

"The inability for the project to collect data specifically on AIDS was evident at all levels," says Tveteraas. "On the technical side, there are no HIV-testing facilities in Hakena or its neighboring villages, but even if there were, most people that I spoke to would not want to know if they were HIV-positive anyway."

There are at least three potential repositories for medical information of the inhabitants of Hakena—the management of Oilpalm, Inc. itself, the clinic and the school. However, each of these refused to divulge any information to the project, even anonymously.

"HIV/AIDS is such a taboo subject that even if someone knew that the disease existed in their family, they would never tell me about it," explains Tveteraas. "From the first fieldwork, I realized that it would be impossible to identify households that had been affected by HIV/AIDS. That is why we decided to focus on long-term diseases that normally resulted in death, and using those to analyze coping mechanisms, which should be essentially the same for families affected by AIDS."

"What we saw in Hakena," says WARDA HIV Focal Point Abamu, "is a taste of the differences between the West African situation, and that in Central and East Africa. There, HIV/AIDS has a longer history and the death toll attributed to AIDS is already marked; in much of West Africa, AIDS is still a relatively unknown factor in the every day lives of farmers. It also gives us a taste of the sort of problems we are likely to face in the rest of the sub-region."

provides monthly, rather than yearly, income. “We have five hectares of oil-palm around the ‘settlement’ and another seven about 3 km away.”

Meat still features in the Ngozo diet, albeit at a reduced level. “We have some chickens,” says Nancy, as we watch a hen and her brood of young chicks pecking about among the coffee trees, “but I don’t know how many. Hawks take some of them.” They also own a goat or two. Thus, they can still manage a meal of meat when one of the other children visits from the city, or on festival days.

The CGIAR HIV/AIDS initiative—the bigger picture

The response of the CGIAR to the HIV/AIDS pandemic has been to launch the System-wide Initiative on HIV/AIDS and Agriculture (SWIHA). Abamu is coordinating WARDA’s contribution to assess the impact of HIV and AIDS on rural agricultural communities. The fact that the initiative is ‘System-wide’ means that it includes several of the CGIAR centers as active players. “To date,” explains Abamu, “thirteen centers and the System-wide Program on Gender and Diversity are involved in the Initiative. As partners, we have on board ministries of health and medical colleges in target countries, sub-regional research organizations (e.g. WECARD/CORAF in West Africa), advanced research institutions, FAO and donor agencies.”

A steering committee has been established to oversee the whole process. WARDA’s Director General Kanayo F. Nwanze is convener for SWIHA. “We have opted for a sub-project *modus operandi*,” he explains, “in which individual members, or combinations of members, prepare and submit separate project proposals to donors for funding. The decision was also made to channel such proposals through the steering committee.”

“Given that linkages between agricultural research and the health sector are generally few and far between, it is necessary to see our role clearly,” explains Abamu. “For example, it is obvious to us that agricultural research cannot eliminate the HIV virus, it cannot cure the AIDS disease, it cannot stop prostitution or unsafe sex, and it cannot eliminate witchcraft or voodoo.” So, what does agricultural research have to offer?

“The agricultural research and development sector has several comparative advantages,” continues Abamu, “not least because agriculture is the largest employer in the region.” Other advantages include:

- functional research and development networks with direct access to farmers;
- higher quality food products that should improve the overall health of agricultural workers, possibly mitigating the effects of HIV-related debilitation;
- improved farm productivity improves rural livelihoods, thereby either reducing the risk of infection or providing financial support for coping mechanisms;
- improvements in rural agriculture should also reduce the continuing trend toward increased rural–urban migration;
- these should combine to encourage increased investment in rural agriculture, not just by donors, but also by individual farming families.

SWIHA: structure and function

The future structure of the CGIAR System as a whole has been under discussion for some time, and one of the proposals currently under consideration is that greater use should be made of Center complementarities through a system of 'global challenge programs.' "There is a good chance," says Nwanze, "that SWIHA may become a global challenge program, but we could not afford to wait for the final structure of such entities to be decided before we launched into this vital area of research."

As is so often the way with new and innovative ideas among a range of partners, a lot of time over the past two years has been dedicated to discussing options—mechanisms for collaboration, subject areas to be researched, and so on—and many ideas are still to be submitted to donors as full proposals. WARDA has been active in presenting ideas and proposals to regional and national partners though such fora as the Forum for Agricultural Research in Africa (FARA)–CG consultation, the West and Central African Council for Research and Development (WECARD/CORAF) General Assembly, and the CGIAR's Mid-Term Meeting in 2001. In addition, WARDA has established partnerships with the UNAIDS in-country team for West and Central Africa and ECODEV—an NGO with experience of working with HIV/AIDS in West Africa.

Meanwhile, a representative of another partner in the initiative (the International Food Policy Research Institute, IFPRI) has addressed the UN Sub-Committee on Nutrition and the UN General Assembly Special Session on HIV/AIDS. The International Service for National Agricultural Research (ISNAR) is already active in two AIDS hot-spot countries in East and Southern Africa, namely Malawi and Uganda. In particular, a network is being established bringing together national stakeholders in agricultural research and development, with those already involved in HIV/AIDS and public health. Linkages between HIV/AIDS and food security and rural livelihood are being ascertained with a view to establishing recommendations that will be considered by agriculture and public-health institutions.

Potential HIV/AIDS impact-mitigation technologies

Part of the reason for the CG Centers becoming involved in the HIV/AIDS arena is that their work has already been addressing issues close to the heart of the problem, especially with respect to labor- and cost-saving technologies. Some WARDA-promoted technologies that are relevant to the HIV/AIDS issue are listed here.

- NERICA varieties
  - Weed-competitiveness and short growth cycle reduce labor requirement for weeding
  - High protein content increases nutritional value to consumers
- Small-scale machinery, such as thresher–cleaner
  - Reduces labor requirements
- Legimunious crops as fallow-replacement
  - Replenish soil fertility, resulting in increased rice yields next season
  - Increase number of years a field can be used before needing to clear new land (thereby reducing labor for land clearance)
- Integrated crop management
  - Improving returns to investment in inputs at no, or minimal, extra cost
- Direct seeding methods
  - Remove need for transplanting (labor)

AIDS in the workplace

Another aspect of the CGIAR initiative involves the Centers preventing the further spread of the disease among staff and their families. With AIDS affecting so many people world-wide, there is a need for awareness raising among the Centers' staff. To this end, the CG's Gender and Diversity Program has produced model policies on HIV/AIDS in the workplace. The goals of these are to:

- prevent further HIV infection among employees and their families;
- preserve the lives of those employees and dependants currently suffering from HIV/AIDS;
- provide compassionate care for those employees and dependants suffering and/or dying from AIDS;
- encourage a commitment to provide HIV/AIDS insurance for all staff;
- foster a workplace that does not discriminate on the basis of disease;
- set an example for local communities and national partners for the compassionate management of HIV/AIDS.

The models have been distributed to all CGIAR Centers, and WARDA has already presented an adapted version to its Board of Trustees for discussion.

WARDA has established a peer-group among staff for mitigating HIV/AIDS. The idea being to bring together staff of diverse gender, culture, religious and social backgrounds to devise a holistic approach to the problem. The goal is to provide a mechanism whereby staff will be able to talk about HIV/AIDS in confidence with colleagues or peers. The NGO ECODEV was called in to brief the peer-group on the outset of their work.

"Unfortunately, it seems that HIV and AIDS are with us for the long haul," says Nwanze. "It is important for us to bring our wealth of knowledge of agriculture and farmers to alleviate the suffering of those families affected by the disease in our region. It is no less a concern that we address the situation in our own house.

"The story of Hakena village shows that this will be an uphill struggle for WARDA and its partners, especially in West Africa, but we trust that a work well begun will lead to fruition in the not-too-distant future."

Donor Country Profile: The Netherlands

RELATIONSHIPS BETWEEN WARDA and The Netherlands date back to at least 1986. Collaboration has been rich and varied. Here, we want to highlight just a few of the areas in which we have worked together, especially over the last few years.

For a geographically small country, The Netherlands has a big input to international agricultural research and development. WARDA is happy to be one of The Netherlands' beneficiaries—and benefit we certainly have, from senior advisers, seconded staff, core, capital and restricted funding, inter-institutional collaboration and trainees.

WARDA's Headquarters in Côte d'Ivoire

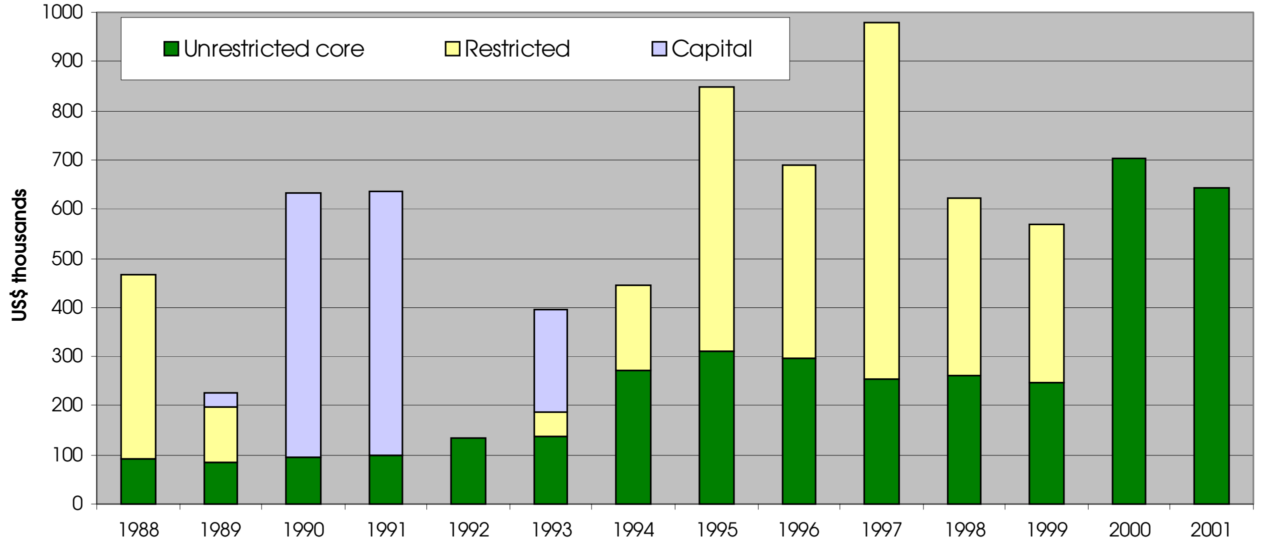
In 1987, WARDA's newly transformed Council of Ministers (previously the Governing Council of the Association, before WARDA joined the Consultative Group on International Agricultural Research in 1986) launched a study to choose a location for the new headquarters and main research center. The search began none too soon, as Liberia disintegrated into a state of civil war in 1988. Although the decision to relocate to the M'bé/Foro-Foro site north of Bouaké, Côte d'Ivoire was made in late 1987, preliminary ground surveys prior to construction only started in 1989. At that time, staff from the Winand Staring Centre for Integrated Land, Soil and Water Research (SC-DLO) worked with WARDA staff on a detailed soil survey of the entire site. The first period of construction of the Headquarters and Main Research Center extended through 1993. In 1990, 1991 and again in 1993, The Netherlands poured significant quantities of capital-development funds into the building project (*see* Fig. 13), thereby demonstrating their commitment to the 'new' WARDA.

"Subsequent to the first phase of building, The Netherlands has played a crucial role in supporting WARDA's research," says Director General Kanayo F. Nwanze. "When other donors were shying away from the CG System in 1993, The Netherlands actually increased its overall contribution to the Association's finances. Even more significantly, they increased their contributions to unrestricted core funding—levels that they have maintained to date."

People on the governing bodies

The late Frans Rudolf Moorman was a member of the last Scientific and Technical Committee of 'old' WARDA in 1986. He was also a member of the selection committee for WARDA's first Director General (in the same year), and thus played an important role while WARDA was in transition to becoming a CG Center. In 1987, Louise O. Fresco joined the newly-created Board of Trustees, and served us in that role through to 1992. Since the mid-1990s, there has been a plethora of Dutch scientists either seconded to WARDA from institutions in The Netherlands, or else directly recruited as core staff. Some of their work is highlighted below.

Figure 13. Dutch funding to WARDA, 1988–2001



Inland Valley Consortium—a long-standing partnership

The link between the Inland Valley Consortium (IVC) and The Netherlands is currently the longest running specific funding agreement between a donor and WARDA. The IVC was established, with WARDA as host institute, in 1993, while Dutch funding for the inland-valley work started in 1992! Until 1999, funding was direct to IVC under a special project arrangement with WARDA, although it amounted to 'core' funding for the IVC itself. Dutch funding to the IVC continues today, though it is now part of The Netherlands' 'core' funding to WARDA as a whole.

In recent years, the IVC 'core' funds provided by both The Netherlands and France have been used for small research grants and to cover operational expenses of the national coordination units (NCUs) in each of the member countries and the Regional Coordination Unit (RCU) based at WARDA. "Such basic funding has been invaluable in the IVC's success to date," says IVC Regional Coordinator, Marie-Jo Dugué. "We cannot underestimate the value of such funding for the NCUs and RCU," concurs IVC Scientific Coordinator, Marco Wopereis (*see* Box 'IVC Small Grant Research Projects').

In addition, the IVC Scientific Coordinator position at WARDA headquarters is salaried directly by the Dutch Government and has to date been filled by Dutch scientists—Pieter Windmeijer from 1994 to 1999 (seconded from SC-DLO), and Marco Wopereis from 2000 to 2002.

The first phase of the IVC ran from 1993 to 1999/2000. Much of the work done then has already been reported in earlier reports—*see* 'Tooling Up for Inland Valley Development,' *WARDA Annual Report 1996*, pages 39–43, and 'Technology Generation and Dissemination: The Role of Agro-ecological Characterization,' *WARDA Annual Report 1998*, pages 23–31. In 1996, an external evaluation of IVC, led by Gerard de Bruijn of the Directorate General for International Cooperation (DGIS), commended IVC for its successes in strengthening research capacity and in strengthening cooperation between national programs and international institutions involved in the Consortium. At

IVC Small Grant Research Projects

"One of the advantages of the Consortium mechanism," explains IVC Regional Coordinator Marie-Jo Dugué, "is that we can make small amounts of money available to national researchers for research projects with regional relevance." All too often, national programs have inadequate funds for conducting the full range of research projects that their other resources might otherwise allow. The IVC enables competitive bidding for funds for national scientists to conduct small projects on subjects of wider interest to the Consortium membership. Much of the money channeled into these projects comes from The Netherlands.

From 1994 to 1999, researchers in the ten IVC member countries received funds totaling US$ 426,921 to conduct 70 such research projects. To give an indication of the kind of work carried out, the table below shows the range of small-grant projects funded via IVC in 2000.

Recipient	Project title
Benin	Participatory development of technologies in the inland valleys of Gankpétin and Gomé
Benin	Finalization and validation of an inland-valley database
Cameroon	Detailed characterization of the inland-valley ecosystem in Akak and Awae key sites in southern Cameroon
CIRAD	'Seed' money to develop a proposal for a regional project to validate and adapt the decision tool DIARPA
Côte d'Ivoire	'Seed' money to develop a proposal for a regional project on integration of aquaculture in inland valleys
Ghana	Comparison of the yield performance of rice under traditional and improved soil, water and crop management
Guinea	Detailed characterization of the Bayewolon catchment, Seredou, Forest Guinea
ILRI, IITA, WARDA	'Seed' money to develop a proposal for a regional benchmark project on land use diversification and intensification (livestock and crops—rice, maize, vegetables and others) in inland valleys
Mali	Evaluation of socio-economic and environmental impact of land development programs for small inland valleys in the Bougouni region
Mali	Improvement of productivity of women's rice fields through organic and mineral fertilization (Bougouni, southern Mali)
Sierra Leone	Socio-economic evaluation of inland-valley swamp rice technologies promoted by the national agricultural research institution
Sierra Leone	Increasing and sustaining sweet potato productivity in an inland-valley toposequence in western Sierra Leone
Togo	Characterization of farming systems in inland valleys of southern Atacora (Adeta pilot-site)
Togo	Collect and disseminate information on inland valleys by setting up a documentation and database unit
WARDA	Occurrence of iron toxicity in West African inland valleys

that time, however, the IVC was still quite young and recommendations were made to strengthen its structure and functioning. Since that time, the Consortium has implemented many of the Review's proposals and today is all the stronger for that valuable input. It was thanks at least in part to this positive review that the main donors (The Netherlands and France) agreed to continue into a second phase.

"The last year [2001] has seen phase 2 of the Consortium's work come on line in all the [IVC] member states, after almost two years of transition in 1999 and 2000," says Wopereis. "This second phase brings a lot of changes in the Consortium's activities and approaches." Not least of these was the decision to bring IVC activities under the umbrella of WARDA core program activities in 1999. "This new relationship with the host institution brings mutual benefits," explains Wopereis, "the wider WARDA community benefits from IVC's expertise and the partnerships that it has developed, while the IVC benefits from WARDA's expertise and relationships. In fact, more WARDA scientists have become involved in IVC activities in 2001 than ever before."

One major shift from phase 1 is the establishment of large 'benchmark areas' for research work, as opposed to the focus on 18 smaller 'key sites.' This, in part, reflects changes in emphases from static agro-ecological characterization work to characterization of dynamic processes, and from a focus on inland-valley lowlands to a holistic approach focusing on inland valleys as a whole, encompassing the upland–hydromorphic zone–lowland continuum. "The establishment of the benchmark areas has been a protracted process," says Wopereis, "but we do hope to have activities at two sites in 2002, where sites that straddle national borders reflect similar interests and joint research themes among countries." One site is shared by Burkina Faso, Côte d'Ivoire and Mali, while the other should be in the Benin–Togo border region. "We hope that some of our new sites will coincide with the benchmark sites of the CGIAR's Ecoregional Program for the Humid Tropics of Africa (EPHTA)," says Wopereis, "for example, the Benin–Togo site." This will speed up technology evaluation and dissemination, as EPHTA already has a mass of data on its sites.

A major component of the IVC phase 2 is indicated by Wopereis's official job title—Natural Resource Management Scientist. "Management of natural resources is crucial to effective crop management," says Wopereis, "so we are looking at integrated natural-resources management (INRM) for inland valleys in the region." With WARDA as host and lead institution in the Consortium, the entry point for inland-valley INRM will be rice. "WARDA's and IVC's research results are being put together into an INRM framework that we want to encourage all our partners to test, adapt and use in their own situations," says Wopereis. "To achieve impact, it is imperative that partnerships are built among inland-valley stakeholders, from farmers to decision-makers." The IVC is ideally suited for this approach as NCUs have already the right partners sitting around the table.

In February–March 2002, IVC and WARDA's technology transfer team conducted a training course on 'Participatory Learning and Action Research on Integrated Rice Management' for extension partners and farmers in Côte d'Ivoire and from IVC member countries. "The training modules are designed to enable extension services to conduct adaptive research," says WARDA Technology Transfer Agronomist Toon Defoer. "After all, technologies that have been developed at one site need to be verified and adapted at new target sites. The technical and facilitators' manuals that we prepared were tested during the course in Côte d'Ivoire, and will subsequently be refined for publication and wider use in all IVC member countries."

"In addition to these 'new' activities, we inherited several unpublished proceedings of IVC-sponsored scientific meetings from phase 1," says Dugué. "We are now in the final stages of producing a combined summary of the general meetings, and a full proceedings of the workshop on hydrology."

"We live in an information age," says GIS Specialist Mahaman Moussa, "and WARDA and IVC are not going to be left behind. In 2001, we developed a web-site for the IVC in both English and French editions." A distinction that gives IVC an 'edge' over every other project within WARDA! "IVC is now visible to the world," says Dugué, "but a major part of the working of the Consortium is communication *among* the members. To help in that respect, we re-launched the *Inland Valley Newsletter* in December 2000, with a further issue in July 2001." The IVC has also proposed that a special issue of an international journal be devoted to inland valleys, with emphasis on West and Central Africa—something that is still under consideration by the first journal approached—to provide a communication channel to peer researchers world-wide.

The IVC is also making the findings from phase 1 more widely available. The inland-valley characterization data from the 10 member countries have been put together in an information system (West Africa Inland Valley Information System, WAIVIS). Mahaman visited *Centre de coopération internationale en recherche agronomique pour le développement* (CIRAD) in Montpellier, France, for two months in 2001, where he worked with Michel Passouant. "My stay in France was very interesting," enthuses Mahaman, "as it allowed me to get acquainted with the latest developments. The growing volume of databases of different types places huge demands on archiving and structuring to provide users with fast and reliable information. This is especially difficult in the field of geographical information and interactive usage." Several options were explored taking into consideration such factors as cost, complexity and demands on programming skills and hardware. In the end, formats were chosen for ease of use on the Internet and CD-ROM platforms. The innovations coming out from this work are: (i) the utilization of conceptual and logical models to conceptualize, integrate and organize different types of databases; (ii) the utilization of Scalable Vector Graphics (SVG) format for dynamic web-publishing of GIS databases; and (iii) the utilization of meta-data techniques (use of key words) to provide a user-friendly tool for accessing information. "The results will be distributed to all member countries for a last check of the data," says Mahaman, "before official release on CD-ROM and the Web."

Soil degradation in irrigated rice fields in the Sahel

Piet van Asten is a Dutch Associate Expert in Soil Science. His time at WARDA's Sahel Station was somewhat of a special deal that he struck with the sponsoring agency, DGIS, before taking up post. "Before I took up my assignment in May 1998," explains van Asten, "the normal routine for DGIS Associate Experts was two two-year assignments, preferably with different hosting organizations and in different countries. It is also more usual for such positions to be less research oriented than they are with the CG centers." Van Asten saw in the research position at WARDA an opportunity to further his qualifications by pursuing a PhD. "The only problem there," he muses, "was that a typical PhD research program runs for three or four years, if I was only to stay two years it would not be practical." Van Asten approached DGIS with his proposal, and received the offer he was looking for. His tenure at WARDA ran from May 1998 through April 2002. The PhD itself is through Wageningen University (now part of the larger Wageningen University & Research Centre—*see* Box 'Wageningen University remodeled'), while the research is actually a UK-funded project.

Much of van Asten's work has already been reported (*see* 'A Holistic Approach to Irrigated Rice Farming Problems Uncovers More Than Just Soil Degradation,' *WARDA Annual Report 1999*, pages 30–37), so here we will summarize the early findings and bring the story up to date.

Wageningen University remodeled

For many years, Wageningen Agricultural University (WAU) has been considered one of the foremost agricultural universities in the world. In addition, the city of Wageningen hosted several other research institutions involved in agriculture-related work, one of them being the Winand Staring Centre for Integrated Land, Soil and Water Research (SC-DLO). With their close geographical proximity, these institutions often linked up with WAU in dealings with collaborators such as WARDA.

In 2000, the decision was made to bring all the disparate entities together under a single umbrella, and so the Wageningen University and Research Centre (WUR) came into being. The university—now simply Wageningen University—retains its academic identity and continues to be the awarding body for postgraduate degrees. However, students may be sponsored by external agencies, including the broader WUR itself. WAU has been the awarding institution for at least six postgraduate students that have worked in collaboration with WARDA.

Founder and active members in IVC, the 'Wageningen Group' actively participates in meetings and workshops, providing a strong scientific background and support, especially on methodological aspects. It is also represented on the Consortium Management Committee. Wageningen scientists contributed to scientific excellence and public awareness through written articles and support of publication under the IVC logo. The Group also provides consultancies on 'cutting-edge' issues such as modeling. Currently, WUR is actively involved in IVC phase 2 priorities of dynamics of biodiversity, benchmark-area research, and will be involved in the aquaculture work when it starts in earnest. Thus, the collaboration between WAU, SC-DLO and IVC that started in 1994, continues today with WUR.

One half of the project is based in the Sourou Valley of Burkina Faso, where farmers complained of unproductive patches, or pockets, in their fields, associated with calcareous deposits (often in the form of nodules) or drainage problems. By the end of 1999, the only relief had come from the application of either manure or compost, thereby improving the organic-matter content of the soils, although application of fresh straw had no effect. At that time, van Asten was inclined to blame the low productivity of the pockets on zinc deficiency.

At the other project site—Foum Gleita in southern Mauritania—alkalinization had been detected in shallow soils, as a result of carbonate release from the schist bedrock. However, improved crop management resulted in significant increases in rice yields, and farmers were becoming less inclined to blame soil degradation for their poor performance. Significant yield increases were being achieved with the use of phosphate fertilizer, but that fertilizer was not easily available for rice in Mauritania.

The following season's trials in Burkina Faso confirmed van Asten's suspicions. “On the plots where we applied zinc,” he enthuses, “we saw uniform crops—no patches with weak rice plants and no two- to three-week delay in harvesting the rice on the unproductive pockets. In 29 farmers' fields, application of 10 kg of zinc sulfate per hectare resulted in average grain yields increasing from 3.3 tonnes per hectare to 6.0 tonnes!” The research team was also rather pleased to discover that these low doses were all that was needed—application of 20 kg zinc sulfate did not give a better yield response than the application of 10 kg. “This means that the farmers do not have to apply large quantities of zinc to their crops,” explains van Asten, “and therefore the cost of 'fixing the problem' is not as high as it might have been.” Meanwhile, the potentially even cheaper option of using straw to increase organic-matter content, and thereby yields, was investigated further. “Given the failure of fresh straw to improve the situation,” says van Asten, “we opted for harvesting, rotting for one season, and then spreading the partially rotted straw on the fields.” This option alone increased average on-farm yields to 5.3 t/ha, and therefore offers itself as a viable relief mechanism for those farmers who might prefer to use straw rather than zinc.

“The latest developments in the Sourou Valley story are extremely encouraging,” says a jubilant van Asten. “The national agricultural research institute, *Institut de l'environnement et des recherches agricoles* (INERA), and the local extension service, *Autorité de mise en valeur de la vallée de Sourou* (AMVS), are setting out plans with farmers' cooperatives to adopt zinc fertilization as soon as possible—the farmers no longer need convincing, they just need access to the fertilizer." Meanwhile, the research and extension staff are approaching fertilizer company representatives and traders with a view to encouraging them to formulate suitable products for rice and make them available to farmers on a wide scale.

Further nutrient studies at Foum Gleita revealed that the recovery rate of both nitrogen and phosphate fertilizer was much lower on the shallow alkaline soils than on the deeper non-degraded soils. This implied that larger amounts of nitrogen and phosphorus fertilizer were needed on the degraded soils in order to obtain yields equal to those on the non-degraded soils. Van Asten decided to follow the low fertilizer recovery rates through a series of field straw trails. Incorporation of fresh straw (5 t/ha) led to an average 1.1 t/ha yield increase irrespective of soil type or fertilizer dose (Fig. 14). The straw affected the soil in a way that enabled the plants to take up more of the applied fertilizer (Fig. 15). These rice plants then grew better and yielded more than those without straw. Farmers often burn the straw after harvest or use it as fodder for their cattle at the end of the dry season. These results show that farmers can incorporate the straw into their fields to improve yields without incurring additional costs.

If all this isn't enough, we find that van Asten is one of those young scientists who just loves to follow clues and ideas, and see where they lead him. He takes up the story: "It was clear that alkalinity is a present problem at Foum Gleita—the shallow soils are alkaline as a result of the underlying parent rock, and the irrigation water used is one of the most alkaline known to date in West Africa." A review of various reports from the 1970s onwards revealed, however, that there has been no secondary increase in alkalinity over the last 30 years as

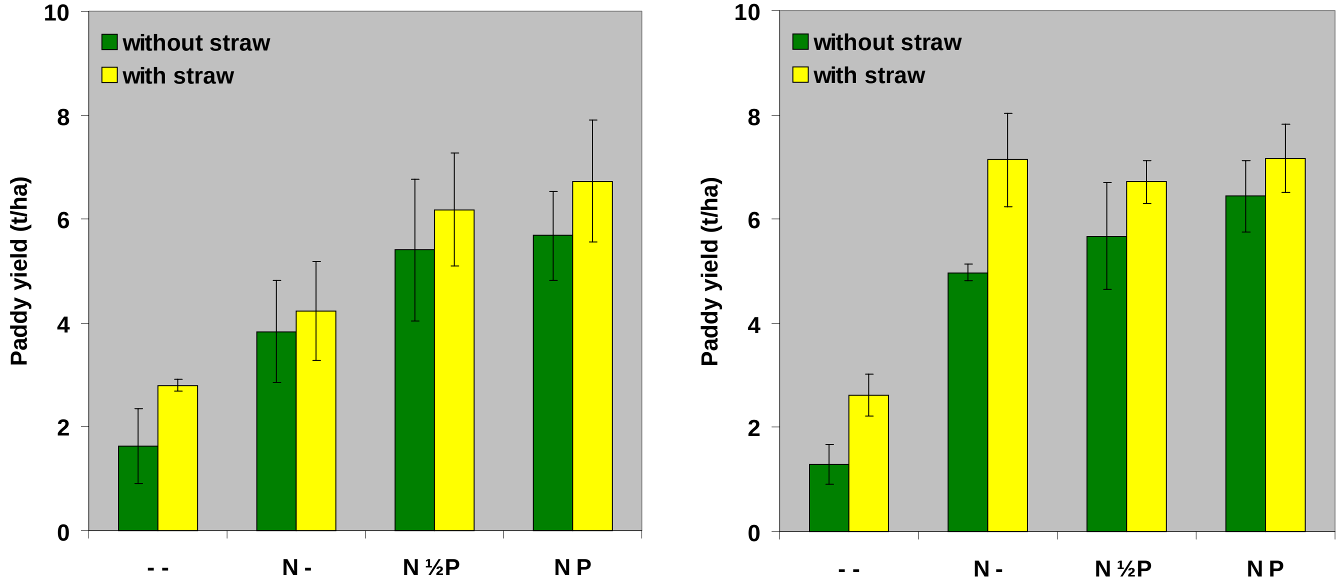


Figure 14. Effects of straw and fertilizer application on yield of rice on 'degraded' (left) and 'non-degraded' (right) soils, Foum Gleita, 2000

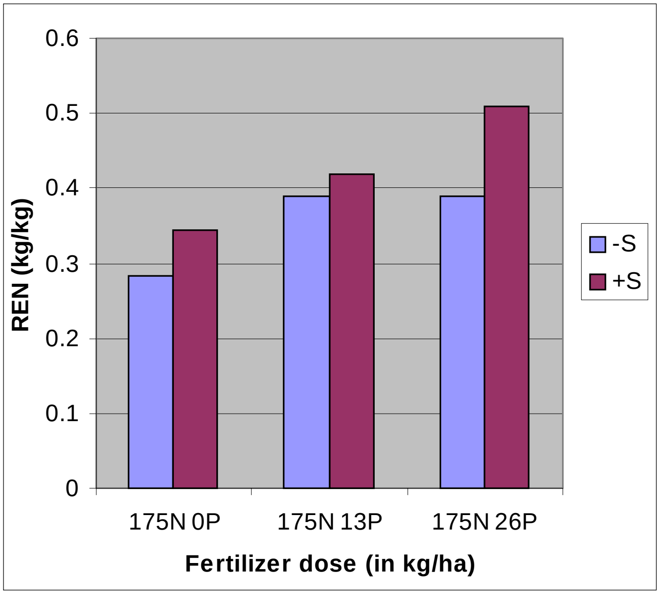
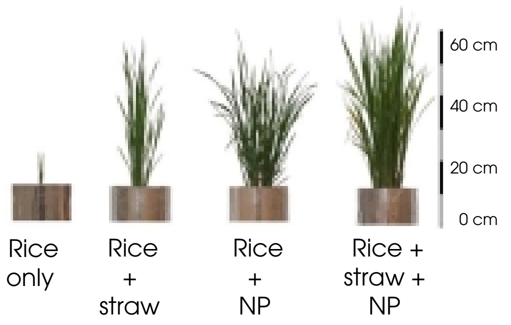


Figure 15. Effects of straw (S) and fertilizer application on nitrogen recovery rate



Soil column test: Laboratory studies showed clearly the effects of incorporating straw into the degraded soil from Foum Gleita, confirming the field straw trials. This photo also shows the beneficial effects of applying nitrogen and phosphate fertilizers either alone or in combination with straw.

a result of irrigation activities. Together with Claude Hammecker of IRD, van Asten used computer simulation (program PHREEQC) to predict the likely future for Foum Gleita. The model showed that most soils in Foum Gleita have a strong buffering capacity against alkalinization processes. It is not yet clear whether this buffering capacity will eventually run out in the long run (decades). Van Asten continues: "Many of the processes that are related to alkalinization in irrigated rice soils are still poorly understood. Simulation tools are available, but none of them fit to the very special conditions found in irrigated rice soils." Dutch MSc student Arjan van't Zelfde (from Wageningen University) conducted soil-column tests that showed that rice cropping can de-alkalinize West African alkaline soils, and that straw incorporation enhances this process, providing there is some drainage. Van Asten concludes that the results of these tests are of great help in verifying and improving results of simulation modeling (PHREEQC is not a fixed model), so that the evolution of these soils can be better predicted under both current and alternative management strategies. "So far," van Asten concludes, "the results of our research and research elsewhere seem to indicate that irrigated rice cropping and incorporation of organic matter into the soil both contribute to decreasing or preventing further alkalinization."

Human health

In 1999, DGIS seconded Olivier Briët to WARDA headquarters to work as Associate Expert in Medical Entomology with the Human Health Consortium. Briët helped researchers from Côte d'Ivoire and Mali to analyze their entomological and epidemiological data on malaria and schistosomiasis. He also helped disseminate the Consortium's results through a web-page, co-organizing a conference on water and health held in Ouagadougou in 2000, and by assisting in the writing and preparation of research articles for publication.

Briët co-authored an article that demonstrated that rice cultivation in the savanna zone of Côte d'Ivoire does not seem to affect the population density of the principal malaria vector (mosquito *Anopheles gambiae*), while in the forest zone a strong linear correlation was evident between surface area of cultivated rice in the vicinity of villages and mosquito population density. Further results from the Consortium are summarized in the Box.

Postgraduate trainees

Wageningen University is perhaps one of the best-known agricultural universities in the world. It is not surprising, therefore, that strong links have been established between Wageningen and WARDA. A number of postgraduate students have come directly from Wageningen to conduct their field studies at WARDA; others have made the Wageningen–WARDA connection by other routes. Piet van Asten is just one example (*see above*). Piet Keijzer is another: "My particular case is probably unique," he explains.

After his transfer to headquarters as Natural Resource Management Scientist with IVC in 2000, Marco Wopereis maintained collaborative links with Wageningen University. This collaboration led to Wopereis encouraging Keijzer to visit WARDA to carry out field studies as part of the latter's MSc research. However, circumstances intervened and Keijzer's work with WARDA was delayed until 2001. "After some discussion," explains Production Economist Olaf Erenstein (coincidentally, also Dutch and from Wageningen!), "we decided to have Piet work on the peri-urban project funded by GTZ, which looks at the effects of market access on rice-based land use systems in a 25-km radius around four urban centers—Korhogo, Bouaké and Daloa in Côte d'Ivoire, and Sikasso in Mali." In each area, village- and lowland-level surveys were conducted; in all, over 1000 lowlands. Keijzer arrived during the finalization phase for the initial database.

Keijzer provides the details: "I visited rice-growing lowlands around Daloa and Sikasso, which took several weeks, to collect data to complete the database and

Human Health Consortium (1994–2000):† Summary of Findings

Sahel (Mali)
Villages with irrigated rice fields showed constant, low-level transmission of malaria, and recorded 0.7 cases per 1000 child-days year-round. In villages without irrigation, no malaria transmission was detectable in the dry season (malaria fevers were still detected); malaria showed a high peak incidence in these villages during the rains—3.3 cases per 1000 child-days in the rainy season. Overall, malaria incidence was 2.2 times higher in the non-irrigated zone than in the irrigated zone, on an annual basis.

Meanwhile, rice double-cropping led to an increase in schistosomes, but no clear-cut difference from other systems in snail population dynamics or transmission pattern.

Savanna (Côte d'Ivoire)
Yearly total transmission of malaria was about the same in villages with irrigated rice fields and those with unimproved wetlands. Some seasonal variation in incidence was recorded, but overall annual incidence was similar in villages with unimproved wetlands, single rice crop and double rice crop.

No differences were detected in the incidence of schistosomes in the three village types.

Forest zone inland valleys (Côte d'Ivoire)
The population density of one malaria-mosquito species (*Anopheles gambiae*) was correlated with surface-water availability in rice fields. This was apparently related to the availability of breeding sites (open water) exposed to sunlight.

Rice cultivation had no effect on the schistosome populations. In fact, there was some correlation between schistosome population and area of *uncultivated* wetlands.

Overall, it appears that introduction and subsequent intensification of water management for rice cropping has no major negative effect on either of the diseases studied—malaria and schistosomiasis—on an annual basis.

† The Human Health Consortium was funded by Denmark (DANIDA), the International Development Research Centre (IDRC, Canada) and Norway, and ran from May 1994 to June 2000.

Natural and human-induced soil degradation affecting rice cultivation in the Casamance, Senegal

Anneke Fermont came to Saint Louis, northern Senegal, at the end of 1998 accompanying her husband, Piet van Asten. The first year or so she worked on the program of Mohammed Kebbeh in Mauritania. Then she saw a possibility to start her own project.

In 1999, van Asten and research assistant Salif Diack conducted a two-day workshop for farmers in the Casamance region (southern Senegal) on rice cultivation. This was at the invitation of an NGO—*Fondation pour le développement des projets à petite échelle* (FDPPE)—that was working on environmental degradation in the region, and which already had a connection with The Netherlands. Multiple constraints to rice production were identified during the workshop, many of them related to soil degradation problems. This led Fermont to write a joint project proposal between FDPPE and WARDA. The project was jointly funded by the Dutch Embassy in Dakar and the Van Rumpt Foundation in The Netherlands in 2000; in 2001, the foundation funded the project alone. Meanwhile, WARDA provided Fermont with office space, soil-sample analysis, technical advice-cum-backstopping, administrative support, daily transportation (to and from the Sahel Station) and a computer. The project sites themselves are in the Bignona valley, which has a watershed of some 800 square-kilometers, and currently about 2500 ha of rice.

"In the first phase of the project," explains Fermont, "we wanted to identify the soil-degradation problems that the local farmers were reporting, and how these problems were affecting the rice crop." Thus, Fermont and her team took a two-pronged approach of sampling the soils, while obtaining farmers' perceptions of the problem through interviews with the farmers themselves, participatory rural appraisals (PRAs), and interviews with local organizations with a vested interest in the rice-farming community.

"The inventory phase proved most revealing," says Fermont. "Decreasing rainfall since the 1970s has led to increasing salinity problems and a lowering of the groundwater table by 30–40 cm. The latter, in turn, has resulted in moderate acidification of the soils in the valley bottom containing pyrite."

In 1987, a Chinese project closed the Bignona valley with a dam. Although the dam succeeded in reducing salinity problems in the valley, its impact has been devastating. "Before the dam," continues Fermont, "the valley contained some water all year—partly due to back-flow from the Casamance River. Now, the valley dries up completely during the dry season." This has resulted in severe soil acidification on a large scale. "The whole scene is one big ecological disaster," mourns Fermont. "The Bignona River now has a pH of 3 (that is the same as a human stomach!) (Fig. 16), one-and-a-half *thousand* hectares of mangrove have been lost, and so has a lot of the area formerly suitable for rice cultivation." In fact, the combination of drought affecting the upland soils, and the recent soil degradation processes affecting the lowlands, has resulted in 50% of the rice area in the valley being abandoned!

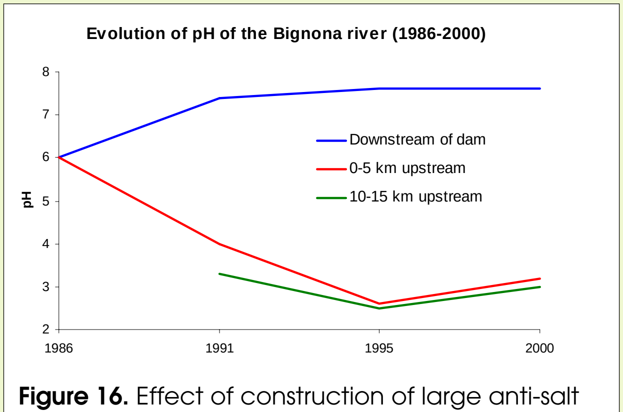


Figure 16. Effect of construction of large anti-salt dam (1987) on water quality of the Bignona river

Farmers assessing rice variety BW 234-1, Bignona valley, Casamance, Senegal

During interviews, it appeared that few local experts had a good understanding of the actual soil problems in the Bignona valley. Contrary to the general opinion, soil surveys showed that soil acidity is the main production constraint in the lowland and salinity is no longer a problem in the Bignona valley. The widespread belief that salinity is still the main production constraint was due to the existence of large barren surfaces covered with salts. However, the sodium chloride (common salt) that used to dominate these surfaces, has been replaced by a range of acidic salts.

Casamance farmers tilling rice field with local *kayando*

During participatory rural appraisal workshops, Fermont found that farmers unanimously identified soil-related problems such as acidity, iron toxicity, poor soil fertility and poor water availability as the main constraints to rice cultivation. "It was encouraging," says Fermont, "to find that, although farmers often use the wrong terms to indicate specific soil degradation problems, they can identify the characteristics and locations of the different problems in detail." This particularly applied to the women, who are responsible for transplanting and harvesting, and the young men who have received a higher level of education than their parents.

The second phase of the project involved trials with farmers in the search for solutions to the problems at hand. Protocols were established by the research team for different zones, but the trials themselves were decided upon and conducted by the farmers. "We held workshops," Fermont explains, "to make our proposals to farmers' groups, but then the farmers decided which zones should be given priority and which trials they wanted to conduct." Thirty-three farmer trials were established across the three project sites in 2000.

Although the team's proposals included trials that addressed crop-management issues, which are easy to adopt, farmers decided to conduct only fertilizer and variety trials. "It was also interesting to note," says Fermont, "that farmers were principally interested in targeting acidic or drought-prone soils to try to improve production on them. However, we found that the response of rice to fertilizer application was greater on non-acidic lowland soils than on acidic soils"—yield increases from application of 30 kg phosphate/ha plus 75 kg nitrogen/ha were 90% and 78% on non-acidic and acidic soils, respectively (Fig. 17). In the drought-prone upland, neither fertilizer nor cultivar had any significant impact.

"One of the outcomes of the first-year trials," says Fermont, "is the need to get the idea across to the farmers that they should use inputs only on good soils, where the returns to investment are much greater. In addition, we found that average yields from trials with no fertilizer were significantly higher than farmers' average yields in the same zone. This is an indication that, even without fertilizer use, farmers can increase rice production by improving their management (early operations and weeding) and using appropriate varieties."

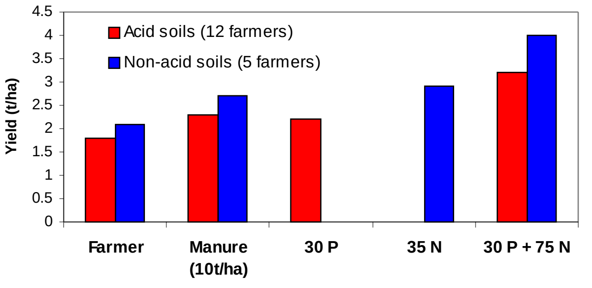


Figure 17. Fertilization trial on lowland soils, Bignona valley, Casamance, Senegal

Happy with the first-year's results, farmers' interest increased in 2001, so that 60–70 farmers conducted trials that year. "What is more," says an enthusiastic Fermont, "the farmers *did* show a shift of interest from the problem to the non-problem soils!"

When asked about the future, Fermont is upbeat: "My final step in the project was to develop extension materials to get these messages to other rice farmers in the Bignona valley." This was done in collaboration with Potin Dieme of FDPPE and fieldworker Ansoumane. "It is good that we were able to make these materials," says Fermont smiling. "Our time here ends in May 2002, and it is good to know that the work is going to continue for the benefit of all the farmers that I've come to know over these two years."

typology analysis." The geo-referenced database is used to characterize land use in the lowlands around urban centers on a north–south gradient. In the next stage, representative lowlands are selected for further in-depth characterization and diagnosis, through surveys and participatory studies. At the same time, farmer-participatory adaptation and validation will be going on. The research is expected to improve targeting of policy recommendations and available production technologies to these key environments.

The future

"We were very pleased to learn in early 2002 that DGIS is offering us five Associate Experts under the revised scheme," says WARDA Director General Nwanze. "You can be sure that we will take full advantage of the offer."

"Over the years, The Netherlands has played a crucial supporting role to WARDA," says Nwanze. "Their consistent support to the IVC in both funding and seconded experts has been a rewarding experience for us. We look forward to continued fruitful collaboration in the years ahead."

The Netherlands, Holland and the Dutch

It has become generally recognized that 'The Netherlands,' rather than 'Holland,' is the correct name of the homeland of the *Dutch* people. Still, however, the nomenclature (at least in English) is almost as confusing as that relating to the United Kingdom and Great Britain (*see WARDA Annual Report 1999*, page 50).

Some definitions of the entities are:

- The Netherlands = the name of the country (in English); however, the *Kingdom* of the Netherlands comprises the European country (The Netherlands per se), and the Netherlands Antilles and Aruba in the Caribbean!
- Holland = former autonomous country comprised of the modern provinces of North and South Holland of The Netherlands; historically, the region of Holland has played a dominant role; South Holland is still the most densely populated among The Netherlands' 12 provinces.
- Dutch = adjectival form, "of or pertaining to The Netherlands"; especially used in reference to the language and people; Dutch is one of the Germanic languages, and is spoken throughout The Netherlands. The origin of the word seems to be in dispute: some claiming it has origins in the Dutch language itself, others claiming it is a corruption of 'Deutsch' (German).

The Year in Review: 2001

IN 2001, WARDA built on its past successes and 'moved along' new developments that were initiated in 2000. In particular, the NERICA varieties became the focus of a whole new shift in the Association's drive to help ensure food security for its mandate region and the rest of Sub-Saharan Africa. But, we move on too fast. As ever, we aim to provide a chronological view of WARDA's plethora of activities through the year with the aim of adding some balance for those areas not covered by Features in this issue of our *Annual Report*.

The 2001 **Annual In-house Review and Planning Meeting** took place at Headquarters from 20 to 23 February. This annual event gives WARDA scientists the opportunity to present the highlights from the previous year's research with the whole staff, while affording the opportunity for discussion of crucial issues and fine-tuning of research planning for the coming year.

On 14–16 March, WARDA hosted a Workshop on **A Collaborative Platform for Agricultural Research in Sub-Saharan Africa**, which was co-organized with the International Service for National Agricultural Research (ISNAR), and sponsored by the Technical Centre for Agricultural and Rural Cooperation (CTA, The Netherlands). The meeting brought 13 university officials from 10 Sub-Saharan countries, together with WARDA and ISNAR staff, and research managers from the Ivorian Ministry of Higher Education, and the *Centre ivoirien de recherches économiques et sociales* (CIRES). The participants established a platform for collaboration among international agricultural research centers, universities, and national agricultural research organizations to maximize the advantages of each partner and improve efficiency in agricultural research and education. (The proceedings were published in English jointly with ISNAR.)

The **Annual Workshop of the Inland Valley Consortium (IVC)** took place on 19–23 March at WARDA Headquarters. Nine of the 10 member countries were represented, along with 5 of the 8 member international institutions. Participants reported on and discussed results from IVC-funded research in 2000; visited the Sustainable Productivity Improvement for Rice in Inland Valleys of West Africa (SPIRIVWA) project site at Gagnoa (Côte d'Ivoire), and discussed the implementation of the IVC Phase II. Working groups discussed the outcome of a preparatory workshop held in January 2001, and identified research priorities under four themes. An action plan was also developed at the workshop for the following six-months activities.

The WARDA **Board of Trustees** held its annual meeting at Headquarters on 26–30 March.

On 27 March, there was a **Meeting on the protection of new varieties of plants in Côte d'Ivoire** held at the Ministry of Industry, Abidjan. The Ivorian Government called the meeting to examine opportunities for the country to set up a national committee to grant plant breeders' right on new and innovative findings concerning planting materials. The meeting was chaired by the Ministry of Industry and participating organizations included the *Agence nationale d'appui au développement rural* (ANADER, Côte d'Ivoire), the *Centre de coopération internationale en recherche agronomique pour le développement* (CIRAD), University Abobo Adjamé, the Ivorian Ministry of Agriculture (Seed Board, Plant Protection Division and Quality Control Division), the private seed companies Syngenta, and Aventis, and WARDA.

As part of the World Food Programme project to promote community-based seed systems (CBSS), WARDA co-organized a **Training Course for Innovative Farmers and Trainers** in CBSS with ANADER and the World Food Programme (WFP) at ANADER's offices in Bouaké from 27 to 31 March.

On 2–4 April, WARDA and the West Africa Rural Foundation (WARF) organized a workshop in Dakar, Senegal, to review, revise and validate a project proposal on **participatory adaptation and evaluation of integrated crop management (ICM) options for irrigated rice** in Burkina Faso, Côte d'Ivoire, The Gambia, Mali, Mauritania, and Senegal. The 34 participants represented national research and extension partners from the target countries; the West and Central African Council for Research and Development (WECARD/CORAF); Coordinators of the FAO Special Program for Food Security from four of the countries; NGO representatives from two countries; Producer organizations from three countries; Winrock International, Senegal; FAO Rome (plus one FAO consultant from Australia) and FAO Africa Office, Accra; WARDA and WARF. The proposal was duly validated and passed for further processing by WARDA. WARDA's ICM work in the irrigated ecology was the subject of a Feature in last year's report.

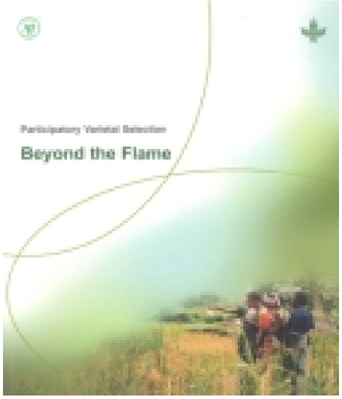
Following the ICM workshop, WARDA Sahel Station hosted a workshop on **Weed Management in Lowland Irrigated Rice: Towards Integrated Weed Management in Lowland Rice**, on 5 April. Twenty-three participants represented the NARES and NGOs of The Gambia, Mali, Mauritania and Senegal, as well as WARDA, FAO and the UK Natural Resources Institute. Results of research, conducted within the framework of the DFID project on Integrated Weed Management in Lowland Rice, were presented and discussed. The participants also identified research priorities and prospects for future collaboration among themselves and with WARF. A common priority area for research and extension was the use of integrated weed management components, while activities on wild rice were more country dependant. The need for documentation on weed management was stressed strongly, while knowledge gaps were identified in weed management for different levels of crop management, namely interactions with nitrogen, plant type, water management and soil type.

On 9–12 April, WARDA hosted an international workshop on **NERICA-based Food Security in Sub-Saharan Africa**, at its headquarters. The workshop was attended by over 90 participants from African and Asian research institutions, including several Ministers and Vice-Ministers from West and Central African states, the President of the Rockefeller Foundation, senior officials from the World Bank, the African Development Bank, the United Nations system and WARDA. Participants unanimously agreed to form a Consortium to coordinate wide dissemination of NERICAs to millions of poor farmers, many of them women, in Sub-Saharan Africa. Following visits to farmers' fields in Central Côte d'Ivoire on Sunday, 8 April, Dr Gordon Conway, President of the Rockefeller Foundation, said: "NERICA rice varieties represent genuine new potential for resource-poor farmers throughout Sub-Saharan Africa and should be disseminated widely throughout the continent."

On 19 April, a full-day **workshop** was held at WARDA Headquarters to review the results of a **Gender and Diversity Survey**, that had been conducted in June 2000. Permanent staff of all levels (management, internationally recruited, and general service) participated in the open and animated discussions. The survey had reviewed the level of implementation of policies and procedures recommended in previous gender and diversity assessments in 1996 and 1998. The survey was supported by the Organizational Change Program (OCP) and Gender and Diversity Program, both parts of the CGIAR; the feedback workshop was facilitated by consultant Charity Kabutha. After the facilitator presented the survey results, there was some open discussion of the results, and on how the report might be improved. Recommendations and strategies for the way forward were then discussed by general-service and internationally-recruited staff separately. At the end, the facilitator presented a synthesized way forward to the whole group.

The **Rice Research and Development Network for West and Central Africa (ROCARIZ) Steering Committee** held its annual meeting at WARDA Headquarters on 24–26 April. The Steering Committee consists of 10 members drawn from the network membership with broad representation of the seven Task Forces; the ROCARIZ Coordinator, who is based at WARDA, serves as secretary to the Committee. The Committee reviewed the Coordinator's annual report and approved the proposed work plan and budget. The members also discussed the upcoming monitoring tour (*see below*) and Second Regional Rice Research Review (4Rs) to be held in 2002.

The **Participatory Rice Improvement and Gender/User Analysis (PRIGA/PVS) Network Annual Workshop** was held at WARDA Headquarters on 2–5 May. The 74 participants represented 16 of WARDA's 17 member countries, NGOs, the Department for International Development (DFID), the System-wide Programme on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation (PRGA) and WARDA. The proceedings were published in early 2002. During the workshop, the PVS teams from each country were interviewed on the issues of impact of the PRIGA research and institutional changes that the work has brought about within the national programs; the results of which will be published by PRGA–CIAT (*Centro Internacional de Agricultura Tropical*) and WARDA in 2002. The proceedings of the workshop have been published as *Participatory Varietal Selection: Beyond the Flame* (WARDA, 2002).



On 7–10 May 2001, the PRGA and WARDA organized a **Workshop on Participatory Plant Breeding in Africa: An Exchange of Experiences**, at WARDA Headquarters. The workshop brought together over 60 scientists (plant breeders, geneticists, agronomists, seed technologists, socio-economists), development specialists, community organizers and farmers drawn from 22 countries (16 African countries were represented). Participants exchanged and compared their experiences in participatory plant breeding and 'dynamic biodiversity enhancement' in Sub-Saharan Africa; contributed to a working document of guidelines for participatory plant breeding; identified follow-up actions to support farmer-led and research-led participatory plant breeding; and, identified follow-up actions to support dynamic biodiversity conservation and enhancement. In addition, the workshop succeeded in encouraging dialog between research and development professionals, on one side, and farmers, on the other side. It also raised the awareness of plant breeders on participatory approaches to crop improvement. The plan to develop joint work-plans was unfortunately hindered by the lack of committed funding at the time of the workshop.

From 14 to 20 May, the INGER-Africa Coordinator and Impact-Assessment Economist visited Guinea to launch the **DFID-funded project on the impact of modern rice varieties on biodiversity**. In addition, discussions were held with the national research (*Institut de recherche agronomique de Guinée*, IRAG) and extension (*Service national de la promotion rurale et de la vulgarisation agricole*, SNPRV) institutions on the prospects of establishing an Impact Assessment Network in Guinea.

On 15–16 May, the steering committee of the **Participatory Adaptation and Diffusion of technologies for rice-based Systems (PADS)** project met at WARDA Headquarters. Eight members from research, extension and NGOs in the project countries—Côte d'Ivoire, The Gambia, Ghana and Guinea—participated to present results of rapid rural appraisals (to identify constraints), to present their work plans and budgets, and to identify activities that cut across international borders.

Former WARDA Visiting Scientist Assétou Kanouté returned to WARDA Headquarters in June to conduct a training course on **Improved cultural techniques for inland-valley and rainfed rice**. The course, from 7 to 8 June, brought 20 participants from NGOs that Kanouté had established linkages with during her term at WARDA.

The West Africa Seed Development Unit (WASDU), based in Accra, Ghana, organized a **National training workshop on the production, marketing and quality control of seed** in collaboration with the Ivorian Ministry of Agriculture (MINAGRA), the *Fonds de développement de la formation professionnelle* (FDFP) and WARDA, at WARDA Headquarters, from 11 to 22 June. The workshop objectives were to improve participants' technical capacity; promote exchange among national seed sectors; improve the availability of quality seed; develop conditions favorable for private investment in the seed sector; and, develop conditions favorable for interaction between private and public sectors. Forty-one participants from Ivorian extension agencies, agricultural projects and NGOs attended the workshop, along with 21 resource persons.

On 25 and 26 June, the Centre for Agriculture and Biosciences International (CABI, UK) and WARDA hosted a **Stakeholder Workshop on Functional Biodiversity in Rice** at WARDA Headquarters. The workshop brought together researchers from four countries, together with others from WARDA and CABI, to review the effects of intensifying rice cultivation on the incidence of rice diseases and pests, and appropriate management practices. The workshop provided an opportunity for the researchers to discuss their proposals for research in this area, and created linkages that will be maintained as the work proceeds.

In July, WARDA, ANADER and *Projet national riz* (PNR) embarked on a nine-month program of intervention methodology development in **Participatory Learning and Action Research in Integrated Rice Management (PLAR-IRM)** in inland valleys. A group of 30 farmers participated in weekly sessions at each location—Bamoro and Lokakpli, Côte d'Ivoire. The

Dr Robert Guei, INGER-Africa Coordinator being interviewed by the media during the WASDU training course activities involved one 3–4 hour session at each site per week. The farmers were completely free to implement any aspect of what they learnt, adding their chosen elements to their own practices on designated IRM fields (part of their own farm). The basic principles of PLAR-IRM are making good field observations, analyzing the observations, and taking appropriate decisions. The participating farmers were encouraged to follow their new practices through stringent self-evaluation by means of an illustrated form; this aspect is expected to help the decision-making process, whereby farmers see how well they can implement their chosen practices and monitor the effects of 'good' or 'poor' implementation. The intervention team (WARDA, ANADER and PNR) used the experience to develop a curriculum for farmer learning through PLAR-IRM, complete with facilitator's guide and technical manual. The first draft of the curriculum is now ready, and comprises 27 learning modules and 27 technical references. The methodology is being fine-tuned at several new sites in Côte d'Ivoire, Benin, Burkina Faso, Guinea, Mali and Togo from 2002.

Participatory Learning and Action Research, Bamoro, Côte d'Ivoire

A team from **Association for International Cooperation of Agriculture and Forestry** (AICAF, Japan) visited WARDA Headquarters on 1 August as part of their survey-tour for the project 'Supporting Development of Small-scale Farming Groups' in Côte d'Ivoire. The project focuses on rice and aims to promote and establish small-scale paddy-field rice farming in Sub-Saharan Africa. The courtesy visit to WARDA enabled a brief exchange of views on the subject between AICAF and WARDA staff.

On 21–22 August, WARDA joined forces with *Institut sénégalais de recherches agricoles* (ISRA) and *Société d'aménagement et d'exploitation des terres du delta du fleuve Sénégal et des vallées du fleuve Sénégal et de la Falémé* (SAED) in a ***Journée riz*** (Rice Day) in Dakar,

Senegal, to coincide with the Council of Ministers meeting on the following two days. Results of all three institutions were presented and a rice field was 'planted' in the center of Dakar. Intensive press coverage accompanied the event.

The **National Experts Committee** met in Dakar, Senegal, on 23 August in preparation for the 23rd Ordinary Session of the WARDA **Council of Ministers** the following day. Among other items, the Council was presented with the draft *Strategic Plan for 2001–2010*. The Council endorsed the use of the upcoming WECARD/CORAF–CGIAR program integration meeting to further incorporate national rice research priorities into the WARDA Strategy. The Council also encouraged member States to make regular and timely payment of their contributions to the Association. The full text of the Council's resolution on "Continued support in research and related activities" is given in the 'Message from the Director General and Chairman of the Board of Trustees' (page 1).

From 27 to 31 August, WARDA participated in **PRIGA/PVS stakeholder meetings** in Senegal and The Gambia. In Dakar, Senegal, scientists from WARDA Headquarters and WARDA Sahel Station met with PVS stakeholders from ISRA, *Fédération des femmes productrices de la région de Saint-Louis du Sénégal* (FEPRODES), *Direction régionale du développement rural* (DRDR), Japanese Overseas Cooperation Volunteers (JOCVs) and a representative from the donor, the Rockefeller Foundation to review PVS, CBSS and other ongoing rice research activities. In Banjul, The Gambia, the WARDA Headquarters team met with researchers from the National Agricultural Research Institute (NARI), together with representative from the Women's Bureau, an NGO, the Chinese Technical Mission and UWTAET (East Timor). PVS and seed-priming trials were discussed—seed priming has been readily adopted by farmers in the project area. The meetings also identified new areas for potential research, especially within the upcoming African Rice Initiative and with the Chinese Technical Mission.

In the process of increasing collaboration, and consequently research and development efficiency, among CGIAR centers and their partners, a **Workshop on Integration of Agricultural Research in West and Central Africa** was held at the International Institute of Tropical Agriculture (IITA), Ibadan, 10–12 September. The meeting was jointly organized by WECARD/CORAF and the three principal CGIAR centers operating in West and Central Africa—IITA, WARDA and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)—and brought together representatives from 9 CORAF Networks and NARS partners, 10 CG centers, 2 Sub-regional Organizations (SROs) and the European Consortium for Agricultural Research in the Tropics (ECART). The workshop identified priority areas for sub-regional research cooperation and made recommendations on mechanisms for integration of activities among partners.

Over the period 3 September to 20 October, a combined **monitoring tour** was organized by **ROCARIZ**, **INGER-Africa**, and the **PRIGA** network. The tour visited the upland rice ecology in Benin, Ghana and Togo, and the Sahel irrigated rice ecology in Mauritania and Senegal. They met with NARS scientists, development agents and farmers to assess on-going collaborative activities. The team included a representative of USAID—a major donor to ROCARIZ.

Scene from the ROCARIZ/INGER-Africa/PRIGA monitoring tour to the Sahel irrigated rice ecology, Mauritania, October 2001

On 21–22 September, WARDA celebrated its **30th Anniversary** at its Headquarters. During the opening ceremony, honors were presented to five WARDA staff in the presence of His Excellency Mr Pascal Affi N'Guéssan, Prime Minister of the Republic of Côte d'Ivoire, on behalf of His Excellency Mr Laurent Gbagbo, President of the Republic. A further award was presented to Ivorian rice farmer Delphine Koudou, Aka 'Bintu' of WARDA video fame. She was awarded "*Chevalier dans l'ordre du mérite ivoirien*" ("Knight in the Ivorian Order of Merit") as a representative of all those farmers who have been involved in the PVS program. (For more details, see the 'Message from the Director General and Chairman of the Board of Trustees,' page 1.)

WARDA staff decorated by the Ivorian Government, with HE the Minister of National Education, Côte d'Ivoire: (from left to right) Dr Kouamé Miézan; Dr Monty P. Jones; Dr Kanayo F. Nwanze; HE Amani N'Guéssan Michel, Minister for National Education, Côte d'Ivoire; Dr Sitapha Diatta; Mme 'Bintu' Delphine Koudou; Mr Mark Etsiba; HE Théophile Nata, Minister of Agriculture, Livestock and Fisheries, Benin (Chairmain, WARDA Council of Ministers)

Concerned by the low implementation level of United Nations Development Programme (UNDP) projects in Côte d'Ivoire (under 38%), the Ministry of Planning and Cooperation organized a **UNDP Information and Training Workshop** with all partners involved in UNDP projects in the country, to discuss major constraints met in fund-raising and implementation of activities, from 25 to 27 September. WARDA participants used the workshop to gain a better understanding of UNDP procedures and also to prepare CBSS activities. The UNDP representatives noted that since the official approval of the CBSS project in May 2001, no funds had been released. WARDA was duly mandated to assist in: (1) planning CBSS activities for the following months; (2) fill funds request forms in relation to activities to be conducted (Start-up workshops, On-farm field workshops, and Awareness and Monitoring workshops, Training of resource persons for selected regions of Bouaké, Daloa, Man, Korhogo); (3) prepare the start-up workshop; (4) prepare official contracts for different categories of stakeholders involved in the CBSS project (ANADER, CNRA [*Centre national de recherche agronomique*], WARDA, PNR, LANADA [*Laboratoire national d'appui au développement agricole*], NGOs, and the private sector). In addition, WARDA would (a)

HE Pascal Affi N'Guessan, Prime Minister of Côte d'Ivoire (second from left), tours the exposition at WARDA's 30th Anniversary facilitate the immediate implementation of the CBSS program in Côte d'Ivoire; (b) produce training materials; (c) set-up a Monitoring and Evaluation framework based on partners involvement, especially ANADER; (d) conduct research and development activities to increase the value of seed produced by farmers; (e) produce Breeder Seed of NERICAs and other WARDA varieties; and (f) assist the National Research Programme to set-up a Foundation-Seed production strategy.

On 13 October, our Ivorian extension partners, ANADER, organized an **open day with farmers** in the village of Kouepleu to demonstrate the work on PVS-extension, in particular the new upland-rice varieties introduced to the Danané region. The work being 'reported' had involved some 436 farmers from 50 villages, together with 25 extension agents, two supervisors, one specialist technician and the *Chef de Zone*. ANADER agents and PVS-extension participant farmers discussed and demonstrated the methodology and results to about 150 previously unexposed farmers. A visit was made to one farmer's field, and the favored varieties were cooked for a palatability test. Group discussions were lively, and the 'new' farmers were keen to join the project.

Training on Rice Participatory Research was held at WARDA Headquarters on 15–20 October. Seven scientists and extension agents from The Gambia (4) and Rwanda (3) participated. The course covered all aspects of rice production from breeding, through diseases and pests, integrated crop management, harvesting, post-harvest processing and marketing. Various participatory methods were also presented.

An **Open Day** was held at the Sahel Station on 24 October. About 50 visitors, representing collaborating institutions, private enterprise, local farmers and farmers' organizations saw the activities of the station.

The **IVC National Coordination Unit of Côte d'Ivoire** met in Gagnoa on 25 October. Representatives from CNRA, the Universities of Cocody (Abidjan) and Bouaké, ANADER and *Bureau national d'études techniques et de développement* (BNETD) met to discuss 11 pre-proposals for possible submission to the Consortium Management Committee for funding in 2002, and visited the inland valley of Guessihio and the SPIRIVWA project site. The latter site suffered serious delays in the establishment of the appropriate infrastructure, and there was little activity and no trials had started at the time of the visit (wet season).

A **training course on rice yellow mottle virus (RYMV)** was held at WARDA Headquarters from 29 October to 9 November, for 17 participants from 8 national programs, and WARDA Sahel Station. Participants learnt to identify the disease and its insect vectors; how to evaluate the severity of the disease in an attacked field, and methods of controlling the disease and screening varieties for resistance.

A **rice stakeholders workshop** was held under the auspices of the Nigeria Rice Sector Study by Nigerian Institute of Social and Economic Research (NISER) and WARDA in Ibadan, Nigeria on 8–9 November. The workshop participants—drawn from the full range of rice stakeholders in the country—discussed constraints to rice-sector development in Nigeria and identified research needs. The state-of-the-art review of Nigeria's rice economy, based mainly on a literature review by Visiting

Open Day at WARDA's Sahel Station, October 2001

Scientist, Godwin Akpokodje, was presented at the workshop.

Impact of our research methods beyond our traditional mandate region of West and Central Africa was demonstrated in the request to conduct a **training course on participatory rice research and seed production**, in Kigali, Rwanda, on 27–30 November. The three-person team from WARDA presented material for 31 Rwandan NAR(E)S personnel.

From 19 to 22 December, WARDA participated in a workshop in Bouaké, Côte d'Ivoire, along with MINAGRA, UNDP and WFP to **train CBSS facilitators**. Some 35 farmers, 10 field extension agents and 5 senior/specialist technicians—representing ANADER, a Korhogo-based cotton company LCCI, *Organisation des volontaires pour le développement local* (OVDL) and PNR—took part, in addition to co-sponsor representatives.

Financial Statement

1. Position for the years ended 31 December 2000 and 2001 (in US$)

ASSETS	2001	2000
Current Assets		
Cash and Cash Equivalent	2 855 982	2 326 415
Accounts Receivable:		
Donor	613 403	950 025
Employees	343 307	382 296
Others	482 118	777 405
Inventories	572 629	615 187
Prepaid Expenses	35 017	19 737
Total Current Assets	**4 902 455**	**5 071 065**
Property and Equipment		
Property and Equipment	8 691 576	8 855 580
Less: Accumulated Depreciation	(6 597 764)	(6 330 906)
Total Property and Equipment-Net	**2 093 812**	**2 524 674**
TOTAL ASSETS	**6 996 267**	**7 595 738**

LIABILITIES AND NET ASSETS	2001	2000
Current Liabilities		
Bank Balances (Overdraft)	138 561	137 160
Accounts Payable:		
Donors	3 188 905	2 976 460
Employees	276 019	231 786
Others	1 219 627	1 914 644
Provisions and Accruals	877 298	1 096 192
Total Current Liabilities	**5 700 410**	**6 356 242**
Total Liabilities	**5 700 410**	**6 356 242**
Net Assets		
Unrestricted Net Assets	1 295 857	1 239 496
Total Net Assets	**1 295 857**	**1 239 496**
TOTAL LIABILITIES AND NET ASSETS	**6 996 267**	**7 595 738**

2. Statement of activities by funding for the years ended 31 December 2000 and 2001 (in US$)

	Unrestricted	Restricted	Total 2001	Total 2000
REVENUE				
Grants	4 272 622	4 796 839	9 069 461	8 086 567
Member States—Operating Income	147 505		147 505	185 077
Member States—Capital Development Income				112 851
Transfer of Restricted Assets—Income	211 567		211 567	112 857
Other Income	354 763		354 763	293 024
TOTAL REVENUE	**4 986 457**	**4 796 839**	**9 783 296**	**8 790 376**
OPERATING EXPENSES				
Program Related Expenses	2 120 760	4 796 839	6 917 599	6 382 721
Management and General Expenses	4 039 265		4 039 265	4 004 156
Total Expenses and Losses	**6 160 025**	**4 796 839**	**10 956 863**	**10 386 877**
Indirect Cost Recovery	(1 322 907)		(1 322 907)	**(1 187 868)**
Total expenses and losses	**4 837 117**	**4 796 839**	**9 633 956**	**9 199 009**
EXCESS/(DEFICIT) OF REVENUE OVER EXPENSES				
Change in Net Assets	**149 340**		**149 340**	**(407 800)**
Net Assets at Beginning of Year	**1 239 496**		**1 239 496**	
Change in Net Assets before Cumulative Effect of Change in Accounting Policy	149 340		149 340	(407 800)
Bad Debt Written Off—CIMMYT				(152 691)
Reversal of GTZ-Soil Nitrogen Over-expenditure	(92 979)		(92 979)	
Cumulative Effect of Change in Accounting Policy				1 799 987
Change in Net Assets	**56 361**		**56 361**	**1 239 496**
Net Assets at End of Year	**1 295 857**		**1 295 857**	**1 239 496**
MEMO ITEM				
Management and General Expenses by Natural Classification				
Personnel Costs	*1 441 393*	*2 508 435*	*3 949 828*	*3 972 222*
Supplies and Services	*1 542 357*	*3 752 216*	*5 294 573*	*4 928 651*
Operational Travel	*258 030*	*483 080*	*741 110*	*480 107*
Depreciation	*683 696*		*683 696*	*805 937*
Capital Expenditures	*113 789*	*173 868*	*287 657*	*199 960*
Gross Operating Expenses	***4 039 265***	***6 917 599***	***10 956 863***	***10 386 877***

3. Grants for the year ended 31 December 2001 (in US$)

UNRESTRICTED	2001	2000
Belgium	131 780	162 069
Canada	452 828	470 212
Denmark	109 311	126 199
France*	148 000	141 000
Germany	140 403	
Japan	412 990	654 340
Netherlands*	642 008	704 920
Norway	241 434	255 807
Sweden	319 041	336 344
United Kingdom*		268 434
USAID	224 991	250 000
World Bank	1 390 000	1 310 000
Côte d'Ivoire	59 836	
Total unrestricted grants	**4 272 622**	**4 679 325**
TEMPORARILY RESTRICTED		
AfDB I (Institutional Support)	99 148	290 274
Canada (Laval University)		7 164
Canada (FDCIC Project)		10 333
CFC/FAO	88 060	
Denmark (Phytosanitary & Seed Health)	34 405	144 391
European Union (Crop & Resources Management)	207 295	94 760
European Union/CORAF Project	74 978	
France (Collaboration IRD)	20 181	3 800
Gatsby Foundation (Containment Facility)	48 625	31 520
Gatsby Foundation (Dissemination)	98 431	138 847
GTZ (Projet riz nord)	6 472	76 467
GTZ (Improved Nutrient Management)	95 066	33 173
GTZ (PTDP)	358 903	316 026
GTZ (Periurban Project)	61665	
IFAD (PADS Project)	388 098	92 393
IVC/CFC Spirivwa		27 545
UNDP-IAEG Germplasm Project		26 001
UNDP/TCDC-IHP Phase 2	161 371	117 350
Collaboration-HRI	10 519	2 501
Japan (Post Doc)	48 845	26 212
Japan (Grain Quality)		68 034
Japan (Interspecific Hybridization Project)	606 640	307 572

*The use of these Grants has been restricted towards selected projects in CGIAR Approved Agenda for WARDA

TEMPORARILY RESTRICTED (continued)

	2001	2000
Japan/MAFF WARDA Project (WFP)	318 889	108 619
Japan (RYMV Project)	250 281	151 491
Japan (Blast Project)	183 227	40 468
Japan (Project 1.3)		200 000
Japan (Project 3.4)	106 233	200 000
Japan (Vegetable Production Project)	25 000	
Japan (Project 2.1)	98 817	
Norway (Training Project)	180 533	12 867
Rockefeller (Anther Culture Project)	161 900	130 323
Rockefeller (Post Doc)	38 898	45 125
Rockefeller (Capacity Building)	26 642	
Rockefeller (FPATDD-Mali/Nigeria)	39 445	
United Kingdom (Weeds Project)	6 313	25 480
United Kingdom (RYMV Attributed)*	139 578	
United Kingdom (RYMV CRF Project)	47 321	67 425
United Kingdom (Soil Degradation CRF Project)	52 871	33 342
United Kingdom (Seed Priming Project)	25 454	7 135
United Kingdom (lNGER-Africa Phase 2)	299 009	141 683
United Kingdom (Wild Rice Project)	13 584	1 0164
United Kingdom (University of Wales)		20 434
United Kingdom (Root Penetration-University of Aberdeen)	4 707	12 002
United Kingdom (Blast Attributed Project)*	59 539	
United Kingdom (Rice Functional Diversity)	12 236	
USAID (Network Project)	195 918	280 130
USAID (Impact Assessment Project)	9 026	100 000
USAID (Nigeria Rice Economy Project)	92 718	
USAID (Sub-Sahara E-mail Project)		6 192
Total Restricted Grants	**4 796 839**	**3 407 242**
TOTAL GRANTS	**9 069 461**	**8 086 567**

*The use of these Grants has been restricted towards selected projects in CGIAR Approved Agenda for WARDA

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1 January 2001 to 30 April 2002

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Monty P. Jones	Deputy Director of Research and Rainfed Rice Program Leader Acting Director of Research**
Willem A. Stoop**	Interim Associate Director of Research
Frank Abamu	Agronomist/Crop Modeler
Emmanuel Abo†	Visiting Scientist (Virology)
Godwin Akpokodje**	Policy Economist (Visiting Scientist, Nigeria)
Enoch Boateng*	GIS Specialist (Visiting Scientist)
Anne Bouma*	Program Support Officer
Toon Defoer*	Technology Transfer Agronomist Acting Rice Policy and Development Program Leader (from 15 Sep 2001)
Aliou Diagne	Impact Assessment Economist
Alassane Diallo**	Documentalist
Sitapha Diatta	Soil Physicist
Olaf Erenstein	Production Economist
Koichi Futakuchi	Crop Ecophysiologist
Howard Gridley*	Lowland Rice Breeder
Robert Guei	INGER-Africa Coordinator
Stephan Häfele	Agronomist for Irrigated Systems (Sahel)* Associate Agronomist (BMZ/GTZ)**
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Monica Idinoba*	Agroclimatologist (Visiting Research Fellow)
Assétou Kanouté**	Technology Transfer Scientist (Visiting Scientist)
Mohamed Kebbeh	Production Economist (Sahel)
Harouna Koré*	Vegetable Economist (Visiting Scientist)
Frédéric Lançon	Policy Economist Acting Rice Policy and Development Program Leader**
Kouamé Miézan	Irrigated Rice Program Leader (Sahel)
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Yacouba Séré	Pathologist
Aïssata Sobia Camara*	Agricultural Economist (Visiting Scientist)
Marco Wopereis‡	Natural Resource Management Scientist (DGIS)
N'guéssan Yoboué**	Germplasm Scientist (Visiting Scientist)

Collaborating Scientists/Staff

Alain Audebert	Physiologist (CIRAD)
Olivier Briët**	Associate Medical Entomologist (DGIS)
Marie-Josèphe Dugué	Inland Valley Consortium Regional Coordinator (*Coopération française*)
Pierrick Fraval	Water Management Economist (Sahel, IWMI/*Cemagref*)
Rebecca Kent**	Weed Scientist (NRI)
Adrian Q. Labor**	Information and Communications Technology Manager (IDRC)
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Petrus van Asten	Associate Soil Scientist (Sahel, DGIS)
Myra Wopereis-Pura‡	Technology Transfer Officer (United Nations Volunteer)

* Joined or changed title in 2001
** Left or changed title in 2001
† Joined or changed title in 2002
‡ Left or changed title in 2002

Visiting Scientists

THE VISITING Scientist Scheme was introduced in 1998 as a mechanism for NARS scientists to be posted at one of WARDA's stations, working as part of the WARDA team. The positions are open to full-time national scientists nominated by their respective institutions. During the secondment, of up to one year, Visiting Scientists are full members of WARDA's inter-disciplinary teams and are involved in the day-to-day activities of the Association.

Visiting Scientists bring fresh blood and insight into the WARDA program and, we hope, take back something valuable to their national programs on completion of their tour of duty with us. In 2001, three Visiting Scientists finished their term of secondment to WARDA, and three more started theirs; one more Visiting Scientist joined WARDA in April 2002.

Emmanuel Abo is Assistant Chief Research Officer in charge of plant virus research at the National Cereals Research Institute (NCRI), Badeggi, Nigeria. As such, he works on rice, sugarcane, beniseed and sesame, and works on both research and extension activities. He joined WARDA's pathology team at Headquarters in April 2002 to work on rice yellow mottle virus (RYMV). He is working to identify alternative hosts of RYMV and associated insect vectors, to determine the persistence of RYMV on farmers' fields, and he will participate in the on-farm testing of promising RYMV-tolerant varieties to test their stability and adaptability. In addition, Abo will be participating in the training for RYMV identification and management.

Godwin Akpokodje is a Research Fellow at the Nigerian Institute of Social and Economic Research (NISER), Ibadan, Nigeria, where he has contributed to several studies on Nigerian agricultural policy in relation with regional and international institutions. He completed his secondment to our Nigeria Station (based at IITA Headquarters, Ibadan) as Policy Economist in October 2001. He conducted a state-of-the-art review of the Nigerian rice economy, as part of the wider rice sector study of Nigeria in Program 3 (*see* Box 'Case study: Nigeria,' page 44). The work initiated at WARDA will continue in cooperation with Akpokodje at NISER, as part of the drive to increase WARDA's influence and impact in the rice 'power house' among the Association's member states.

Enoch Boateng, is a Senior Scientific Officer at the Soil Research Institute (part of the Council for Scientific and Industrial Research), Accra, Ghana. He joined WARDA's Systems Analysis and GIS Unit in September 2001 as GIS Specialist. The first goal of his assignment at WARDA Headquarters is to use computerized GIS systems to assess potential areas which could support rice cultivation in Ghana. This is with a view to developing a decision-support tool for rice policy that will act as an input into priority-setting for rice production research. The second goal is to use the GIS software

Almanac Characterization Tool (ACT) to develop a database (known as an almanac) of biophysical and socio-economic data relevant to rice production in West Africa. The latter aspect will focus initially on Ghana and Côte d'Ivoire.

Assétou Kanouté is a Lecturer–Researcher at *Institut polytechnique rural de Katibogou*, Mali. She is a range-management ecologist, with experience in working with NGOs and grass-roots organizations, especially rural women's organizations. She came to WARDA in February 2000 to join the technology transfer team, with special interest and emphasis on partnerships. She has assisted with an assessment of traditional seed-exchange mechanisms at three key sites in Côte d'Ivoire, and with participatory legume assessments at the same sites. With the PTDP Coordinator, she organized the first rice planning workshops with farmers in two states in Nigeria (Ogun and Kogi) and in Benin. In addition, Kanouté organized the Ivorian NGO workshop at WARDA, and initiated a socio-economic survey on financial systems in Ogun State. She also has initiated a directory of Ivorian NGOs. Along with the Production Economist, Kanouté represented WARDA at a gender and diversity workshop in Kenya. She also completed a socio-economic study on constraints and opportunities on rice farming systems in four regions of Côte d'Ivoire.

Harouna Koré is Assistant Lecturer in the Faculty of Agriculture at the University of Niamey, Niger. Koré has carried out research on the dynamics of integrated production systems in the Sahel for over 10 years, with particular interest in the relationship between the comparative advantages of certain major crops (rice, onion) and food security of households. He came to WARDA in September 2001, to work as Vegetable Economist, mainly on the OFDA (Office of US Foreign Disaster Assistance, USAID) vegetable project, 'Rice-based vegetable production in the WARDA-targeted region.' He is compiling information from Burkina Faso, Côte d'Ivoire and Ghana on the integration of vegetable cropping and lowland rice systems. The review includes the status of research, characterization of rice–vegetable systems, and strategic elements for addressing micronutrient deficiencies through rice–vegetable cropping systems. The review feeds into collaborative research efforts in West Africa of the NARS, the Asian Vegetable Research and Development Center (AVRDC) and WARDA.

Aïssata Sobia Camara is a scientist at the *Centre ivoirien de recherches économiques et sociales* (CIRES), Cocody University, Abidjan, Côte d'Ivoire. In August 2001, she joined WARDA's Program 3 team as an agricultural economist. She has extensively studied rice processing and marketing in Côte d'Ivoire, managing a country-wide survey on the entire commodity chain in 1997. At WARDA, she has undertaken an updated review of the rice sector in the country and contributed to the development of an econometric model to analyze rice millers' strategies. She has also coordinated studies on rice production and marketing in the Bandama and Zanzan regions, within the framework of the World Food Programme (WFP) project in Côte d'Ivoire.

N'guéssan Yoboué is a Lecturer–Researcher in the Department of Agriculture and Animal Resources at the *Institut national polytechnique Houphouët-Boigny* (INP-HB), Yamoussoukro, Côte d'Ivoire. He is a rice breeder and geneticist. He completed his assignment with WARDA's Genetic Resources Unit in May 2001. During his time at WARDA, he contributed to the assessment of the impact of new rice varieties on farmers (economic, general well-being, poverty reduction), the effect of the introduced varieties on farm-level rice diversity, and the characterization of the current level of on-farm rice biodiversity. The material that he collected will be characterized at WARDA.

Training

Courses Given in 2001

Title and dates	Location	Language	Participants		
			Male	Female	Total
Formation des paysans innovateurs et des formateurs 27–31 March	Bouaké, Côte d'Ivoire (ANADER)	French	35	7	42
Initiation à la biométrie pour les chercheurs d'Afrique francophone 17–21 April	M'bé, Bouaké, Côte d'Ivoire (WARDA)	French	16	1	17
Les techniques améliorées de culture de riz de bas-fond et de riz pluvial 7–8 June	M'bé, Bouaké, Côte d'Ivoire (WARDA)	French	16	4	20
Les techniques de production, de commercialisation et de contrôle de qualité des semences en Côte d'Ivoire 11–22 June	M'bé, Bouaké, Côte d'Ivoire (WARDA)	French, English	35	6	41
Integrated Crop Management for Irrigated Rice [for farmers] July–October (4 training course days per site)	Boundoum and Podor, Senegal	Wolof	80	0	80
Participatory Learning and Action Research for Integrated Rice Management [for farmers] July 2001 to January 2002 (weekly)	Bamoro, Côte d'Ivoire	French	30	0	30
Participatory Learning and Action Research for Integrated Rice Management [for farmers] July 2001 to January 2002 (weekly)	Lokakpli, Côte d'Ivoire	French	25	5	30

Participatory Technology Development 26 August to 14 September	Abeokuta, Nigeria	English	23	9	32
Construction of the Thresher–Cleaner 1–26 October	Accra, Ghana	English	10	0	10
Training on Rice Participatory Research 15–20 October	M'bé, Bouaké, Côte d'Ivoire (WARDA)	English, French	5	2	7
Training on Rice Yellow Mottle Virus 29 October to 9 November	M'bé, Bouaké, Côte d'Ivoire (WARDA)	French, English	17	0	17
Sustainable Crop–Livestock Production for Improved Livelihoods and Natural Resources Management in West Africa 19–22 November	Ibadan, Nigeria	English	70	20	90
Participatory Rice Research and Seed Production [for national partners] 27–30 November	Kigali, Rwanda	French, English	29	2	31
Participatory Varietal Selection–Extension 19–21 December	M'bé, Bouaké, Côte d'Ivoire (WARDA)	French	20	1	21
Atelier de formation des facilitateurs du CBSS [MINAGRA/WARDA/UNDP/WFP] 19–22 December	Bouaké, Côte d'Ivoire (ANADER)	French	42	8	50
Total			**453**	**65**	**518**

Postgraduate Trainees in 2001

Name and thesis topic/subject	Institution	Sponsor	Degree
*Abi, Monnet Innocent*** *Impact des innovations variétales sur la gestion de la biodiversité : exemple des variétés améliorées de riz en Côte d'Ivoire*	Institut national polytechnique Houphouet-Boigny (INP-HB) Ecole supérieure d'agronomie (ESA)	WARDA/DFID	DAA
Adesanwo, O.O. Legume/phosphate rock combination for sustainable rice production in southwestern Nigeria	University of Agriculture, Abeokuta, Nigeria	WARDA	PhD
Afolabi, Aboladi Development of 'clean gene' technology for rice transformation	University of East Anglia/ John Innes Centre, UK	DFID/ Rockefeller Foundation	PhD
*Akanvou, René*** Quantitative understanding of the performance of upland rice–cover legume cropping systems in West Africa	Wageningen Agricultural University	Netherlands/ WARDA	PhD
Aluko, Kiodé Gabriel Genetic studies of soil acidity tolerance in rice	Louisiana State University	Rockefeller Foundation	PhD
*Amoussou, Pierre-Louis** Genomics of rice yellow mottle virus	University of East Anglia, UK	Rockefeller Foundation/ John Innes Centre	PhD
Assingbé, Paulin *Intégration des légumineuses dans la rotation des cultures du riz pluvial au Bénin*	University of Cocody-Abidjan	BMZ/GTZ	PhD
*Bissouma, Laurence** *Criblage de variétés locales de riz pour la résistance à la pyriculariose*	INP-HB/ESA	MESRS/ WARDA	DAA/ MSc
Bognonkpe, Jean Pierre Irénée The influence of land use on the dynamics of native soil nitrogen at watershed scale in West Africa	University of Bonn	DAAD/ Volkswagen Foundation	PhD

*Cairns, Jill*** Root penetration and QTL mapping in upland rice	University of Aberdeen	DFID	PhD
Chérif, Mamadou *Effet de la toxicité ferreuse sur l'activité photosynthétique du riz : étude de la variabilité génétique*	Université d'Abidjan	AfDB	PhD
Chovwen, Anthony Evaluation of participatory research approaches in Nigeria	University of Agriculture Abeokuta, Nigeria	BMZ/GTZ	PhD
Clark, Cary Rural finance systems and related constraints for lowland rice intensification	University of Reading	Private/ WARDA	PhD
Djadjaglo, David *Détermination des facteurs influencant la productivité des systèmes de production à base de riz au sud du Bénin*	Hohenheim University	BMZ/GTZ	PhD
*Dudnik, Nina** Molecular biology	—	Fulbright	—
Guèye, Talla Nitrogen use efficiency in irrigated rice	University of Göttingen	DAAD	PhD
*Häfele, Stephan*** Soil fertility management in irrigated rice	University of Hamburg	BMZ/GTZ	PhD
*Horna, Daniela** Brokering of knowledge and information in the rice production system in Southern Nigeria and Benin Republic	Hohenheim University	BMZ/GTZ	PhD
Keijzer, Pieter Plant science	Wageningen University	Wageningen University/ WARDA	MSc
Kotchi, Valère *Dynamique du phosphore dans les sols en région tropicale : le cas de la Côte d'Ivoire*	Université d'Abidjan	AfDB	PhD
*Kouamé, Arsène Kouadio*** *Analyse de la gestion des semences de riz et de l'adoption des variétés modernes en milieu paysan*	INP-HB/ESA	WARDA/ DFID	DAA

*Kouassi Niankan, Aubin** *Evaluation de la résistance à la panachure jaune du riz de 297 variétés locales de riz de la région de Gagnoa*	INP-HB/ESA	MESRS/ WARDA	DAA/ MSc
*Lago, N'brin Gaston*** *Méchanismes de résistances à la cécidomyie africaine du riz,* Orseolia oryzivora	INP-HB/ESA	ESA/WARDA	DAA
*Larbaigt, Frédéric*** Sustainability and maintenance in community-based irrigation schemes in the Senegal River floodplain	Ecole nationale du Génie de l'eau et de l'environnement de Strasbourg	IWMI/ WARDA	MSc
Maji, Alhassan Tswako Genetics of resistance to African rice gall midge in *Oryza glaberrima*	University of Ibadan	Rockefeller Foundation	PhD
Mandé, Sémon Assessment of biodiversity in *Oryza glaberrima* using microsatellite markers	Cornell University	Rockefeller Foundation	PhD
*Mesmin, Meye Mella** Influence of spatial variability on fertilizer recommendations	Technical School Bambey	—	Agro- nomic engineer
*Mulder, Linda** Effect of straw application on yield and on plant availability of N and P for alkaline irrigated rice soils	Wageningen University	DFID	MSc
*Soko Dago, Faustin** *Epidémiologie du RYMV : étude des conditions d'établissement et de déroulement des épidémies pour une gestion integrée de la panachure jaune du riz en Côte d'Ivoire*	Université d'Abidjan	Japan	PhD
Sorho, Fatogoma Assessment of rice yellow mottle virus pathology as a prerequisite of the deployment and the durability of the natural genetic resistance to rice yellow mottle disease	Université d'Abidjan	IRD	PhD
*Tia, Dro Daniel** *Caractérisation morphologique de la biodiversité du riz local de la région de Gagnoa*	INP-HB/ESA	WARDA	DAA

*Tonessia, Dolou Charlotte** *Identification de la flore bactérienne et fongique hébergée par les semences de riz et tentative de lutte contre ces pathogènes*	Université de Cocody-Abidjan	MESRS/ WARDA	DEA
*Traoré, Karim** Marker-assisted selection for improving drought resistance in rice root traits and osmotic adjustment	University of Texas	Rockefeller Foundation	PhD
*Tveteraas, Astrid** The impact of AIDS on livelihood security in rural areas of Côte d'Ivoire	Agricultural University of Norway	Agricultural University of Norway/WARDA	MSc
van Asten, Petrus Salt-related soil degradation in irrigated rice-based cropping systems in the Sahel	Wageningen University	DGIS	PhD
*van't Zelfde, Arjan** Identification and quantification of processes contributing to alkalinization in irrigated rice soils	Wageningen University	DFID	MSc
Yao, Kouadio Nasser *Androgène in vitro chez le riz* Oryza glaberrima *et d'hybrides interspecifiques* sativa-glaberrima	Université d'Abidjan	AfDB	PhD
*Zamble, Lout T. Corinne** *Caractérisation morphologique de la biodiversité du riz local de la région de Danané*	INP-HB/ESA	WARDA	DAA
*Zekre, Sylvestre** *Caractérisation morphologique de la biodiversité du riz local des régions de Boundiali et Touba*	INP-HB/ESA	WARDA	DAA
*Zeller, Heiko** Characterization of rainfed upland rice production systems in southern Nigeria	Hohenheim University	BMZ/GTZ	PhD

* Started in 2001
** Completed in 2001

Publications

(2001)

Abo, M.E., M.N. Ukwungwu, J. d'A. Hughes and S.M. Misari, 2001. Possible sources of resistance to rice yellow mottle virus (RYMV) genus sobemovirus in some genotypes in Nigeria. *Journal of Agriculture and Environment* 2(2): 263–270.

Ahmadi, N., A. Audebert, B. Traoré, J. Bozza, B. Feuillette and M. Simpara, 2001. Référentiel agronomique disponible pour l'intensification de la riziculture de bas-fonds en zone soudanienne. In: *Mise en valeur et aménagement des bas-fonds d'Afrique de l'Ouest* [CD-ROM]. CIRAD, Montpellier, France; CBF, Bouaké, Côte d'Ivoire; IER, Bamako, Mali; SARI, Koumassi, Ghana, & PSI, Dakar, Sénégal.

Akanvou, R., M. Becker, L. Bastiaans and M. Kropff, 2001. Effects of sowing dates on cover legumes-upland rice intercropping systems in West Africa. *Biology and Fertility of Soils* 33: 15–21.

Akanvou, R., M. Becker, M. Chano, D.E. Johnson, H. Gbaka-Tcheche and A. Touré, 2001. Fallow residue management effects on upland rice in three agro-ecological zones of West Africa. *Biology and Fertility of Soils* 31: 501–507.

Akanvou, R., M. Becker, M. Kropff, L. Bastiaans and G. Dea, 2001. Optimum rice yield under short-term cover crop fallow systems. In: W.J. Horst, M.K. Schenk, A. Burkert, N. Claassen, H. Flessa, W.B. Frommer, H. Goldbach, H.W. Olfs, V. Romheld *et al*. (ed.) *Plant Nutrition: Food security and sustainability of agro-ecosystems through basic and applied research*. Kluwer Academic, Dordrecht, The Netherlands. Pp. 1000–1001.

Asch, F. and M.C.S. Wopereis, 2001. Responses of field-grown irrigated rice cultivars to varying levels of flood-water salinity in a semi-arid environment. *Field Crops Research* 70: 127–137.

Audebert, A., M. Becker and D.E. Johnson, 2001. Differential response of rice to hydrological conditions and agronomic management. *African Crop Science Journal* 4: 107–111.

Audebert, A. and S. Diatta, 2001. Toxicité ferreuse dans les bas-fonds rizicoles Ouest Africains. Diagnostic du risque et méthodes de lutte. In: *Mise en valeur et aménagement des bas-fonds d'Afrique de l'Ouest* [CD-ROM]. CIRAD, Montpellier, France; CBF, Bouaké, Côte d'Ivoire; IER, Bamako, Mali; SARI, Koumassi, Ghana, & PSI, Dakar, Sénégal.

Becker, M. and D.E. Johnson, 2001. Cropping intensity effects on upland rice yield and sustainability in West Africa. *Nutrient Cycling in Agroecosystems* 59: 107–117.

Becker, M. and D.E. Johnson, 2001. Improved water control and crop management effects on lowland rice productivity in West Africa. *Nutrient Cycling in Agroecosystems* 59: 119–127.

Becker, M., M.S.C. Wopereis and D.E. Johnson, 2001. The role of N nutrition on rice yields along an agroecological gradient in West Africa. In: W.J. Horst, M.K. Schenk, A. Burkert, N. Claassen, H. Flessa, W.B. Frommer, H. Goldbach, H.W. Olfs, V. Romheld *et al*. (ed.) *Plant Nutrition: Food security and sustainability of agro-ecosystems through basic and applied research*. Kluwer Academic, Dordrecht, The Netherlands. Pp. 970–971.

Carsky, R.J., M. Becker and S. Hauser, 2001. Mucuna cover crop fallow systems: Potential and limitations. In: Carsky *et al*. (ed.) *Sustaining Soil Fertility in West Africa*. SSSA Special Publication No. 58. Soil Science Society of America, Madison, USA. Pp. 111–135.

Chipili, J., S. Sreenivasaprasad, A.E. Brown, N. J. Talbot, M. Holderness, Y. Séré, S.K. Nutsugah, J. Twumasi and K. Dartey, 2001. Characterisation of the blast pathogen populations at rice screening sites in West Africa. In: S. Sreenivasaprasad and R. Johnson (ed.) *Major Fungal Diseases of Rice: Recent Advances.* Kluwer Academic, Dordrecht, The Netherlands. Pp. 9–20.

Coyne, D., M. Smith and R. Plowright, 2001. Plant parasitic nematode populations on upland and hydromorphic rice in Côte d'Ivoire: Relationship with moisture availability and crop development on a valley slope. *Agriculture, Ecosystems and Environment* 84(1): 31–43.

Defoer, T. and I. Scoones, 2001. Participatory approaches to integrated soil fertility management. In: I. Scoones (ed.) *Dynamics and Diversity: Soil fertility management and farming livelihoods in Africa: Case studies from Ethiopia, Mali and Zimbabwe*. Earthscan Publications Ltd, London, UK. Pp. 64–75.

Diagne, A. and M. Zeller, 2001. Access to Credit and its Impact on Welfare in Malawi. *Research Report* 116. International Food Policy Research Institute, Washington, DC, USA.

Dingkuhn, M., F. Tivet, P. Siband, F. Asch, A. Audebert and A. Sow, 2001. Varietal differences in specific leaf area: A common physiological determinant of tillering ability and early growth vigor? In: S. Peng and B. Hardy (ed.) *Proceedings of Rice Research for Food Security and Poverty Alleviation*, International Rice Research Institute, Los Baños, The Philippines. Pp. 95-108.

Futakuchi, K., 2001. Reseach and extension activities of West African Rice Development Association (WARDA). (Review article) *Japanese Journal of Crop Science* 70(1): 115.

Futakuchi, K., 2001. Submergence tolerance and deep-water avoidance in *Oryza glaberrima* Steud. and interspecific progenies. In: Y. Takagi, O. Ito and M. Iwanaga (ed.) *Oryza glaberrima* Genetic Resources: Evaluation and Use. *JIRCAS Working Report* No. 22. JIRCAS, Tsukuba, Japan. Pp. 41–47.

Futakuchi, K., M.P. Jones and R. Ishii, 2001. Physiological and morphological mechanisms of submergence resistance in African rice (*Oryza glaberrima* Steud). *Japanese Journal of Tropical Agriculture* 45(1): 8–14.

Haefele, S.M., 2001. Improved and sustainable nutrient management for irrigated rice-based cropping systems in West Africa. PhD thesis, Hamburger Bodenkundliche Arbeiten, Band 49, Hamburg, Germany, 240 p.

Häfele, S., M.C.S. Wopereis, C. Donovan and J. Maubuisson, 2001. Improving productivity and profitability of irrigated rice production in Mauritania. *European Journal of Agronomy* 14(3): 181–196.

Idinoba, M.E., 2001. Carbon emission from used imported automobiles to West Africa: Implication for climate change and sustainable environmental quality. In: *Abstracts of The Challenges of a Changing Earth: Global Change Open Science Conference*, Amsterdam, The Netherlands, 10–13 July 2001. International Geosphere-Biosphere Programme (IGBP), Stockholm, Sweden. P. 398.

Kang, D.J., K. Futakuchi, S. Dumnoenngam, T. Mechai, B. Chakranon and R. Ishii, 2001. Factors related to differences in rice yield among districts in Narathiwat Province, southern Thailand. *Japanese Journal of Tropical Agriculture* 45(1): 49–56.

Kent, R.J. and D.E. Johnson, 2001. Influence of flood depth and duration on growth of lowland rice weeds, Cote d'Ivoire. *Crop Protection* 20: 691–694.

Kent, R.J., D.E. Johnson and M. Becker, 2001. The influences of cropping system on weed communities of rice in Côte d'Ivoire, West Africa. *Agriculture, Ecosystems and Environment* 87: 299–307.

Kleinschmidt, I., J. Omumbo, O. Briët, N. van de Giessen, N. Sogoba, N. Kumasenu Mensah, P. Windmeijer, M. Mahaman and T. Teuscher, 2001. An empirical malaria distribution map for West Africa. *Tropical Medicine and International Health* 6(10): 779–786.

Larbaigt, F., 2001. La gestion de la maintenance dans les périmètres irrigués villageois de la moyenne vallée du fleuve Sénégal. Mémoire d'ingénieur, Ecole nationale du génie de l'eau et de l'environnement de Strasbourg, 65 p.

Meye Mella, M., 2001. Etude de la variabilité spatiale des éléments fertilisants N P K, et leurs effets sur le rendement et sur la stratégie de fertilisation. Mémoire d'ingénieur agricole, Ecole nationale des cadres ruraux, Bambey, 45 p.

Nguessan, P., A. Pinel, A-A. Sy, A. Ghesquiere and D. Fargette, 2001. Distribution, pathogenicity and interactions of two strains of rice yellow mottle virus in forest and savanna zones of West Africa. *Plant Disease* 85: 59–64.

Nwanze, K.F., P.J. Kouka and M.P. Jones, 2001. South-South cooperation on food security: Rice in West Africa. *Cooperation South* 2-2001: 114-131. [La coopération Sud-Sud pour la sécurité alimentaire : Le cas du riz en Afrique de l'Ouest. *Coopération Sud* 2-2001: 134-154.]

Nwilene, F.E., K.F. Nwanze and M.P. Jones, 2001. Recent advances in host plant resistance and biological control of *Orseolia oryzivora* in West Africa. In: *Book of Abstract of the 14th African Association of Insect Scientists and the 9th Crop Protection Society of Ethiopia Joint Conference on Pests and Vectors Management for the Food Security and Public Health in Africa: Challenges for the 21st Century*, Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia, 4–8 June 2001. P. 13.

Sahrawat, K.L. and L.T. Narteh, 2001. Organic matter and reducible iron control of ammonium production in submerged soils. *Communications in Soil Science and Plant Analysis* 32(9–10): 1543–1550.

Sahrawat, K.L., M.K. Abekoe and S. Diatta, 2001. Application of inorganic phosphorus fertilizer. Chapter 11 in: G. Tian, F. Ishida and D. Keatinge (ed.) *Sustaining Soil Fertility in West Africa* (SSSA Special Publication Number 58). Soil Science Society of America & American Society of Agronomy, Madison, USA. Pp. 225–426.

Sahrawat, K.L., M.P. Jones, S. Diatta and A. Adam, 2001. Response of upland rice to fertilizer phosphorus and its residual value in an Ultisol. *Communications in Soil Science and Plant Analysis* 32(15&16): 2457–2468.

Sakurai, T., 2001. Risk and Household Behavior in Pakistan’s Agriculture (Book Review). *Economic Review* 52(2): 187–188.

Sakurai, T. and K. Palanisami, 2001. Tank irrigation management as a local common property: The case of Tamil Nadu, India. *Agricultural Economics* 25(2–3): 273–283.

Sakurai, T., Y. Kijima, R. Pokharel, S. Rayamajhi and K. Otsuka, 2001. Timber forest management in Nepal and Japan. In: K. Otsuka and F. Place (ed.) *Land Tenure and Natural Resource Management: A comparative study in agrarian communities in Asia and Africa*. Johns Hopkins University Press, Baltimore, USA. Pp. 315–355.

Sanyang S. 2001. Field observations on the appearance of acridids and their natural enemies in The Gambia. *Insect Science and its Application* 21(3): 219–223.

Segda, Z., F. Lompo, M.C.S. Wopereis and P.M. Sedogo, 2001. Amélioration de la fertilité du sol par l’utilisation du compost en riziculture irriguée. *Agronomie Africaine* 13(2): 45–58.

Somado, E.A., M. Becker, R.F. Kuehne, K.L. Sahrawat and P.L.G. Vlek, 2001. Improving rock-P solubility and uptake and yields of lowland rice grown on acidic soil amended with legume green manure. In: B. Vanlauwe, J. Diels, N. Sanginga and R. Merckx (ed.) *Integrated Nutrient Management in Sub-Saharan Africa*. CAB International, Wallingford, UK. Pp. 251–263.

Somado, E.A., R.F. Kühne, M. Becker, K.L. Sahrawat and P.L.G. Vlek, 2001. Rock-P effects on fallow legumes for upland crop production systems in humid West Africa. In: Dakora, F. (ed.) *Proceedings 7th Meeting of the African Association for Biological Nitrogen Fixation (AABNF)*, Cape Town, South Africa. Pp. 26–29.

Watanabe, H., 2001. Grain quality characteristics of *Oryza glaberrima* Steud. and interspecific progenies, with a view to breed high protein rice. In: Y. Takagi, O. Ito and M. Iwanaga (ed.) *Oryza glaberrima* Genetic Resources: Evaluation and Use. *JIRCAS Working Report* No. 22. JIRCAS, Tsukuba, Japan. Pp. 33–39.

Wopereis, M.C.S., S.M. Haefele, M. Kebbeh, K. Miézan and B.S. Diack, 2001. Improving the productivity and profitability of irrigated rice production in Sahelian West Africa. In: *Proceedings of the Expert Consultation Meeting on Yield Gap and Productivity Decline in Rice Production*, FAO, Rome, Italy, 5–7 September 2000. Pp. 117–142.

Wopereis, M.C.S., T. Sakurai, P. Idinoba and R. Kent, 2001. Constraints and opportunities for rice cropping in West Africa's inland valley lowlands. In: *Proceedings of the International Workshop on "Integrated Watershed Management of Inland Valley—Ecotechnology Approach,"* 6–8 February 2001, Accra, Ghana. Pp. 27–38.

WARDA titles
(1 January 2001 to 30 April 2002)

ADRAO : 1971-2001. 2001. ADRAO, Bouaké, Côte d'Ivoire, 17 p. ISBN 92 9113 223 3.

African Rice Gall Midge Research Guide. C.T. Williams, K.M. Harris, M.N. Ukwungwu, S. Nacro, D. Dakouo, F.E. Nwilene, B.N. Singh and O. Okhidievbie, 2002. WARDA, Bouaké, Côte d'Ivoire, and CABI, Wallingford, UK, 28 p. ISBN 92 9113 197 0.

Agricultural Input Markets in Nigeria: An Assessment and a Strategy for Development. 2001. Paper Series IFDC—P-23. International Fertilizer Development Center (IFDC), Muscle Shoals, USA; International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria; WARDA, Bouaké, Côte d'Ivoire, 31 p. ISBN 0 88090 128 4.

Annual Report 2000. 2001. WARDA, Bouaké, Côte d'Ivoire, 84 p. ISBN 92 9113 216 0.

Bintou et son nouveau riz pour l'Afrique : Briser la spirale de la culture itinérante dans la région la plus pauvre du monde. 2002. ADRAO, Bouaké, Côte d'Ivoire, 32 p. ISBN 92 9113 234 9.

Bintu and Her New Rice for Africa: Breaking the shackles of slash-and-burn farming in the world's poorest region. 2001. WARDA, Bouaké, Côte d'Ivoire, 32 p. ISBN 92 9113 207 1. [Winner of the CGIAR King Baudouin Award 2000.]

BOFANI (WAB 450-I-B-P-38-HB) [fiche technique]. [2001]. [ADRAO for Ministère de l'Agriculture et des ressources animales, Côte d'Ivoire], [1] p.

Bulletin ROCARIZ n° 1, avril 2002.

Collaboration ADRAO/SNRA : Potentiel d'une révolution verte dans le domaine de la riziculture en Afrique de l'Ouest et du Centre. Rapport de la deuxième réunion biennale ADRAO/Comité des experts nationaux, 20-21 mars 2000, M'bé, Bouaké, Côte d'Ivoire. *Rapport de réunion biennale ADRAO/Comité des experts nationaux* n° 2. 2001. ADRAO, Bouaké, Côte d'Ivoire, 110 p. ISBN 92 9113 209 8.

Current Contents at WARDA (Monthly issue).

Development of Training Materials in Agriculture. A course manual. A. Youdeowei and J. Kwarteng, 1995. WARDA, Bouaké, Côte d'Ivoire, 104 p. ISBN 92 9113 072 9. [Reprint.]

Elaboration de matériel didactique en matière d'agriculture : un manuel de cours. Anthony Youdeowei et Joseph Kwarteng, 1995. ADRAO, Bouaké, Côte d'Ivoire, & Centre technique de coopération agricole et rurale (CTA), Wageningen, Pays-Bas, 104 p. [ISBN 92 9113 073 7]. [Reprint.]

La ferme expérimentale de l'ADRAO. 2001. ADRAO, Bouaké, Côte d'Ivoire, [6] p. ISBN 92 9113 221 7.

Gestion intégrée pour la riziculture irriguée dans la vallée du fleuve Sénégal, région Bokhol à Matam [fiche technique]. [2001]. ADRAO, [Bouaké, Côte d'Ivoire], SAED [Société nationale d'aménagement et d'exploitation des terres du delta du fleuve Sénégal et des vallées du fleuve Sénégal et de la Falémé, St-Louis, Sénégal], & ISRA [Institut sénégalais de recherches agricoles, Dakar, Sénégal], [2] pp.

Gestion intégrée pour la riziculture irriguée dans la vallée du fleuve Sénégal, (Saint-Louis – Bokhol) [fiche technique]. [2001]. ADRAO, [Bouaké, Côte d'Ivoire], SAED [Société nationale d'aménagement et d'exploitation des terres du delta du fleuve Sénégal et des vallées du fleuve Sénégal et de la Falémé, St-Louis, Sénégal], & ISRA [Institut sénégalais de recherches agricoles, Dakar, Sénégal], [2] pp.

Inland Valley Newsletter No. 5, July 2001. 6 p.

International Network for Genetic Evaluation of Rice in Africa (INGER-Africa) First Review and Planning Workshop, WARDA, Bouaké, 14–15 April 2000, Synthesis Report. 2001. WARDA, Bouaké, Côte d'Ivoire, 14 p. ISBN 92 9113 211 X.

KEAH (WAB 450-11-1-P31-1-HB) [fiche technique]. [2001]. [ADRAO for Ministère de l'Agriculture et des ressources animales, Côte d'Ivoire], [1] p.

Life in Rice. [poster, 2001.]

Manuel pratique de riziculture irriguée dans la vallée du fleuve Sénégal (Version 1). [2001]. ADRAO, [Bouaké, Côte d'Ivoire] et Société nationale d'aménagement et d'exploitation des terres du delta du fleuve Sénégal et des vallées du fleuve Sénégal et de la Falémé (SAED), [St-Louis, Sénégal], 121 + [xxiii] p. [ISBN 92 9113 215 2.]

Medium Term Plan 2002–2004. 2001. WARDA, M'bé, Côte d'Ivoire, 62 p.

Merger of WARDA Task Forces and CORAF Rice Network. 2001. WARDA, Bouaké, Côte d'Ivoire, 26 p. ISBN 92 9113 213 6.

Mise en valeur et aménagement des bas-fonds d'Afrique de l'Ouest. Proposition d'un outil d'aide à l'aménagement : le diagnostic rapide de pré-aménagement (DIARPA): Synthèse des résultats du CIRAD et des partenaires sur la caractérisation des bas-fonds et l'intensification de leur mise en valeur (CD-ROM). Jean-Claude Legoupil, Bruno Lidon, François Blanchet et Jean-Yves Jamin, [2001]. Consortium bas-fonds (IVC/CBF), Bouaké, Côte d'Ivoire, et CIRAD, Montpellier, France.

New Rice for Africa: NERICA—Rice for Life. 2001. WARDA, Bouaké, Côte d'Ivoire, [8] p. ISBN 92 9113 217 9.

Nouveau riz pour l'Afrique : NERICA – Le riz, source de vie. 2001. ADRAO, Bouaké, Côte d'Ivoire, [8] p. ISBN 92 9113 218 7.

Plan à moyen terme 2002-2004. 2001. ADRAO, M'bé, Côte d'Ivoire, 66 p.

Participatory Varietal Selection: Beyond the Flame. 2002. WARDA, Bouaké, Côte d'Ivoire, 80 p. ISBN 92 9113 233 0.

Participatory Varietal Selection: The Flame Spreads into 2000. 2001. WARDA, Bouaké, Côte d'Ivoire, 84 p. ISBN 92 9113 204 7.

Promising Technologies for Rice Production in West and Central Africa. 2002. WARDA, Bouaké, Côte d'Ivoire and FAO, Rome, Italy, 28 p. ISBN 92 9113 226 8.

Rapport annuel 1999. 2002. ADRAO, Bouaké, Côte d'Ivoire, 72 p. ISBN 92 9113 225 X.

Rapport annuel 2000. 2002. ADRAO, Bouaké, Côte d'Ivoire, 84 p. ISBN 92 9113 232 2.

Rice cultivation and soil degradation in the Bignona Valley, Senegal. Developing management options for rice cultivation on degraded soils using a participatory approach. A.M. Fermont, 2001. Joint project report of WARDA and FDPPE, 72 p.

Rice for Life. [poster, 2001.]

Rice Interspecific Hybridization Project: Research Highlights 2000. 2001. WARDA, Bouaké, Côte d'Ivoire, 36 p. ISBN 92 9113 224 1.

Rice in the Economy of West Africa. A time series set for economic analysis / Le riz dans l'économie ouest africaine. Une collection de séries temporelles pour l'analyse économique. M.B. Djayeola, 2000. WARDA/ADRAO, Bouaké, Côte d'Ivoire, 36 p. ISBN 92 9113 193 8. *Print publication.*

Rice Seed Production by Farmers: A Practical Guide. A.M. Bèye and R.G. Guei, 2001. WARDA, Bouaké, Côte d'Ivoire, 14 p. ISBN 92 9113 212 8.

Rice Yellow Mottle Virus (RYMV): Economic Importance, Diagnosis and Management Strategies / La panachure jaune du riz : Importance économique, diagnostic et stratégies de gestion. A.A. Sy, J. Hughes and A. Diallo (Ed.), 2001 [2002]. WARDA/ADRAO, Bouaké, Côte d'Ivoire, 252 p. ISBN 92 9113 119 9.

ROCARIZ Newsletter No. 1, April 2002.

Sélection variétale participative : L'étincelle d'où jaillit la flamme. 2002. ADRAO, Bouaké, Côte d'Ivoire, 32 p. ISBN 92 9113 228 4.

Spread of NERICAs in Guinea: Towards Food Security. The History and Keys of Success. 2001. WARDA, Bouaké, Côte d'Ivoire, 10 p. ISBN 92 9113 210 1.

Suivi par télédétection des cultures de décrue dans la vallée du fleuve Sénégal en saison froide 2000/2001. Landing Karim Mané et Pierrick Fraval, 2001. SAED, ADRAO et IWMI, St-Louis, Sénégal, 29 p.

Summary of WARDA/NARS Task Forces Activities 1991–1997. N. Yobouet and M.A.B. Fakorede (Comp.), 2001. WARDA, Bouaké, Côte d'Ivoire, 204 p. ISBN 92 9113 214 4.

Synthèse de la recherche rizicole en Afrique de l'Ouest n° 3 (revisé). Impact de l'amélioration variétale sur différentes écologies agricoles d'Afrique de l'Ouest. 2000. ADRAO, Bouaké, Côte d'Ivoire, 2 p. *Print publication.*

Utilisation efficace des herbicides en riziculture de bas-fonds. Fiche technique. 2001. ADRAO, [Bouaké, Côte d'Ivoire] et ANADER, [Abidjan, Côte d'Ivoire], [6] p.

WARDA: 1970–2001. 2001. WARDA, Bouaké, Côte d'Ivoire, 16 p. ISBN 92 9113 222 5.

WARDA/NARS Collaboration: Potential for a Green Revolution in Rice in West and Central Africa. Report of the Second Biennial WARDA/National Experts Committee Meeting, 20–21 March 2000, M'bé, Bouaké, Côte d'Ivoire. *Biennial WARDA/National Experts Committee Meeting Report* No. 2. 2001. WARDA, Bouaké, Côte d'Ivoire, 95 p. ISBN 92 9113 208 X.

WARDA's Experimental Farm. 2001. WARDA, Bouaké, Côte d'Ivoire, [6] p. ISBN 92 9113 220 9.

West Africa Rice Research Brief No. 3 (revised). Impact of varietal improvement in West African crop ecologies. 2000. WARDA, Bouaké, Côte d'Ivoire, 2 p. *Print publication.*

Workshop on a Collaborative Platform for Agricultural Research in Sub-Saharan Africa, WARDA, Bouaké, 14–16 March 2001. Workshop Report. 2001. International Service for National Agricultural Research (ISNAR), The Hague, The Netherlands, and WARDA, Bouaké, Côte d'Ivoire, 29 p. ISBN 92 9113 229 2.

Abbreviations and Acronyms

4Rs	Regional Rice Research Review (biennial meeting of ROCARIZ)
AABNF	African Association for Biological Nitrogen Fixation
ACT	Almanac Characterization Tool
ADRAO	Association pour le développement de la riziculture en Afrique de l'Ouest (French name of WARDA)
AfDB	African Development Bank
AICAF	Association for International Cooperation of Agriculture and Forestry (Japan)
AIDS	Acquired Immune Deficiency Syndrome
AMVS	Authorité de mise en valeur de la vallée de Sourou (Burkina Faso) [Sourou Valley extension service]
ANADER	Agence nationale d'appui au développement rural (Côte d'Ivoire)
ARI	African Rice Initiative
ASI	ADRAO/SAED/ISRA thresher–cleaner (ADRAO, Senegal)
AVRDC	Asian Vegetable Research and Development Center (Taiwan)
BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit (Germany)
BNETD	Bureau national d'études techniques et de développement
CABI	Centre for Agriculture and Biosciences International (United Kingdom)
CBF	Consortium bas-fonds (French name of IVC)
CBSS	community-based seed (production) system(s)
CD-ROM	compact disk – read-only memory
CDC	Center Directors Committee (CGIAR)
CERAAS	Centre d'étude régional pour l'amélioration de l'adaptation à la sécheresse (Senegal)
CERDI	Centre d'études et de recherches sur le développement international
CFA	Communauté financière africaine franc(s)
CFC	Common Fund for Commodities [donor]
CG	Consultative Group on International Agricultural Research
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIFOR	Center for International Forestry Research
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CIP	Centro Internacional de la Papa
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement (France)
CIRES	Centre ivoirien de recherches économiques et sociales
cm	centimeter(s)
CNRA	Centre national de recherche agronomique (Côte d'Ivoire, *formerly* IDESSA)
CNRS	Centre national de recherche scientifique (France)
CORAF	Conseil ouest et centre africain pour la recherche et le développement agricole [French name of WECARD]
CRF	Competitive Research Funds (DFID)
CTA	Technical Centre for Agricultural and Rural Cooperation (The Netherlands)
DAA	Diplôme d'agronomie appliquée
DAAD	Deutscher Akademischer Austauschdienst
DAF	Director of Administration and Finance (WARDA)

DANIDA	Danish International Development Agency
DC	District of Columbia (USA)
DEA	Diplôme d'études approfondies (degree)
DFID	Department for International Development (UK)
DGIS	Directorate General for International Cooperation (The Netherlands)
DIARPA	Diagnostique rapide de pré-aménagement (diagnostic tool)
Dr	doctor
Drs	doctors
DRDR	Direction régionale du développement rural
DRC	Domestic Resource Cost ratio
ECA	Economic Commission for Africa (UN)
ECART	European Consortium for Agricultural Research in the Tropics
ECODEV	Association a but non-lucratif l'approche intégrée au développement [NGO]
Ed. / ed.	editor(s)
e.g.	for example
EPHTA	Ecoregional Program for the Humid Tropics of Africa (CGIAR)
ESA	Ecole supérieure d'agronomie (INP-HB)
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FDCIC	Fonds de contrepartie ivoiro-canadien
FDFP	Fonds de développement de la formation professionnelle
FDPPE	Fondation pour le développement des projets à petite echelle [NGO, Senegal]
Fe	iron
FEPRODES	Fédération des femmes productrices de la région de Saint-Louis du Sénégal (Senegal)
Fig.	Figure
FPATDD	Farmer Participatory Approaches to Technology Development and Dissemination (WARDA Project)
GDP	Gross Domestic Product
GIS	geographical information system(s)
GTZ	Gesellschaft für Technische Zusammenarbeit (Germany)
ha	hectare(s)
HE	His Excellency
HIV	Human Immunodeficiency Virus
HRI	Horticultural Research International (UK)
IAEG	Impact Assessment and Evaluation Group (CGIAR)
ICARDA	International Center for Agricultural Research in the Dry Areas
ICLARM	International Center for Living Aquatic Resources
ICM	integrated crop management
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDESSA	Institut des savannes (*now* CNRA, Côte d'Ivoire)
IDRC	International Development Research Centre (Canada)
i.e.	that is
IER	Institut d'économie rurale (Mali)
IFAD	International Fund for Agricultural Development
IFDC	International Fertilizer Development Corporation
IFPRI	International Food Policy Research Institute (Washington, DC, USA)
IGBP	International Geosphere-Biosphere Programme
IHP	Interspecific Hybridization Project (WARDA)

IITA	International Institute of Tropical Agriculture (Ibadan, Nigeria)
ILRI	International Livestock Research Institute (Nairobi, Kenya and Addis Ababa, Ethiopia)
Inc.	Incorporated (company)
INERA	Institut de l'environnement et des recherches agricoles (Burkina Faso)
INGER	International Network for the Genetic Evaluation of Rice
INP-HB	Institut national polytechnique Houphouët-Boigny (Yamoussoukro, Côte d'Ivoire)
INRM	integrated natural-resources management
IPGRI	International Plant Genetic Resources Institute (Rome, Italy)
IRAG	Institut de recherche agronomique de Guinée (Guinea)
IRAT	Institut de recherches agronomiques tropicales et des cultures vivrières
IRD	Institut de recherche pour le développement (*formerly* ORSTOM, France)
IRM	integrated rice management
IRRI	International Rice Research Institute (Los Baños, The Philippines)
IRTP	International Rice Testing Program (forerunner of INGER, IRRI)
ISBN	International Standard Book Number
ISNAR	International Service for National Agricultural Research (The Hague, The Netherlands)
ISRA	Institut sénégalais de recherches agricoles (Senegal)
IVC	Inland Valley Consortium (WARDA)
IWMI	International Water Management Institute
JIRCAS	Japan International Research Center for Agricultural Sciences
JOCV	Japanese Overseas Cooperation Volunteer
K	potassium
kg	kilogram(s)
km	kilometer(s)
LANADA	Laboratoire national d'appui au développement agricole (Côte d'Ivoire)
Ltd	Limited (company)
MAFF	Ministry of Agriculture, Forestry and Fisheries (Japan)
MESRS	Ministry of Higher Education and Scientific Research (Côte d'Ivoire)
MINAGRA	Ministry of Agriculture (Côte d'Ivoire)
MSc	Master of Science (degree)
N	nitrogen
NARES	national agricultural research and extension system(s)
NARI	National Agricultural Research Institute (The Gambia); national agricultural research institution
NARS	national agricultural research system(s)
NCRI	National Cereals Research Institute (Nigeria)
NCU	National Coordination Unit (IVC)
NERICA	New Rice for Africa
NGO	non-governmental organization
NISER	Nigerian Institute of Social and Economic Research
n°	number [French usage]
no.	number
NRI	Natural Resources Institute (UK)
OAU	Organization of African Unity
OCP	Organizational Change Program (CGIAR)
OECD	Organisation for Economic Co-operation and Development
OFDA	Office of US Foreign Disaster Assistance (part of USAID)
ORSTOM	Institut français de recherche scientifique pour le développement en coopération (*now* IRD, France)
OVDL	Organisation des volontaires pour le développement local (Côte d'Ivoire) [NGO]

P	phosphorus
P. / p.	page(s)
Pp. / pp.	pages
PADS	Participatory Adaptation and Diffusion of technologies for rice-based Systems (WARDA project)
PhD	Doctor of Philosophy (doctorate)
PLAR	participatory learning and action research
PNR	Projet national riz (Côte d'Ivoire)
PRA	participatory rural appraisal
PRGA	System-wide Programme on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation (CGIAR)
PRIGA	Participatory Rice Improvement and Gender/User Analysis (WARDA)
PSI	Pôle systèmes irriguès (CORAF)
PTDP	Participatory Technology Development Project (WARDA)
PVS	participatory varietal selection
QTL	quantitative trait locus
RCU	Regional Coordination Unit (IVC)
REN	nitrogen recovery rate
RIDEV	rice development (crop model)
ROCARIZ	Reseau ouest et centre africain du riz (WARDA/CORAF Rice Research and Development Network for West and Central Africa)
RYMV	rice yellow mottle virus
SAED	Société d'aménagement et d'exploitation des terres du delta du fleuve Sénégal et des vallées du fleuve Sénégal et de la Falémé (Senegal)
SARI	Savanna Research Institute (Ghana)
SC-DLO	Winand Staring Centre for Integrated Land, Soil and Water Research (Wageningen, The Netherlands)
SES	Standard Evaluation Score (IRRI)
SNPRV	Service national de la promotion rurale et de la vulgarisation agricole (Guinea)
SNRA	système(s) national/nationaux de recherche agricole (French for NARS)
SPIRIVWA	Sustainable Productivity Improvement for Rice in Inland Valleys of West Africa (IVC project funded by CFC)
SRO	Sub-regional Organization
SSSA	Soil Science Society of America
subsp.	subspecies
SVG	Scalable Vector Graphics
SWIHA	System-wide Initiative on HIV/AIDS and Agriculture (CGIAR)
t	tonne(s)
TCDC	Technical Cooperation among Developing Countries (UNDP)
UK	United Kingdom
UN	United Nations
UNAIDS	Joint United Nations Programme on HIV/AIDS
UNDP	United Nations Development Programme
US	United States
USA	United States of America
USAID	United States Agency for International Development
WAIVIS	West Africa Inland Valley Information System
WARDA	West Africa Rice Development Association
WARF	West Africa Rural Foundation (NGO)
WASDU	West Africa Seed Development Unit

WAU	Wageningen Agricultural University
WCV	wide compatibility variety
WECARD	West and Central African Council for Research and Development (English of CORAF)
WFP	World Food Programme (FAO)
WUR	Wageningen University and Research Centre
Zn	zinc

About the Consultative Group on International Agricultural Research (CGIAR)

The Consultative Group on International Agricultural Research (CGIAR) was founded in 1971 as a global endeavor of cooperation and goodwill. The CGlAR's mission is to contribute to food security and poverty eradication in developing countries through research, partnership, capacity building and policy support, promoting sustainable agricultural development based on the environmentally sound management of natural resources. The CGIAR works to help ensure food security for the twenty-first century through its network of 16 international and autonomous research centers, including WARDA. Together, the centers conduct research on crops, livestock, fisheries and forests, develop policy initiatives, strengthen national agricultural organizations, and promote sustainable resource management practices that help provide people world-wide with better livelihoods.

The CGIAR works in partnership with national governmental and non-governmental organizations, universities and private industry. The United Nations Development Programme, the United Nations Environment Programme, the World Bank, and the Food and Agriculture Organization of the United Nations sponsor the CGIAR. The CGlAR's 57 members include developing and developed countries, private foundations, and international and regional organizations. Developing world participation has doubled in recent years. All members of the OECD (Organisation for Economic Co-operation and Development) Development Assistance Committee belong to the CGIAR.

The CGIAR is actively planning for the world's food needs well into the twenty-first century. It will continue to do so with its mission always in mind and with its constant allegiance to scientific excellence.

CGIAR Centers

CIAT	Centro Internacional de Agricultura Tropical (Cali, Colombia)
CIFOR	Center for International Forestry Research (Bogor, Indonesia)
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (Mexico, DF, Mexico)
CIP	Centro Internacional de la Papa (Lima, Peru)
ICARDA	International Center for Agricultural Research in the Dry Areas (Aleppo, Syria)
ICLARM	International Center for Living Aquatic Resources Management (Penang, Malaysia)
ICRAF	International Centre for Research in Agroforestry (Nairobi, Kenya)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (Patencheru, India)
IFPRI	International Food Policy Research Institute (Washington, DC, USA)
IITA	International Institute of Tropical Agriculture (Ibadan, Nigeria)
ILRI	International Livestock Research Institute (Nairobi, Kenya)
IPGRI	International Plant Genetic Resources Institute (Rome, Italy)
IRRI	International Rice Research Institute (Los Baños, Philippines)
ISNAR	International Service for National Agricultural Research (The Hague, Netherlands)
IWMI	International Water Management Institute (Colombo, Sri Lanka)
WARDA	West Africa Rice Development Association (Bouaké, Côte d'Ivoire)

West Africa Rice Development Association

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